EMC TEST REPORT for Intentional Radiator
No. 131000486SHA-002

Applicant	:	Ecovacs Robotics Co.,Ltd. No.108 Shihu Road (West), Wuzhong Zone, Suzhou , China 215168
Manufacturer	:	Ecovacs Robotics Co.,Ltd. No.108 Shihu Road (West), Wuzhong Zone, Suzhou , China 215168
Product Name	:	2.4G module
Type/Model	:	LSD4RF-25410N15

SUMMARY

The equipment complies with the requirements according to the following standard(s):

47CFR Part 15 (2013): Radio Frequency Devices

ANSI C63.4 (2009): American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

RSS-210 Issue 8 (December 2010): Low-power Licence-exempt Radiocommunication Devices (All Frequency Bands): Category I Equipment

RSS-Gen Issue 3 (December 2010): General Requirements and Information for the Certification of Radiocommunication Equipment

Date of issue: November 27, 2014

Prepared by: Reviewed by:

Jackson Huang (*Project Engineer*) Daniel Zhao (*Reviewer*)

Description of Test Facility

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Content

1. General Information

1.1 Applicant Information

Applicant	:	Ecovacs Robotics Co.,Ltd. No.108 Shihu Road (West), Wuzhong Zone, Suzhou , China 215168
Name of contact	:	Ms. Geng Hongxia
Tel	:	86 0512 67072006
Fax	:	86 0512 65274820
Manufacturer	:	Ecovacs Robotics Co.,Ltd. No.108 Shihu Road (West), Wuzhong Zone, Suzhou , China 215168

1.2 Identification of the EUT

Equipment:	2.4G module
Type/model:	LSD4RF-25410N15
FCC ID:	2AAL3-LSD4RF
IC ID:	12253A-LSD4RF

1.3 Technical specification

Frequency Range: 2438.99 – 2458.98 MHz

Modulation: 2-FSK

Gain of Antenna: PCB antenna, 0 dBi

Rating: 3.3VDC

Description of EUT: The EUT is a 2.4GHz wireless module.

Channel Description: 101Channel for 2438.99~2458.98MHz.

The channel spacing is 200 kHz.

Channel	Frequency (MHz)
0	2438.99
1	2439.19
2	2439.38
.	.
.	.
.	.
100	2458.98

1.4 Mode of operation during the test / Test peripherals used

While testing transmitting mode of EUT, the internal modulation and continuously transmission was applied.

The lowest, middle and highest channel were tested as representatives.

Freq. Band	Lowest(MHz)	Middle(MHz)	Highest(MHz)
2438.99~2458.98MHz	2438.99	2448.98	2458.98

The data rate of EUT is fixed and cannot by adjusted.

Test software setting:
The test setting software is offered by the manufactory.

Test hardware setting:

Product	Model	Manufactory
Test Board	LSD4RMZJA0760V1.00	Lierda Science & Technology Group Co.,Ltd.

2. Test Specification

2.1 Instrument list

Equipment	Type	Manu.	Internal no.	Cal. Date	Due date
Test Receiver	ESCS 30	R&S	EC 2107	2013-10-21	2014-10-20
Test Receiver	ESIB 26	R&S	EC 3045	2013-10-21	2014-10-20
Test Receiver	ESCI 7	R&S	EC4501	2013-12-29	2014-12-28
Spectrum Analyzer	N9010	Agilent	EC4890	2013-10-21	2014-10-20
Power meter	ML 2495A	Anritsu	EC 4895	2013-10-21	2014-10-20
A.M.N.	ESH2-Z5	R&S	EC 3119	2014-1-9	2015-1-8
Bilog Antenna	CBL 6112D	TESEQ	EC 4206	2014-5-16	2015-5-15
Horn antenna	HF 906	R&S	EC 3049	2014-5-13	2015-5-12
Pre-amplifier	Pre-amp 18	R&S	EC 3222	2014-4-12	2015-4-11
Pre-amplifier	Tpa0118-40	R&S	EC 4792-2	2014-4-12	2015-4-11
Log-period antenna	AT 1080	AR	EC 3044-7	2014-5-22	2015-5-21
Biconical antenna	3109PX	ETS	EC3564	2013-8-25	2014-8-24
Semi-anechoic chamber	-	Albatross project	EC 3048	2014-5-21	2015-5-20
Shielded room	-	Zhongyu	EC 2838	2014-1-12	2016-1-11
Shielded room	-	Zhongyu	EC 2839	2014-1-12	2016-1-11
High Pass Filter	WHKX 1.0/15G-10SS	Wainwright	EC4297-1	2014-2-1	2015-1-31
High Pass Filter	WHKX 2.8/18G-12SS	Wainwright	EC4297-2	2014-2-1	2015-1-31
High Pass Filter	WHKX 7.0/1.8G-8SS	Wainwright	EC4297-3	2014-2-1	2015-1-31
Band Reject Filter	WRCGV 2400/2483-2390/2493-35/10SS	Wainwright	EC4297-4	2014-2-1	2015-1-31

2.2 Test Standard

47CFR Part 15 (2013)
ANSI C63.4 (2009)
RSS-210 Issue 8 (December 2010)
RSS-Gen Issue 3 (December 2010)

2.3 Test Summary

This report applies to tested sample only. This report shall not be reproduced in part without written approval of Intertek Testing Service Shanghai.

