FCC

RF TEST REPORT

ISSUED BY
Shenzhen BALUN Technology Co., Ltd.

FOR

Outdoor LoRa Gateway

ISSUED TO
Shenzhen RAKwireless Technology Co., Ltd.

Room 506, Bldg B, New Compark, Pingshan First Road, Taoyuan Street, XiLi town Nanshan District, Shenzhen, China

Report No.:	BL-SZ1920035-602
EUT Name:	Outdoor LoRa Gateway
Model Name:	RAK7240 (refer section 2.4)
Brand Name:	RAK
Test Standard:	47 CFR Part 15 Subpart C
FCC ID:	2AF6B-RAK724X
Test Conclusion:	Pass
Test Date:	Feb. 21, 2019 ~ Mar. 19, 2019
Date of Issue:	Apr. 15, 2019

Tested by: Heng Aiping
Heng Aiping
(Engineer)
Date: Apr. 15. 2019

Approved by:
Wei Yanquan
(Chief Engineer)
Date: Apr. 15. 2019

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Revision History

Version	Issue Date	Revisions Content
Rev. 01	Apr. 03, 2019	Initial Issue
Rev. 02	Apr. 15, 2019	Updated KDB version and antenna information

TABLE OF CONTENTS

1 ADMINISTRATIVE DATA (GENERAL INFORMATION)

1.1 Identification of the Testing Laboratory

Company Name	Shenzhen BALUN Technology Co., Ltd.
Address	Block B, 1st FL, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China
Phone Number	+86 755 6685 0100
Fax Number	+86 755 6182 4271

1.2 Identification of the Responsible Testing Location

Test Location	Shenzhen BALUN Technology Co., Ltd.
Address	Block B, 1st FL, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China
Accreditation Certificate	The laboratory has been listed by Industry Canada to perform electromagnetic emission measurements. The recognition numbers of test site are 11524A-1. The laboratory is a testing organization accredited by FCC as a accredited testing laboratory. The designation number is CN1196. The laboratory is a testing organization accredited by American Association for Laboratory Accreditation (A2LA) according to ISO/IEC 17025.The accreditation certificate is 4344.01. The laboratory is a testing organization accredited by China National Accreditation Service for Conformity Assessment (CNAS) according to ISO/IEC 17025. The accreditation certificate number is L6791.
Description	All measurement facilities used to collect the measurement data are located at Block B, FL 1, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China 518055

1.3 Laboratory Condition

Ambient Temperature	20℃ to 25℃
Ambient Relative Humidity	45% to 55%
Ambient Pressure	100 kPa to 102 kPa

1.4 Announce

(1) The test report reference to the report template version v2.2.

(2) The test report is invalid if not marked with the signatures of the persons responsible for preparing and approving the test report.

(3) The test report is invalid if there is any evidence and/or falsification.

(4) The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein.

(5) This document may not be altered or revised in any way unless done so by BALUN and all revisions are duly noted in the revisions section.

(6) Content of the test report, in part or in full, cannot be used for publicity and/or promotional purposes without prior written approval from the laboratory.

2 PRODUCT INFORMATION

2.1 Applicant Information

Applicant	Shenzhen RAKwireless Technology Co., Ltd.
Address	Room 506, Bldg B, New Compark, Pingshan First Road, Taoyuan Street, XiLi town Nanshan District, Shenzhen, China

2.2 Manufacturer Information

Manufacturer	Shenzhen RAKwireless Technology Co., Ltd.
Address	Room 506, Bldg B, New Compark, Pingshan First Road, Taoyuan Street, XiLi town Nanshan District, Shenzhen, China

2.3 Factory Information

Factory	N/A
Address	N/A

2.4 General Description for Equipment under Test (EUT)

EUT Name	Outdoor LoRa Gateway
Model Name Under Test	RAK7240
Series Model Name	RAK7249
Description of Model name differentiation	All models are same with electrical parameters and internal circuit structure, but only different on enclosure.
Hardware Version	VA
Software Version	1.1.0024_Release
Dimensions (Approx.)	N/A
Weight (Approx.)	N/A

2.5 Technical Information

Network and Wireless connectivity	3G Network WCDMA Band 2/4/5/8 4G Network FDD LTE Band 2/4/5/12/13 WIFI 802.11b, 802.11g and 802.11n (HT20/40) GPS, Lora

The requirement for the following technical information of the EUT was tested in this report:

Modulation Technology	Frequency hopping system, Hybrid system
Modulation Type	Chirp Spread Spectrum
Product Type	☒ Mobile ☐ Portable ☐ Fix Location
Frequency Range	The frequency range used is 902 MHz to 928 MHz.
Number of channel	8
Tested Channel	1 (923.3 MHz), 4 (925.1 MHz), 8 (927.5 MHz)
Antenna Type	Fiberglass Antenna
Antenna Gain	5.5 dBi (In test items related to antenna gain, the final results reflect this figure.)
Antenna System(MIMO Smart Antenna)	N/A
About the Product	The EUT is supply the DTS, Frequency hopping system and Hybrid system, only the frequency hopping system and hybrid system were tested in this report.

All channel was listed on the following table:

Channel number	Freq. (MHz)	Channel number	Freq. (MHz)	Channel number	Freq. (MHz)	Channel number	Freq. (MHz)
1	**923.3**	3	924.5	5	925.7	7	926.9
2	923.9	**4**	**925.1**	6	926.3	**8**	**927.5**

2.6 Additional Instructions

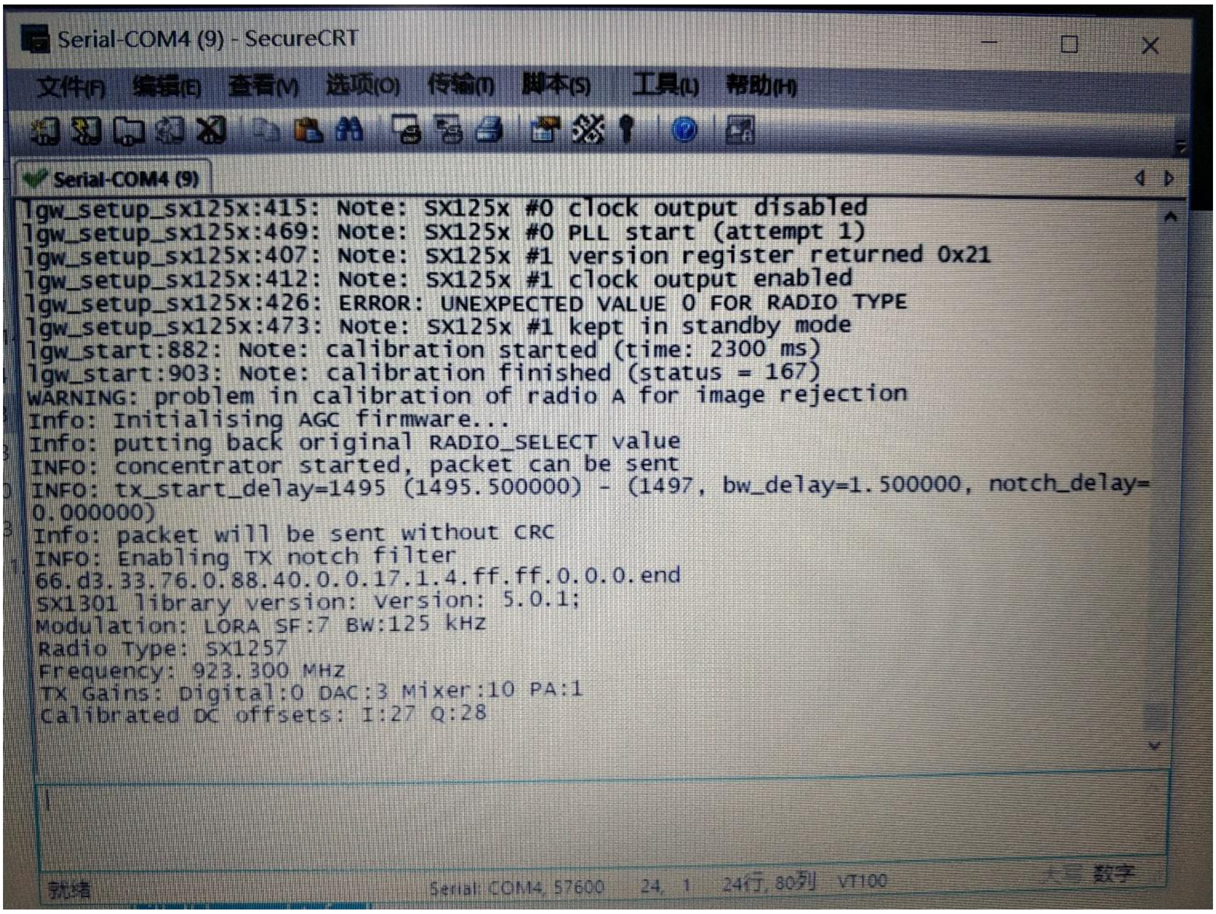
EUT Software Settings:

Mode	☒ Special software is used. The software provided by client to enable the EUT under transmission condition continuously at specific channel frequencies individually.

During testing, Channel and Power Controlling Software provided by the customer was used to control the operating channel as well as the output power level. The RF output power selection is for the setting of RF output power expected by the customer and is going to be fixed on the firmware of the final end product.

Power level setup in software		
Test Software Version	SecureCRT	
Mode	Freq. (MHz)	Soft Set
LoRa	923.3	11
	925.1	12
	927.5	13

Run Software



3 SUMMARY OF TEST RESULTS

3.1 Test Standards

No.	Identity	Document Title
1	47 CFR Part 15, Subpart C	Miscellaneous Wireless Communications Services
2	FCC PUBLIC NOTICE DA 00-705 (Mar. 30, 2000)	Filling and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
3	ANSI C63.10-2013	American National Standard for Testing Unlicensed Wireless Devices
4	KDB Publication 558074 D01v05r02	GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES

3.2 Verdict

No.	Description	FCC Part No.	Modulation Technology	Channel	Test Result	Verdict	Remark
1	Antenna Requirement	15.203	N/A	N/A	--	Pass	Note [1]
2	Number of Hopping Frequencies	15.247(a)	Frequency hopping system	Hopping Mode	ANNEX A.1	N/A	--
3	Peak Output Power	15.247(b)	Frequency hopping system, Hybrid system	Low/Middle/ High	ANNEX A.2	Pass	--
4	Occupied Bandwidth	15.247(a)	Frequency hopping system, Hybrid system	Low/Middle/ High	ANNEX A.3	Pass	Note [2]
5	Carrier Frequency Separation	15.247(a)	Frequency hopping system, Hybrid system	Hopping Mode	ANNEX A.4	Pass	Note [2]
6	Time of Occupancy (Dwell time)	15.247(a)	Frequency hopping system, Hybrid system	Hopping Mode	ANNEX A.5	Pass	Note [2]
7	Conducted Spurious Emission & Authorized-band band-edge	15.247(d)	Frequency hopping system, Hybrid system	Low/Middle/ High, Hopping Mode	ANNEX A.6	Pass	Note [2]
8	Conducted Emission	15.207	Frequency hopping system, Hybrid system	Low/Middle/ High	ANNEX A.7	Pass	--

9	Radiated Spurious Emission	15.209 15.247(d)	Frequency hopping system, Hybrid system	Low/Middle/ High, Hopping Mode	ANNEX A.8	Pass	--
10	Band Edge (Restricted-band band-edge)	15.209 15.247(d)	Frequency hopping system, Hybrid system	Low/Middle/ High, Hopping Mode	ANNEX A.9	Pass	Note [2]
11	Power spectral density (PSD)	15.247(e)	--	--	ANNEX A.10	Pass	Note [2]

Note [1]: Please refer to section 5.1.
Note [2]: Because the RF module installed in the EUT is electronically and mechanically identical to the original certified module in the test report No. RSZ181207002-00B (FCC ID: 2AF6B-RAK2247) (which issued by Bay Area Compliance Laboratories Corp. (Shenzhen) on Dec. 24, 2018), so just cabinet radiation test of Peak Output Power & Conducted Emission & Radiated Spurious Emission were retested in this report. Other test items please refer to the No. RSZ181207002-00B (FCC ID: 2AF6B-RAK2247) (which issued by Bay Area Compliance Laboratories Corp. (Shenzhen) on Dec. 24, 2018).
Note [3]: Both model RAK7240 and model RAK7249 were tested, but the report only showed the data of the worst model, and model RAK7240 has the worst data.

