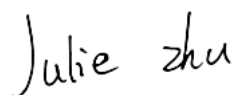


TEST REPORT

Applicant: Seeed Technology Co., Ltd.
Address: 9F, G3 Building, TCL International E City,
Zhongshanyuan Road, Nanshan District, Shenzhen,
Guangdong Province, P.R.C
Equipment Type: Wio-E5-LE Wireless Module
Model Name: Wio-E5-LE-HF
Brand Name: Seeed Studio
FCC ID: Z4T-WIO-E5-LE
Test Standard: 47 CFR Part 15 Subpart C
(refer to section 3.1)
Sample Arrival Date: May 26, 2023
Test Date: May 30, 2023 - Jul. 07, 2023
Date of Issue: Jul. 24, 2023

ISSUED BY:

Shenzhen BALUN Technology Co., Ltd.

Tested by: Julie Zhu**Checked by:** Ye Hongji**Approved by:** Liao Jianming
(Technical Director)

Revision History

Version	Issue Date	Revisions
<u>Rev. 01</u>	<u>Jul. 18, 2023</u>	<u>Initial Issue</u>
<u>Rev. 02</u>	<u>Jul. 24, 2023</u>	<u>Corrected the Frequency Range in Section 2.5.</u>

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1 GENERAL INFORMATION

1.1 Test Laboratory

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

1.2 Test Location

Name	Shenzhen BALUN Technology Co., Ltd.
Location	☒ Block B, 1/F, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China
	☐ 1/F, Building B, Ganghongji High-tech Intelligent Industrial Park, No. 1008, Songbai Road, Yangguang Community, Xili Sub-district, Nanshan District, Shenzhen, Guangdong Province, P. R. China
Accreditation Certificate	The laboratory is a testing organization accredited by FCC as a accredited testing laboratory. The designation number is CN1196.

2 PRODUCT INFORMATION

2.1 Applicant Information

Applicant	Seeed Technology Co., Ltd.
Address	9F, G3 Building, TCL International E City, Zhongshanyuan Road, Nanshan District, Shenzhen, Guangdong Province, P.R.C

2.2 Manufacturer Information

Manufacturer	Seeed Technology Co., Ltd.
Address	9F, G3 Building, TCL International E City, Zhongshanyuan Road, Nanshan District, Shenzhen, Guangdong Province, P.R.C

2.3 Factory Information

Factory	N/A
Address	N/A

2.4 General Description for Equipment under Test (EUT)

EUT Name	Wio-E5-LE Wireless Module
Model Name Under Test	Wio-E5-LE-HF
Series Model Name	N/A
Description of Model name differentiation	N/A
Hardware Version	v2.0
Software Version	v4.0.11
Dimensions (Approx.)	N/A
Weight (Approx.)	N/A

2.5 Technical Information

Network and Wireless connectivity	LoRa
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The requirement for the following technical information of the EUT was tested in this report:

Modulation Technology	Frequency hopping system
Modulation Type	LoRa
Product Type	☒ Mobile ☐ Portable ☐ Fix Location
Frequency Range	The frequency range used is 902.3 MHz to 914.9 MHz.
Frequency Bandwidth	125 kHz
Number of channel	64
Tested Channel	1 (902.3 MHz), 32 (908.5 MHz), 64 (914.9 MHz)
Antenna Type	Dipole Antenna
Antenna Gain	2.4 dBi
Antenna System(MIMO Smart Antenna)	N/A

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	902.3	17	905.5	33	908.7	49	911.9
2	902.5	18	905.7	34	908.9	50	912.1
3	902.7	19	905.9	35	909.1	51	912.3
4	902.9	20	906.1	36	909.3	52	912.5
5	903.1	21	906.3	37	909.5	53	912.7
6	903.3	22	906.5	38	909.7	54	912.9
7	903.5	23	906.7	39	909.9	55	913.1
8	903.7	24	906.9	40	910.1	56	913.3
9	903.9	25	907.1	41	910.3	57	913.5
10	904.1	26	907.3	42	910.5	58	913.7
11	904.3	27	907.5	43	910.7	59	913.9
12	904.5	28	907.7	44	910.9	60	914.1
13	904.7	29	907.9	45	911.1	61	914.3
14	904.9	30	908.1	46	911.3	62	914.5
15	905.1	31	908.3	47	911.5	63	914.7
16	905.3	32	908.5	48	911.7	64	914.9

3 SUMMARY OF TEST RESULTS

3.1 Test Standards

No.	Identity	Document Title
1	47 CFR Part 15, Subpart C	Intentional radiators of radio frequency equipment
2	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	ANSI C63.10-2013	American National Standard for Testing Unlicensed Wireless Devices

3.2 Test Verdict

No.	Description	FCC Part No.	Modulation Technology	Channel	Test Result	Verdict
1	Antenna Requirement	15.203	N/A	N/A	--	Pass ^{Note}
2	Number of Hopping Frequencies	15.247(a)	Frequency hopping system	Hopping Mode	ANNEX A.1	Pass
3	Peak Output Power	15.247(b)	Frequency hopping system	Low/Middle/High	ANNEX A.2	Pass
4	Occupied Bandwidth	15.247(a)	Frequency hopping system	Low/Middle/High	ANNEX A.3	Pass
5	Carrier Frequency Separation	15.247(a)	Frequency hopping system	Hopping Mode	ANNEX A.4	Pass
6	Time of Occupancy (Dwell time)	15.247(a)	Frequency hopping system	Hopping Mode	ANNEX A.5	Pass
7	Conducted Spurious Emission & Authorized-band band-edge	15.247(d)	Frequency hopping system	Low/Middle/High, Hopping Mode	ANNEX A.6	Pass
8	Conducted Emission	15.207	Frequency hopping system	Low/Middle/High	ANNEX A.7	Pass
9	Radiated Spurious Emission	15.209 15.247(d)	Frequency hopping system	Low/Middle/High	ANNEX A.8	Pass
10	Band Edge(Restricted-band band-edge)	15.209 15.247(d)	Frequency hopping system	Low/High	ANNEX A.9	Pass

Note: Please refer to section 5.1

4 GENERAL TEST CONFIGURATIONS

4.1 Test Environments

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

Relative Humidity	40% to 61%	
Atmospheric Pressure	100 kPa to 102 kPa	
Temperature	NT (Normal Temperature)	+22.3°C to +25.1°C
Working Voltage of the EUT	NV (Normal Voltage)	3.3 V

4.2 Test Equipment List

Description	Manufacturer	Model	Serial No.	Cal. Date	Cal. Due
Spectrum Analyzer	KEYSIGHT	N9020A	MY50330200	2023.05.16	2024.05.15
Spectrum Analyzer	ROHDE&SCHWARZ	FSV-40	101544	2022.12.28	2023.12.27
Spectrum Analyzer	KEYSIGHT	N9020A	MY52510065	2022.09.06	2023.09.05
Test Antenna-Bi-Log	SCHWARZBECK	VULB 9163	01415	2021.03.08	2024.03.07
Test Antenna-Horn	SCHWARZBECK	BBHA 9120D	01631	2022.02.03	2025.02.02
Test Antenna-Horn	A-INFO	LB- 180400KF	J211060273	2021.07.02	2024.07.01
Anechoic Chamber	RAINFORD	9m*6m*6m	144	2022.02.19	2024.09.03
EMI Receiver	ROHDE&SCHWARZ	ESRP	101036	2022.09.09	2023.09.08
Test Antenna-Bi-Log	SCHWARZBECK	VULB 9168	00883	2022.04.01	2025.03.31
Test Antenna-Loop	SCHWARZBECK	FMZB 1519	1519-037	2021.04.16	2024.04.15
Anechoic Chamber	EMC Electronic Co., Ltd	20.10*11.60 *7.35m	130	2021.08.15	2024.08.14
EMI Receiver	KEYSIGHT	N9010B	MY57110309	2022.09.09	2023.09.08
LISN	SCHWARZBECK	NSLK 8127	8127-687	2023.05.16	2024.05.15
Shielded Enclosure	YiHeng Electronic Co., Ltd	3.5m*3.1m* 2.8m	112	2022.02.19	2025.02.18
Amplifier	COM-MV	LSCX_LNA1 -12G-01	180602	2020.09.08	2023.09.07
Amplifier	COM-MV	XKu_LNA7- 18G-01	180601	2020.09.08	2023.09.07
Amplifier	COM-MV	KA_LNA18- 40G-01	18050001	2020.09.08	2023.09.07
Amplifier	COM-MV	ZT30- 1000M	B2017119082	2022.12.07	2023.12.06

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.

Parameters	Uncertainty
Occupied Channel Bandwidth	2.8%
RF output power, conducted	1.28 dB
Power Spectral Density, conducted	1.30 dB
Unwanted Emissions, conducted	1.84 dB
All emissions, radiated	5.36 dB
Temperature	0.8 °C
Humidity	4 %

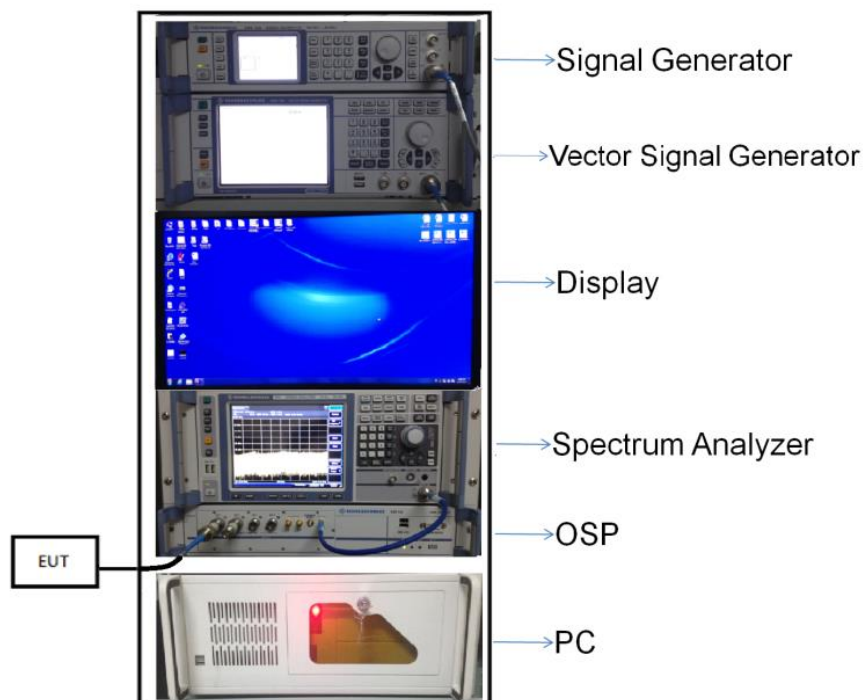
4.4 Description of Test Setup

4.4.1 For Antenna Port Test

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

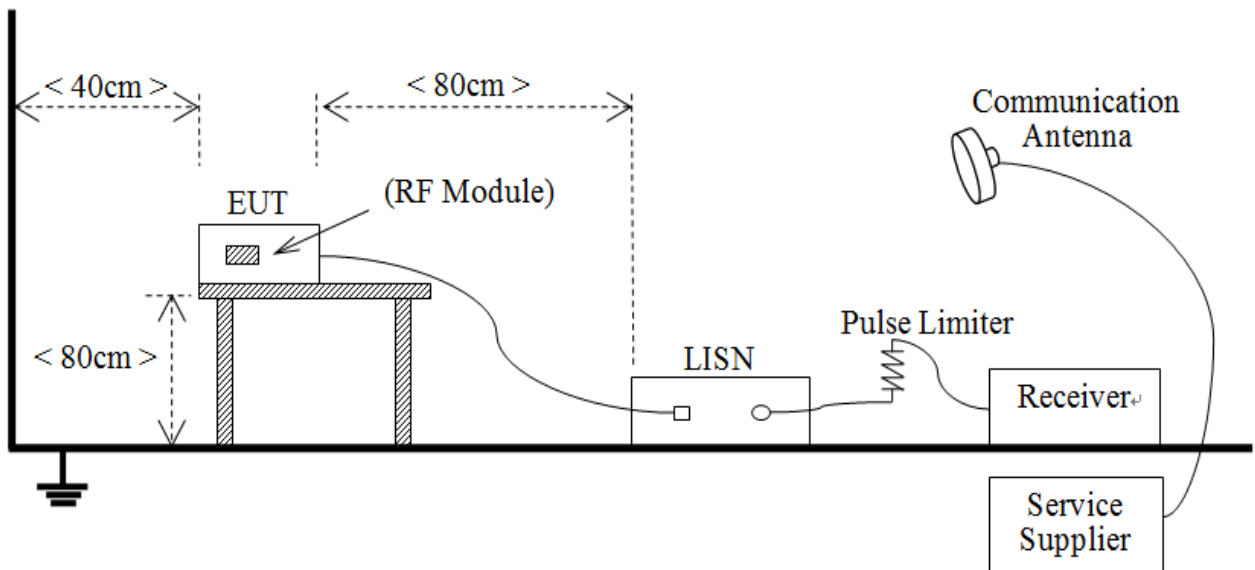
For example: the measurement value is 10 dBm and the cable 0.5dBm used, then the final result of EUT:

Conducted value (dBm) = 10 dBm + 0.5 dB = 10.5 dBm



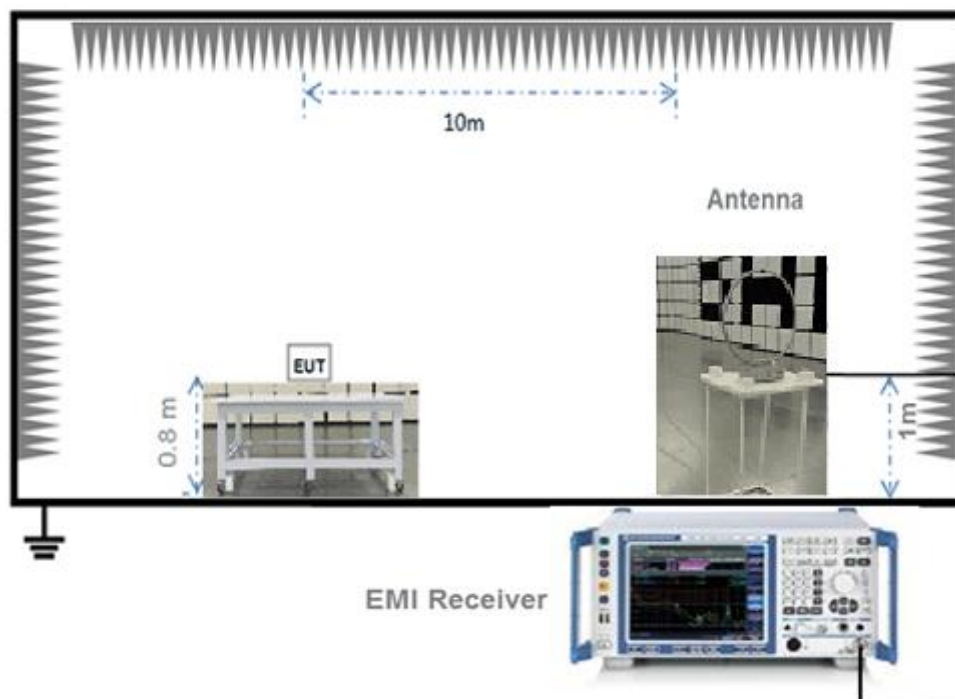
(Diagram 1)