TEST ITEM	FCC REFERANCE	FCC REFERANCE	RESULT
Minimum 6dB Bandwidth	15.247(a)(2)	RSS-210 Issue 8 Annex 8	Pass
Maximum peak output power	15.247(b)	RSS-210 Issue 8 Annex 8	Pass
Power spectrum density	15.247(e)	RSS-210 Issue 8 Annex 8	Pass
Radiated emission	15.205 & 15.209	RSS-210 Issue 8 Clause 2	Pass
Emission outside the frequency band	15.247(d)	RSS-210 Issue 8 Annex 8	Pass
Power line conducted emission	15.207	RSS-Gen Issue 3 Clause 7.2.4	Pass
Occupied bandwidth	-	RSS-Gen Issue 3 Clause 4.6.1	Tested

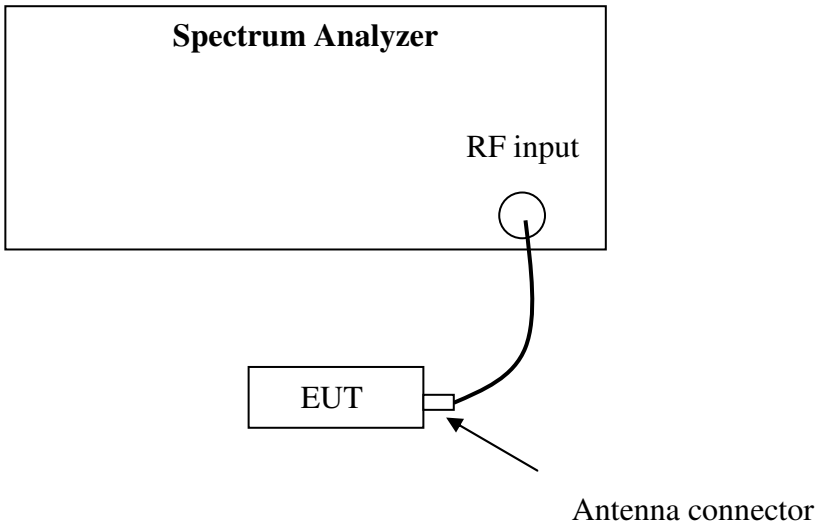
3. Minimum 6dB Bandwidth

Test result: PASS

3.1 Limit

For systems using digital modulation techniques that may operate in the 902 - 928 MHz, 2400 - 2483.5 MHz and 5725 - 5850 MHz bands, the minimum 6 dB bandwidth shall be at least 500 kHz.

3.2 Test Configuration



3.3 Test Procedure and test setup

The minimum 6dB bandwidth per FCC §15.247(a)(2) is measured using the Spectrum Analyzer according to DTS test procedure of "KDB558074 D01 DTS Meas Guidance v03r01" for compliance to FCC 47CFR 15.247 requirements.