4 GENERAL TEST CONFIGURATIONS

4.1 Test Environments

During the measurement, the normal environmental conditions were within the listed ranges:

Relative Humidity	45% to 55%	
Atmospheric Pressure	100 kPa to 102 kPa	
Temperature	NT (Normal Temperature)	+22℃ to +25℃
Working Voltage of the EUT	NV (Normal Voltage)	48 V

4.2 Test Equipment List

Description	Manufacturer	Model	Serial No.	Cal. Date	Cal. Due
Spectrum Analyzer	ROHDE&SCHWARZ	FSV-30	103118	2018.06.15	2019.06.14
Vector Signal Generator	ROHDE&SCHWARZ	SMBV100A	260592	2018.06.15	2019.06.14
Signal Generator	ROHDE&SCHWARZ	SMB100A	177746	2018.06.15	2019.06.14
Switch Unit with OSP-B157	ROHDE&SCHWARZ	OSP120	101270	2018.06.15	2019.06.14
Spectrum Analyzer	AGILENT	E4440A	MY45304434	2018.11.01	2019.10.31
EMI Receiver	ROHDE&SCHWARZ	ESRP	101036	2018.06.13	2019.06.12
LISN	SCHWARZBECK	NSLK 8127	8127-687	2018.06.13	2019.06.12
Bluetooth Tester	ROHDE&SCHWARZ	CBT	101005	2018.06.15	2019.06.14
Power Splitter	KMW	DCPD-LDC	1305003215	--	--
Power Sensor	ROHDE&SCHWARZ	NRP-Z21	103971	2018.06.15	2019.06.14
Attenuator (20 dB)	KMW	ZA-S1-201	110617091	--	--
Attenuator (6 dB)	KMW	ZA-S1-61	1305003189	--	--
DC Power Supply	ROHDE&SCHWARZ	HMP2020	018141664	2018.06.14	2019.06.13
Temperature Chamber	ANGELANTIONI SCIENCE	NTH64-40A	1310	2018.06.26	2019.06.25
Test Antenna-Loop(9 kHz-30 MHz)	SCHWARZBECK	FMZB 1519	1519-037	2017.11.09	2019.11.08
Test Antenna-Bi-Log(30 MHz-3 GHz)	SCHWARZBECK	VULB 9163	9163-624	2017.07.22	2019.07.21
Test Antenna-Horn(1-18 GHz)	SCHWARZBECK	BBHA 9120D	9120D-1148	2018.07.11	2020.07.10
Test Antenna-Horn(15-26.5 GHz)	SCHWARZBECK	BBHA 9170	9170-305	2018.06.21	2019.06.20
Test Antenna-Horn (18-40 GHz)	A-INFO	LB-180400 KF	J211060273	2017.01.06	2019.01.05
Anechoic Chamber	RAINFORD	9m*6m*6m	N/A	2017.02.21	2020.02.20
Anechoic Chamber	EMC TECHNOLOGY LTD	21.1m*11.6 m*7.35m	N/A	2017.08.08	2019.08.07
Shielded Enclosure	ChangNing	CN-130701	130703	--	--
Signal Generator	ROHDE&SCHWARZ	SMB100A	177746	2018.06.15	2019.06.14
Power Amplifier	OPHIR RF	5225F	1037	2019.02.28	2020.02.27
Power Amplifier	OPHIR RF	5273F	1016	2019.02.28	2020.02.27

Description	Manufacturer	Model	Serial No.	Cal. Date	Cal. Due
Directional Coupler	Werlantone	C5982-10	109275	N/A	N/A
Directional Coupler	Werlantone	CHP-273E	S00801z-01	N/A	N/A
Feld Strength Meter	Narda	EP601	511WX51129	2018.05.21	2019.05.20
Amplifier	COM-MW	KL_LNA_18 -40G-01	N/A	2018.06.26	2019.06.25
RF Cable 1	ROHDE&SCHWARZ	JUNFLON	APR0914004	2018.07.10	2019.10.09
RF Cable 2	Huber&suhner	RG_400_/U	N/A	2018.07.10	2019.10.09
RF Cable 3	Huber&suhner	RG_400_/U	N/A	2018.07.10	2019.10.09
RF Cable 4	Huber&suhner	SX_04172_ B-60	N/A	2018.07.10	2019.10.09
RF Cable 5	COM-MW	RFJA360-2. 92mm-J/J3 M	N/A	2018.07.10	2019.10.09
Note: The calibration period on the Cable is three month.					

4.3 Measurement Uncertainty

The following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2.

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

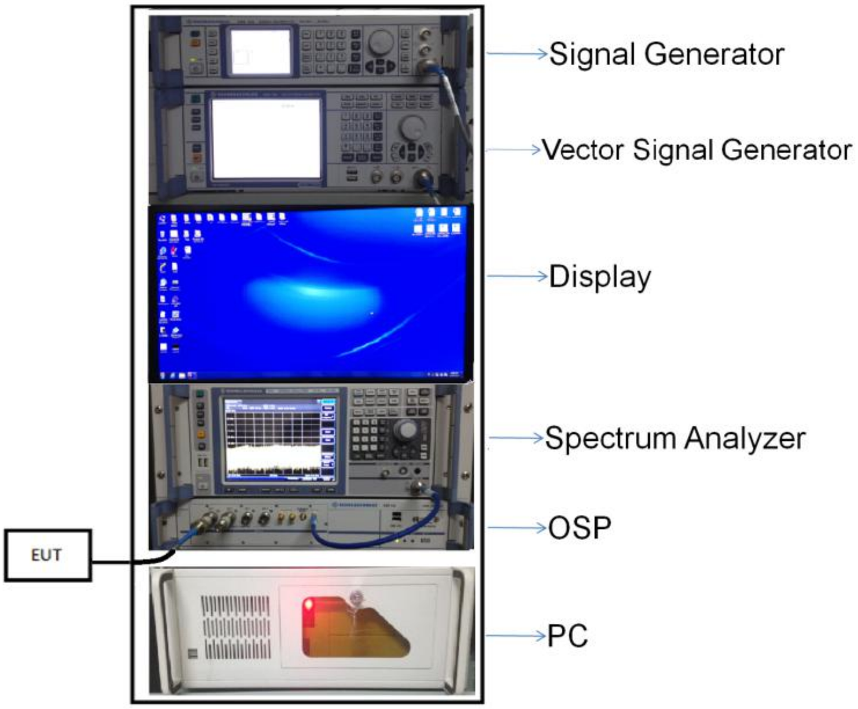
Measurement	Value
Occupied Channel Bandwidth	±4%
RF output power, conducted	±1.4 dB
Power Spectral Density, conducted	±2.5 dB
Unwanted Emissions, conducted	±2.8 dB
All emissions, radiated	±5.4 dB
Temperature	±1°C
Humidity	±4%

4.4 Description of Test Setup

4.4.1 For Antenna Port Test

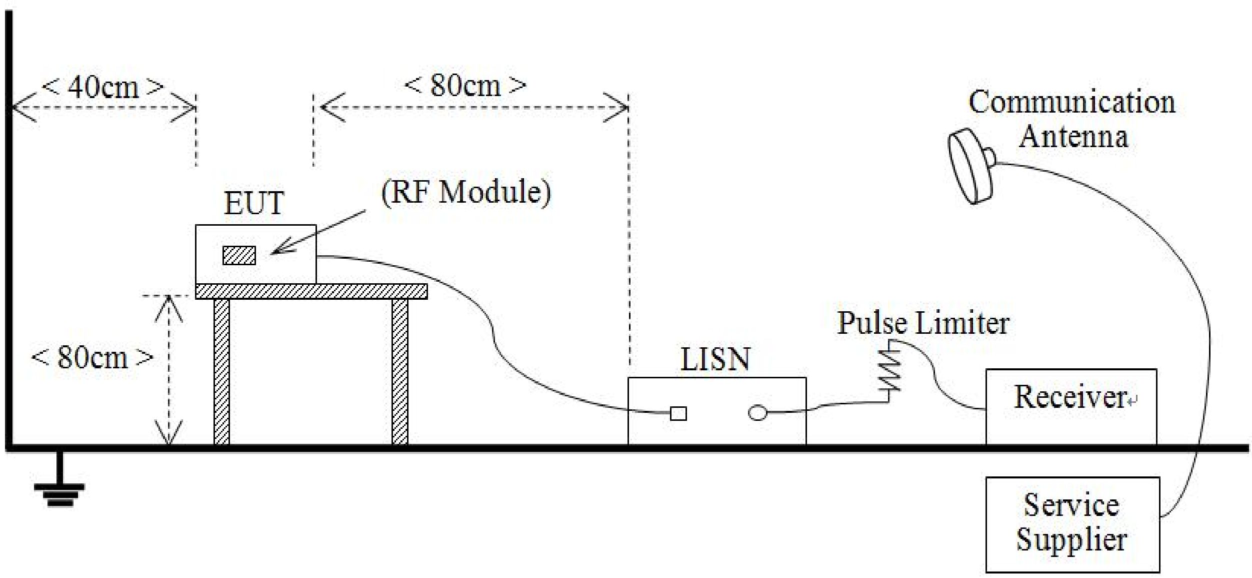
Conducted value (dBm) = Measurement value (dBm) + cable loss (dB)

For example: the measurement value is 10 dBm and the cable 0.5dBm used, then the final result of EUT:
Conducted value (dBm) = 10 dBm + 0.5 dB = 10.5 dBm



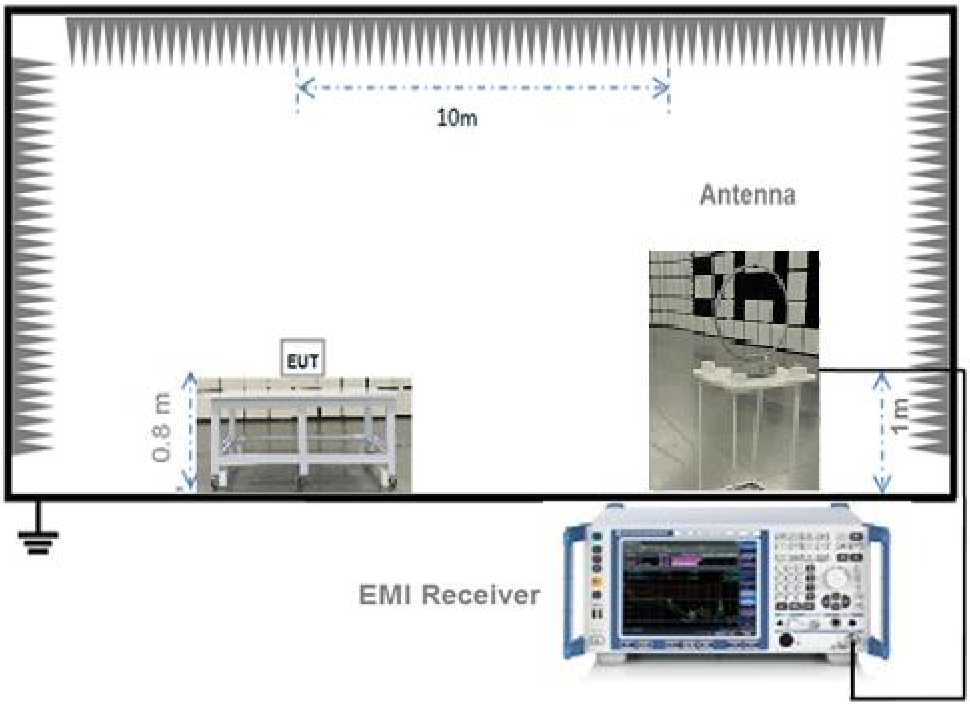
(Diagram 1)