4.4.2 For AC Power Supply Port Test



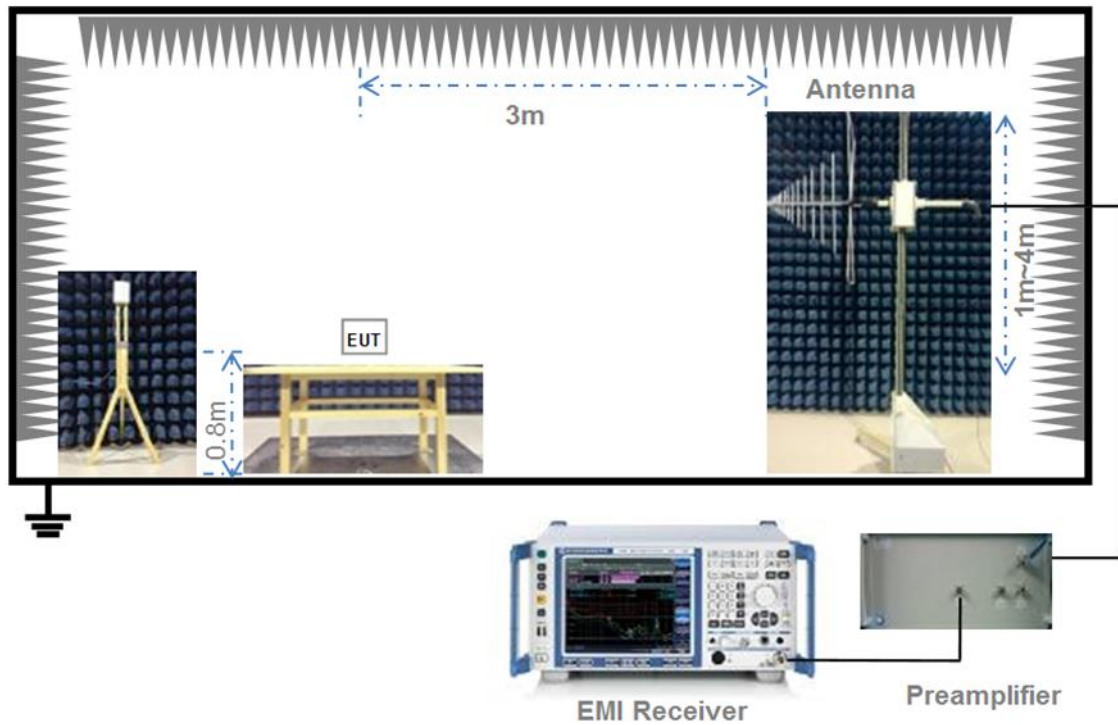
(Diagram 2)

4.4.3 For Radiated Test (Below 30 MHz)



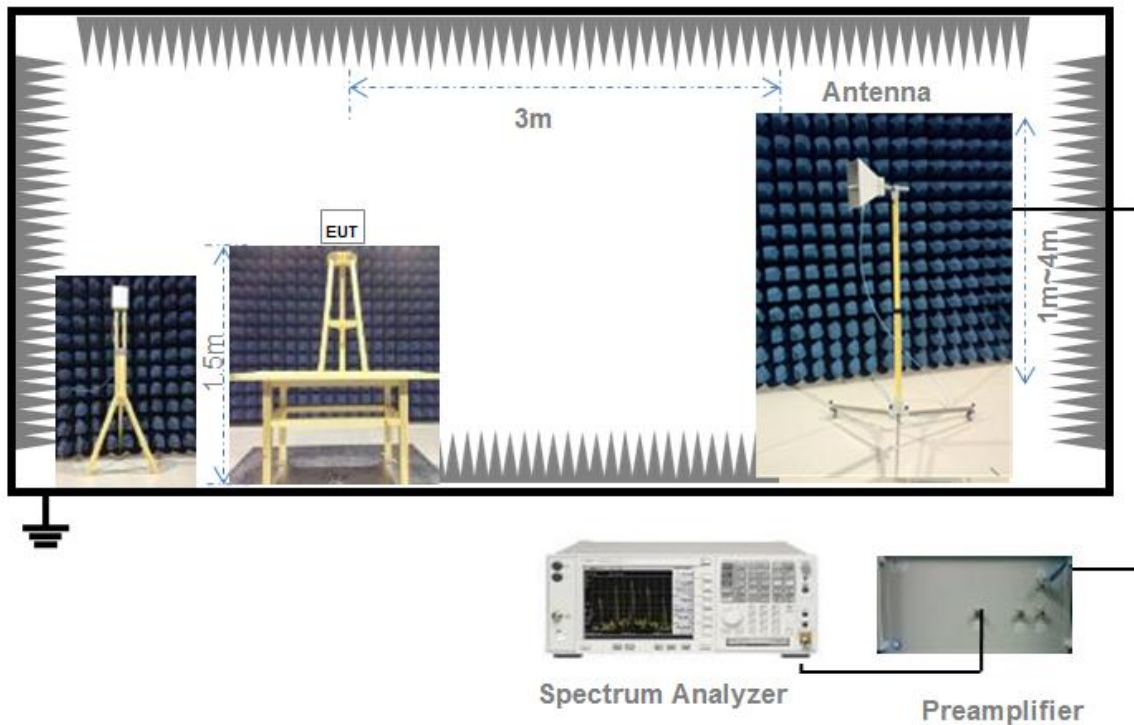
(Diagram 3)

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.

5 TEST ITEMS

5.1 Antenna Requirements

5.1.1 Relevant Standards

FCC §15.203

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	Description
The antenna is embedded in the product	The antenna is welded on the mainboard, can't be replaced by the consumer

Reference Documents	Item
Photo	Please refer to the EUT Photo documents.

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)

For FHSs in the band 902-928 MHz: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels and the average time of occupancy on any channel 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 channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 10-second period. The maximum 20 dB bandwidth of the hopping channel shall be 500 kHz.

5.2.2 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.

5.2.3 Test Procedure

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

Span = the frequency band of operation

RBW $\geq$ 1% of the span

VBW $\geq$ RBW

Sweep = auto

Detector function = peak

Trace = max hold

Allow the trace to stabilize

5.2.4 Test Result

Please refer to ANNEX A.1.

5.3 Peak Output Power

5.3.1 Test Limit

FCC § 15.247(b)

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.

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 $\geq$ 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)

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 $\geq$ 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)

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) $\geq 1\%$ of the span

Video (or Average) Bandwidth (VBW) $\geq$ 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)

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)

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 $\geq$ 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

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 50 μ H/50 Ω line impedance stabilization network (LISN).

Frequency range (MHz)	Conducted Limit (dB μ V)	
	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)

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 $f \geq 1$ GHz, 100 kHz for $f < 1$ GHz

VBW $\geq$ 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 $f \geq 1$ GHz, 100 kHz for $f < 1$ GHz

VBW $\geq$ 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.

ANNEX A TEST RESULT

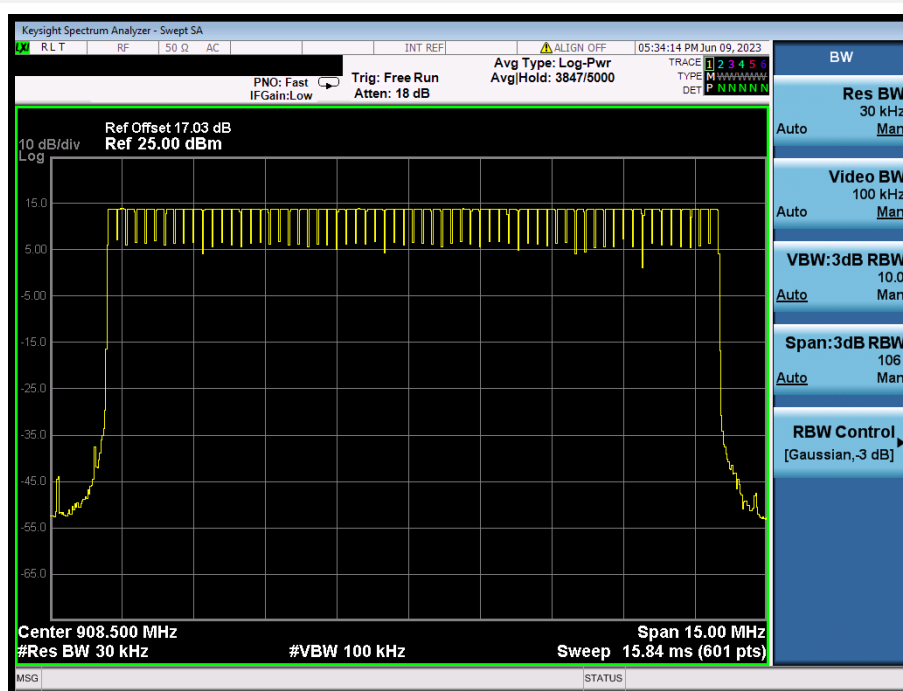
A.1 Number of Hopping Frequency

Test Data

Test Mode	Frequency Block (MHz)	Measured Channel Numbers	Min. Limit	Verdict
LoRa	902-928	64	50	Pass

Test Plots

LoRa



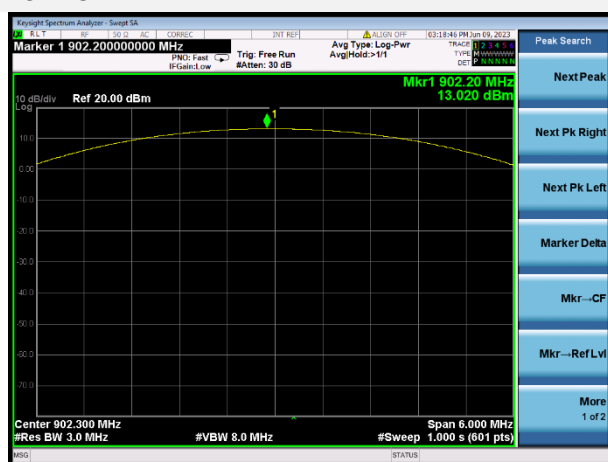
A.2 Peak Output Power

Test Data

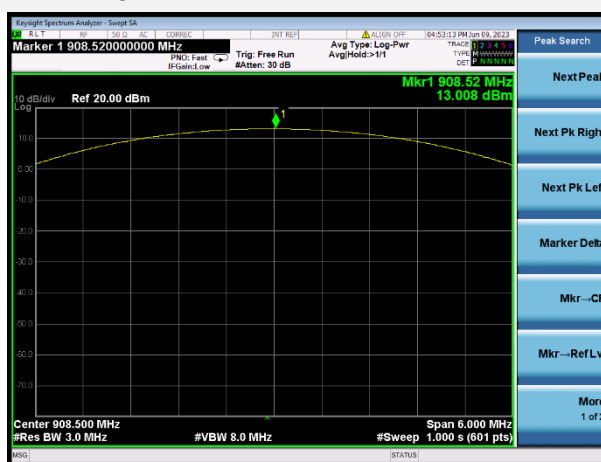
Channel	Measured Output Peak Power		Limit		Verdict
	LoRa		dBm	mW	
	dBm	mW			
Low	13.02	20.04	30	1000	Pass
Middle	13.01	19.99			Pass
High	12.95	19.71			Pass

Test Plots

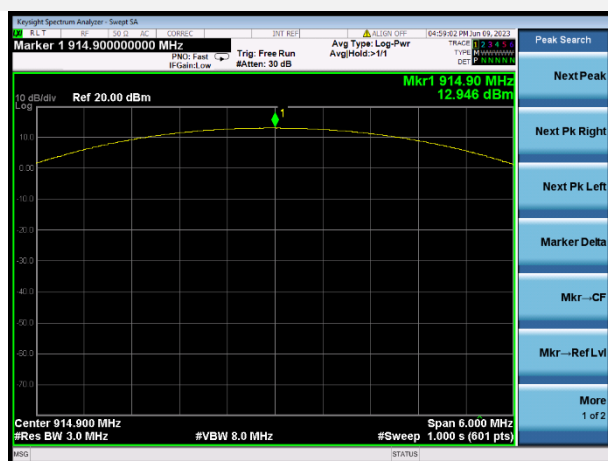
LOW CHANNEL



MIDDLE CHANNEL



HIGH CHANNEL



A.3 20 dB and 99% bandwidth

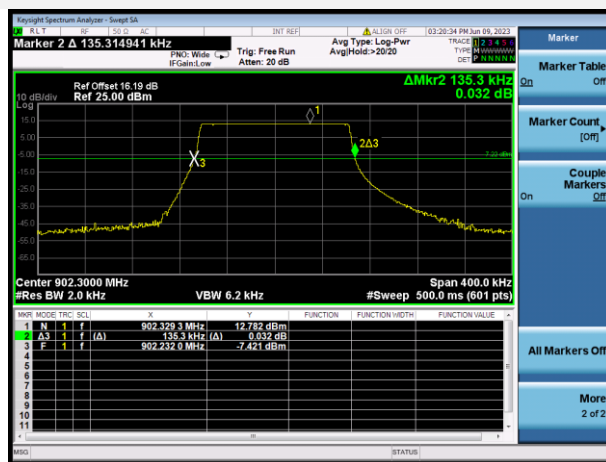
Test Data

LoRa				
Channel	20 dB Bandwidth (MHz)	99% Bandwidth (MHz)	Limit (MHz)	Verdict
Low	0.135300	0.125440	0.25	Pass
Middle	0.135300	0.125350	0.25	Pass
High	0.135400	0.125260	0.25	Pass