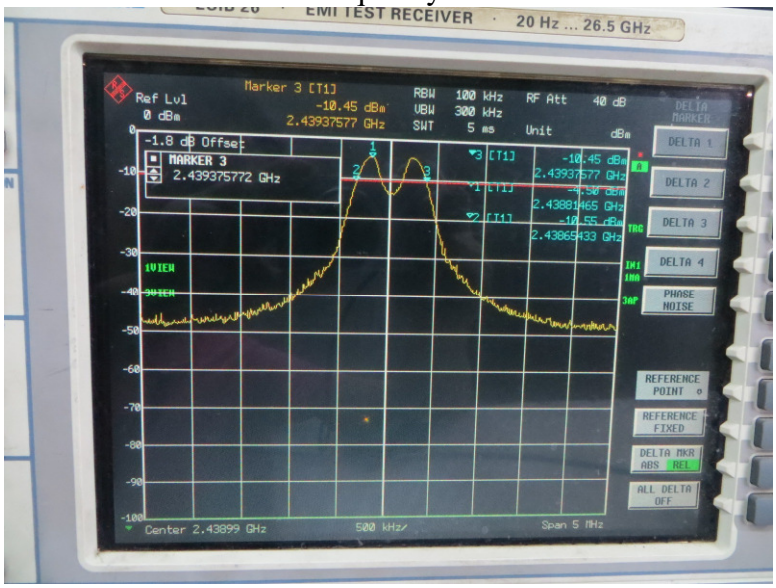
3.4 Test Protocol

Temperature : 25°C

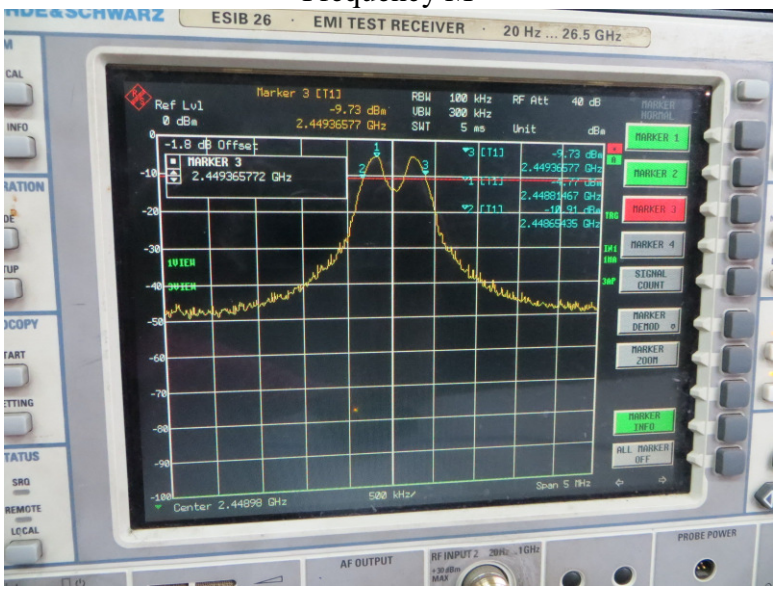
Relative Humidity : 55%

CH	Bandwidth (MHz)	Limit (MHz)
L	0.72	⩾0.5
M	0.71	
H	0.69	

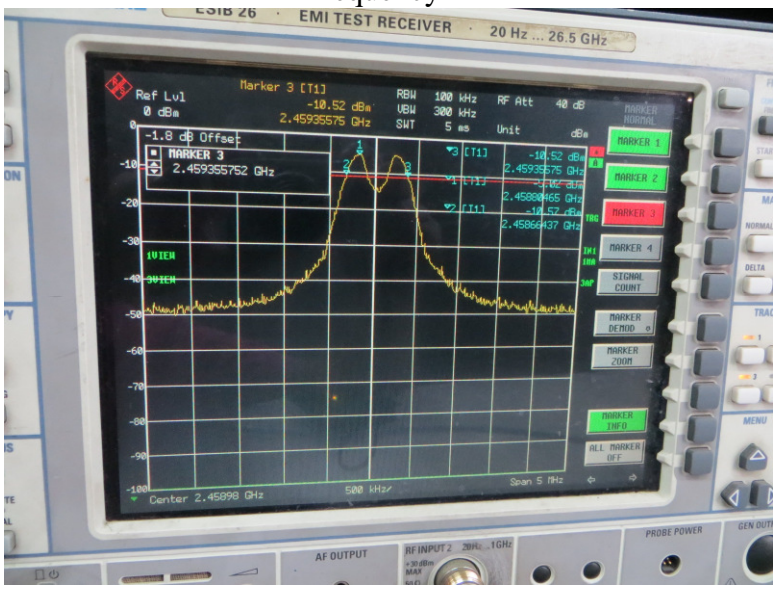
Frequency L



Frequency M



Frequency H


EMI TEST RECEIVER
20 Hz ... 26.5 GHz
Ref Lvl
0 dBm
Marker 3 [T1]
-10.52 dBm
2.45935575 GHz
RBW 100 kHz
VBW 300 kHz
SWT 5 ms
RF Att 40 dB
Unit dBm
-1.8 dB Offset
MARKER 3
2.459356752 GHz
MARKER 1
MARKER 2
MARKER 3
MARKER 4
SIGNAL COUNT
MARKER DEMOD
MARKER ZOOM
MARKER INFO
ALL MARKER OFF
Center 2.45098 GHz
500 kHz/
Span 5 MHz
AF OUTPUT
PROBE POWER

4. Maximum peak output power

Test result: Pass

4.1 Test limit

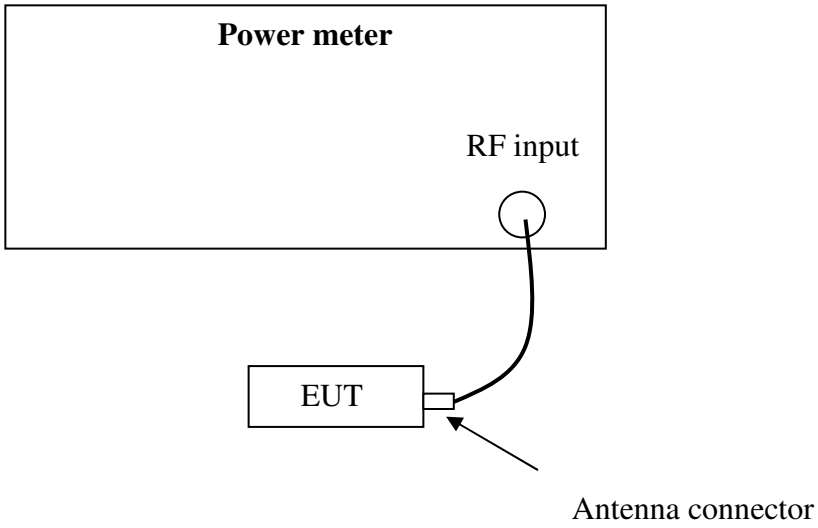
☐ For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt

☐ For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts

☒ For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt.

If the transmitting antenna of directional gain greater than 6dBi is used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

4.2 Test Configuration



4.3 Test procedure and test setup

The EUT was tested according to DTS test procedure of "KDB558074 D01 DTS Meas Guidance v03r01" for compliance to FCC 47CFR 15.247 requirements (clause 9.1.2).

4.4 Test protocol

Temperature : 25 °C
Relative Humidity : 55 %

Freq. (MHz)	Reading (dBm)	Limit (dBm)	Margin (dB)
2438.99	3.57	30.00	26.43
2448.98	3.84	30.00	26.16
2458.98	3.29	30.00	26.71

