

TEST REPORT

Applicant: Seeed Technology Co., Ltd.
Address: 9F, G3 Building, TCL International E City,
Zhongshanyuan Road, Nanshan District, Shenzhen
518055, China
Equipment Type: SenseCAP Indicator
Model Name: D1Pro (refer section 2.4)
Brand Name: Seeed Studio
FCC ID: Z4T-D1-A
Test Standard: 47 CFR Part 15 Subpart C
(refer section 3.1)
Sample Arrival Date: Apr. 06, 2023
Test Date: Apr. 12, 2023 - Apr. 19, 2023
Date of Issue: May 08, 2023

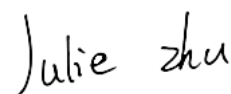
ISSUED BY:

Shenzhen BALUN Technology Co., Ltd.

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(Technical Director)



Revision History		
Version	Issue Date	Revisions
<u>Rev. 01</u>	<u>May 08, 2023</u>	<u>Initial Issue</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	<input checked="" type="checkbox"/> Block B, 1/F, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China
	<input type="checkbox"/> 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 518055, China

2.2 Manufacturer Information

Manufacturer	Seeed Technology Co., Ltd.
Address	9F, G3 Building, TCL International E City, Zhongshanyuan Road, Nanshan District, Shenzhen 518055, China

2.3 Factory Information

Factory	Shenzhen Xinxian Technology Co., Limited
Address	F5, Building B17, Hengfeng Industrial City, No. 739 Zhoushi Rd, Baoan District, Shenzhen, Guangdong, P.R.C.

2.4 General Description for Equipment under Test (EUT)

EUT Name	SenseCAP Indicator				
Model Name Under Test	D1Pro				
Series Model Name	D1L				
Description of Model name differentiation	All models are same with electrical parameters and internal circuit structure, but only differ as below (this information provided by the customer):				
	Model	BT/WIFI	LoRa	CO2, tVOC sensor	Accessory
	D1Pro	Support	Support	Support	Type C cable, Grove ATH20 TH Sensor
	D1L	Support	Support	Not support	Type C cable
Hardware Version	v1.3				
Software Version	v1.0				
Dimensions (Approx.)	N/A				
Weight (Approx.)	N/A				

2.5 Technical Information

Network and Wireless connectivity	Bluetooth (BLE), LoRa 2.4G WIFI 802.11b, 802.11g, 802.11n(HT20/HT40)
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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	<input checked="" type="checkbox"/> Mobile <input type="checkbox"/> Portable <input type="checkbox"/> Fix Location
Frequency Range	The frequency range used is 902 MHz to 928 MHz.
Number of channel	64
Tested Channel	1 (902.3 MHz), 32 (908.5 MHz), 64 (914.9 MHz)
Antenna Type	PIFA Antenna
Antenna Gain	0.59 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	54% to 63%	
Atmospheric Pressure	100 kPa to 102 kPa	
Temperature	NT (Normal Temperature)	+20.2°C to +23.2°C
Working Voltage of the EUT	NV (Normal Voltage)	5.0 V

4.2 Test Equipment List

Description	Manufacturer	Model	Serial No.	Cal. Date	Cal. Due
Spectrum Analyzer	KEYSIGHT	N9020A	MY50330200	2022.05.19	2023.05.18
Spectrum Analyzer	ROHDE&SCHWARZ	FSV-40	101544	2022.12.28	2023.12.27
Spectrum Analyzer	KEYSIGHT	N9020A	MY52510065	2022.09.06	2023.09.05
Signaling Unit	ROHDE&SCHWARZ	CMW500	171150	2022.06.29	2023.06.28
Test Antenna-Bi-Log	SCHWARZBECK	VULB 9163	00884	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-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	2022.06.01	2023.05.31
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