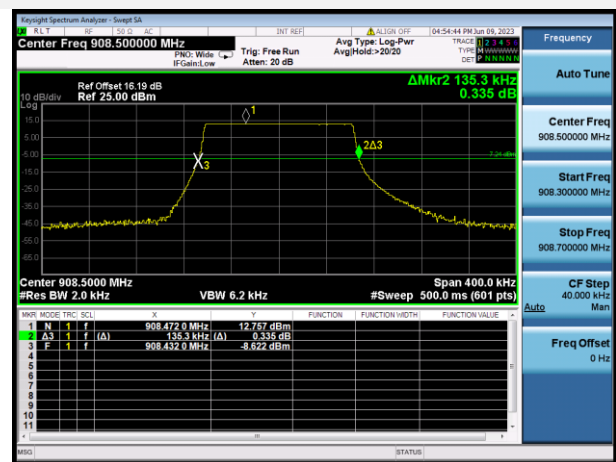
Test Plots

20 dB Bandwidth

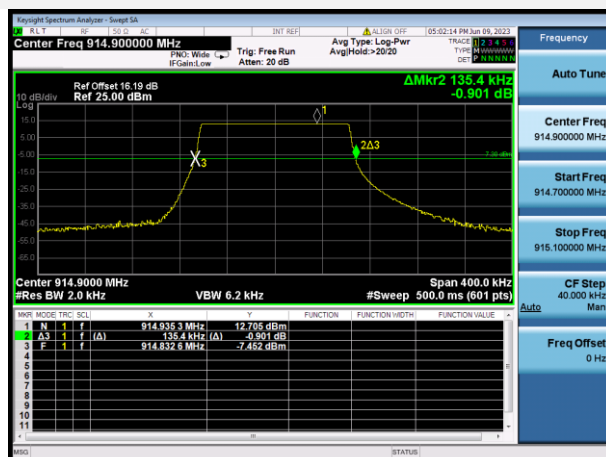
LOW CHANNEL



MIDDLE CHANNEL

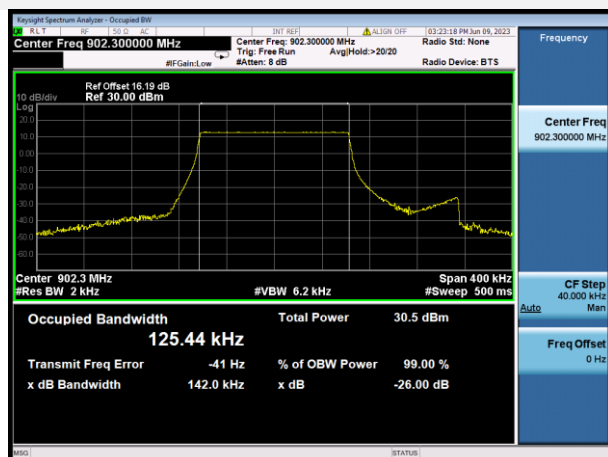


HIGH CHANNEL



99% Bandwidth

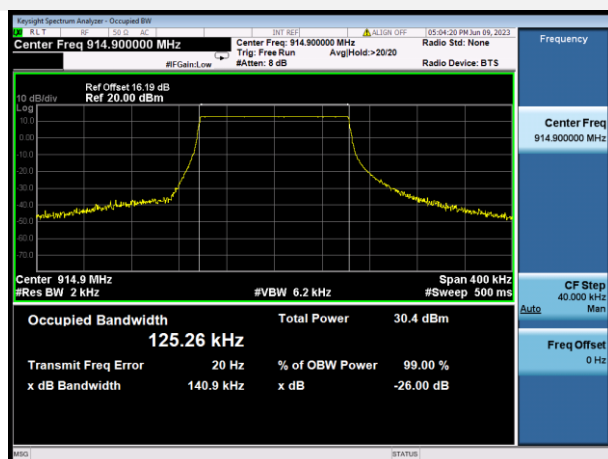
LOW CHANNEL



MIDDLE CHANNEL



HIGH CHANNEL



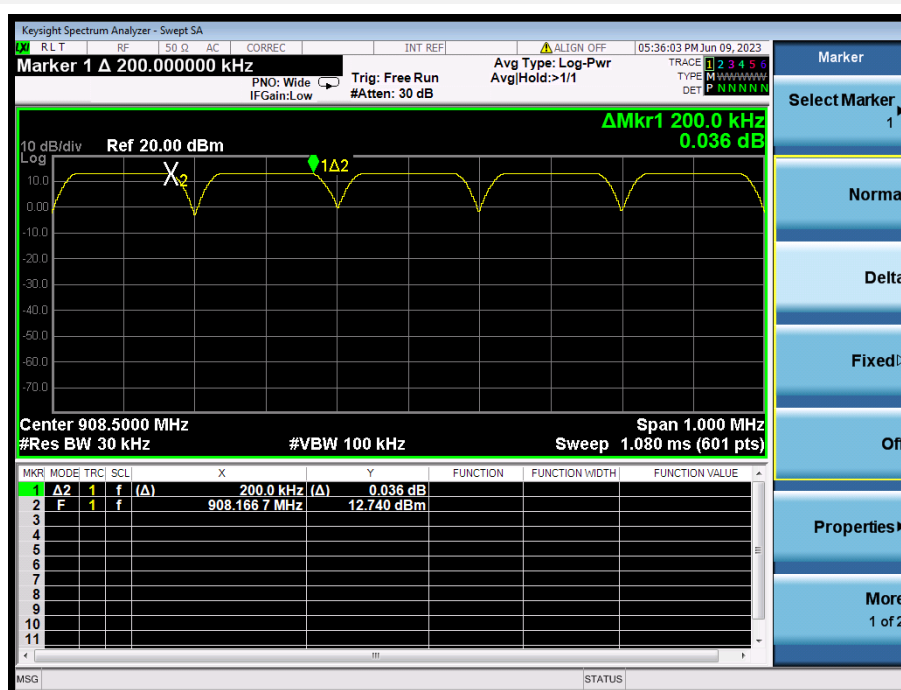
A.4 Hopping Frequency Separation

Test Data

Mode	Frequency separation (MHz)	Max 20 dB Bandwidth (MHz)	Verdict
LoRa	0.200	0.135	Pass

Test Plots

LoRa

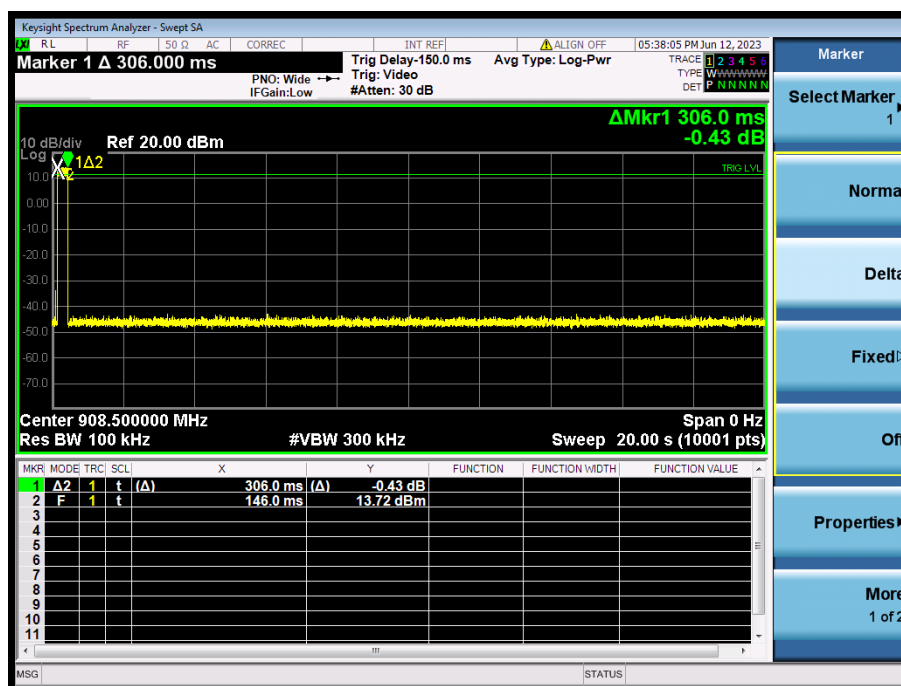


A.5 Average Time of Occupancy

Test Data

LoRa		
Total of Dwell (ms)	Limit (sec)	Verdict
306.0	0.4	Pass

LoRa



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

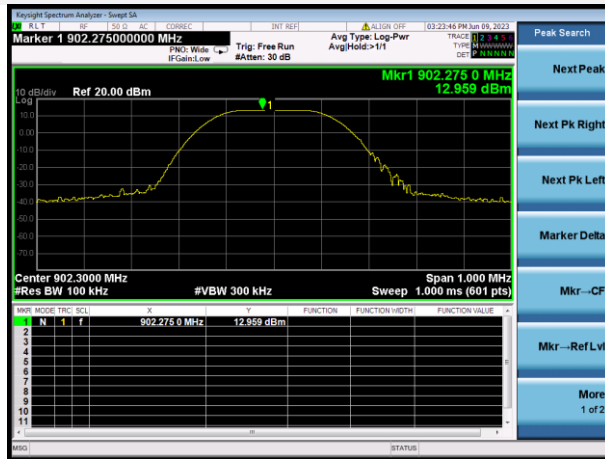
Test Data

LoRa				
Channel	Measured Max. Out of Band Emission (dBm)	Limit (dBm)		Verdict
		Carrier Level	Calculated 20 dBc Limit	
Low	-24.91	12.96	-7.04	Pass
Middle	-25.63	12.94	-7.06	Pass
High	-24.85	12.89	-7.11	Pass

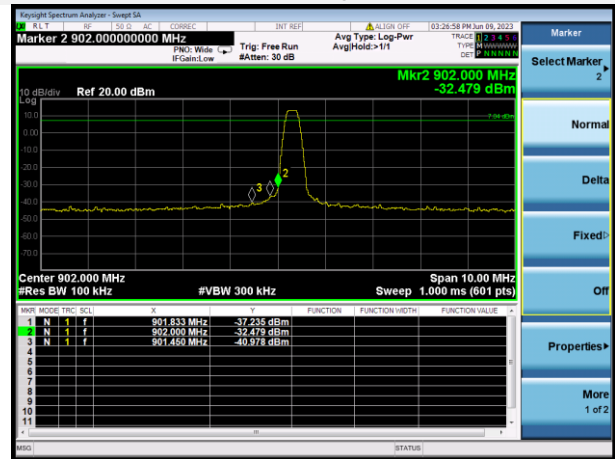
LoRa				
Mode	Measured Max. Out of Band Emission (dBm)	Limit (dBm)		Verdict
		Carrier Level	Calculated 20 dBc Limit	
Hopping	-24.16	13.10	-6.90	Pass

Test Plots

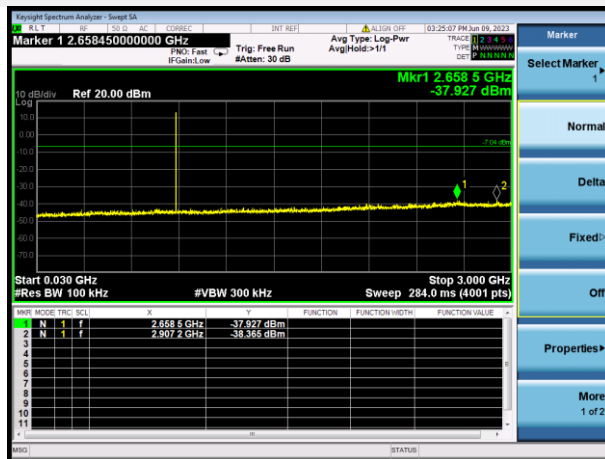
LOW CHANNEL, CARRIER LEVEL



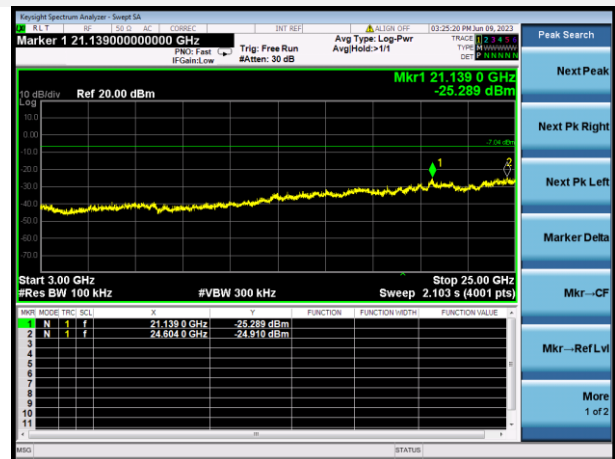
LOW CHANNEL, Band Edge



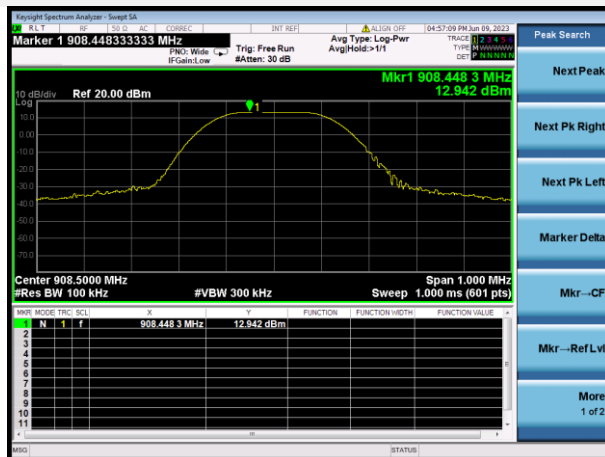
LOW CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