4.4.2 For AC Power Supply Port Test



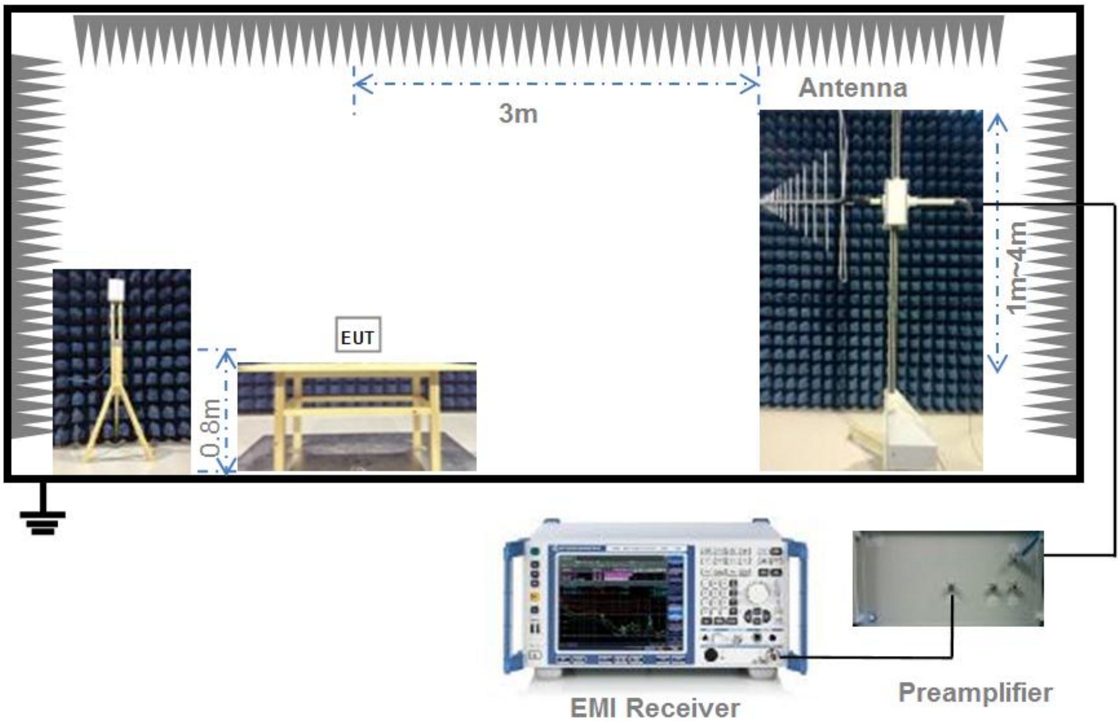
(Diagram 2)

4.4.3 For Radiated Test (Below 30 MHz)



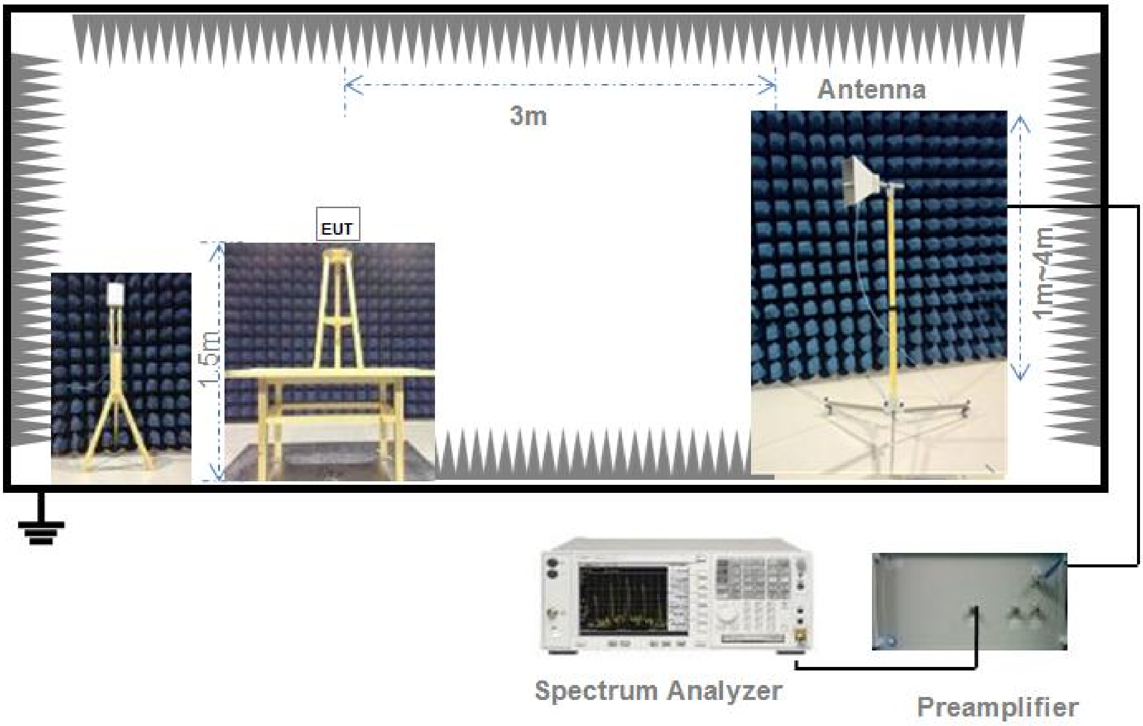
(Diagram 3)

4.4.4 For Radiated Test (30 MHz-1 GHz)



(Diagram 4)

4.4.5 For Radiated Test (Above 1 GHz)



(Diagram 5)

4.5 Measurement Results Explanation Example

4.5.1 For conducted test items:

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

4.5.2 For radiated band edges and spurious emission test:

Per part 15.35(c), the EUT Bluetooth average emission level could be determined by the peak emission level applying duty cycle correction factor, to represent averaging over the whole pulse train.
The average level is derived from the peak level corrected with “Duty cycle correction factor”.
Average Emission Level (dBuV/m) = Peak Emission Level (dBuV/m) + Duty cycle correction factor (dB)
Duty cycle correction factor (dB) = 20 * log (Duty cycle).
Duty cycle = on time / 100 milliseconds
On time = dwell time * hopping number in 100 ms
For example: bluetooth with dwell time 2.9 ms and 3 hops in 100 ms, then
Duty cycle correction factor (dB) = 20 * log ((2.9 * 3) / 100) = -21.21 dB
Following shows an average computation example with duty cycle correction factor = -21.21 dB, and the peak emission level is 45.61 dBuV/m.
Example:
Average Emission Level (dBuV/m) = Peak Emission Level (dBuV/m) + duty cycle correction factor (dB)
= 45.61 + (-21.21) = 24.4 (dBuV/m)

5 TEST ITEMS

5.1 Antenna Requirements

5.1.1 Relevant Standards

FCC §15.203 & 15.247(b); RSS-247, 5.4 (6)

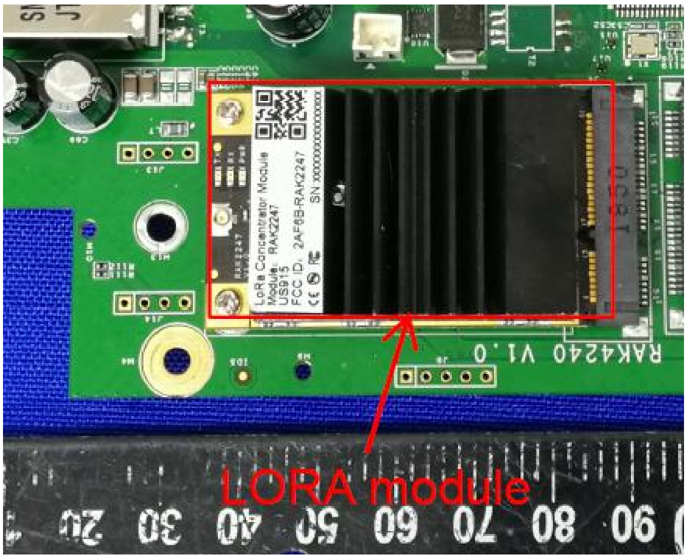
An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of § 15.211, § 15.213, § 15.217, § 15.219, or § 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with § 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

If directional gain of transmitting antennas is greater than 6 dBi, the power shall be reduced by the same level in dB comparing to gain minus 6 dBi. For the fixed point-to-point operation, the power shall be reduced by one dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi. 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 FCC rule.

5.1.2 Antenna Anti-Replacement Construction

The Antenna Anti-Replacement as following method:

Protected Method
This device is professionally installed.

Reference Documents	Item
Photo	 

5.1.3 Antenna Gain

The antenna peak gain of EUT is less than 6 dBi. Therefore, it is not necessary to reduce maximum peak output power limit.

5.2 Number of Hopping Frequencies

5.2.1 Limit

FCC §15.247(a) (1) (i); RSS-247, 5.1 (4)

For frequency hopping systems operating in the 902-928 MHz band: the system shall use at least 50 hopping frequencies.

Test Setup

See section 4.4.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.2.2 Test Procedure

The EUT must have its hopping function enabled. Use the following spectrum analyzer settings:

Span = the frequency band of operation

RBW ≥ 1% of the span

VBW ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

Allow the trace to stabilize

5.2.3 Test Result

Please refer to ANNEX A.1.

5.3 Peak Output Power and E.I.R.P

5.3.1 Test Limit

FCC § 15.247(b)(1)

For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

RSS-247, 5.4 (2)

For FHSs operating in the band 902-928 MHz, the maximum peak conducted output power shall not exceed 1.0 W and the e.i.r.p. shall not exceed 4 W if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W and the e.i.r.p. shall not exceed 0.5 W if the hopset uses less than 75 hopping channels (see Section 5.4(5) for exceptions).

5.3.2 Test Setup

See section 4.4.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.3.3 Test Procedure

The Module operates at hopping-off test mode. The lowest, middle and highest channels are selected to perform testing to verify the conducted RF output peak power of the Module.

Use the following spectrum analyzer settings:

Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel

RBW > the 20 dB bandwidth of the emission being measured

VBW ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

Allow the trace to stabilize.

5.3.4 Test Result

Please refer to ANNEX A.2.

5.4 Occupied Bandwidth

5.4.1 Limit

FCC §15.247(a)(1)(i); RSS-247, 5.1 (1)

Measurement of the 20dB bandwidth of the modulated signal. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

5.4.2 Test Setup

See section 4.4.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.4.3 Test Procedure

Use the following spectrum analyzer settings:

Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel

RBW = in the range of 1% to 5% of the OBW

VBW ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

The EUT should be transmitting at its maximum data rate, Allow the trace to stabilize.

5.4.4 Test Result

Please refer to ANNEX A.3.

5.5 Carrier Frequency Separation

5.5.1 Limit

FCC §15.247(a)(1); RSS-247, 5.1 (2)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

5.5.2 Test Setup

See section 4.4.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.5.3 Test Procedure

The EUT must have its hopping function enabled. Use the following spectrum analyzer settings:

Span = wide enough to capture the peaks of two adjacent channels

Resolution (or IF) Bandwidth (RBW) ≥ 1% of the span

Video (or Average) Bandwidth (VBW) ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

Allow the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

5.5.4 Test Result

Please refer to ANNEX A.4.

5.6 Time of Occupancy (Dwell time)

5.6.1 Limit

FCC §15.247(a)(1)(i); RSS-247, 5.1 (4)

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period.

5.6.2 Test Setup

See section 4.4.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.6.3 Test Procedure

The lowest, middle and highest channels are selected to perform testing to record the dwell time of each occupation measured in this channel, which is called Pulse Time here.

5.6.4 Test Result

Please refer to ANNEX A.5

5.7 Conducted Spurious Emission & Authorized-band band-edge

5.7.1 Limit

FCC §15.247(d); RSS-247, 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated 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, based on either an RF conducted or a radiated measurement.

5.7.2 Test Setup

See section 4.4.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.7.3 Test Procedure

Use the following spectrum analyzer settings:

Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic. Typically, several plots are required to cover this entire span.
RBW = 100 kHz
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold
Allow the trace to stabilize

5.7.4 Test Result

Please refer to ANNEX A.6 and A.7

5.8 Conducted Emission

5.8.1 Limit

FCC §15.207; RSS-GEN, 8.8

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50μH/50Ω line impedance stabilization network (LISN).

Frequency range (MHz)	Conducted Limit (dBμV)	
	Quai-peak	Average
0.15 - 0.50	66 to 56	56 to 46
0.50 - 5	56	46
0.50 - 30	60	50

5.8.2 Test Setup

See section 4.4.2 for test setup description for the AC power supply port. The photo of test setup please refer to ANNEX B.

5.8.3 Test Procedure

The maximum conducted interference is searched using Peak (PK), if the emission levels more than the AV and QP limits, and that have narrow margins from the AV and QP limits will be re-measured with AV and QP detectors. Tests for both L phase and N phase lines of the power mains connected to the EUT are performed. Refer to recorded points and plots below.
Devices subject to Part 15 must be tested for all available U.S. voltages and frequencies (such as a nominal 120 VAC, 50/60 Hz and 240 VAC, 50/60 Hz) for which the device is capable of operation. A device rated for 50/60 Hz operation need not be tested at both frequencies provided the radiated and line conducted emissions are the same at both frequencies.

5.8.4 Test Result

Please refer to ANNEX A.7.