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	0.82°C
Humidity	4.1%

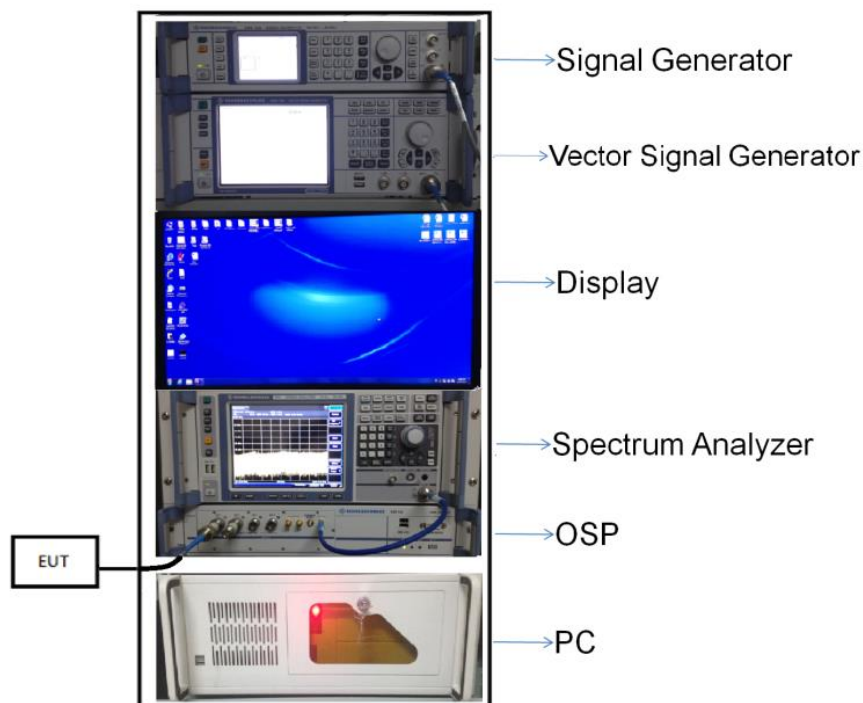
4.4 Description of Test Setup

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



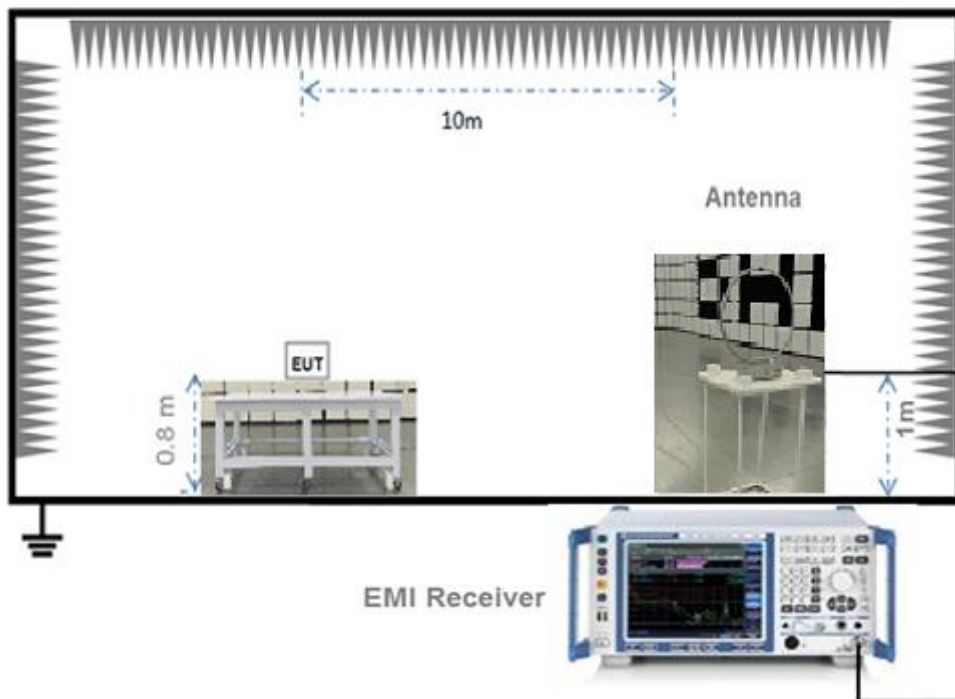
(Diagram 1)

4.4.2 For AC Power Supply Port Test



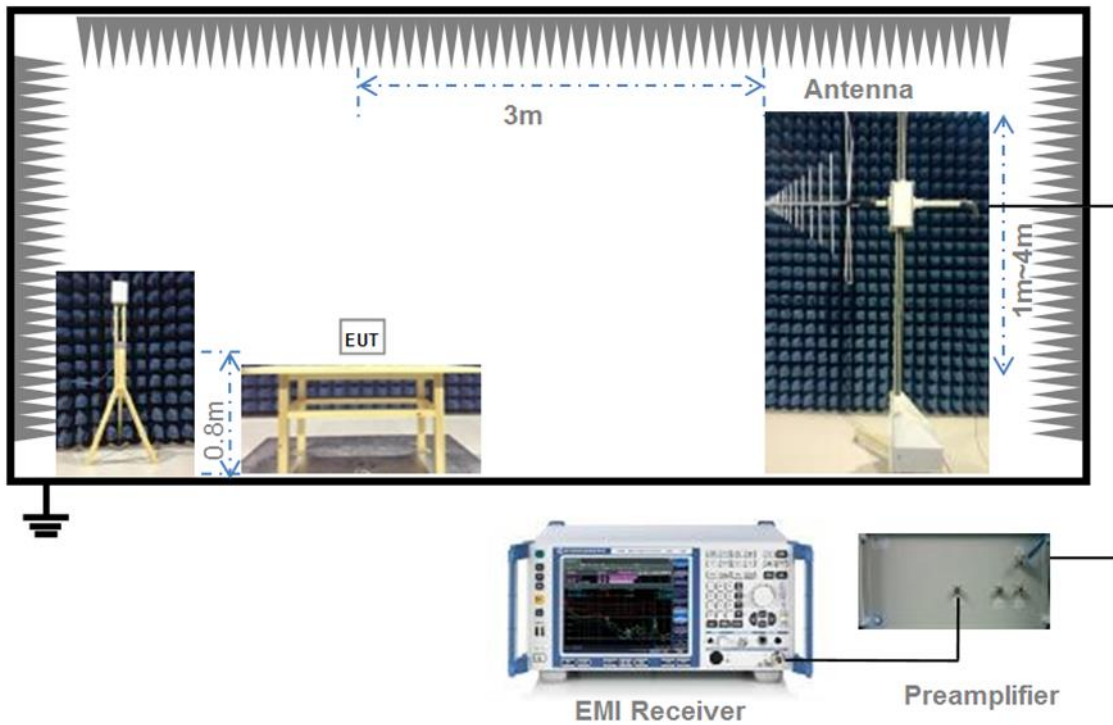
(Diagram 2)

4.4.3 For Radiated Test (Below 30 MHz)



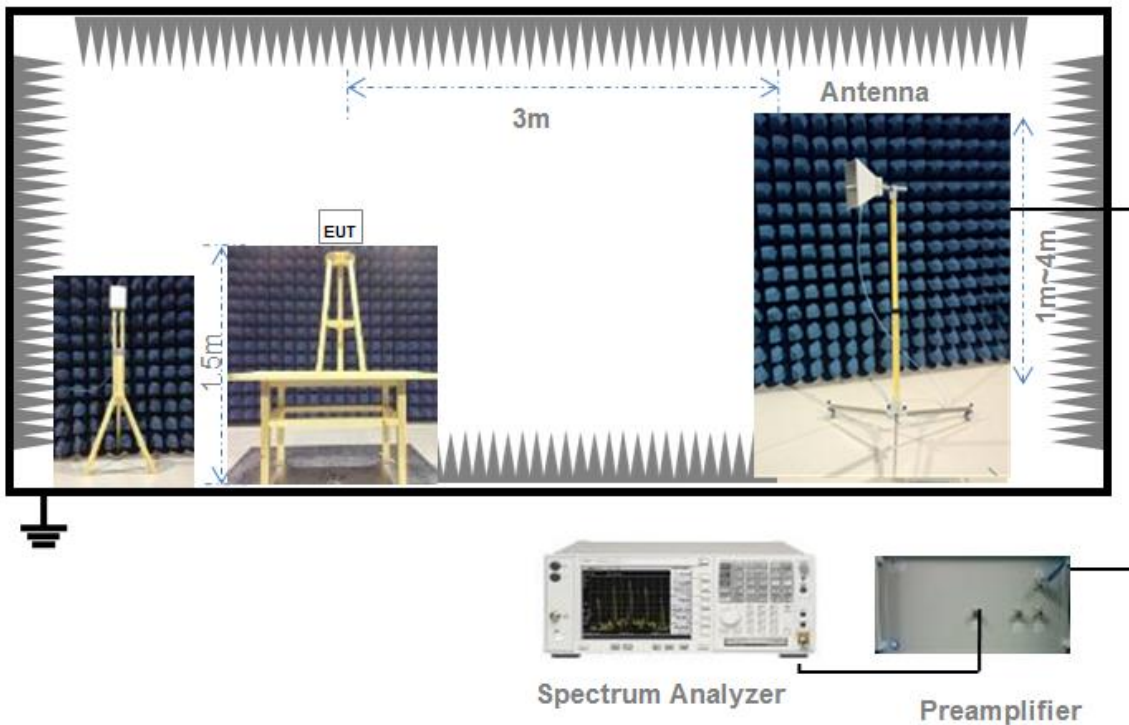
(Diagram 3)