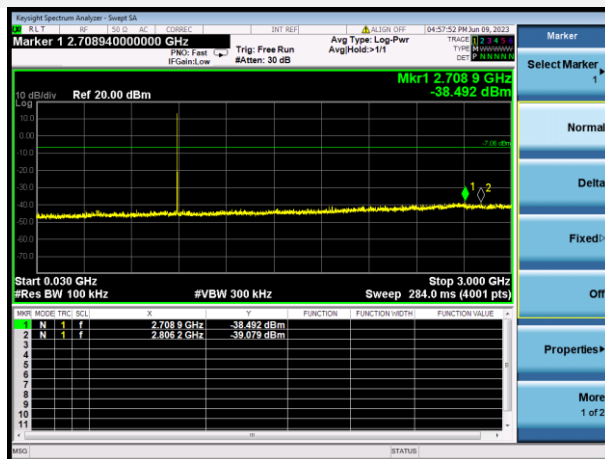
LOW CHANNEL, SPURIOUS 3 GHz ~ 25 GHz



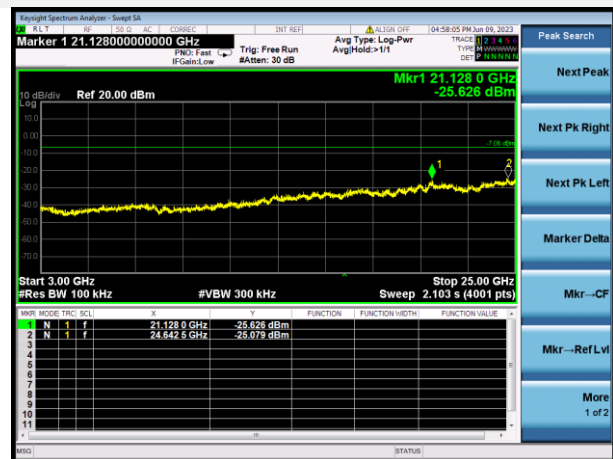
MIDDLE CHANNEL, CARRIER LEVEL



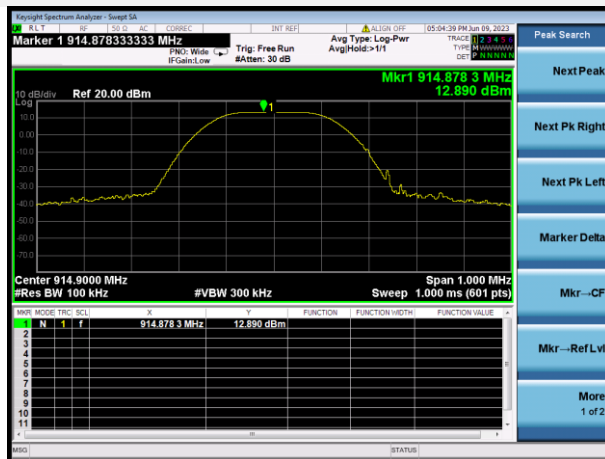
MIDDLE CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



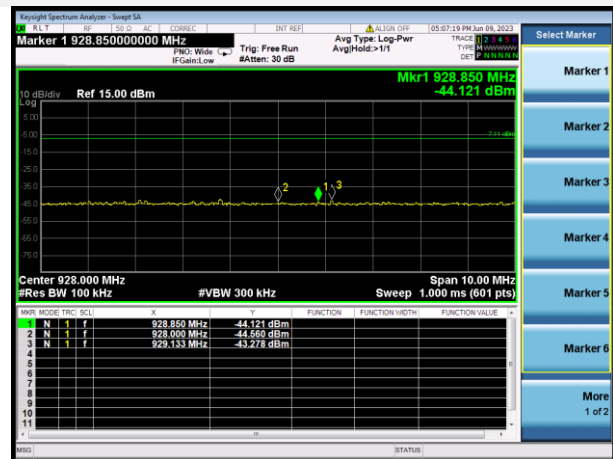
MIDDLE CHANNEL, SPURIOUS 3 GHz ~ 25 GHz



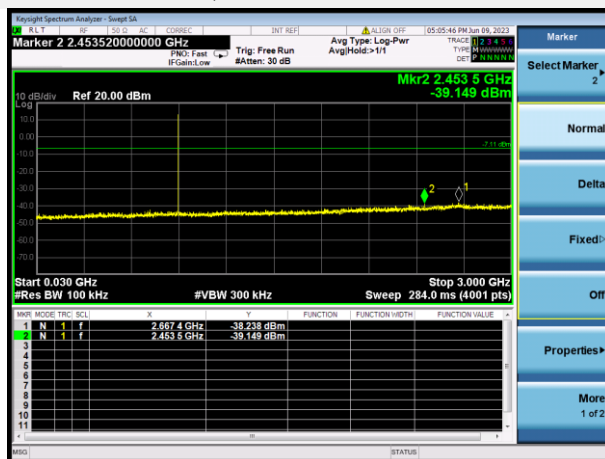
HIGH CHANNEL, CARRIER LEVEL



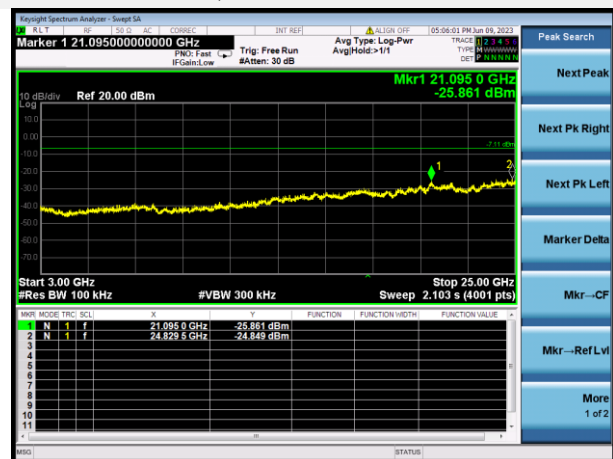
HIGH CHANNEL, BAND EDGE

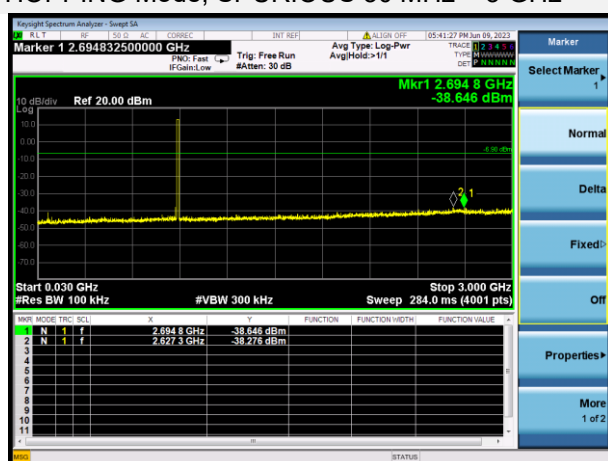
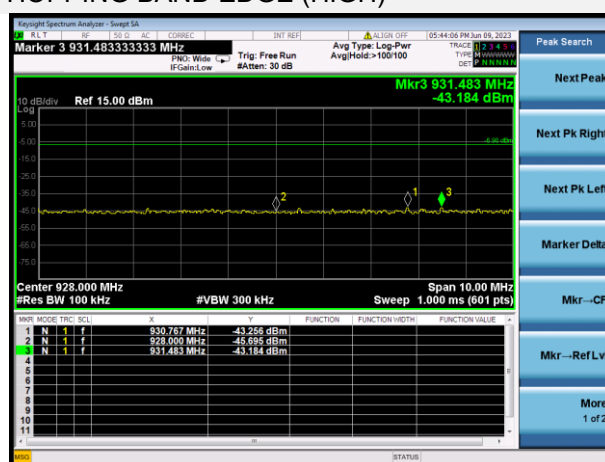
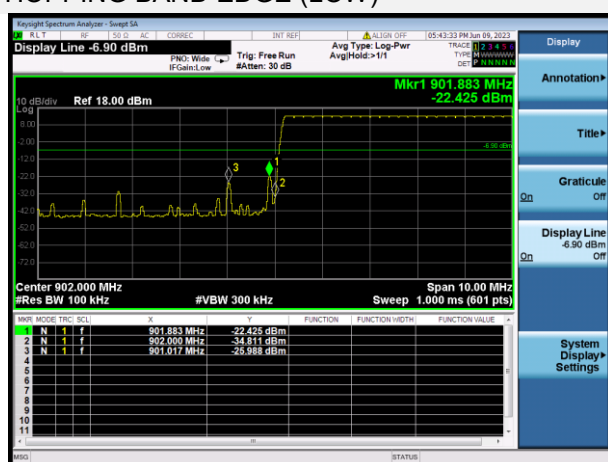
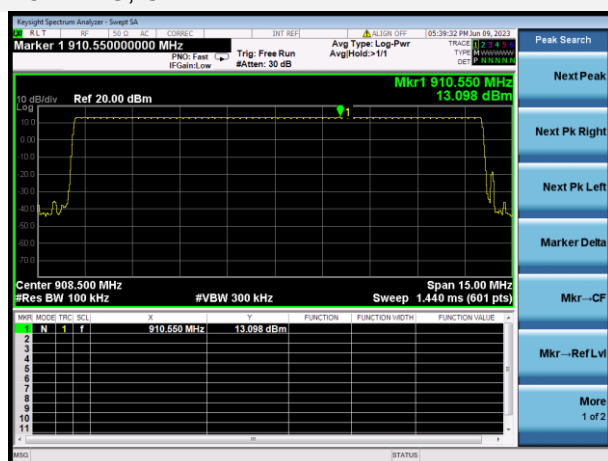


HIGH CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



HIGH CHANNEL, SPURIOUS 3 GHz ~ 25 GHz





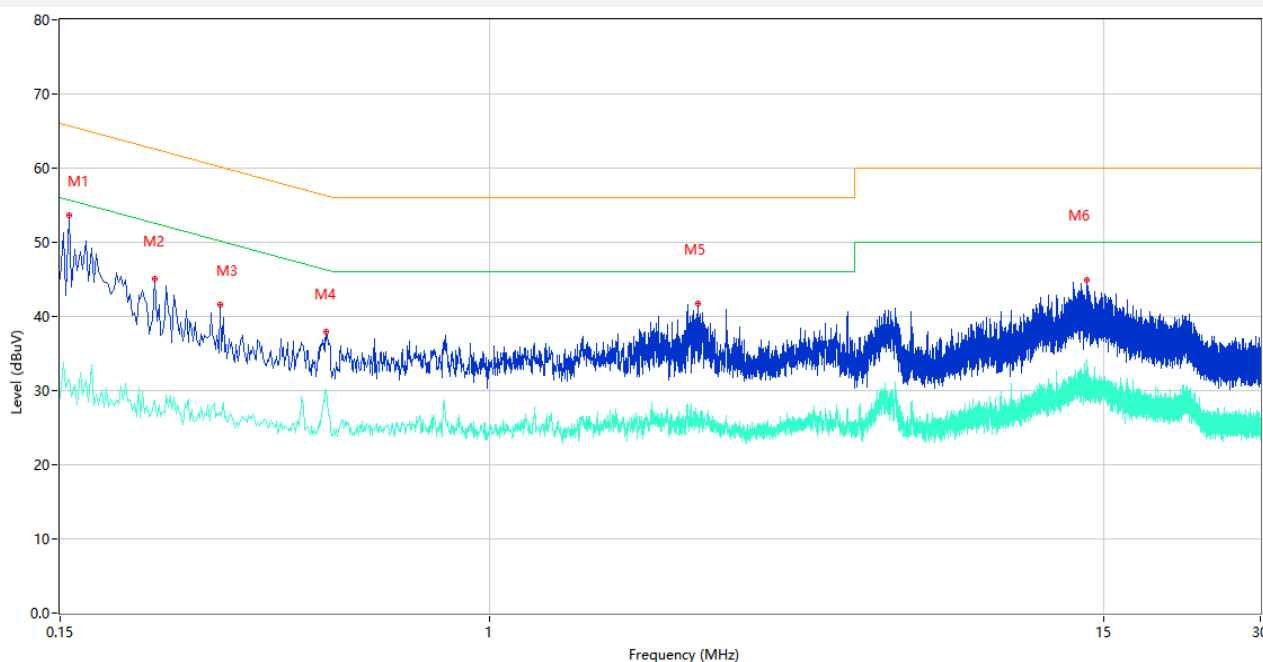
A.7 Conducted Emissions

Note ¹: The EUT is working in the Normal link mode. All modes have been tested and normal link mode is worst.

Note ²: Results (dBuV) = Original reading level of Spectrum Analyzer (dBuV) + Factor (dB)

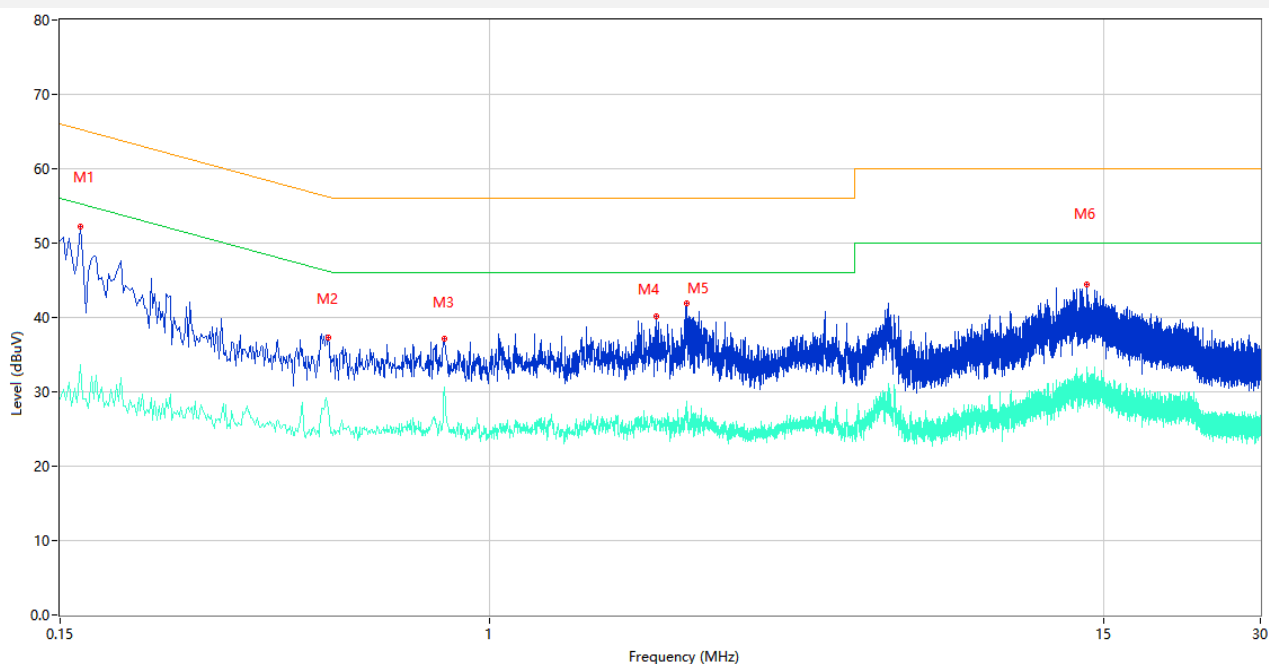
Test Data and Plots

PHASE L



No.	Frequency (MHz)	Results (dBuV)	Factor (dB)	Limit (dBuV)	Margin (dB)	Detector	Line	Verdict
1	0.156	53.64	9.78	65.67	12.03	Peak	L	Pass
1**	0.156	31.58	9.78	55.67	24.09	AV	L	Pass
2	0.228	45.11	9.77	62.52	17.41	Peak	L	Pass
2**	0.228	28.74	9.77	52.52	23.78	AV	L	Pass
3	0.304	41.55	9.84	60.13	18.58	Peak	L	Pass
3**	0.304	27.06	9.84	50.13	23.07	AV	L	Pass
4	0.486	37.98	10.00	56.24	18.26	Peak	L	Pass
4**	0.486	30.17	10.00	46.24	16.07	AV	L	Pass
5	2.502	41.70	10.16	56.00	14.30	Peak	L	Pass
5**	2.502	26.66	10.16	46.00	19.34	AV	L	Pass
6	13.968	44.86	10.41	60.00	15.14	Peak	L	Pass
6**	13.968	31.83	10.41	50.00	18.17	AV	L	Pass

PHASE N



No.	Frequency (MHz)	Results (dBuV)	Factor (dB)	Limit (dBuV)	Margin (dB)	Detector	Line	Verdict
1	0.164	52.17	9.78	65.26	13.09	Peak	N	Pass
1**	0.164	33.68	9.78	55.26	21.58	AV	N	Pass
2	0.490	37.36	9.99	56.17	18.81	Peak	N	Pass
2**	0.490	27.69	9.99	46.17	18.48	AV	N	Pass
3	0.820	37.09	10.57	56.00	18.91	Peak	N	Pass
3**	0.820	30.43	10.57	46.00	15.57	AV	N	Pass
4	2.082	40.21	10.09	56.00	15.79	Peak	N	Pass
4**	2.082	25.43	10.09	46.00	20.57	AV	N	Pass
5	2.382	41.95	10.21	56.00	14.05	Peak	N	Pass
5**	2.382	28.25	10.21	46.00	17.75	AV	N	Pass
6	13.950	44.50	10.47	60.00	15.50	Peak	N	Pass
6**	13.950	32.56	10.47	50.00	17.44	AV	N	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.