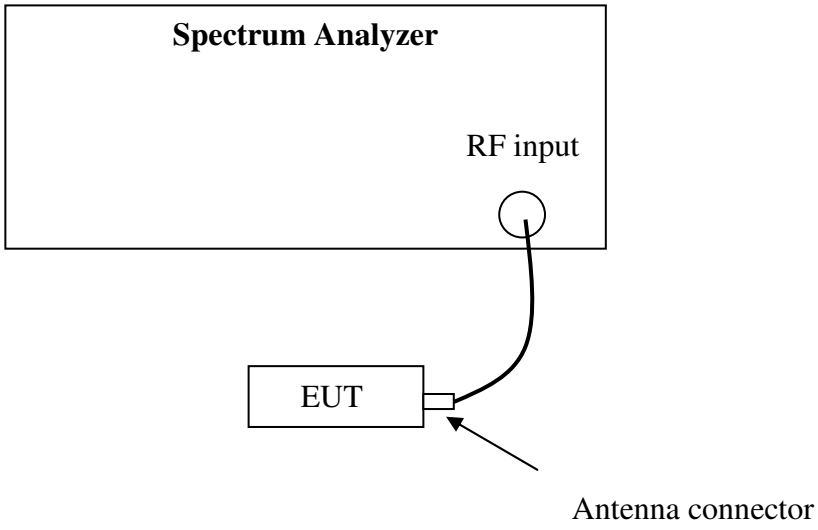
5. Power spectrum density

Test result: **Pass**

5.1 Test limit

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

5.2 Test Configuration



5.3 Test procedure and test setup

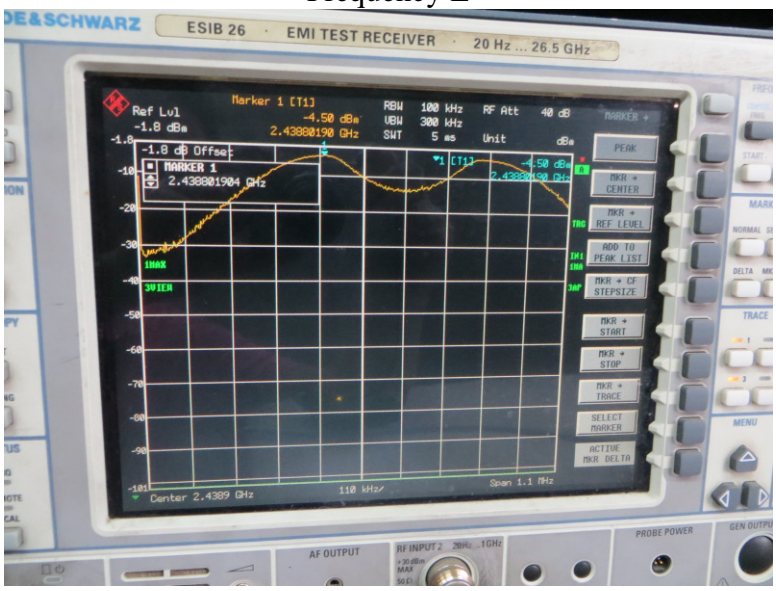
The power output per FCC §15.247(e) was tested according to DTS test procedure of "KDB558074 D01 DTS Meas Guidance v03r01" (clause 10.2) for compliance to FCC 47CFR 15.247 requirements.

5.4 Test Protocol

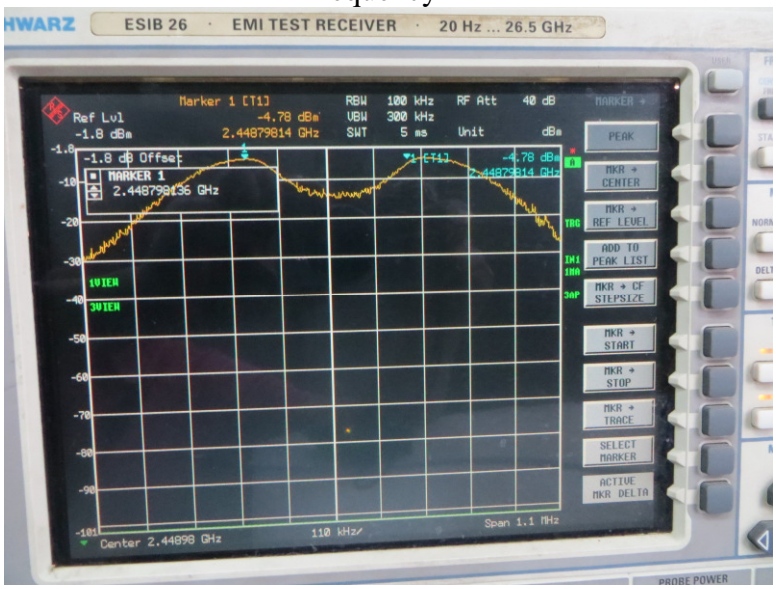
Temperature : 25 °C
Relative Humidity: 55 %

CH	Cable loss (dB)	PSD (dBm/100kHz)	Limit (dBm/3kHz)
L	2.00	-4.50	≤8.00
M	2.00	-4.78	
H	2.00	-4.92	