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 ($\mu\text{V}/\text{m}$)	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 (dB $\mu\text{V}/\text{m}$) = 20*log[Field Strength ($\mu\text{V}/\text{m}$)].
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

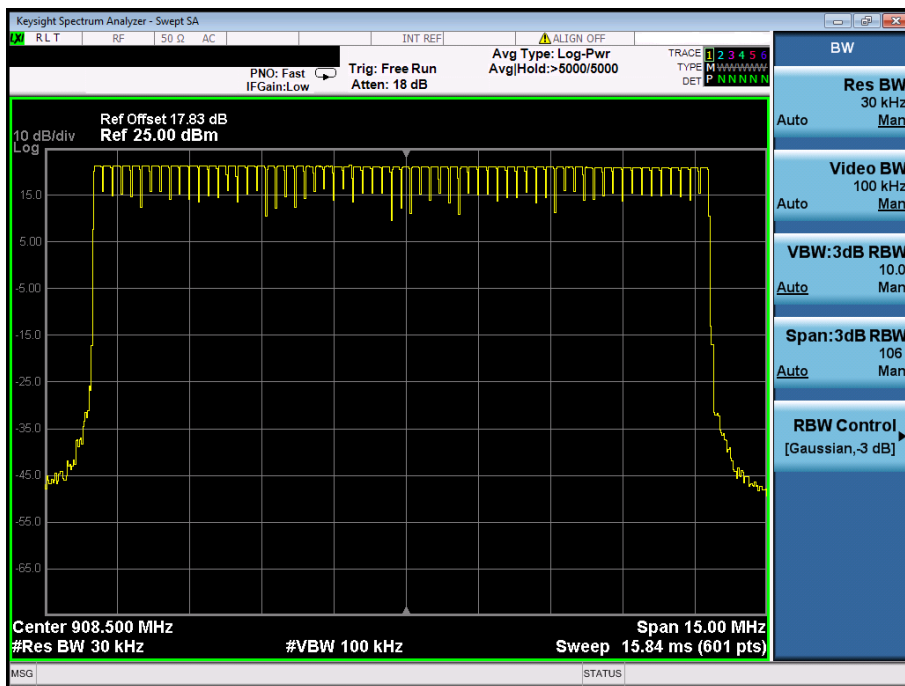
A.1 Number of Hopping Frequency

Test Data

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

Test Plots

LoRa



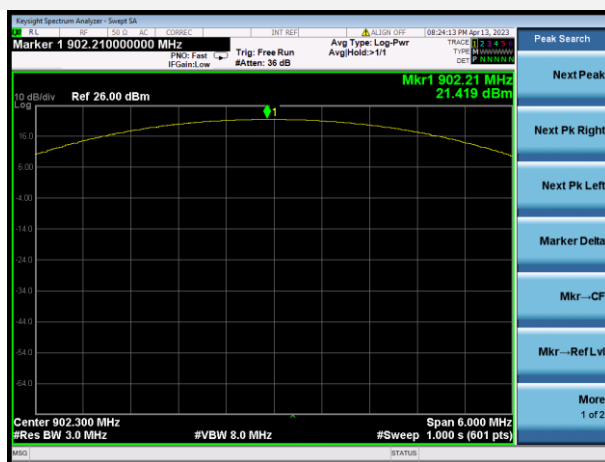
A.2 Peak Output Power

Test Data

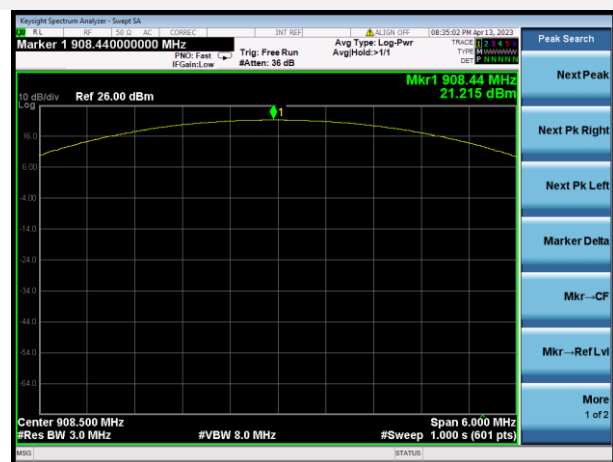
Channel	Measured Output Peak Power		Limit		Verdict
	LoRa		dBm	mW	
	dBm	mW			
Low	21.42	138.64	30	1000	Pass
Middle	21.22	132.28			Pass
High	20.99	125.57			Pass

Test Plots

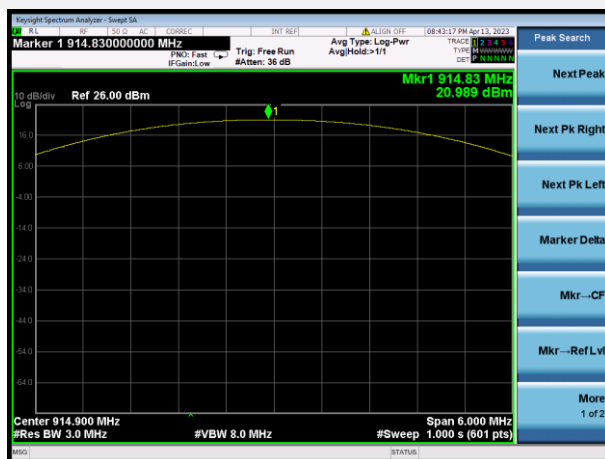
LOW CHANNEL



MIDDLE CHANNEL



HIGH CHANNEL



A.3 20 dB and 99% bandwidth

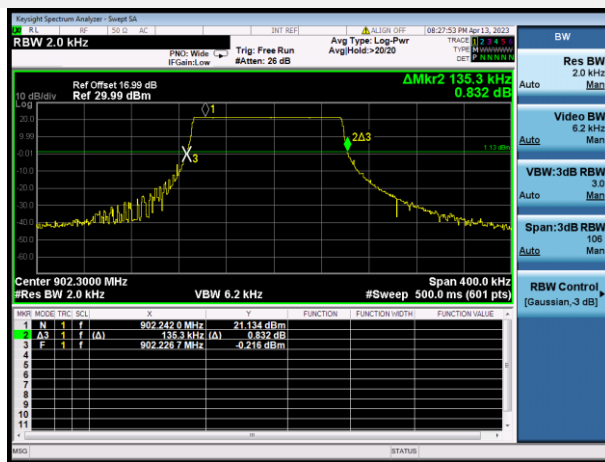
Test Data

LoRa			
Channel	20 dB Bandwidth (MHz)	99% Bandwidth (MHz)	Verdict
Low	0.135300	0.125240	Pass
Middle	0.135300	0.125340	Pass
High	0.135300	0.125350	Pass