5.9 Radiated Spurious Emission

5.9.1 Limit

FCC §15.209&15.247(d); RSS-247, 5.5

Radiated emission outside the frequency band attenuation below the general limits specified in FCC section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in FCC section 15.205(a), must also comply with the radiated emission limits specified in FCC section 15.209(a).

According to FCC section 15.209 (a), 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 (μV/m)	Measurement Distance (m)
0.009 - 0.490	902/F(kHz)	300
0.490 - 1.705	9020/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

Note:

1. Field Strength (dBμV/m) = 20*log[Field Strength (μV/m)].
2. In the emission tables above, the tighter limit applies at the band edges.
3. For Above 1000 MHz, the emission limit in this paragraph is based on measurement instrumentation employing an average detector, measurement using instrumentation with a peak detector function, corresponding to 20dB above the maximum permitted average limit.
4. For above 1000 MHz, limit field strength of harmonics: 54dBuV/m@3m (AV) and 74dBuV/m@3m (PK).

5.9.2 Test Setup

See section 4.4.3 to 4.4.5 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.9.3 Test Procedure

The measurement frequency range is from 9 kHz to the 10th harmonic of the fundamental frequency. The Turn Table is actuated to turn from 0° to 360°, and both horizontal and vertical polarizations of the Test Antenna are used to find the maximum radiated power. Mid channels on all channel bandwidth verified. Only the worst RB size/offset presented.

The power of the EUT transmitting frequency should be ignored.

All Spurious Emission tests were performed in X, Y, Z axis direction. And only the worst axis test condition was recorded in this test report.

Use the following spectrum analyzer settings:

Span = wide enough to fully capture the emission being measured
RBW = 1 MHz for f ≥ 1 GHz, 100 kHz for f < 1 GHz
VBW ≥ RBW
Sweep = auto

Detector function = peak
Trace = max hold
For measurement below 1GHz, If the emission level of the EUT measured by the peak detector is 3 dB lower than the applicable limit, the peak emission level will be reported, Otherwise, the emission measurement will be repeated using the quasi-peak detector and reported.

5.9.4 Test Result

Please refer to ANNEX A.8.

5.10 Band Edge (Restricted-band band-edge)

5.10.1 Limit

FCC §15.209&15.247(d)

Radiated emission outside the frequency band attenuation below the general limits specified in FCC section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in FCC section 15.205(a), must also comply with the radiated emission limits specified in FCC section 15.209(a).

5.10.2 Test Setup

See section 4.4.3 to 4.4.5 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.10.3 Test Procedure

The measurement frequency range is from 9 kHz to the 10th harmonic of the fundamental frequency. The Turn Table is actuated to turn from 0° to 360°, and both horizontal and vertical polarizations of the Test Antenna are used to find the maximum radiated power. Mid channels on all channel bandwidth verified. Only the worst RB size/offset presented.

The power of the EUT transmitting frequency should be ignored.

All Spurious Emission tests were performed in X, Y, Z axis direction. And only the worst axis test condition was recorded in this test report.

Use the following spectrum analyzer settings:

Span = wide enough to fully capture the emission being measured
RBW = 1 MHz for f ≥ 1 GHz, 100 kHz for f < 1 GHz
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

For measurement below 1GHz, If the emission level of the EUT measured by the peak detector is 3 dB lower than the applicable limit, the peak emission level will be reported, Otherwise, the emission measurement will be repeated using the quasi-peak detector and reported.

5.10.4 Test Result

Please refer to ANNEX A.9.

5.11 Power Spectral density (PSD)

5.11.1 Limit

FCC §15.247(e); RSS-247, 5.2 (2)

The same method of determining the conducted output power shall be used to determine the power spectral density. If a peak output power is measured, then a peak power spectral density measurement is required. If an average output power is measured, then an average power spectral density measurement should be used.

The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of Section 5.4(4), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

5.11.2 Test Setup

See section 4.4.1 (Diagram 1) for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.11.3 Test Procedure

Set analyzer center frequency to DTS channel center frequency.

Set the span to 1.5 times the DTS bandwidth.

Set the RBW to: 3 kHz ≤ RBW ≤ 100 kHz.

Set the VBW ≥ 3 RBW.

Detector = peak.

Sweep time = auto couple.

Trace mode = max hold.

Allow trace to fully stabilize.

Use the peak marker function to determine the maximum amplitude level within the RBW.

If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

5.11.4 Test Result

Please refer to ANNEX A.10.

ANNEX A TEST RESULT

A.1 Number of Hopping Frequency

Note: Not applicable.

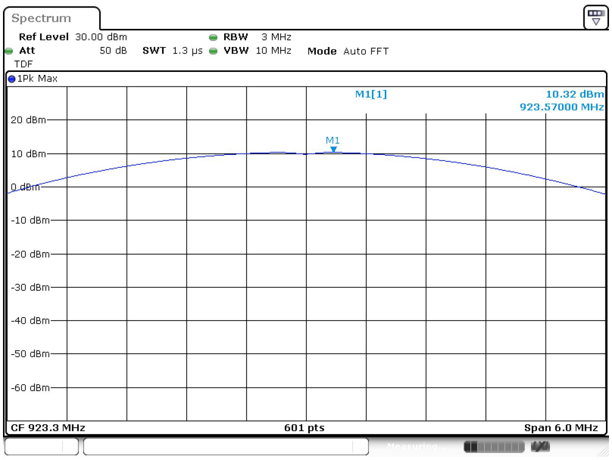
A.2 Peak Output Power

Peak Power Test Data

Channel	Measured Output Peak Power		Limit		Verdict
	LoRa		dBm	mW	
	dBm	mW			
Low	10.32	10.76	30	1000	Pass
Middle	11.20	13.18			Pass
High	12.34	17.14			Pass

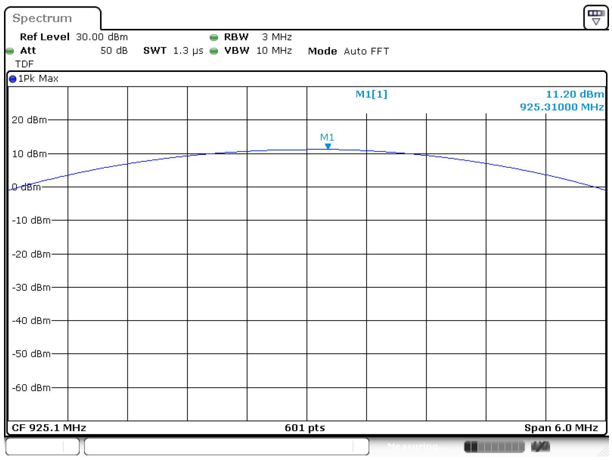
Test plots

LOW CHANNEL



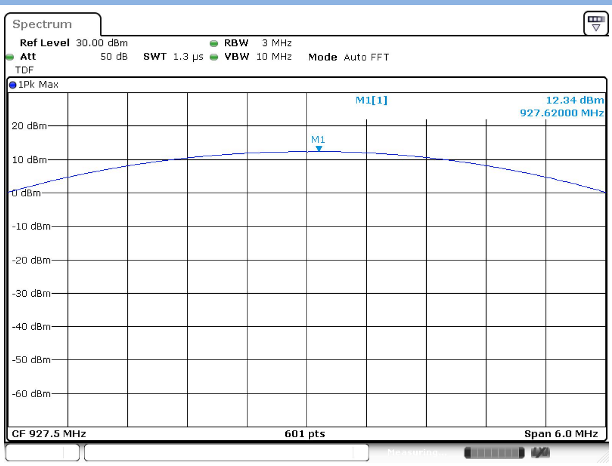
Date: 5.MAR.2019 19:37:09

MIDDLE CHANNEL



Date: 5.MAR.2019 19:52:09

HIGH CHANNEL



Date: 5.MAR.2019 19:56:01

A.3 20 dB and 99% bandwidth

Note: The 20 dB and 99% bandwidth please refer to the Report No. RSZ181207002-00B (FCC ID: 2AF6B-RAK2247) (which issued by Bay Area Compliance Laboratories Corp. (Shenzhen) on Dec. 24, 2018), **Section 6 dB EMISSION BANDWIDTH.**

A.4 Hopping Frequency Separation

Note: The Hopping Frequency Separation please refer to the Report No. RSZ181207002-00B (FCC ID: 2AF6B-RAK2247) (which issued by Bay Area Compliance Laboratories Corp. (Shenzhen) on Dec. 24, 2018), **Section 6 dB EMISSION BANDWIDTH.**

A.5 Average Time of Occupancy

Note: The Hopping Frequency Separation please refer to the Report No. RSZ181207002-00B (FCC ID: 2AF6B-RAK2247) (which issued by Bay Area Compliance Laboratories Corp. (Shenzhen) on Dec. 24, 2018), **Section Maximum Conducted Output Power.**

A.6 Conducted Spurious Emissions & Authorized-band band-edge

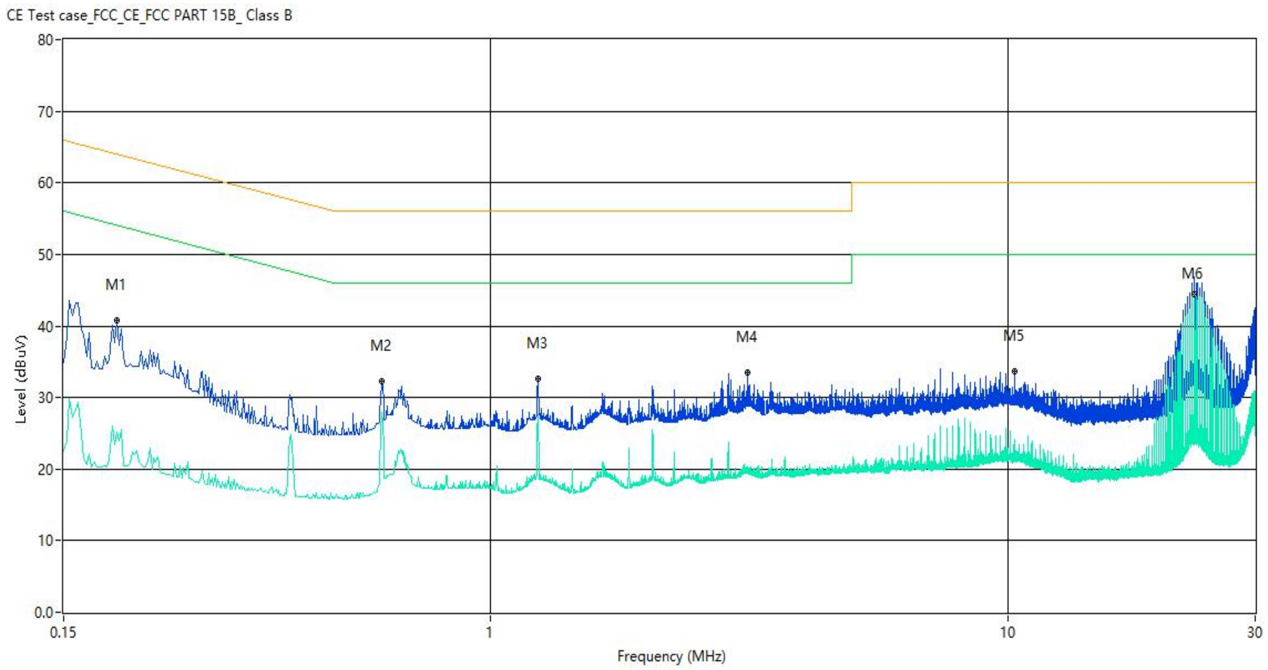
Note: The Conducted Spurious Emissions & Authorized-band band-edge please refer to the Report No. RSZ181207002-00B (FCC ID: 2AF6B-RAK2247) (which issued by Bay Area Compliance Laboratories Corp. (Shenzhen) on Dec. 24, 2018), **Section Spurious Emissions.**

A.7 Conducted Emissions

Note [1]: The EUT is working in the Normal link mode.
Note [2]: Devices subject to Part 15 must be tested for all available U.S. voltages and frequencies (such as a nominal 120 VAC, 60 Hz and 240 VAC, 50 Hz) for which the device is capable of operation. So, The configuration 120 VAC, 60 Hz and 240 VAC, 50 Hz were tested respectively, but only the worst configuration (120 VAC, 60 Hz) shown here.
Note [3]: Results (dBuV) = Original reading level of Spectrum Analyzer (dBuV) + Factor (dB)