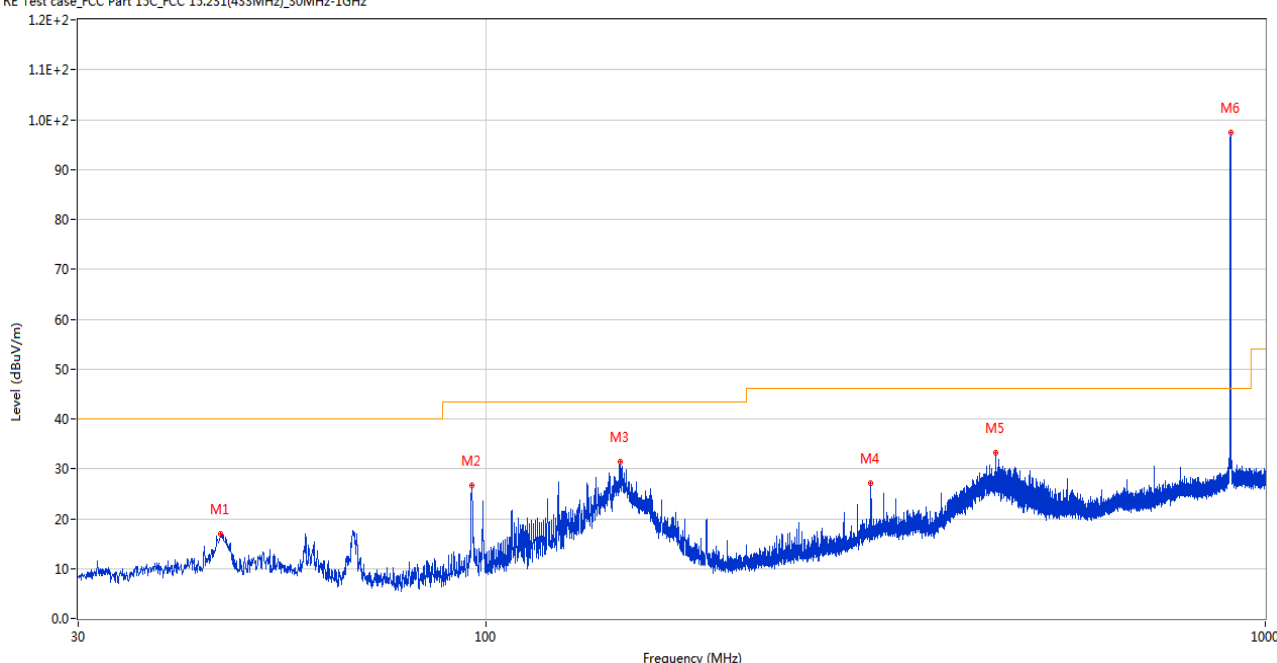
Note ³: The low frequency, which started from 9 kHz to 30 MHz, was pre-scanned and the result which was 20 dB lower than the limit line per 15.31(o) was not reported.

Note ⁴: The marked spikes near 900 MHz with circle should be ignored because they are Fundamental signal.

Test Data and Plots

LOW CHANNEL, 30 MHz to 1 GHz, ANT H

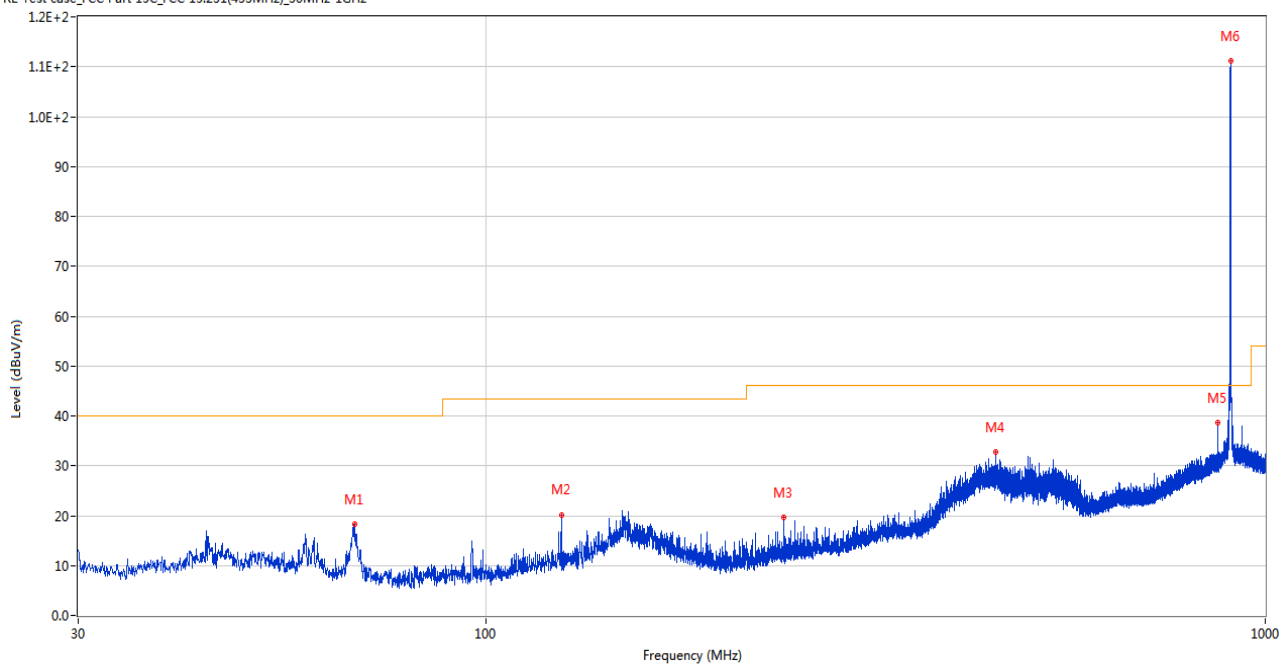
RE Test case_FCC Part 15C_FCC 15.231(433MHz)_30MHz-1GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	45.714	16.99	-26.19	40.0	23.01	Peak	330.00	200	Horizontal	Pass
2	96.008	26.69	-29.08	43.5	16.81	Peak	32.00	150	Horizontal	Pass
3	148.680	31.46	-24.41	43.5	12.04	Peak	237.00	300	Horizontal	Pass
4	311.930	27.01	-23.40	46.0	18.99	Peak	99.00	200	Horizontal	Pass
5	451.174	33.15	-19.18	46.0	12.85	Peak	186.00	150	Horizontal	Pass
6	902.321	97.33	-7.59	46.0	-51.33	Peak	223.00	150	Horizontal	N/A

LOW CHANNEL, 30 MHz to 1 GHz, ANT V

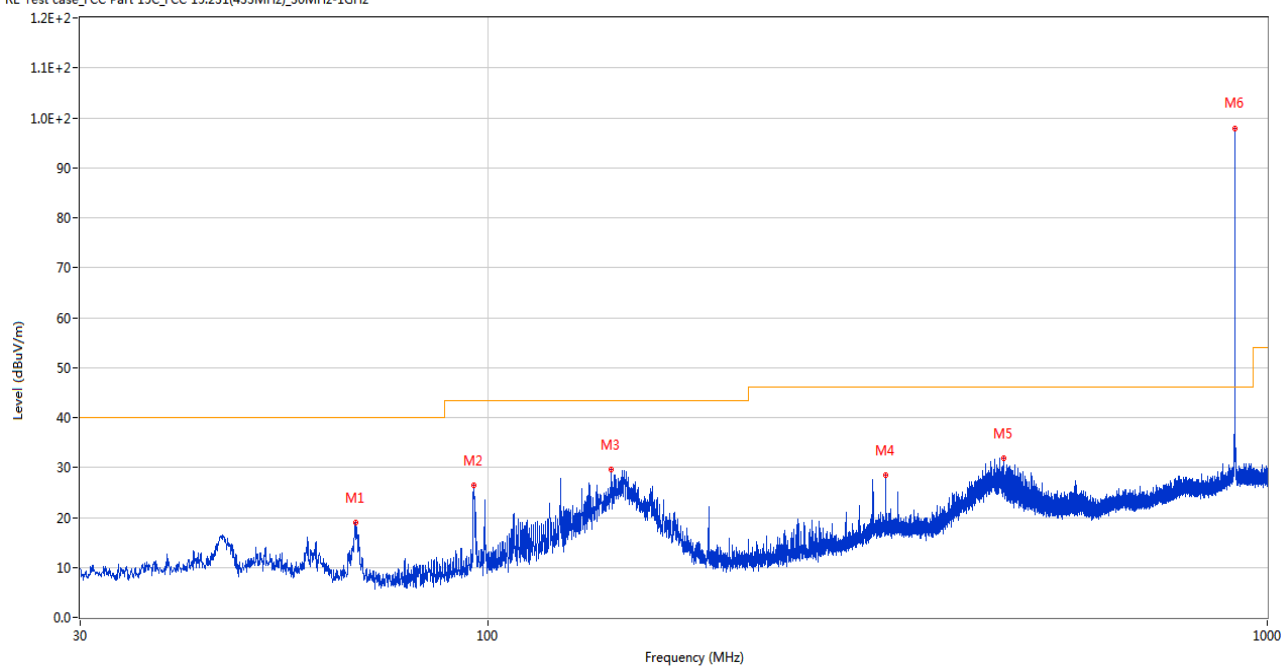
RE Test case_FCC Part 15C_FCC 15.231(433MHz)_30MHz-1GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	67.830	18.32	-28.03	40.0	21.68	Peak	209.00	300	Vertical	Pass
2	125.011	20.21	-26.17	43.5	23.29	Peak	43.00	150	Vertical	Pass
3	240.926	19.64	-25.89	46.0	26.36	Peak	182.00	200	Vertical	Pass
4	450.786	32.76	-19.15	46.0	13.24	Peak	86.00	150	Vertical	Pass
5	870.311	38.60	-9.02	46.0	7.40	Peak	101.00	150	Vertical	Pass
6	902.321	111.26	-7.59	46.0	-65.26	Peak	107.00	150	Vertical	N/A

MIDDLE CHANNEL, 30 MHz to 1 GHz, ANT H

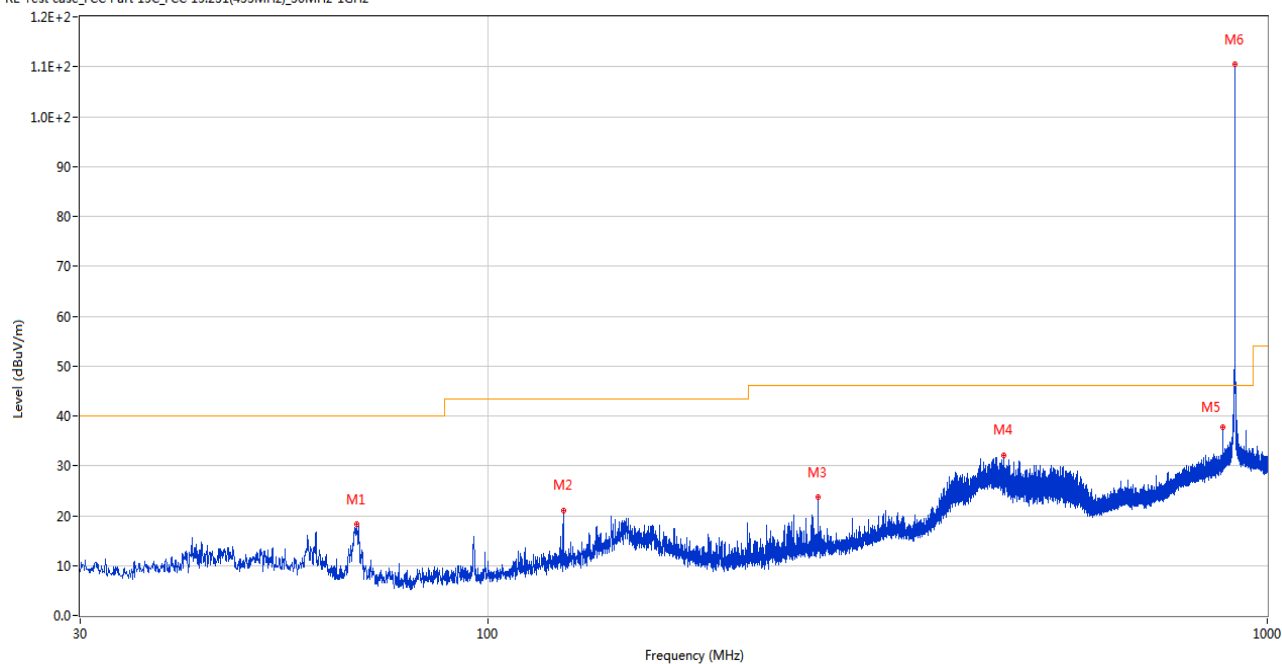
RE Test case_FCC Part 15C_FCC 15.231(433MHz)_30MHz-1GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	67.636	18.98	-28.01	40.0	21.02	Peak	338.00	150	Horizontal	Pass
2	96.057	26.47	-29.08	43.5	17.03	Peak	58.00	100	Horizontal	Pass
3	144.120	29.64	-24.81	43.5	13.86	Peak	52.00	150	Horizontal	Pass
4	324.056	28.53	-23.03	46.0	17.47	Peak	242.00	150	Horizontal	Pass
5	458.983	31.86	-19.19	46.0	14.14	Peak	159.00	200	Horizontal	Pass
6	908.529	97.96	-7.61	46.0	-51.96	Peak	221.00	150	Horizontal	N/A