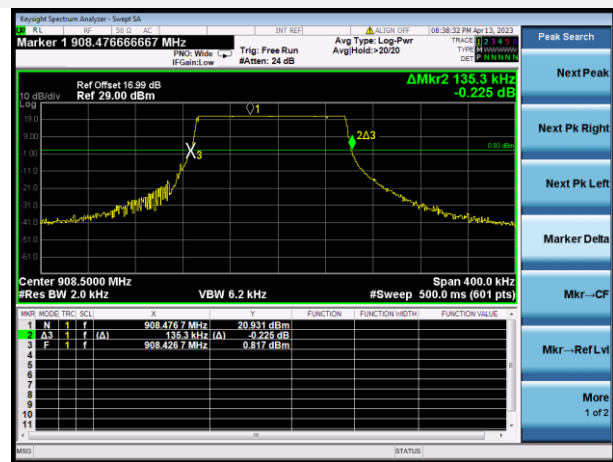
Test Plots

20 dB Bandwidth

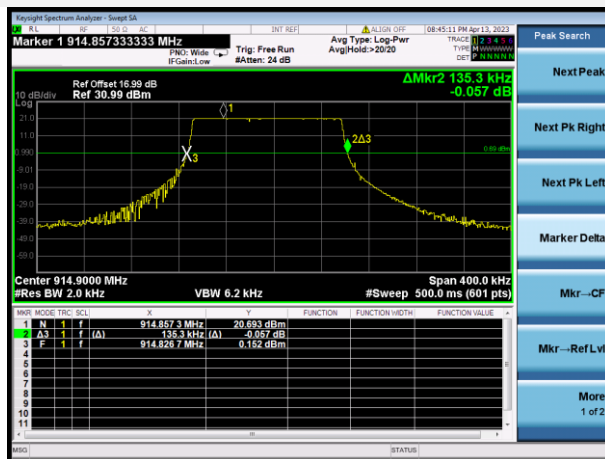
LOW CHANNEL



MIDDLE CHANNEL

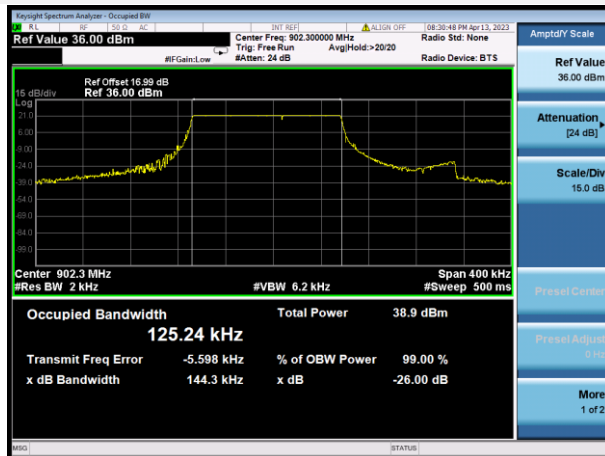


HIGH CHANNEL

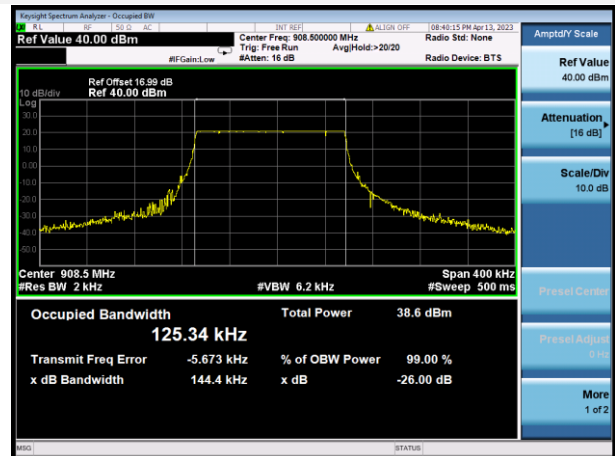


99% Bandwidth

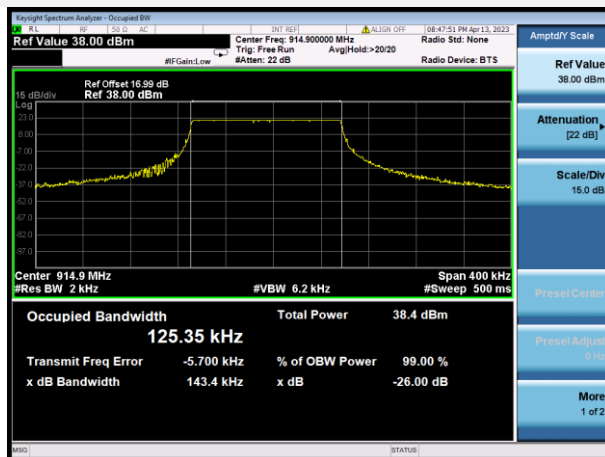
LOW CHANNEL



MIDDLE CHANNEL



HIGH CHANNEL



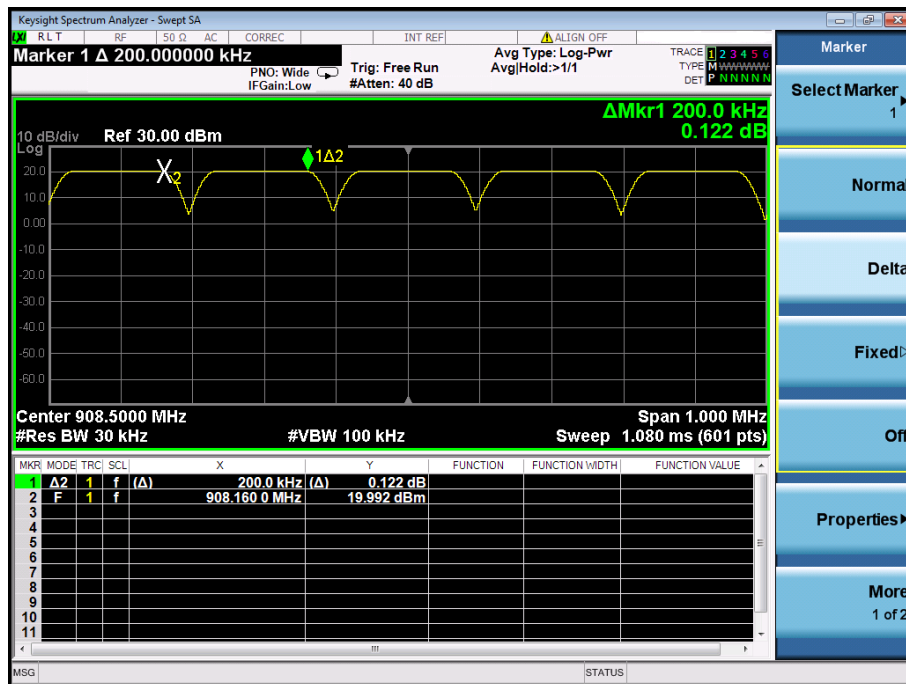
A.4 Hopping Frequency Separation

Test Data

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

Test Plots

LoRa

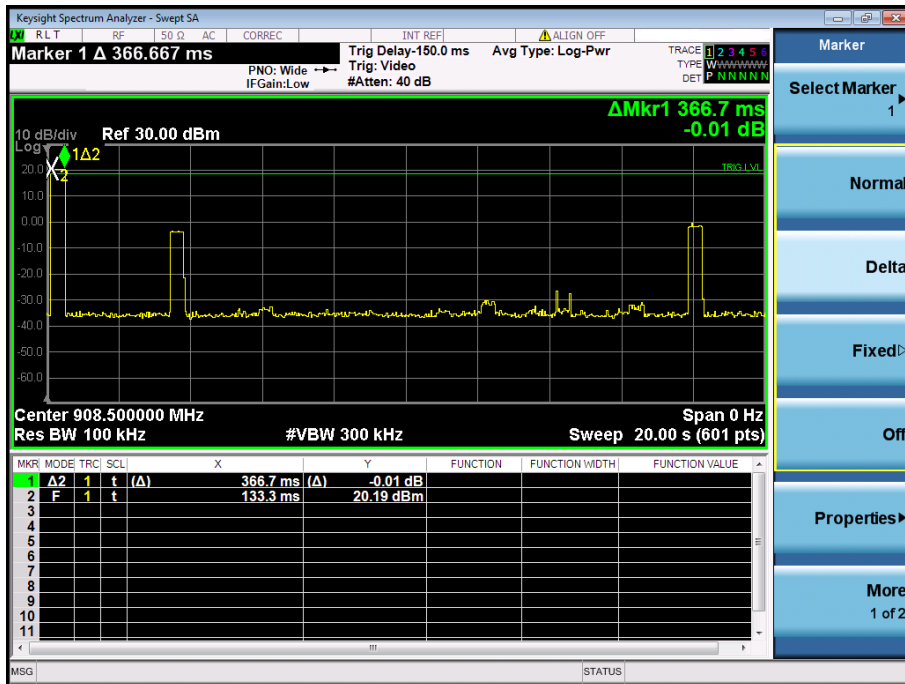


A.5 Average Time of Occupancy