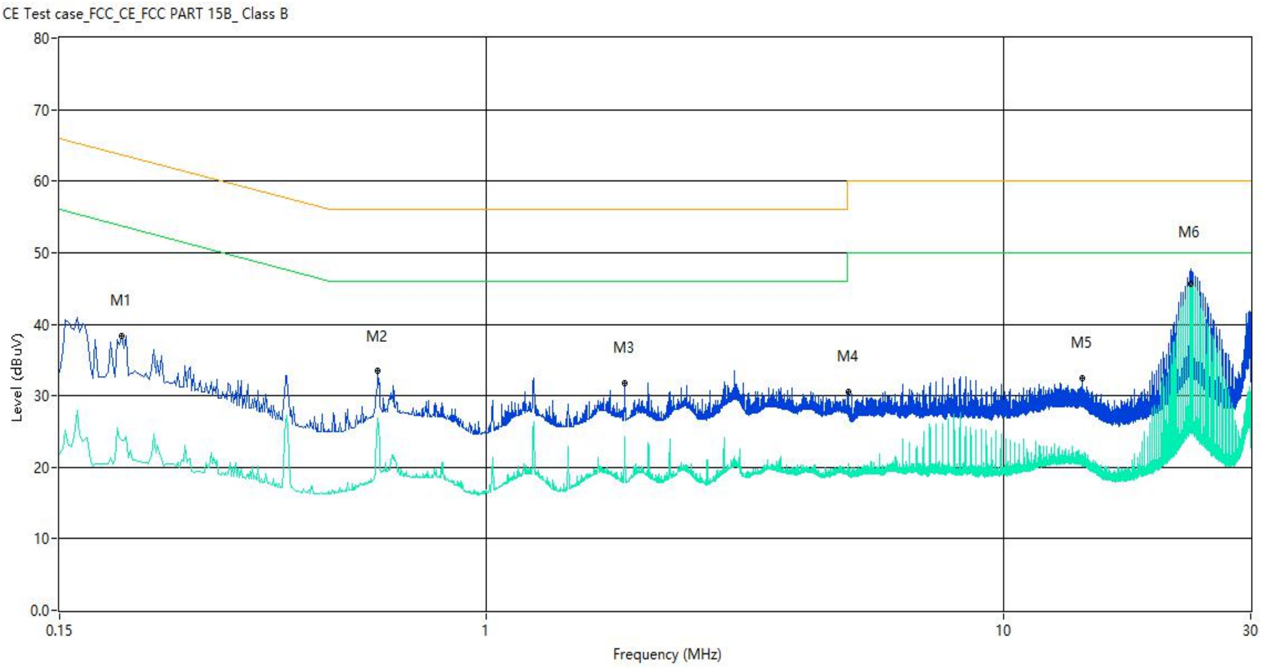
Test Data and Plots

PHASE L



No.	Frequency (MHz)	Results (dBuV)	Factor (dB)	Limit (dBuV)	Over Limit (dB)	Detector	Line	Verdict
1	0.190	40.9	10.01	64.0	-23.10	Peak	L Line	Pass
1**	0.190	25.2	10.01	54.0	-28.80	AV	L Line	Pass
2	0.618	32.3	10.03	56.0	-23.70	Peak	L Line	Pass
2**	0.618	28.0	10.03	46.0	-18.00	AV	L Line	Pass
3	1.234	32.7	10.05	56.0	-23.30	Peak	L Line	Pass
3**	1.234	27.6	10.05	46.0	-18.40	AV	L Line	Pass
4	3.140	33.4	10.09	56.0	-22.60	Peak	L Line	Pass
4**	3.140	19.3	10.09	46.0	-26.70	AV	L Line	Pass
5	10.290	33.6	10.17	60.0	-26.40	Peak	L Line	Pass
5**	10.290	23.8	10.17	50.0	-26.20	AV	L Line	Pass
6	22.846	46.3	10.28	60.0	-13.70	Peak	L Line	Pass
6**	22.846	44.5	10.28	50.0	-5.50	AV	L Line	Pass

PHASE N



No.	Frequency (MHz)	Results (dBuV)	Factor (dB)	Limit (dBuV)	Over Limit (dB)	Detector	Line	Verdict
1	0.198	38.4	10.01	63.7	-25.30	Peak	N Line	Pass
1**	0.198	23.8	10.01	53.7	-29.90	AV	N Line	Pass
2	0.618	33.4	10.03	56.0	-22.60	Peak	N Line	Pass
2**	0.618	27.0	10.03	46.0	-19.00	AV	N Line	Pass
3	1.852	31.7	10.05	56.0	-24.30	Peak	N Line	Pass
3**	1.852	23.5	10.05	46.0	-22.50	AV	N Line	Pass
4	5.016	30.6	10.11	60.0	-29.40	Peak	N Line	Pass
4**	5.016	19.0	10.11	50.0	-31.00	AV	N Line	Pass
5	14.202	32.4	10.20	60.0	-27.60	Peak	N Line	Pass
5**	14.202	21.5	10.20	50.0	-28.50	AV	N Line	Pass
6	23.046	47.6	10.28	60.0	-12.40	Peak	N Line	Pass
6**	23.046	45.6	10.28	50.0	-4.40	AV	N Line	Pass

A.8 Radiated Spurious Emission

Note [1]: The symbol of "--" in the table which means not application.

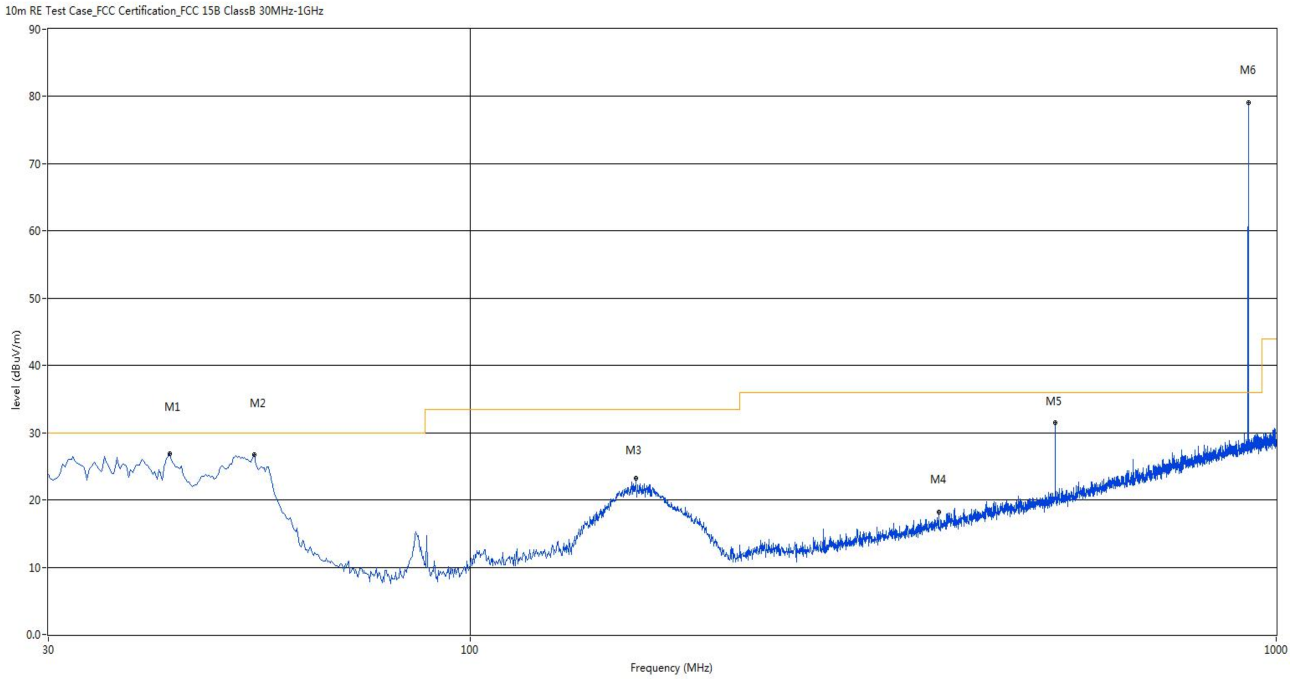
Note [2]: For the test data above 1 GHz, according the ANSI C63.10-2013, where limits are specified for both average and peak (or quasi-peak) detector functions, if the peak (or quasi-peak) measured value complies with the average limit, it is unnecessary to perform an average measurement.

Note [3]: The low frequency, which started from 9 kHz to 30 MHz, was pre-scanned and the result which was 20 dB lower than the limit line per 15.31(o) was not reported.

Note [4]: The marked spikes near 900 MHz with circle should be ignored because they are Lora carrier frequency.