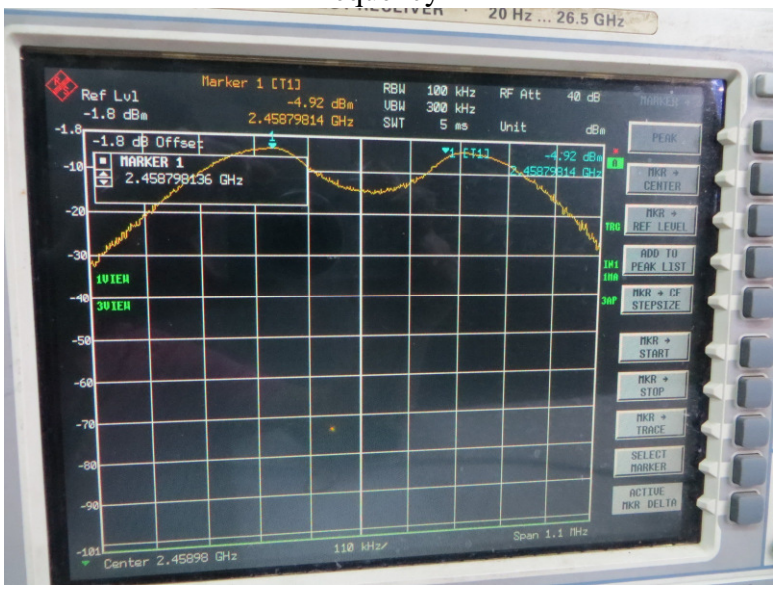
Frequency L



Frequency M



Frequency H


20 Hz ... 26.5 GHz
Ref Lvl
-1.8 dBm
Marker 1 [T1]
-4.92 dBm
2.45879814 GHz
RBW 100 kHz
VBW 300 kHz
SWT 5 ms
RF Att 40 dB
Unit dBm
-1.8 dB Offset
MARKER 1
2.458798136 GHz
PEAK
MKR → CENTER
MKR → REF LEVEL
ADD TO PEAK LIST
MKR → CF STEPSIZE
MKR → START
MKR → STOP
MKR → TRACE
SELECT MARKER
ACTIVE MKR DELTA
Center 2.45898 GHz
110 kHz/
Span 1.1 MHz

6. Radiated emission

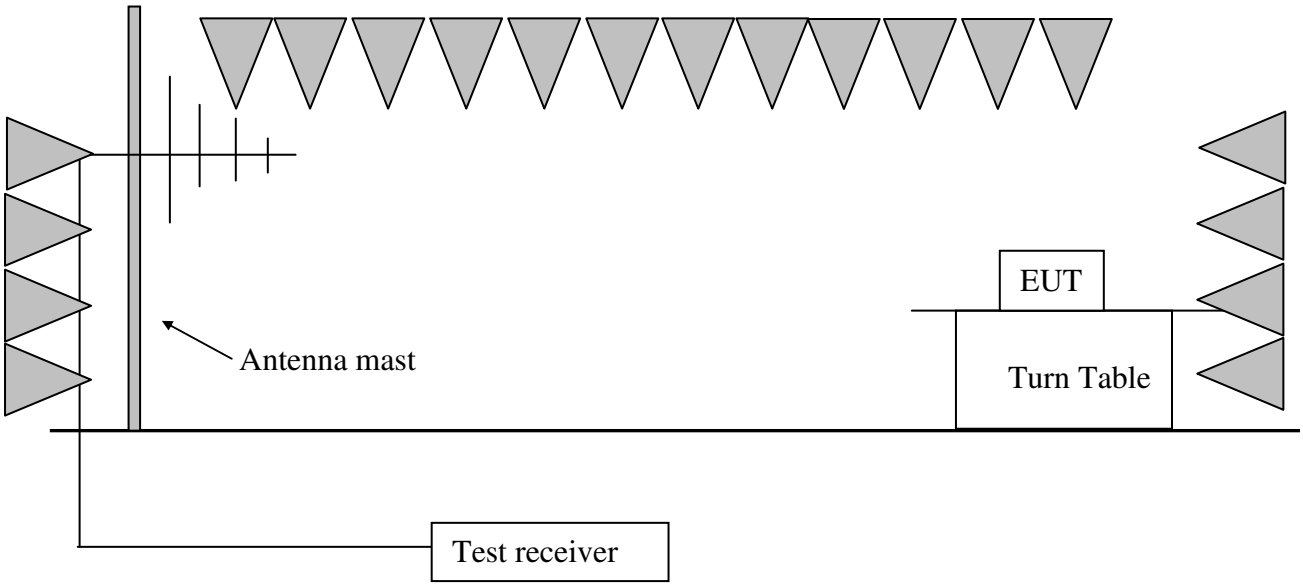
Test result: PASS

6.1 Test limit

The radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) showed as below:

Frequency (MHz)	Field Strength (dBuV/m)	Measurement Distance (m)
30 - 88	40.0	3
88 - 216	43.5	3
216 - 960	46.0	3
Above 960	54.0	3

6.2 Test Configuration



6.3 Test procedure and test setup

The measurement was applied in a semi-anechoic chamber. While testing for spurious emission higher than 1GHz, if applied, the pre-amplifier would be equipped just at the output terminal of the antenna.
The EUT and simulators were placed on a 0.8m high wooden turntable above the horizontal metal ground plane. The turn table rotated 360 degrees to determine the position of the maximum emission level. The EUT was set 3 meters away from the receiving antenna which was mounted on an antenna mast. The antenna moved up and down between from 1meter to 4 meters to find out the maximum emission level.
The EUT was tested according to DTS test procedure of KDB558074 D01 DTS “Meas Guidance v03r01” (clause 12.1) for compliance to FCC 47CFR 15.247 requirements.

6.4 Test protocol

Temperature : 18 °C
Relative Humidity : 54 %

We test from 30M~26GHz and list the worst data below.