Test Data

LoRa		
Total of Dwell (ms)	Limit (sec)	Verdict
366.7	0.4	Pass

LoRa



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

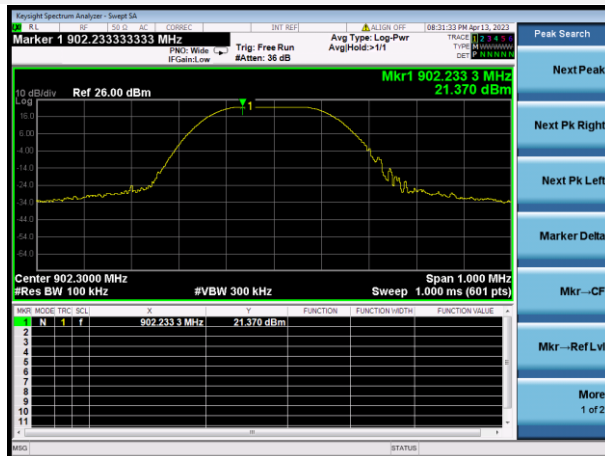
Test Data

LoRa				
Channel	Measured Max. Out of Band Emission (dBm)	Limit (dBm)		Verdict
		Carrier Level	Calculated 20 dBc Limit	
Low	-18.18	21.37	1.37	Pass
Middle	-17.84	21.16	1.16	Pass
High	-18.22	20.95	0.95	Pass

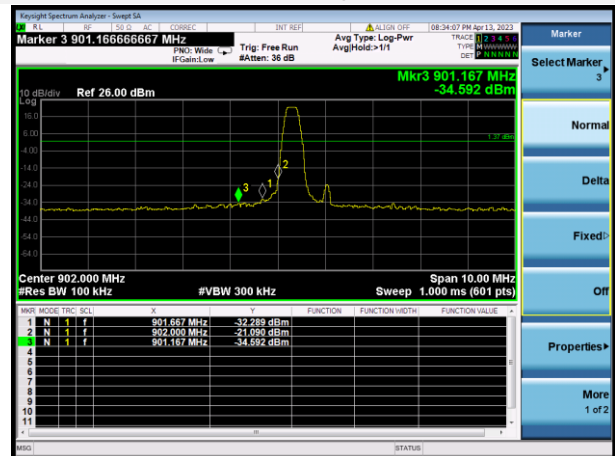
LoRa				
Mode	Measured Max. Out of Band Emission (dBm)	Limit (dBm)		Verdict
		Carrier Level	Calculated 20 dBc Limit	
Hopping	-15.35	20.45	0.45	Pass