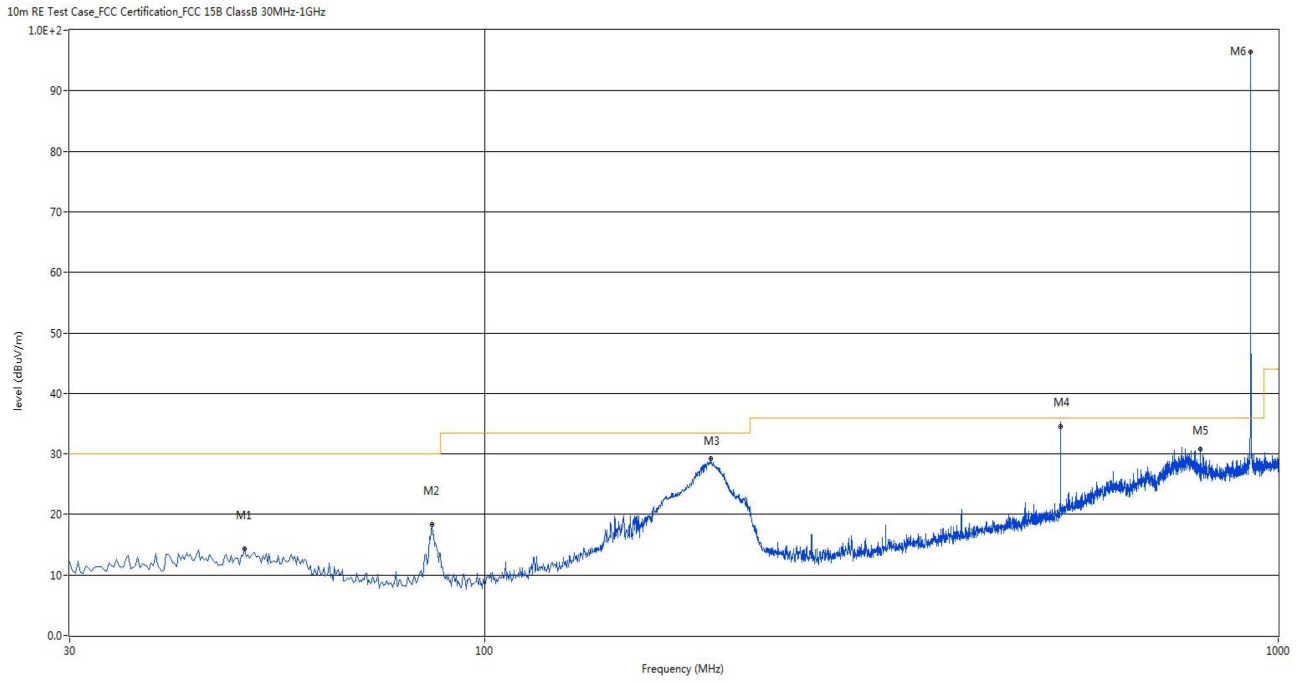
Test Data and Plots

LOW CHANNEL ANT V



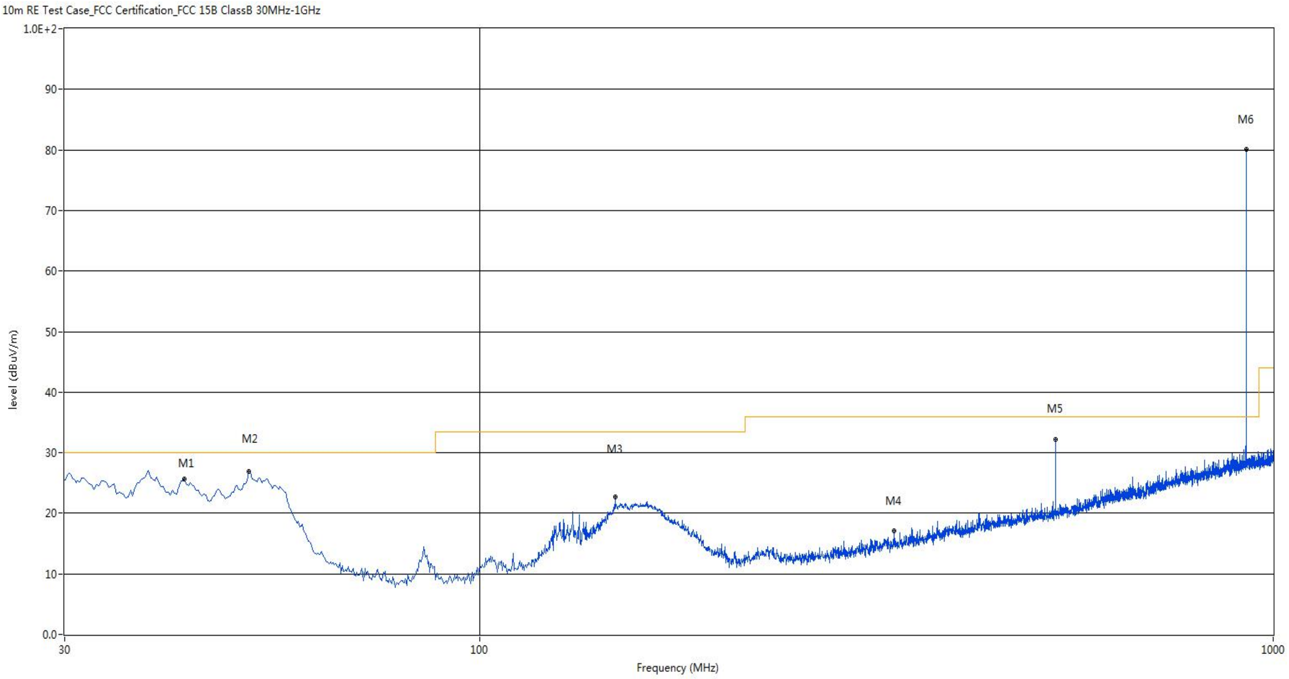
No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Over Limit (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	42.610	26.91	-26.74	30.0	-3.09	Peak	360.00	100	Vertical	Pass
2	54.250	26.85	-27.59	30.0	-3.15	Peak	331.00	300	Vertical	Pass
3	161.435	23.54	-25.88	33.5	-9.96	Peak	249.00	100	Vertical	Pass
4	381.382	18.16	-23.53	36.0	-17.84	Peak	0.00	200	Vertical	Pass
5	531.975	31.51	-19.73	36.0	-4.49	Peak	331.00	100	Vertical	Pass
6	923.370	79.05	-12.07	36.0	43.05	Peak	211.00	200	Vertical	N/A

LOW CHANNEL, ANT H



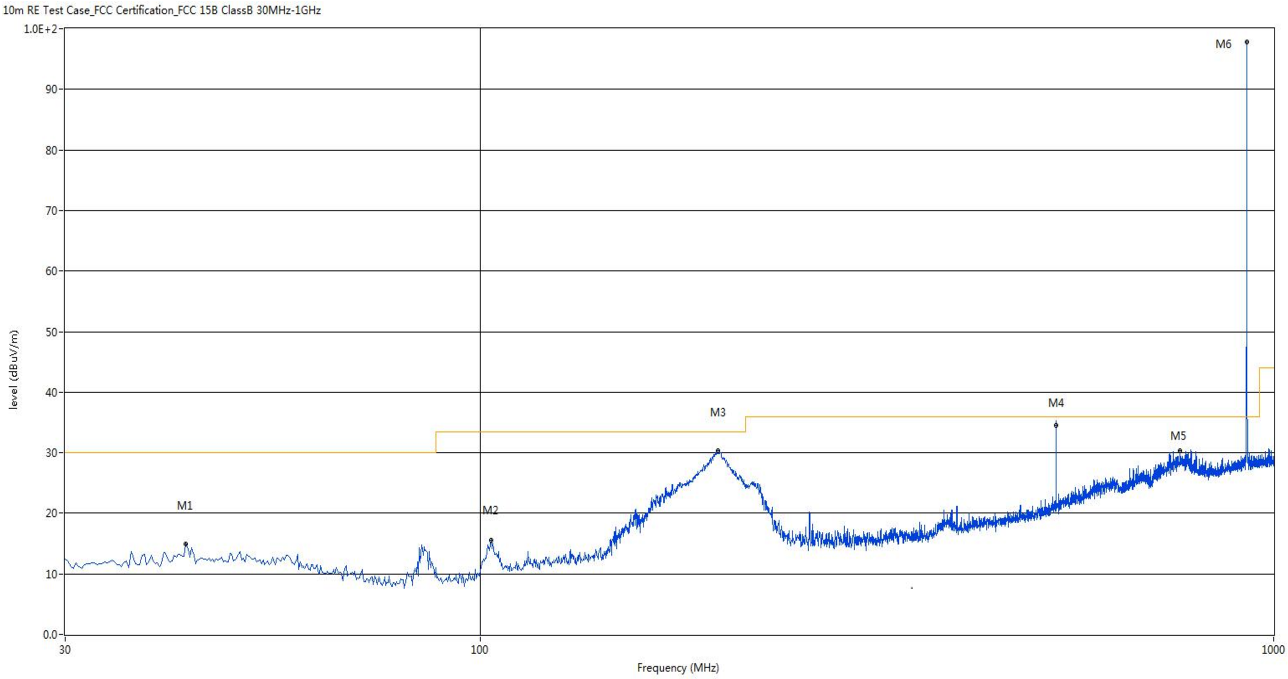
No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Over Limit (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	49.885	14.29	-27.28	30.0	-15.71	Peak	22.00	200	Horizontal	Pass
2	85.775	18.34	-31.12	30.0	-11.66	Peak	47.00	100	Horizontal	Pass
3	202.778	29.90	-29.45	33.5	-3.60	Peak	255.00	300	Horizontal	Pass
4	531.975	34.99	-19.73	36.0	-1.01	Peak	218.00	174	Horizontal	N/A
4*	531.975	34.75	-19.73	36.0	-1.25	QP	218.00	174	Horizontal	Pass
5	797.998	30.95	-14.17	36.0	-5.05	Peak	237.00	100	Horizontal	Pass
6	923.127	96.48	-12.08	36.0	60.48	Peak	218.00	100	Horizontal	N/A

MIDDLE CHANNEL ANT V



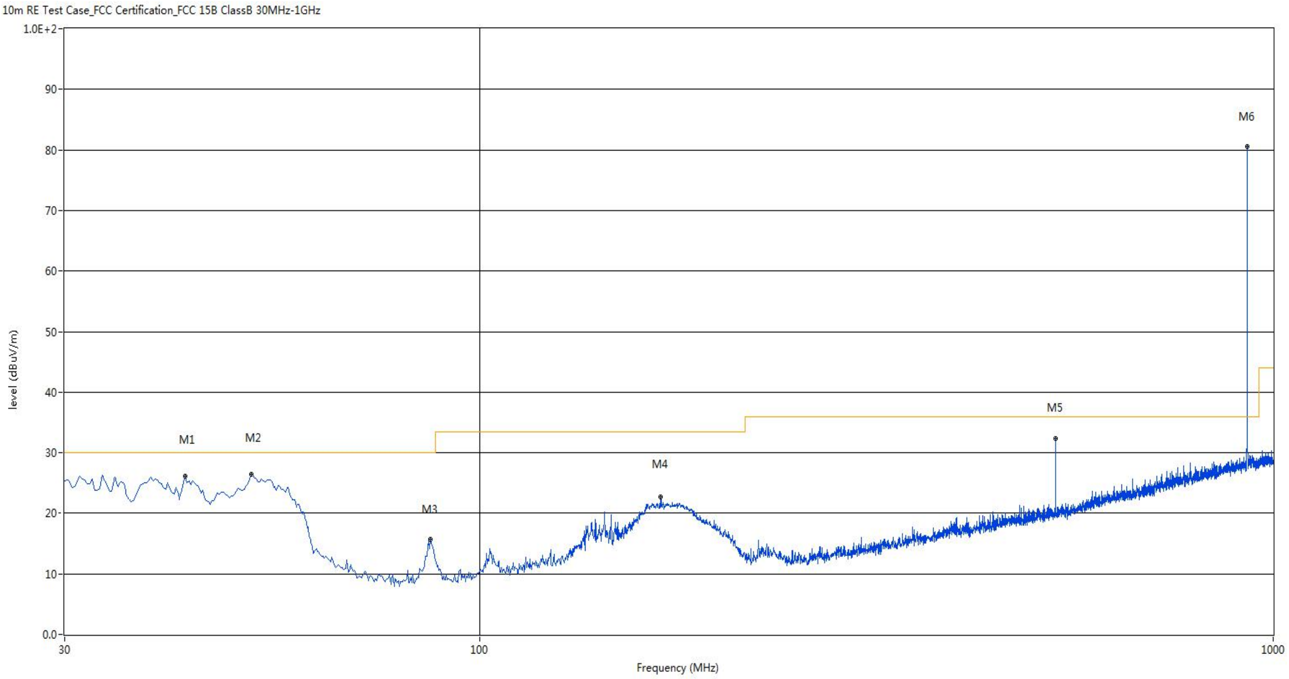
No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Over Limit (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	42.610	26.45	-26.74	30.0	-3.55	Peak	143.00	100	Vertical	Pass
2	51.340	26.93	-27.23	30.0	-3.07	Peak	360.00	200	Vertical	Pass
3	148.098	22.98	-25.94	33.5	-10.52	Peak	263.00	100	Vertical	Pass
4	332.882	17.14	-24.69	36.0	-18.86	Peak	143.00	300	Vertical	Pass
5	531.975	32.26	-19.73	36.0	-3.74	Peak	338.00	100	Vertical	Pass
6	925.068	80.05	-12.03	36.0	44.05	Peak	199.00	200	Vertical	N/A

MIDDLE CHANNEL, ANT H



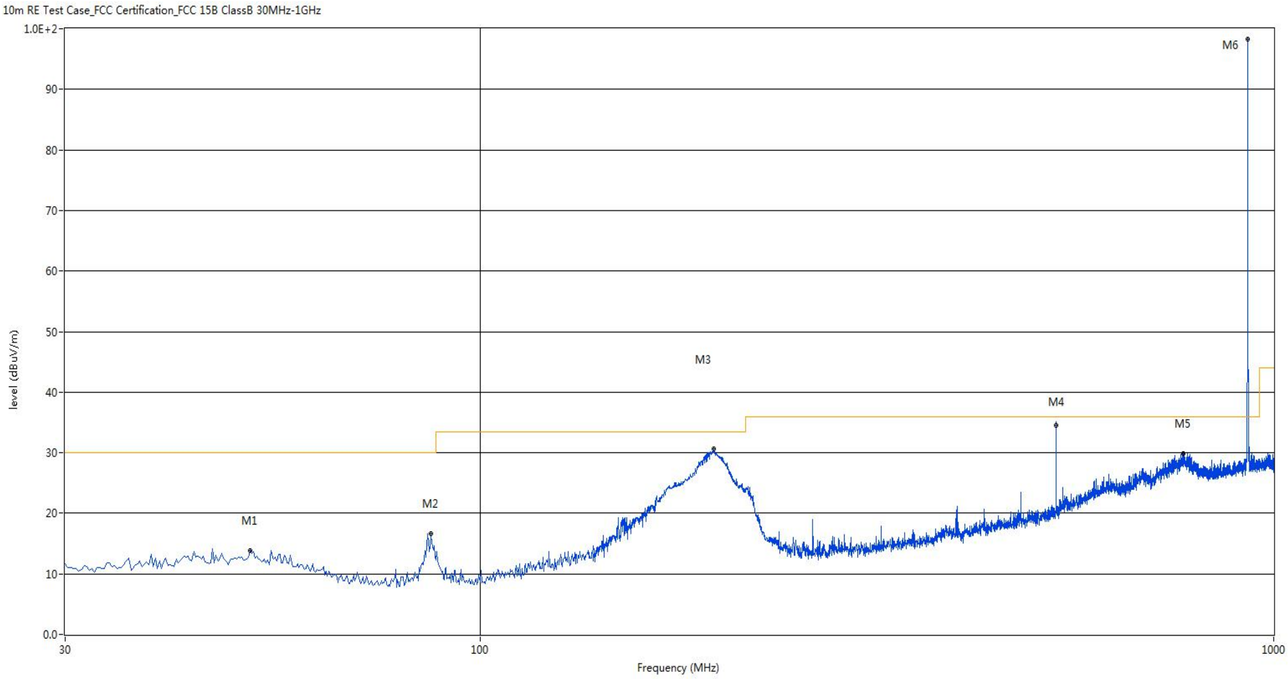
No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Over Limit (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	42.610	14.92	-26.74	30.0	-15.08	Peak	161.00	300	Horizontal	Pass
2	103.235	15.59	-29.86	33.5	-17.91	Peak	224.00	200	Horizontal	Pass
3	202.417	30.12	-29.45	33.5	-3.38	Peak	256.00	200	Horizontal	Pass
4	531.975	34.97	-19.73	36.0	-1.03	Peak	218.00	198	Horizontal	N/A
4*	531.975	34.74	-19.73	36.0	-1.26	QP	218.00	198	Horizontal	Pass
5	762.593	30.31	-14.76	36.0	-5.69	Peak	237.00	100	Horizontal	Pass
6	925.068	97.77	-12.03	36.0	61.77	Peak	262.00	100	Horizontal	N/A