CH	Polarization	Frequency (MHz)	Factor	Measure Level (dBuV/m)	Limit (dBuV/m)	Over Limit (dB)	Type
L	V	2438.99	-11.6	73.2	Fundamental	/	PK
	H	156.35	14.0	25.7	43.5	17.8	QP
	H	311.86	25.3	31.8	46.0	14.2	QP
	V	2385.45	-10.9	34.3	54.0	9.7	PK
	V	4877.98	-3.4	51.1	74.0	22.9	PK
	V	4877.98	-3.4	48.9	54.0	5.1	AV
M	V	2448.98	-11.6	74.0	Fundamental	/	PK
	V	4897.96	-3.3	50.0	74.0	24.0	PK
	V	4897.96	-3.3	47.5	54.0	6.5	AV
H	V	2458.98	-3.5	74.50	Fundamental	/	PK
	V	155.99	14.0	24.9	43.5	28.6	QP
	V	312.05	24.8	32.5	46.0	13.5	QP
	V	2484.00	-10.9	34.5	54.0	9.5	PK
	V	4917.96	-3.3	52.6	74.0	21.4	PK
	V	4917.96	-3.3	48.5	54.0	5.5	AV

Remark: 1. Factor = Antenna Factor + Cable Loss (-Amplifier, is employed)
2. Measure level = Original Receiver Reading Level+ Correct Factor
3. Over Limit = Measure level - limit
4. If the PK reading is lower than AV limit, the AV test can be elided.

Example: Assuming Antenna Factor = 30.20dB/m, Cable Loss = 2.00dB,
Gain of Preamplifier = 32.00dB, Original Receiver Reading level = 10dBuV.
Then Factor = 30.20 + 2.00 – 32.00 = 0.20dB/m; Measure level = 10dBuV + 0.20dB/m = 10.20dBuV/m
Assuming limit = 54dBuV/m, Measure level = 10.20dBuV/m, then Over Limit = 10.20 - 54= -43.80dBuV/m

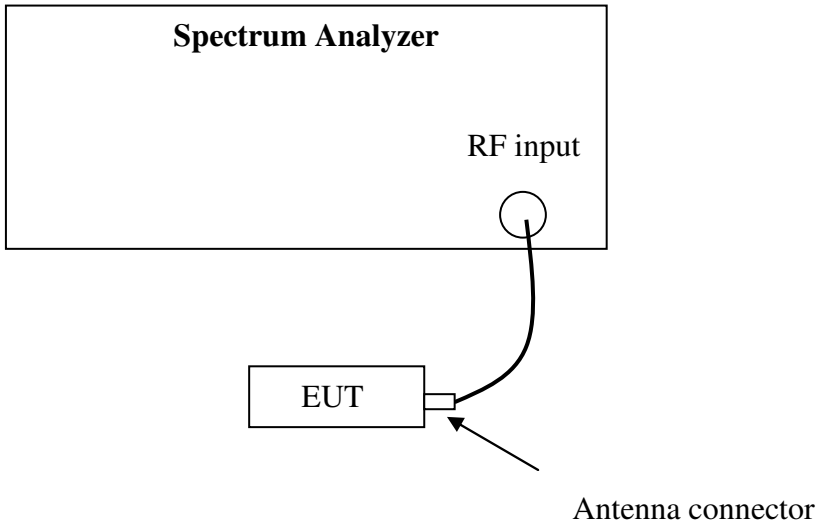
7. Emission outside the frequency Band

Test result: **PASS**

7.1 Limit

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.

7.2 Test Configuration



7.3 Test procedure and test setup

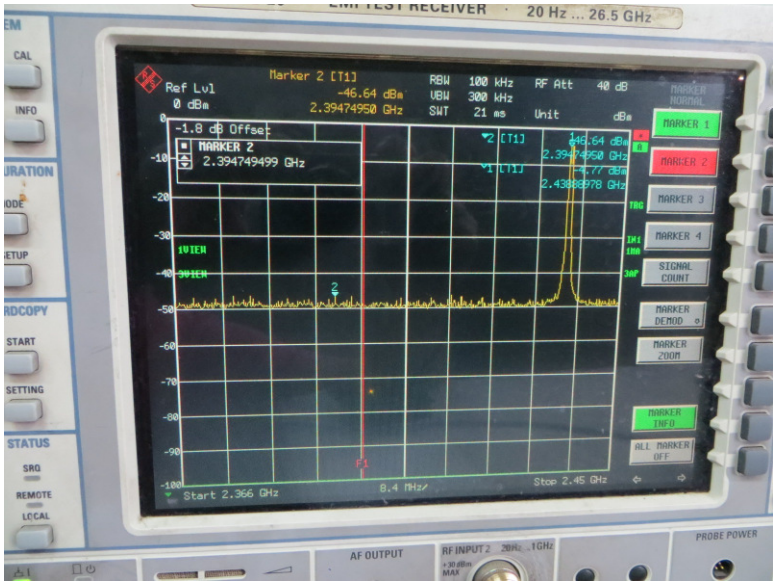
The Emission outside the frequency Band per FCC §15.247(d) is measured using the Spectrum Analyzer with the resolutions bandwidth set at 100kHz, the video bandwidth set at 300kHz, and the SPAN>>RBW.
The EUT was tested according to DTS test procedure of "KDB558074 D01 DTS Meas Guidance v03r01" (clause 11.0) for compliance to FCC 47CFR 15.247 requirements.