Test Plots

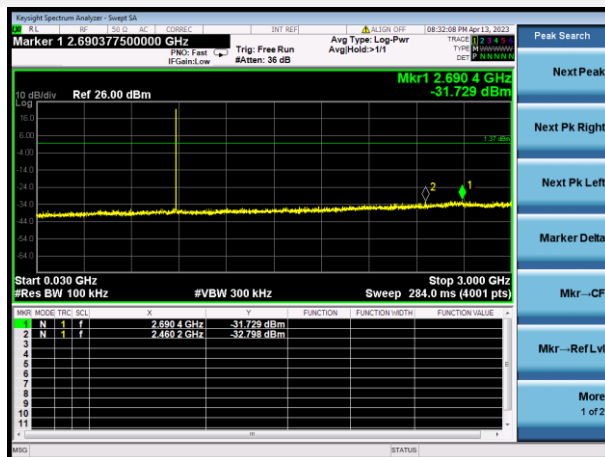
LOW CHANNEL, CARRIER LEVEL



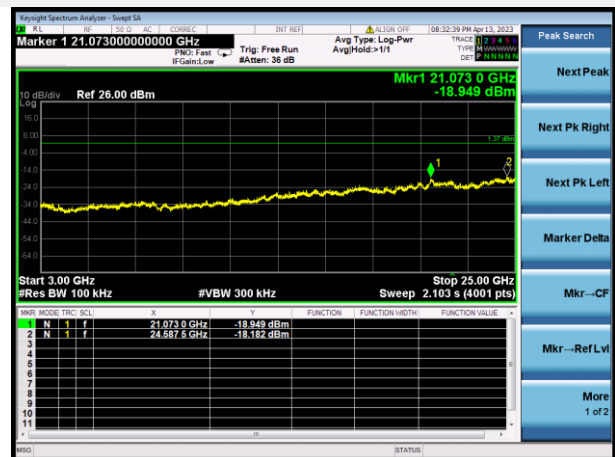
LOW CHANNEL, Band Edge



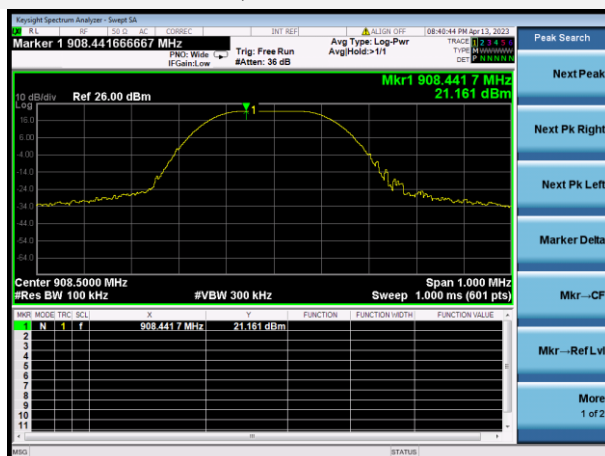
LOW CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



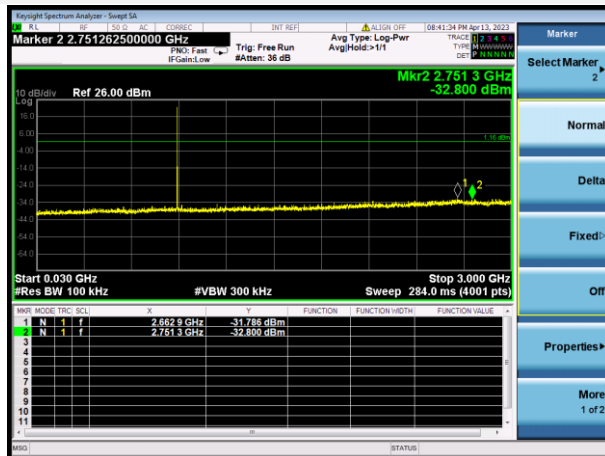
LOW CHANNEL, SPURIOUS 3 GHz ~ 25 GHz



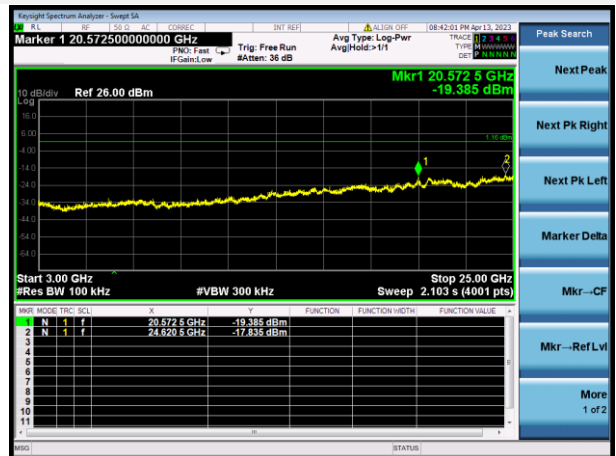
MIDDLE CHANNEL, CARRIER LEVEL



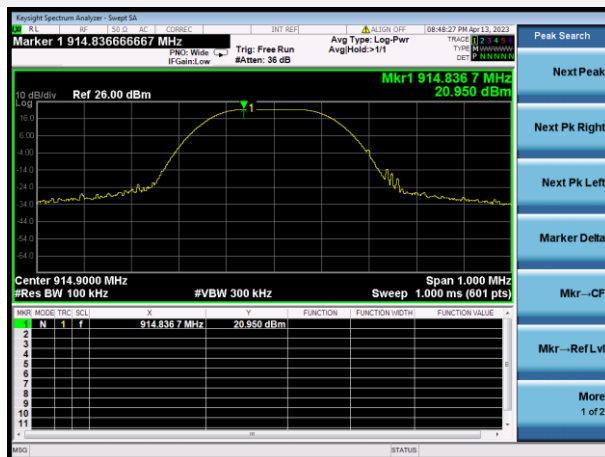
MIDDLE CHANNEL , SPURIOUS 30 MHz ~ 3 GHz



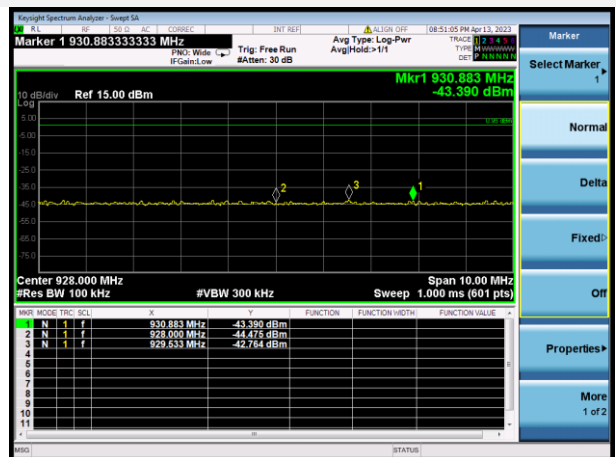
MIDDLE CHANNEL , SPURIOUS 3 GHz ~ 25 GHz