MIDDLE CHANNEL, 30 MHz to 1 GHz, ANT V

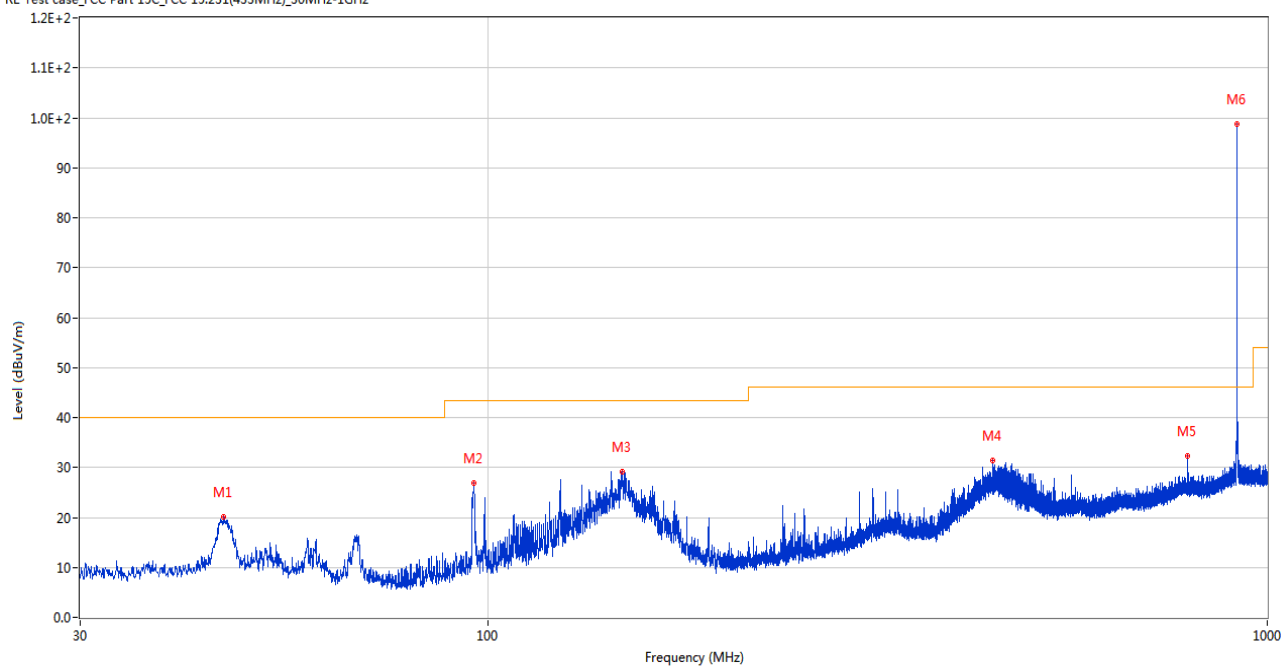
RE Test case_FCC Part 15C_FCC 15.231(433MHz)_30MHz-1GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	67.879	18.30	-28.03	40.0	21.70	Peak	0.00	150	Vertical	Pass
2	125.011	21.11	-26.17	43.5	22.39	Peak	224.00	200	Vertical	Pass
3	265.565	23.79	-25.15	46.0	22.21	Peak	53.00	150	Vertical	Pass
4	459.128	32.20	-19.19	46.0	13.80	Peak	60.00	100	Vertical	Pass
5	876.567	37.76	-8.70	46.0	8.24	Peak	249.00	150	Vertical	Pass
6	908.432	110.43	-7.61	46.0	-64.43	Peak	107.00	150	Vertical	N/A

HIGH CHANNEL, 30 MHz to 1 GHz, ANT H

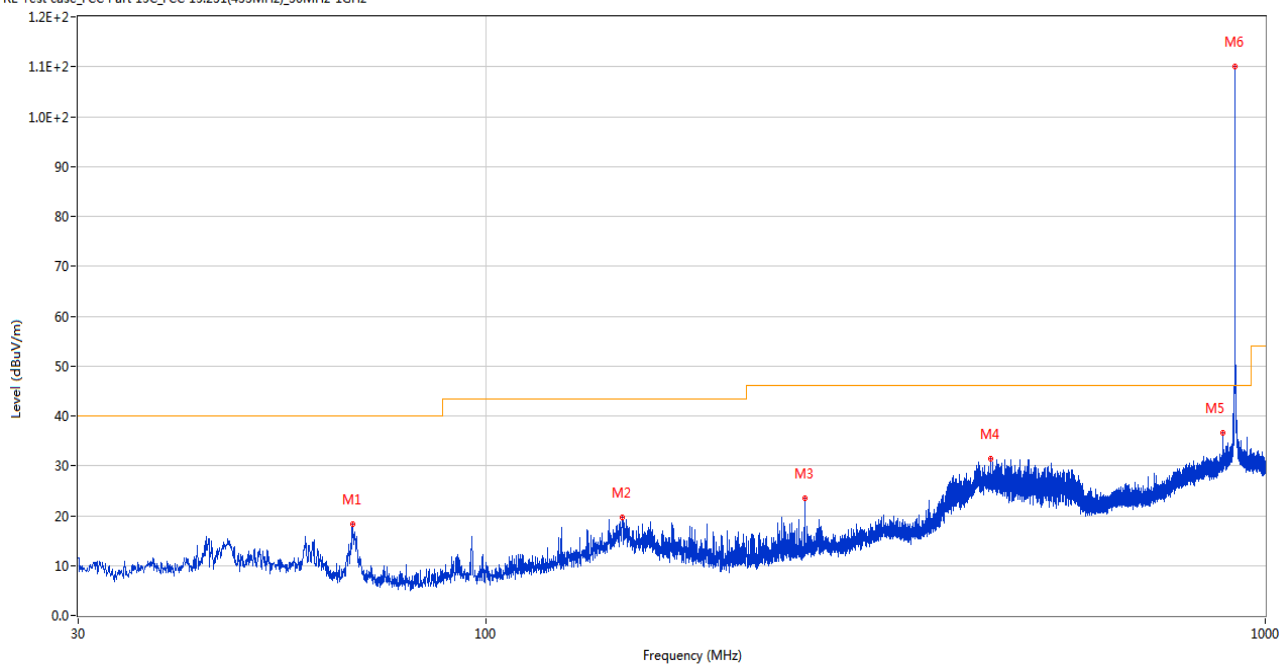
RE Test case_FCC Part 15C_FCC 15.231(433MHz)_30MHz-1GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	45.859	20.19	-26.19	40.0	19.81	Peak	170.00	200	Horizontal	Pass
2	96.008	26.83	-29.08	43.5	16.67	Peak	237.00	150	Horizontal	Pass
3	148.680	29.20	-24.41	43.5	14.30	Peak	229.00	100	Horizontal	Pass
4	443.948	31.44	-19.61	46.0	14.56	Peak	170.00	150	Horizontal	Pass
5	790.092	32.38	-9.84	46.0	13.62	Peak	103.00	100	Horizontal	Pass
6	914.882	98.68	-7.83	46.0	-52.68	Peak	221.00	150	Horizontal	N/A

HIGH CHANNEL, 30 MHz to 1 GHz, ANT V

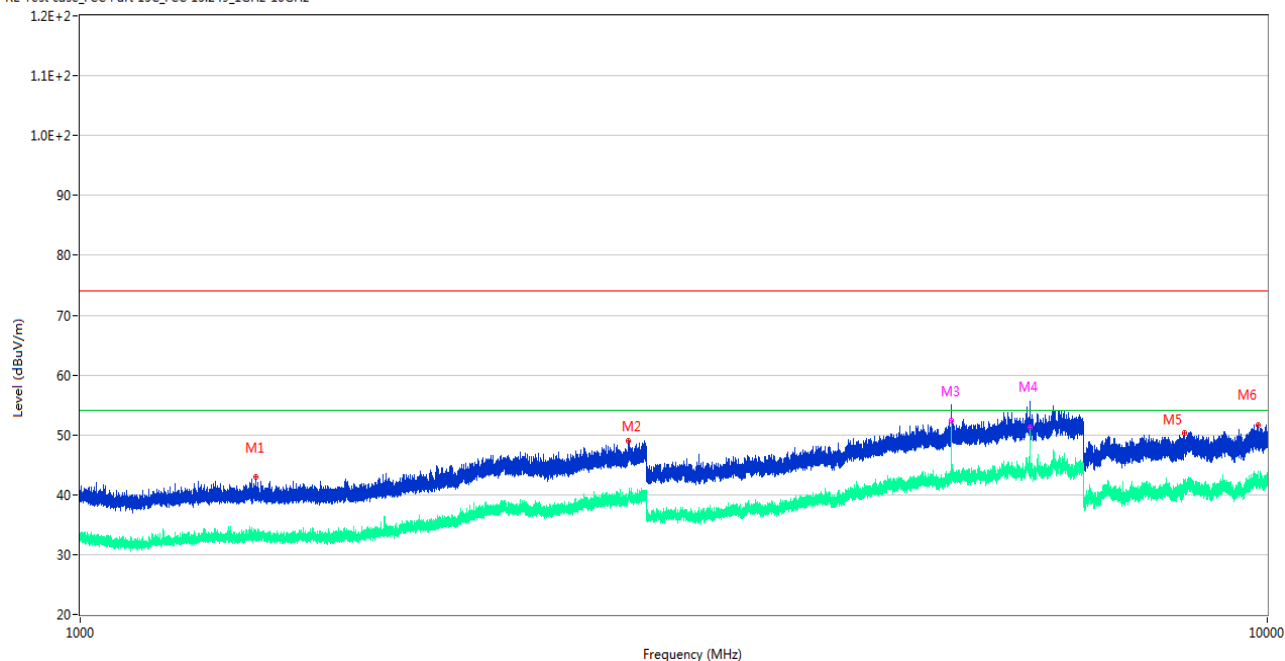
RE Test case_FCC Part 15C_FCC 15.231(433MHz)_30MHz-1GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	67.442	18.21	-28.00	40.0	21.79	Peak	58.00	300	Vertical	Pass
2	149.747	19.71	-24.33	43.5	23.79	Peak	183.00	150	Vertical	Pass
3	256.592	23.54	-25.59	46.0	22.46	Peak	104.00	100	Vertical	Pass
4	444.093	31.40	-19.60	46.0	14.60	Peak	78.00	150	Vertical	Pass
5	882.969	36.66	-8.56	46.0	9.34	Peak	100.00	150	Vertical	Pass
6	914.931	109.99	-7.83	46.0	-63.99	Peak	104.00	150	Vertical	N/A

LOW CHANNEL 1 GHz to 10 GHz, ANT H

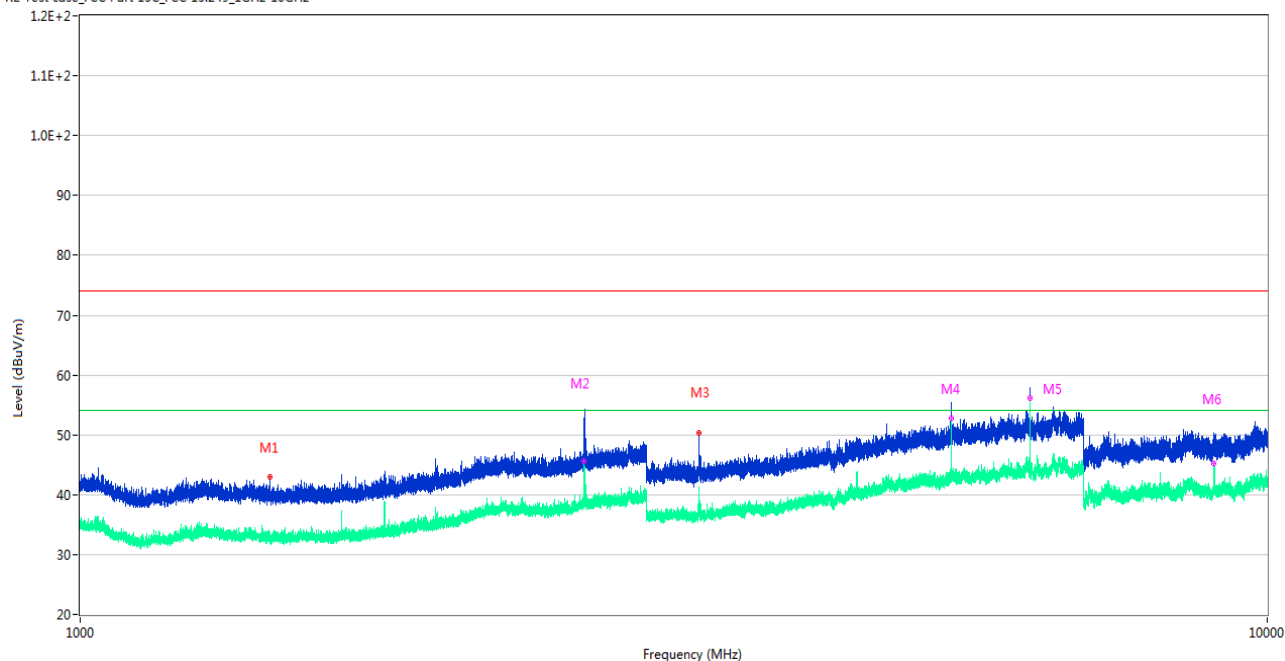
RE Test case_FCC Part 15C_FCC 15.249_1GHz-10GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1406.100	42.93	-13.28	74.0	31.07	Peak	47.00	150	Horizontal	Pass
1**	1406.100	32.33	-13.28	54.0	21.67	AV	47.00	150	Horizontal	Pass
2	2895.700	49.09	-4.67	74.0	24.91	Peak	3.00	150	Horizontal	Pass
2**	2895.700	39.48	-4.67	54.0	14.52	AV	3.00	150	Horizontal	Pass
3	5414.000	54.22	-2.40	74.0	19.78	Peak	197.00	150	Horizontal	Pass
3**	5414.000	52.36	-2.40	54.0	1.64	AV	197.00	150	Horizontal	Pass
4	6316.000	53.79	-1.28	74.0	20.21	Peak	0.00	150	Horizontal	Pass
4**	6316.000	51.25	-1.28	54.0	2.75	AV	0.00	150	Horizontal	N/A
5	8524.000	50.28	-1.70	74.0	23.72	Peak	0.00	150	Horizontal	Pass
5**	8524.000	40.67	-1.70	54.0	13.33	AV	0.00	150	Horizontal	Pass
6	9816.401	51.68	-0.01	74.0	22.32	Peak	311.00	150	Horizontal	Pass
6**	9816.401	43.50	-0.01	54.0	10.50	AV	311.00	150	Horizontal	Pass