7.4 Test protocol

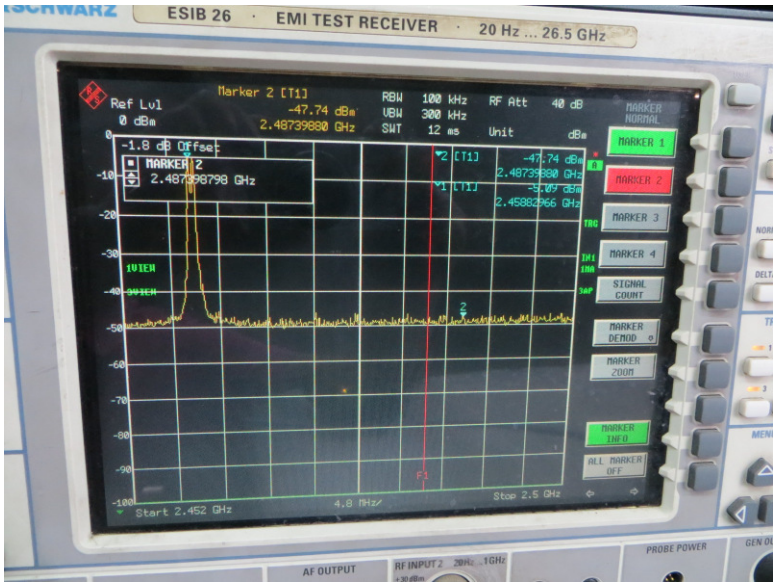
CH	Max reading among band (dBm)	The most restrict Attenuation outside band (dB)	Limit (dB)
L	-4.77	41.87	≥20
H	-5.09	42.65	

Note: The test was performed from 9kHz to 26GHz and the graph of band edge emission is listed below.

Low Band Edge - Frequency L



High Band Edge - Frequency H



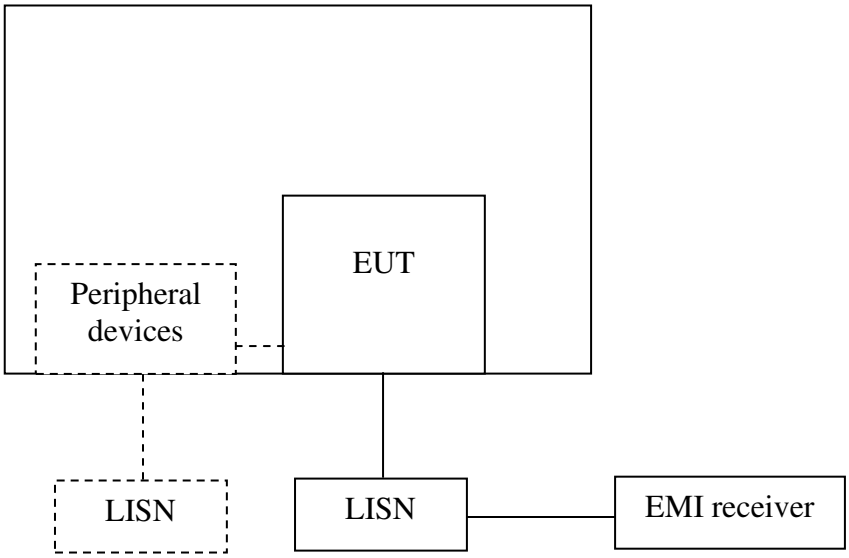
8. Power line conducted emission

Test result: **NA**

8.1 Limit

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	QP	AV
0.15-0.5	66 to 56*	56 to 46 *
0.5-5	56	46
5-30	60	50
* Decreases with the logarithm of the frequency.		

8.2 Test configuration



☒ For table top equipment, wooden support is 0.8m height table

☐ For floor standing equipment, wooden support is 0.1m height rack.

8.3 Test procedure and test set up

The EUT are connected to the main power through a line impedance stabilization network (LISN). This provides a 50Ω/50uH coupling impedance for the measuring equipment. The peripheral devices are also connected to the main power through a LISN that provides a 50Ω/50uH coupling impedance with 50Ω termination.
Both sides (Line and Neutral) of AC line are checked for maximum conducted interference. In order to find the maximum emission, the relative positions of equipment and all of the interface cables must be changed according to ANSI C63.4 on conducted measurement.
The bandwidth of the test receiver is set at 9 kHz.