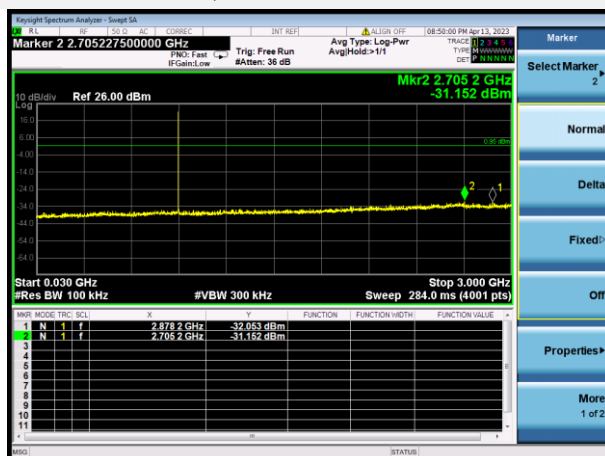
HIGH CHANNEL, CARRIER LEVEL



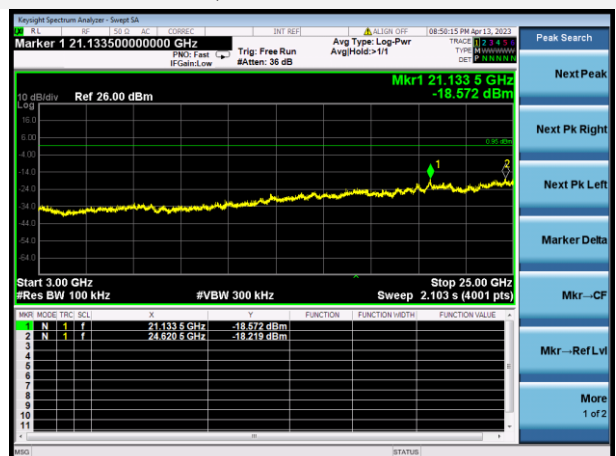
HIGH CHANNEL , BAND EDGE



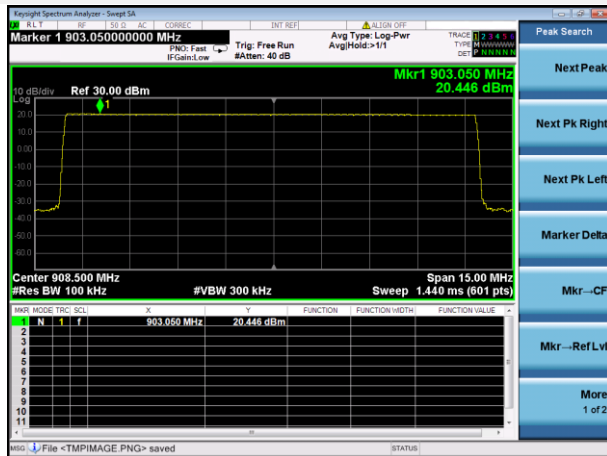
HIGH CHANNEL , SPURIOUS 30 MHz ~ 3 GHz



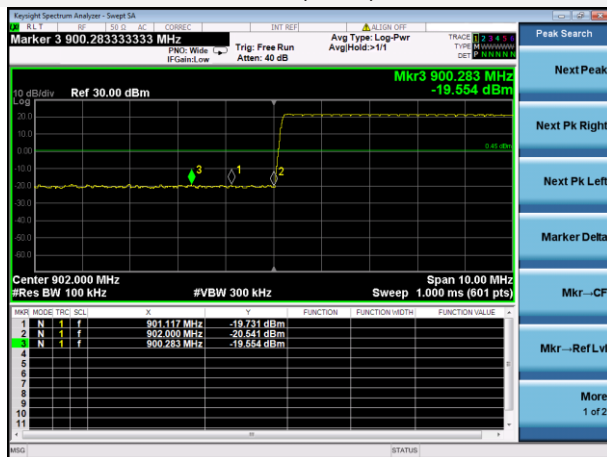
HIGH CHANNEL , SPURIOUS 3 GHz ~ 25 GHz



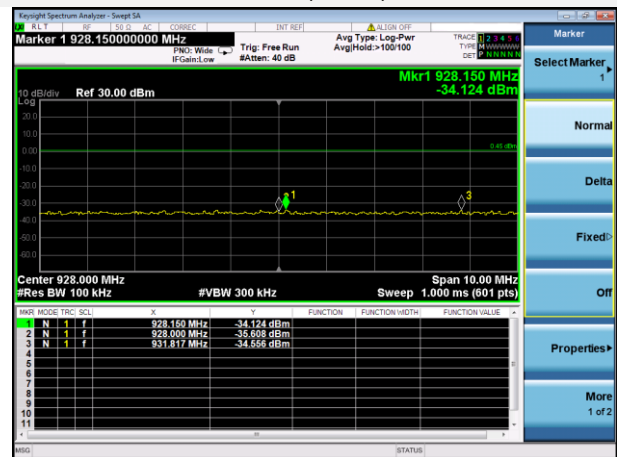
HOPPING, CARRIER LEVEL



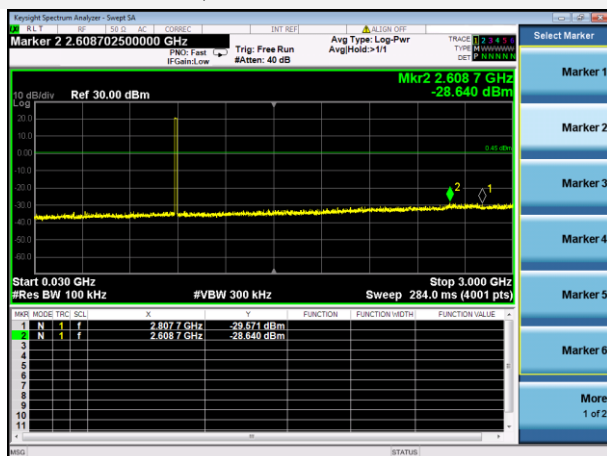
HOPPING BAND EDGE (LOW)



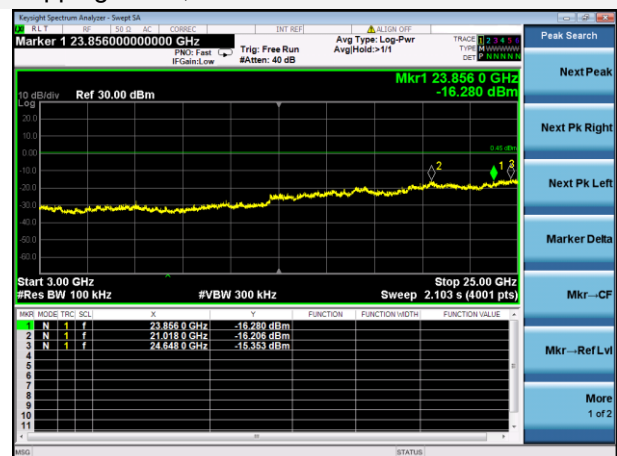
HOPPING BAND EDGE (HIGH)