LOW CHANNEL 1 GHz to 10 GHz, ANT V

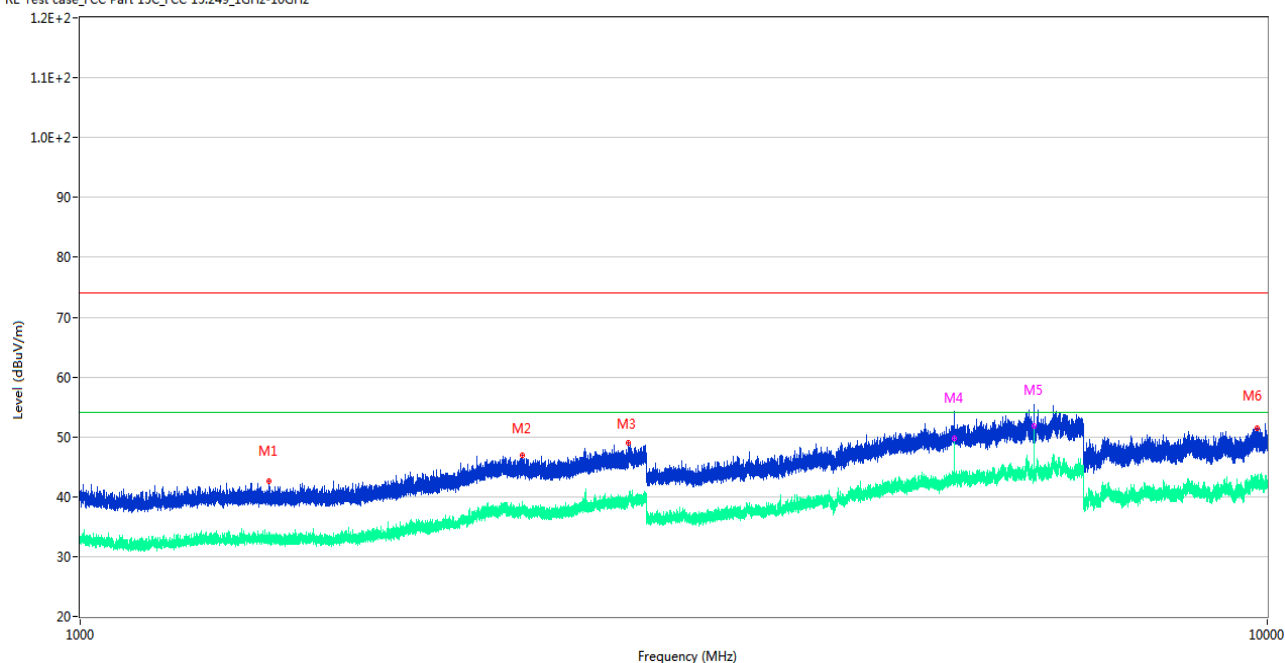
RE Test case_FCC Part 15C_FCC 15.249_1GHz-10GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1445.700	42.91	-13.70	74.0	31.09	Peak	294.00	150	Vertical	Pass
1**	1445.700	32.36	-13.70	54.0	21.64	AV	294.00	150	Vertical	Pass
2	2657.000	52.64	-7.07	74.0	21.36	Peak	187.00	150	Vertical	Pass
2**	2657.000	45.66	-7.07	54.0	8.34	AV	187.00	150	Vertical	Pass
3	3321.200	50.40	-8.31	74.0	23.60	Peak	201.00	150	Vertical	Pass
3**	3321.200	37.22	-8.31	54.0	16.78	AV	201.00	150	Vertical	Pass
4	5413.800	55.45	-2.40	74.0	18.55	Peak	355.00	150	Vertical	Pass
4**	5413.800	52.71	-2.40	54.0	1.29	AV	355.00	150	Vertical	Pass
5	6316.200	57.34	-1.31	74.0	16.66	Peak	222.00	150	Vertical	Pass
5**	6316.200	56.23	-1.31	54.0	-2.23	AV	222.00	150	Vertical	N/A
6	9022.900	49.54	-0.58	74.0	24.46	Peak	104.00	150	Vertical	Pass
6**	9022.900	45.15	-0.58	54.0	8.85	AV	104.00	150	Vertical	Pass

MIDDLE CHANNEL 1 GHz to 10 GHz, ANT H

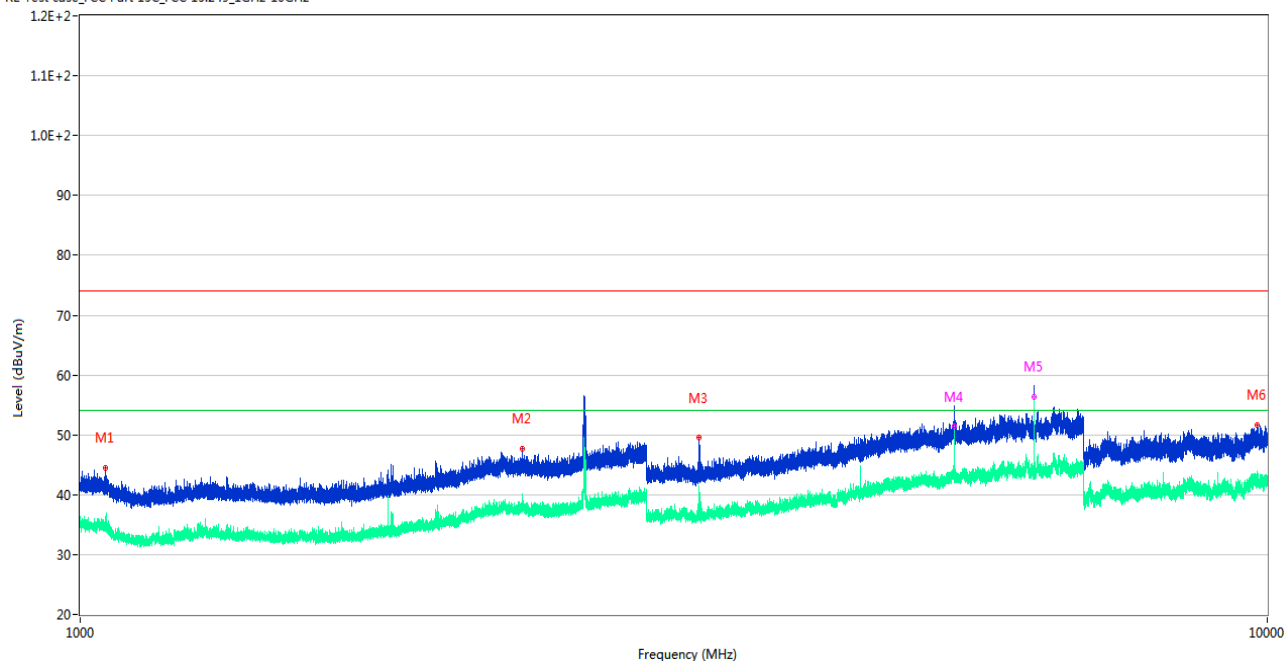
RE Test case_FCC Part 15C_FCC 15.249_1GHz-10GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1441.600	42.62	-13.53	74.0	31.38	Peak	300.00	300	Horizontal	Pass
1**	1441.600	32.53	-13.53	54.0	21.47	AV	300.00	300	Horizontal	Pass
2	2357.000	46.91	-7.69	74.0	27.09	Peak	267.00	200	Horizontal	Pass
2**	2357.000	37.73	-7.69	54.0	16.27	AV	267.00	200	Horizontal	Pass
3	2896.700	49.01	-4.44	74.0	24.99	Peak	213.00	200	Horizontal	Pass
3**	2896.700	39.32	-4.44	54.0	14.68	AV	213.00	200	Horizontal	Pass
4	5451.000	52.76	-2.03	74.0	21.24	Peak	202.00	150	Horizontal	Pass
4**	5451.000	49.74	-2.03	54.0	4.26	AV	202.00	150	Horizontal	Pass
5	6359.400	55.13	-2.13	74.0	18.87	Peak	225.00	150	Horizontal	Pass
5**	6359.400	51.84	-2.13	54.0	2.16	AV	225.00	150	Horizontal	N/A
6	9810.700	51.48	-0.02	74.0	22.52	Peak	205.00	300	Horizontal	Pass
6**	9810.700	43.06	-0.02	54.0	10.94	AV	205.00	300	Horizontal	Pass

MIDDLE CHANNEL 1 GHz to 10 GHz, ANT V

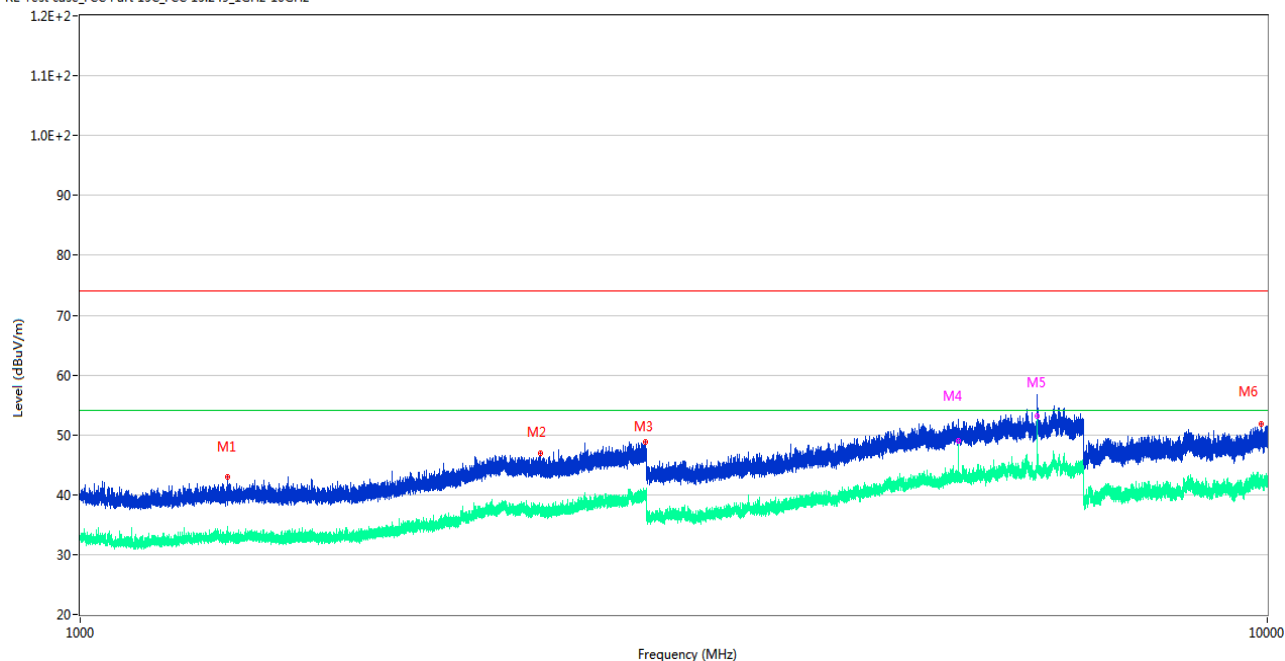
RE Test case_FCC Part 15C_FCC 15.249_1GHz-10GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1050.100	44.52	-13.84	74.0	29.48	Peak	34.00	300	Vertical	Pass
1**	1050.100	34.26	-13.84	54.0	19.74	AV	34.00	300	Vertical	Pass
2	2358.000	47.73	-7.83	74.0	26.27	Peak	175.00	400	Vertical	Pass
2**	2358.000	40.06	-7.83	54.0	13.94	AV	175.00	400	Vertical	Pass
3	3318.000	49.64	-8.07	74.0	24.36	Peak	184.00	150	Vertical	Pass
3**	3318.000	37.46	-8.07	54.0	16.54	AV	184.00	150	Vertical	Pass
4	5450.800	54.84	-2.02	74.0	19.16	Peak	0.00	150	Vertical	Pass
4**	5450.800	51.39	-2.02	54.0	2.61	AV	0.00	150	Vertical	Pass
5	6359.200	58.28	-2.12	74.0	15.72	Peak	229.00	150	Vertical	Pass
5**	6359.200	56.41	-2.12	54.0	-2.41	AV	229.00	150	Vertical	N/A
6	9814.450	51.63	-0.03	74.0	22.37	Peak	180.00	300	Vertical	Pass
6**	9814.450	42.25	-0.03	54.0	11.75	AV	180.00	300	Vertical	Pass