8.4 Test protocol

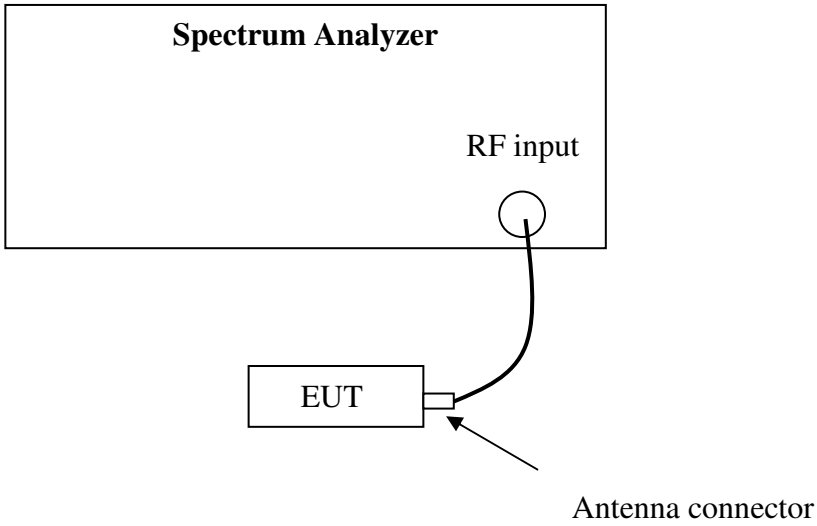
9. Occupied Bandwidth

Test Status: Tested

9.1 Test limit

None

9.2 Test Configuration



9.3 Test procedure and test setup

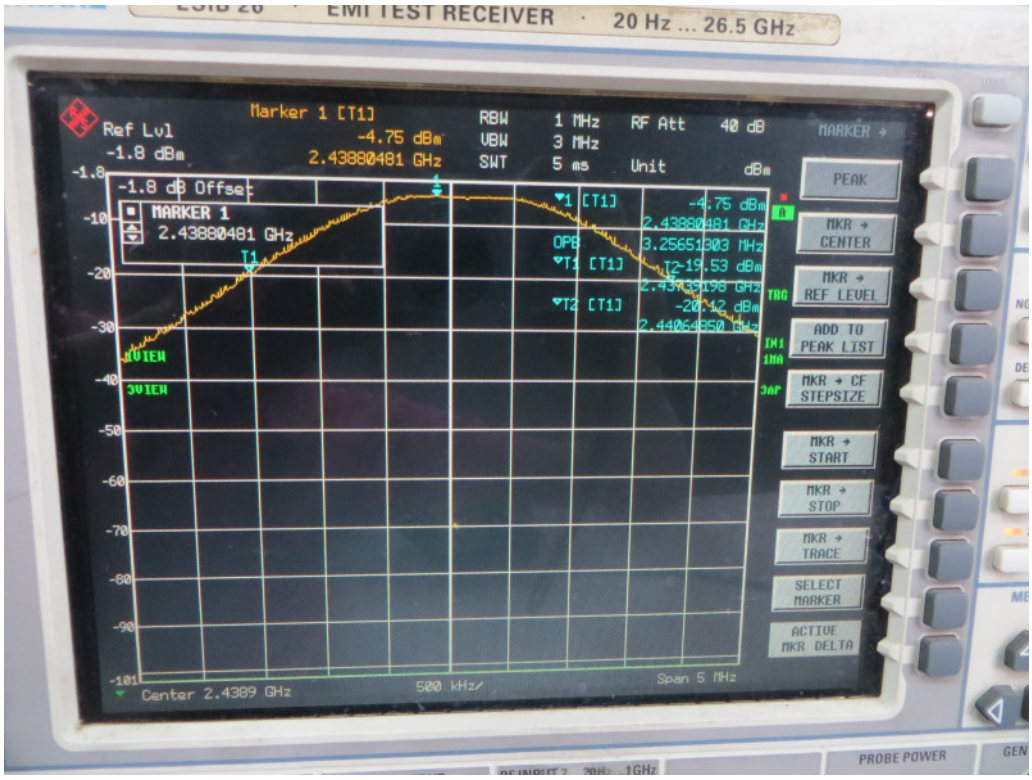
The occupied bandwidth per RSS-Gen Issue 3 Clause 4.6.1 was measured using the Spectrum Analyzer.

9.4 Test protocol

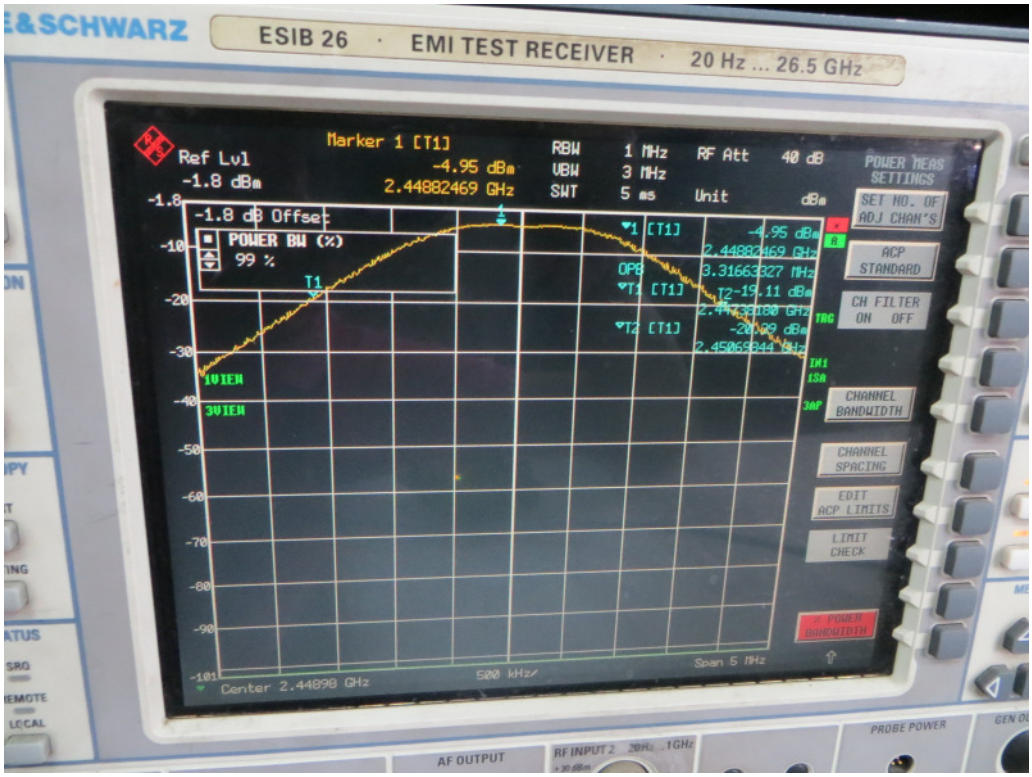
Temperature : 25 °C
Relative Humidity : 55 %

CH	99% Bandwidth (MHz)
L	3.26
M	3.32
H	3.28

Channel L



Channel M



Channel H