HIGH CHANNEL ANT V



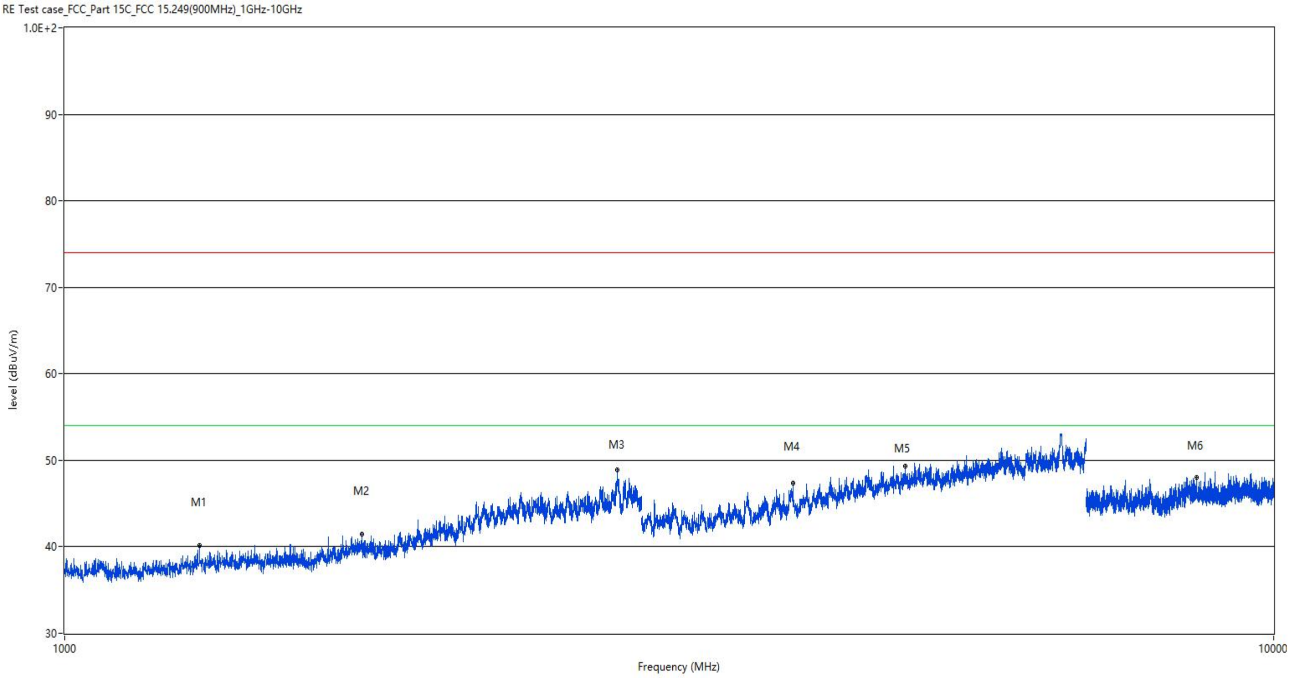
No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Over Limit (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	42.367	26.85	-26.74	30.0	-3.15	Peak	92.00	100	Vertical	Pass
2	51.340	26.91	-27.23	30.0	-3.09	Peak	360.00	200	Vertical	Pass
3	86.745	15.75	-31.08	30.0	-14.25	Peak	360.00	200	Vertical	Pass
4	169.922	23.16	-26.71	33.5	-10.34	Peak	268.00	100	Vertical	Pass
5	531.975	32.42	-19.73	36.0	-3.58	Peak	337.00	300	Vertical	Pass
6	927.492	80.56	-12.03	36.0	44.56	Peak	218.00	200	Vertical	N/A

HIGH CHANNEL, ANT H



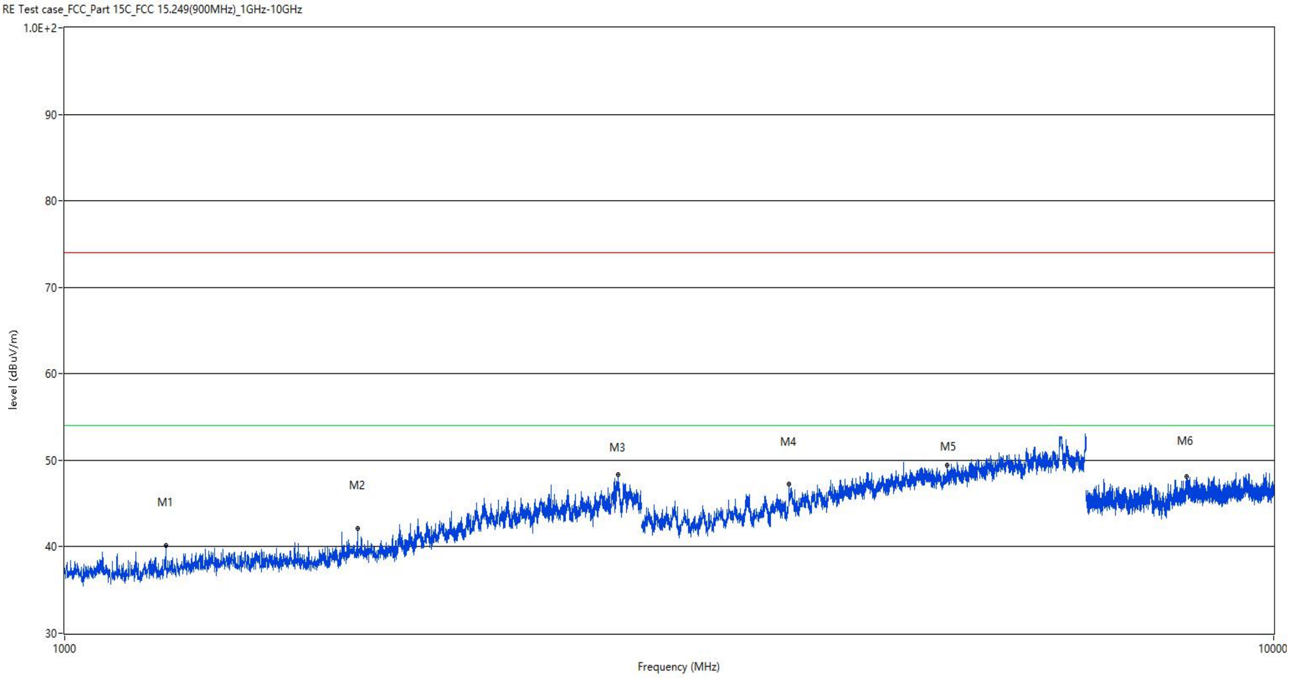
No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Over Limit (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	51.340	13.83	-27.23	30.0	-16.17	Peak	16.00	300	Horizontal	Pass
2	86.745	16.63	-31.08	30.0	-13.37	Peak	249.00	100	Horizontal	Pass
3	204.842	30.49	-29.44	33.5	-3.01	Peak	281.00	100	Horizontal	Pass
4	531.975	34.95	-19.73	36.0	-1.05	Peak	230.00	169	Horizontal	N/A
4	531.975	34.77	-19.73	36.0	-1.23	QP	230.00	169	Horizontal	Pass
5	769.625	29.82	-14.49	36.0	-6.18	Peak	243.00	100	Horizontal	Pass
6	927.492	98.24	-12.03	36.0	62.24	Peak	262.00	100	Horizontal	N/A

LOW CHANNEL 1 GHz to 10 GHz, ANT V



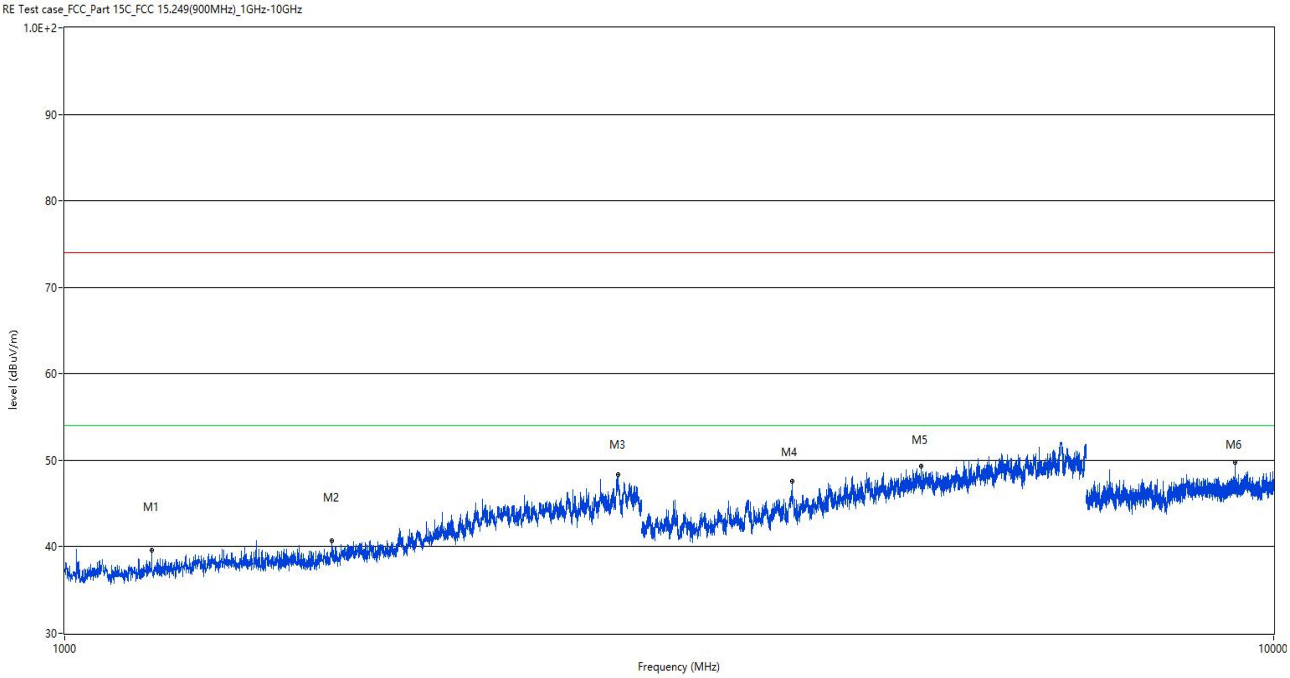
No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Over Limit (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	1293.000	40.17	-13.86	74.0	-33.83	Peak	146.00	150	Vertical	Pass
2	1760.000	41.47	-12.74	74.0	-32.53	Peak	94.00	150	Vertical	Pass
3	2865.500	48.93	-4.18	74.0	-25.07	Peak	0.00	150	Vertical	Pass
4	4003.000	47.34	-4.39	74.0	-26.66	Peak	112.00	150	Vertical	Pass
5	4954.000	49.31	-2.81	74.0	-24.69	Peak	42.00	150	Vertical	Pass
6	8632.750	48.01	-1.38	74.0	-25.99	Peak	63.00	150	Vertical	Pass