HIGH CHANNEL 1 GHz to 10 GHz, ANT H

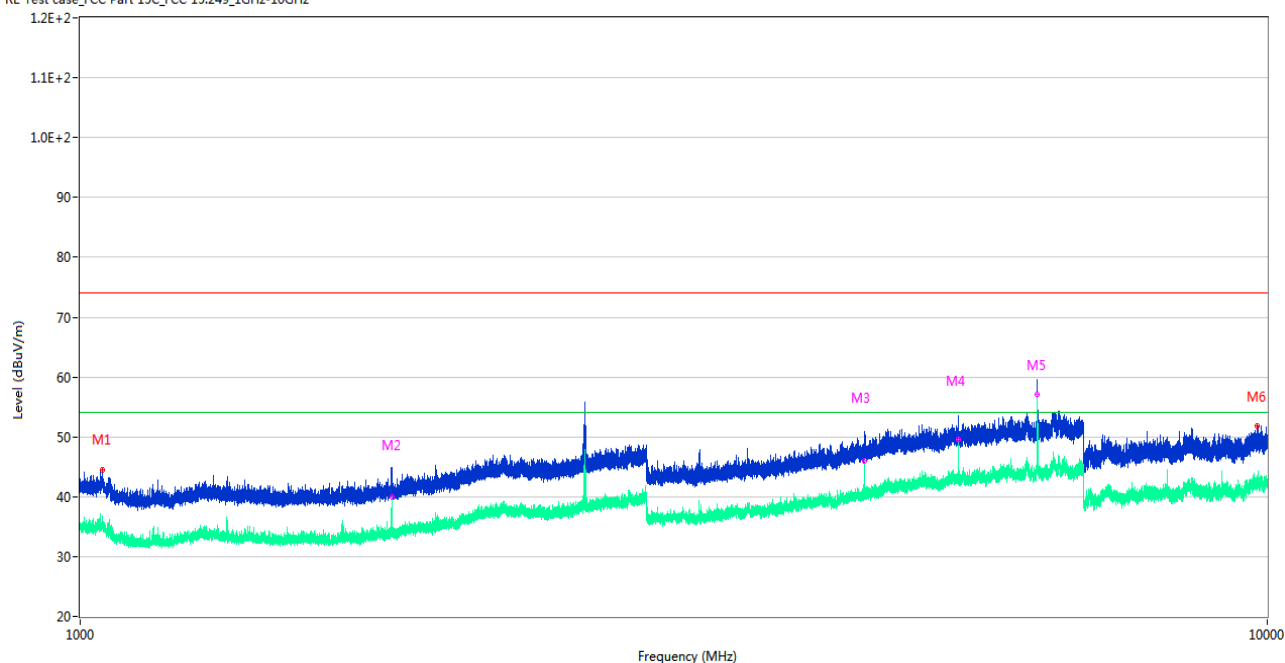
RE Test case_FCC Part 15C_FCC 15.249_1GHz-10GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1329.900	43.04	-13.39	74.0	30.96	Peak	110.00	200	Horizontal	Pass
1**	1329.900	32.13	-13.39	54.0	21.87	AV	110.00	200	Horizontal	Pass
2	2442.300	47.01	-8.84	74.0	26.99	Peak	146.00	300	Horizontal	Pass
2**	2442.300	37.23	-8.84	54.0	16.77	AV	146.00	300	Horizontal	Pass
3	2994.200	48.84	-4.87	74.0	25.16	Peak	360.00	200	Horizontal	Pass
3**	2994.200	40.00	-4.87	54.0	14.00	AV	360.00	200	Horizontal	Pass
4	5489.200	52.42	-2.46	74.0	21.58	Peak	179.00	150	Horizontal	Pass
4**	5489.200	49.02	-2.46	54.0	4.98	AV	179.00	150	Horizontal	Pass
5	6404.600	56.33	0.24	74.0	17.67	Peak	288.00	150	Horizontal	Pass
5**	6404.600	53.11	0.24	54.0	0.89	AV	288.00	150	Horizontal	N/A
6	9873.849	51.75	-0.83	74.0	22.25	Peak	226.00	400	Horizontal	Pass
6**	9873.849	42.54	-0.83	54.0	11.46	AV	226.00	400	Horizontal	Pass

HIGH CHANNEL 1 GHz to 10 GHz, ANT V

RE Test case_FCC Part 15C_FCC 15.249_1GHz-10GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1044.300	44.51	-13.36	74.0	29.49	Peak	44.00	300	Vertical	Pass
1**	1044.300	34.71	-13.36	54.0	19.29	AV	44.00	300	Vertical	Pass
2	1830.100	43.83	-12.55	74.0	30.17	Peak	97.00	150	Vertical	Pass
2**	1830.100	39.87	-12.55	54.0	14.13	AV	97.00	150	Vertical	Pass
3	4574.800	49.82	-4.27	74.0	24.18	Peak	62.00	150	Vertical	Pass
3**	4574.800	45.94	-4.27	54.0	8.06	AV	62.00	150	Vertical	Pass
4	5489.600	53.05	-2.45	74.0	20.95	Peak	84.00	150	Vertical	Pass
4**	5489.600	49.66	-2.45	54.0	4.34	AV	84.00	150	Vertical	Pass
5	6404.200	59.08	0.20	74.0	14.92	Peak	211.00	150	Vertical	Pass
5**	6404.200	57.02	0.20	54.0	-3.02	AV	211.00	150	Vertical	N/A
6	9814.300	51.81	-0.03	74.0	22.19	Peak	360.00	200	Vertical	Pass
6**	9814.300	42.76	-0.03	54.0	11.24	AV	360.00	200	Vertical	Pass

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

Note ¹: The lowest and highest channels are tested to verify the band edge emissions. Please refer to the following the plots for emissions values.

Note ²: The test data all are tested in the vertical and horizontal antenna which the trace is max hold. So these plots have shown the worst case.

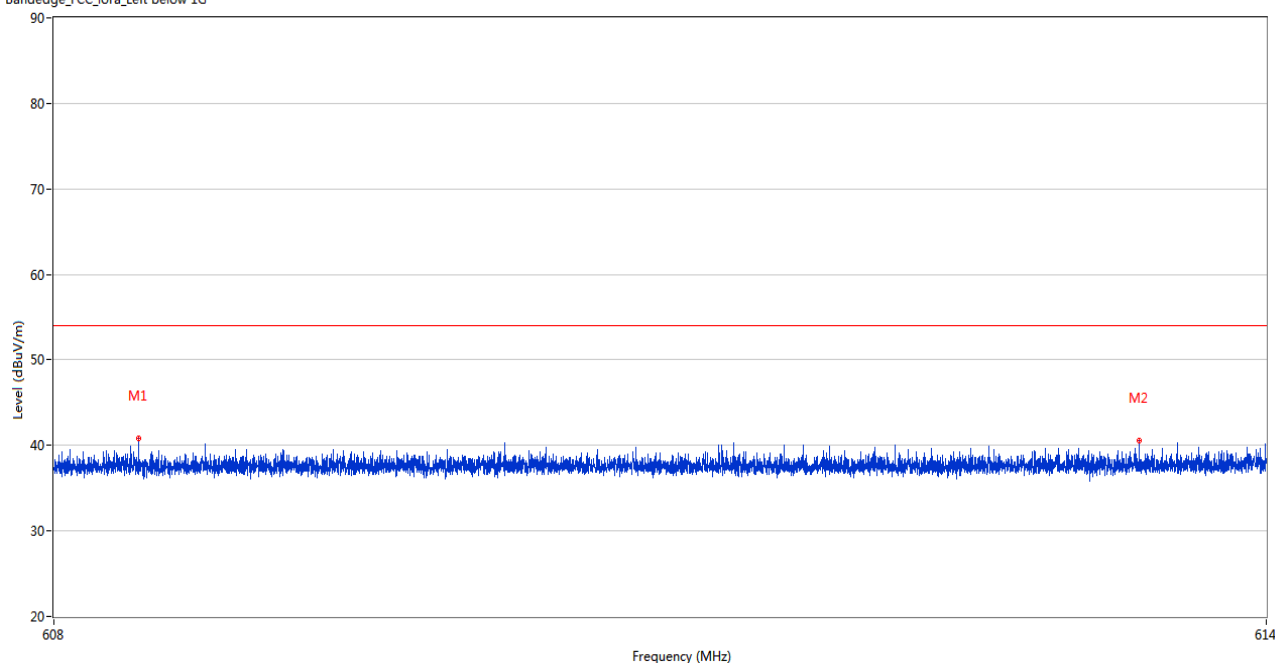
Note ³: According the ANSI C63.10-2013, where limits are specified for both average and peak (or quasi-peak) detector functions, if the peak (or quasi-peak) measured value complies with the average limit, it is unnecessary to perform an average measurement.

Note ⁴: The Level (dBuV/m) has been corrected by factor.

Test Data and Plots

LOW CHANNEL

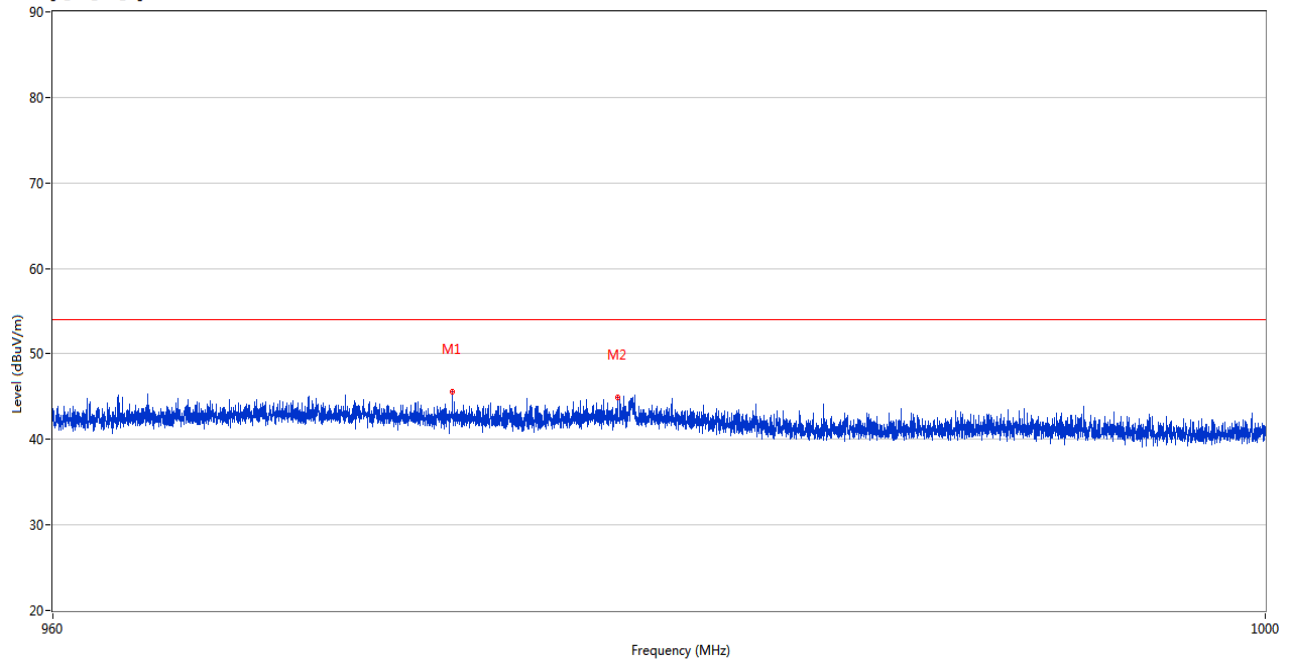
Bandedge_FCC_lora_Left below 1G



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	608.418	40.89	3.00	54.0	13.11	Peak	106.00	150	Vertical	Pass
2	613.369	40.51	3.19	54.0	13.49	Peak	41.00	200	Vertical	Pass

HIGH CHANNEL

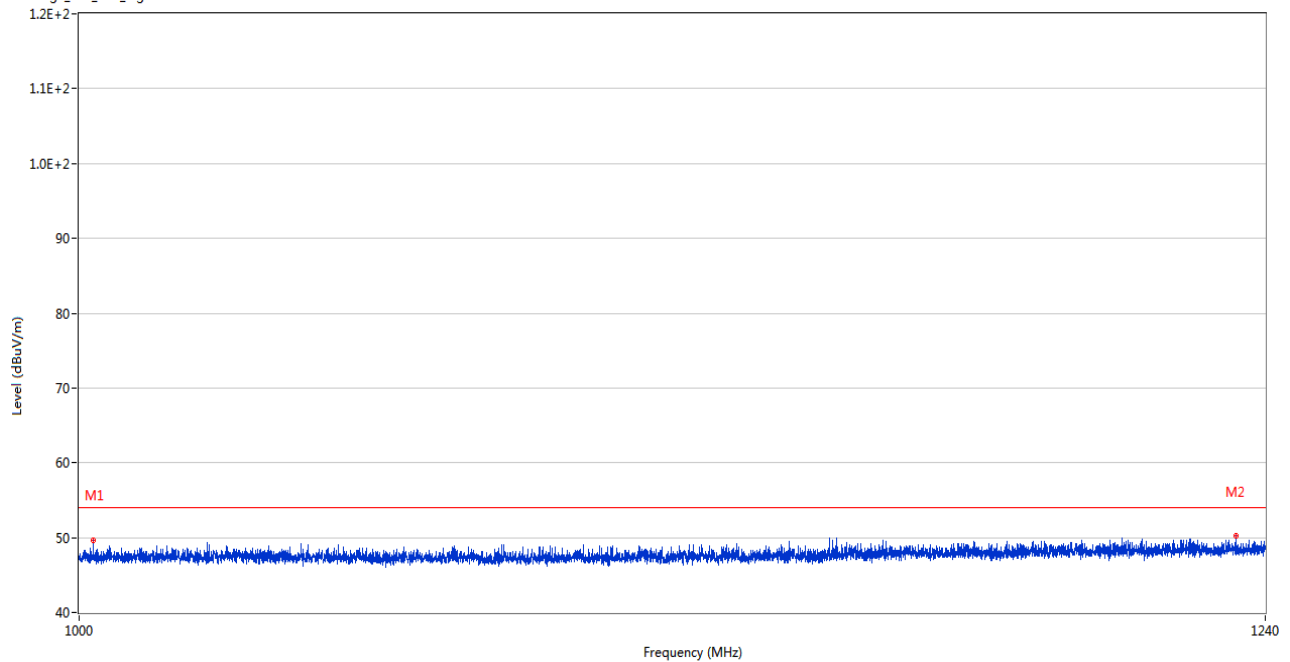
Bandedge_FCC_lora_Right below 1G



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	973.000	45.55	-3.29	54.0	8.45	Peak	199.00	150	Vertical	Pass
2	978.440	44.87	-3.43	54.0	9.13	Peak	212.00	150	Vertical	Pass

HIGH CHANNEL

Bandedge_FCC_lora_Right above 1G



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1002.560	49.60	-6.18	54.0	4.40	Peak	350.00	150	Vertical	Pass
2	1233.440	50.19	-5.62	54.0	3.81	Peak	75.00	150	Vertical	Pass

ANNEX B TEST SETUP PHOTOS

Please refer the document “BL-SZ2351174-AR.PDF”.

ANNEX C EUT EXTERNAL PHOTOS

Please refer the document “BL-SZ2351174-AW.PDF”.

ANNEX D EUT INTERNAL PHOTOS

Please refer the document “BL-SZ2351174-AI.PDF”.

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--END OF REPORT--