LOW CHANNEL 1 GHz to 10 GHz, ANT H



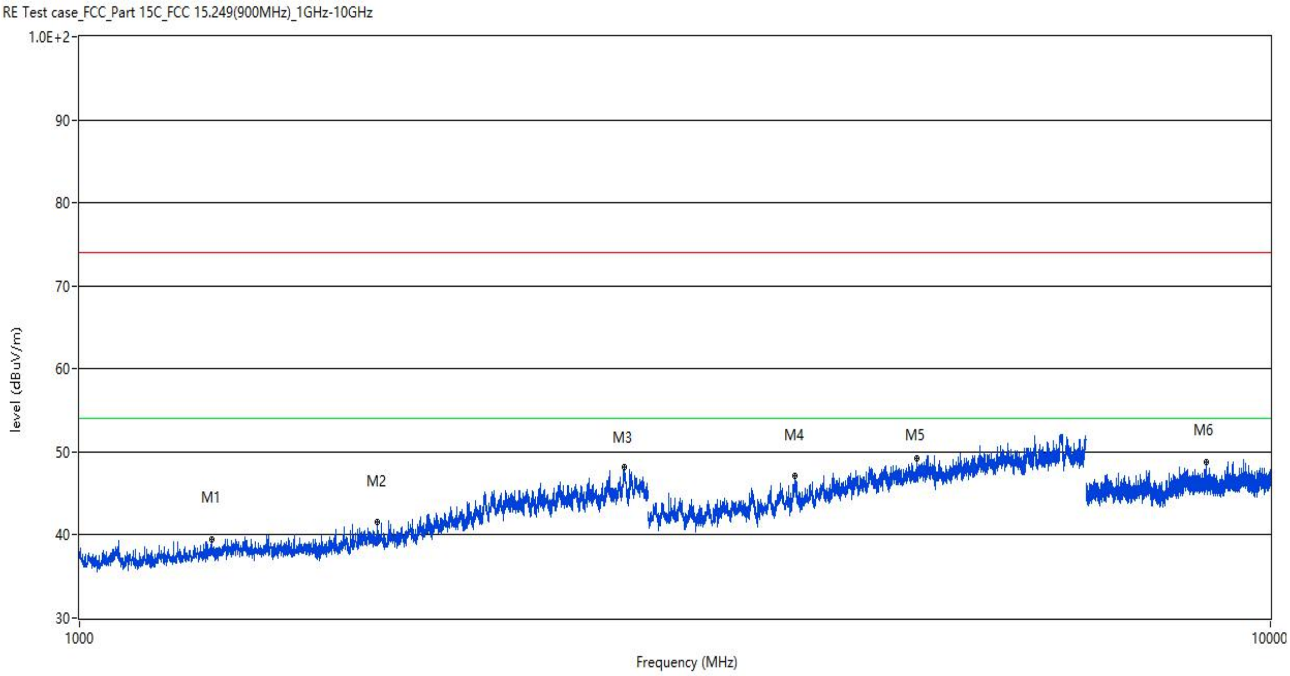
No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Over Limit (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	1212.000	40.18	-14.65	74.0	-33.82	Peak	135.00	150	Horizontal	Pass
2	1746.000	42.10	-13.17	74.0	-31.90	Peak	19.00	150	Horizontal	Pass
3	2868.500	48.36	-4.01	74.0	-25.64	Peak	286.00	150	Horizontal	Pass
4	3972.000	47.21	-4.84	74.0	-26.79	Peak	122.00	150	Horizontal	Pass
5	5373.000	49.41	-2.25	74.0	-24.59	Peak	287.00	150	Horizontal	Pass
6	8470.750	48.12	-0.68	74.0	-25.88	Peak	163.00	150	Horizontal	Pass

MIDDLE CHANNEL 1 GHz to 10 GHz, ANT V



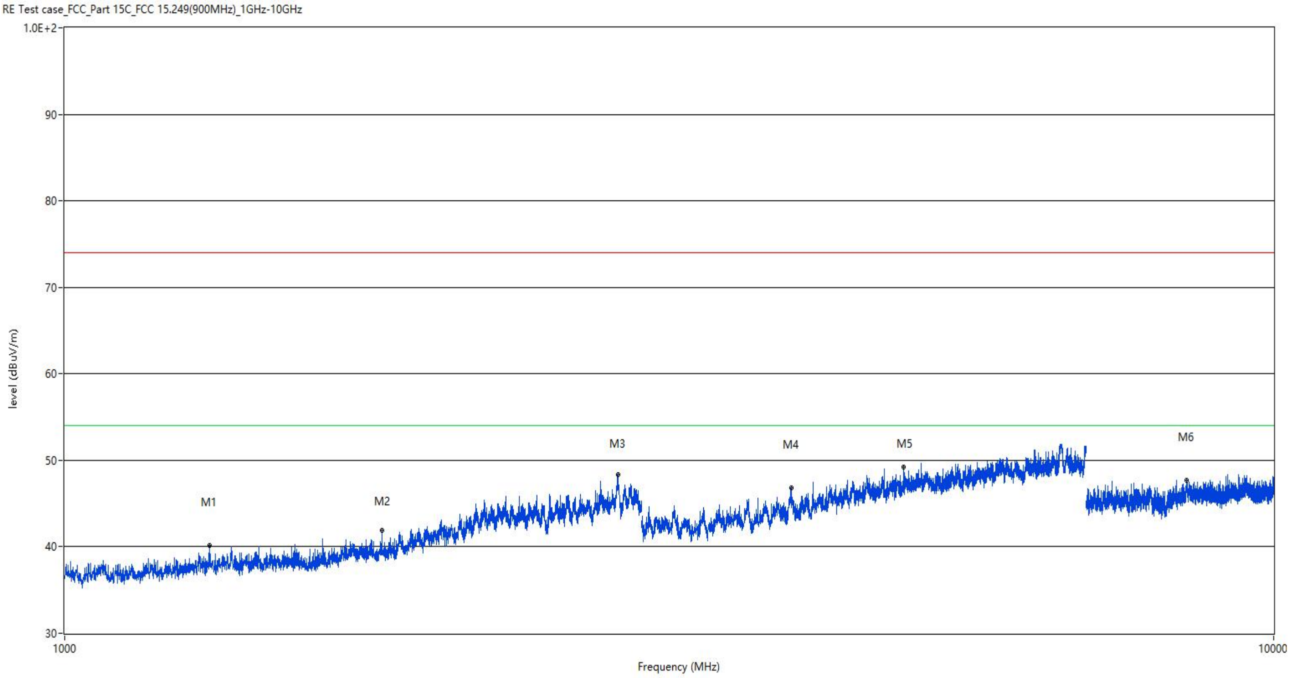
No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Over Limit (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	1180.000	39.57	-14.68	74.0	-34.43	Peak	53.00	150	Vertical	Pass
2	1664.000	40.69	-13.40	74.0	-33.31	Peak	33.00	150	Vertical	Pass
3	2867.500	48.40	-4.05	74.0	-25.60	Peak	1.00	150	Vertical	Pass
4	3998.000	47.55	-4.12	74.0	-26.45	Peak	271.00	150	Vertical	Pass
5	5113.000	49.31	-2.63	74.0	-24.69	Peak	278.00	150	Vertical	Pass
6	9287.500	49.81	-1.02	74.0	-24.19	Peak	319.00	150	Vertical	Pass

MIDDLE CHANNEL 1 GHz to 10 GHz, ANT H



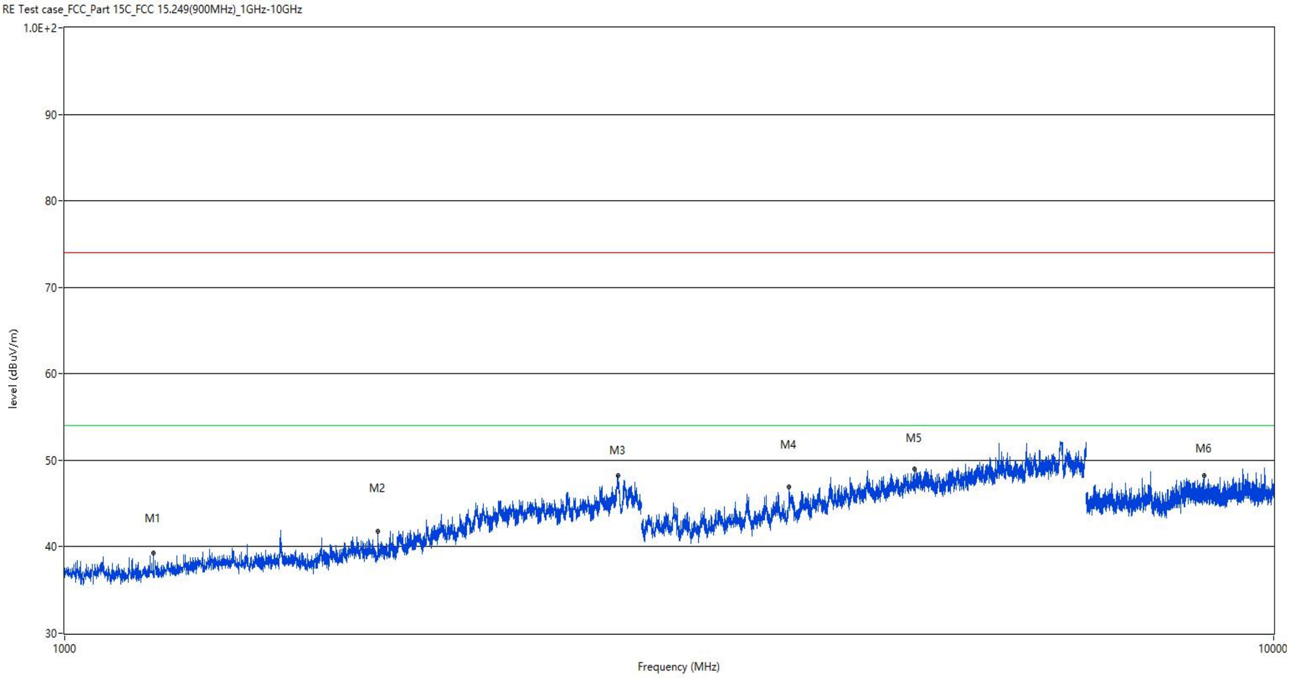
No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Over Limit (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	1291.000	39.50	-13.87	74.0	-34.50	Peak	318.00	150	Horizontal	Pass
2	1780.000	41.53	-13.22	74.0	-32.47	Peak	301.00	150	Horizontal	Pass
3	2868.000	48.18	-4.03	74.0	-25.82	Peak	145.00	150	Horizontal	Pass
4	3991.000	47.06	-3.95	74.0	-26.94	Peak	95.00	150	Horizontal	Pass
5	5052.000	49.17	-2.83	74.0	-24.83	Peak	303.00	150	Horizontal	Pass
6	8834.500	48.84	-0.41	74.0	-25.16	Peak	358.00	150	Horizontal	Pass

HIGH CHANNEL 1 GHz to 10 GHz, ANT V



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Over Limit (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	1318.500	40.13	-14.06	74.0	-33.87	Peak	41.00	150	Vertical	Pass
2	1829.500	41.87	-12.70	74.0	-32.13	Peak	253.00	150	Vertical	Pass
3	2870.000	48.38	-4.05	74.0	-25.62	Peak	3.00	150	Vertical	Pass
4	3989.000	46.87	-3.88	74.0	-27.13	Peak	27.00	150	Vertical	Pass
5	4942.000	49.24	-2.84	74.0	-24.76	Peak	0.00	150	Vertical	Pass
6	8477.500	47.73	-0.74	74.0	-26.27	Peak	360.00	150	Vertical	Pass

HIGH CHANNEL 1 GHz to 10 GHz, ANT H



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Over Limit (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	1184.000	39.26	-14.47	74.0	-34.74	Peak	226.00	150	Horizontal	Pass
2	1815.500	41.83	-13.25	74.0	-32.17	Peak	109.00	150	Horizontal	Pass
3	2870.500	48.25	-4.07	74.0	-25.75	Peak	0.00	150	Horizontal	Pass
4	3973.000	46.88	-4.84	74.0	-27.12	Peak	280.00	150	Horizontal	Pass
5	5042.000	49.03	-2.85	74.0	-24.97	Peak	334.00	150	Horizontal	Pass
6	8761.000	48.19	-0.87	74.0	-25.81	Peak	273.00	150	Horizontal	Pass

A.9 Band Edge (Restricted-band band-edge)

Note: The Band Edge (Restricted-band band-edge) please refer to the Report No. RSZ181207002-00B (FCC ID: 2AF6B-RAK2247) (which issued by Bay Area Compliance Laboratories Corp. (Shenzhen) on Dec. 24, 2018), **Section 100kHz Bandwidth of Frequency Band Edge.**

A.10 Power Spectral Density (PSD)

Note: The Power Spectral Density (PSD) please refer to the Report No. RSZ181207002-00B (FCC ID: 2AF6B-RAK2247) (which issued by Bay Area Compliance Laboratories Corp. (Shenzhen) on Dec. 24, 2018), **Section Power Spectral Density.**

ANNEX B   TEST SETUP PHOTOS

Please refer the document “BL-SZ1920035-AR.PDF”.

ANNEX C   EUT EXTERNAL PHOTOS

Please refer the document “BL-SZ1920035-AW.PDF”.

ANNEX D   EUT INTERNAL PHOTOS

Please refer the document “BL-SZ1920035-AI.PDF”.

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