HOPPING Mode, SPURIOUS 30 MHz ~ 3 GHz



Hopping Mode, SPURIOUS 3 GHz ~ 25 GHz



A.7 Conducted Emissions

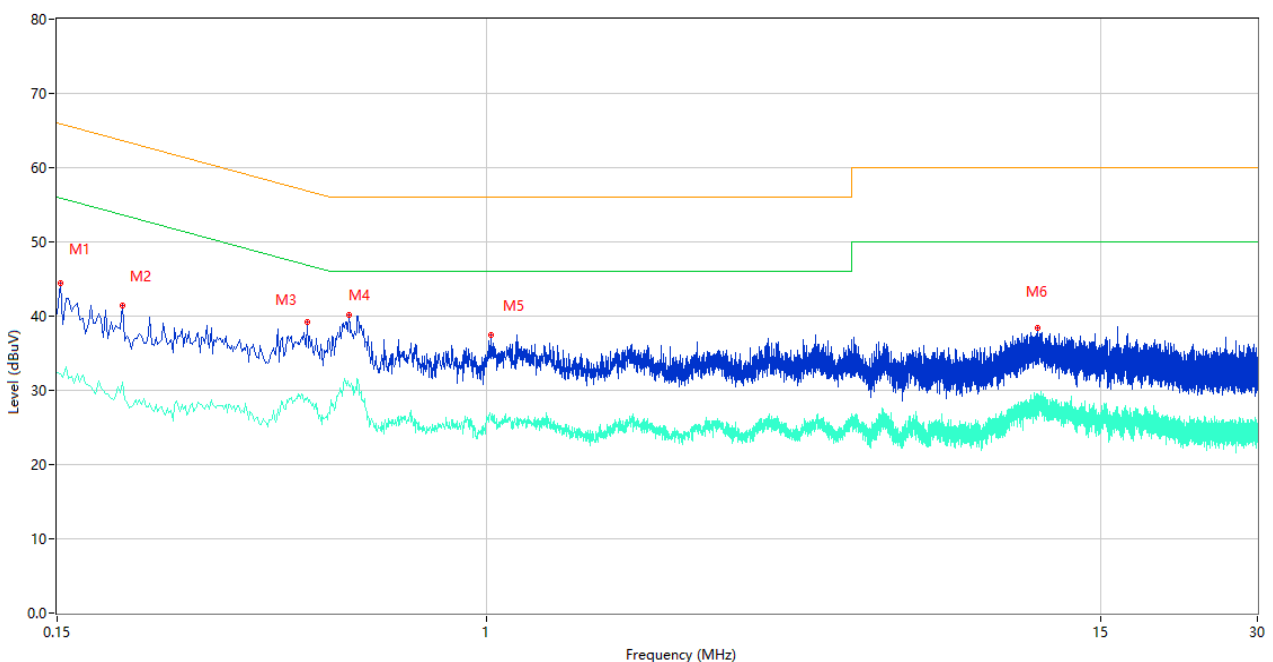
Note ¹: The EUT is working in the Normal link mode. All modes have been tested and normal link mode is worst.

Note ²: 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)

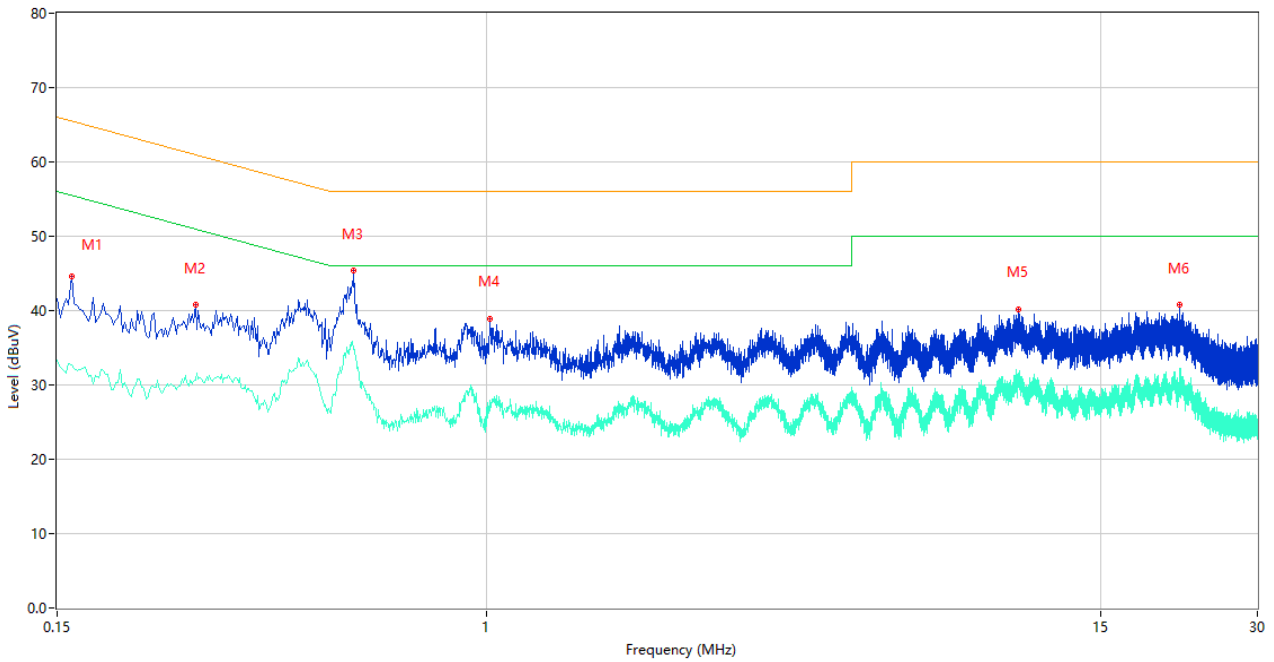
Test Data and Plots

PHASE L



No.	Frequency (MHz)	Results (dBuV)	Factor (dB)	Limit (dBuV)	Margin (dB)	Detector	Line	Verdict
1	0.152	44.48	10.09	65.89	21.41	Peak	L	Pass
1**	0.152	32.22	10.09	55.89	23.67	AV	L	Pass
2	0.200	41.38	10.05	63.61	22.23	Peak	L	Pass
2**	0.200	31.04	10.05	53.61	22.57	AV	L	Pass
3	0.452	39.17	10.22	56.84	17.67	Peak	L	Pass
3**	0.452	29.08	10.22	46.84	17.76	AV	L	Pass
4	0.544	40.08	10.21	56.00	15.92	Peak	L	Pass
4**	0.544	30.71	10.21	46.00	15.29	AV	L	Pass
5	1.016	37.41	10.15	56.00	18.59	Peak	L	Pass
5**	1.016	26.35	10.15	46.00	19.65	AV	L	Pass
6	11.358	38.35	10.26	60.00	21.65	Peak	L	Pass
6**	11.358	28.33	10.26	50.00	21.67	AV	L	Pass

PHASE N



No.	Frequency (MHz)	Results (dBuV)	Factor (dB)	Limit (dBuV)	Margin (dB)	Detector	Line	Verdict
1	0.160	44.59	10.08	65.46	20.87	Peak	N	Pass
1**	0.160	32.66	10.08	55.46	22.80	AV	N	Pass
2	0.276	40.72	10.00	60.94	20.22	Peak	N	Pass
2**	0.276	30.69	10.00	50.94	20.25	AV	N	Pass
3	0.556	45.36	10.23	56.00	10.64	Peak	N	Pass
3**	0.556	35.18	10.23	46.00	10.82	AV	N	Pass
4	1.012	38.92	10.13	56.00	17.08	Peak	N	Pass
4**	1.012	26.51	10.13	46.00	19.49	AV	N	Pass
5	10.424	40.17	10.43	60.00	19.83	Peak	N	Pass
5**	10.424	30.84	10.43	50.00	19.16	AV	N	Pass
6	21.302	40.76	10.68	60.00	19.24	Peak	N	Pass
6**	21.302	32.18	10.68	50.00	17.82	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.

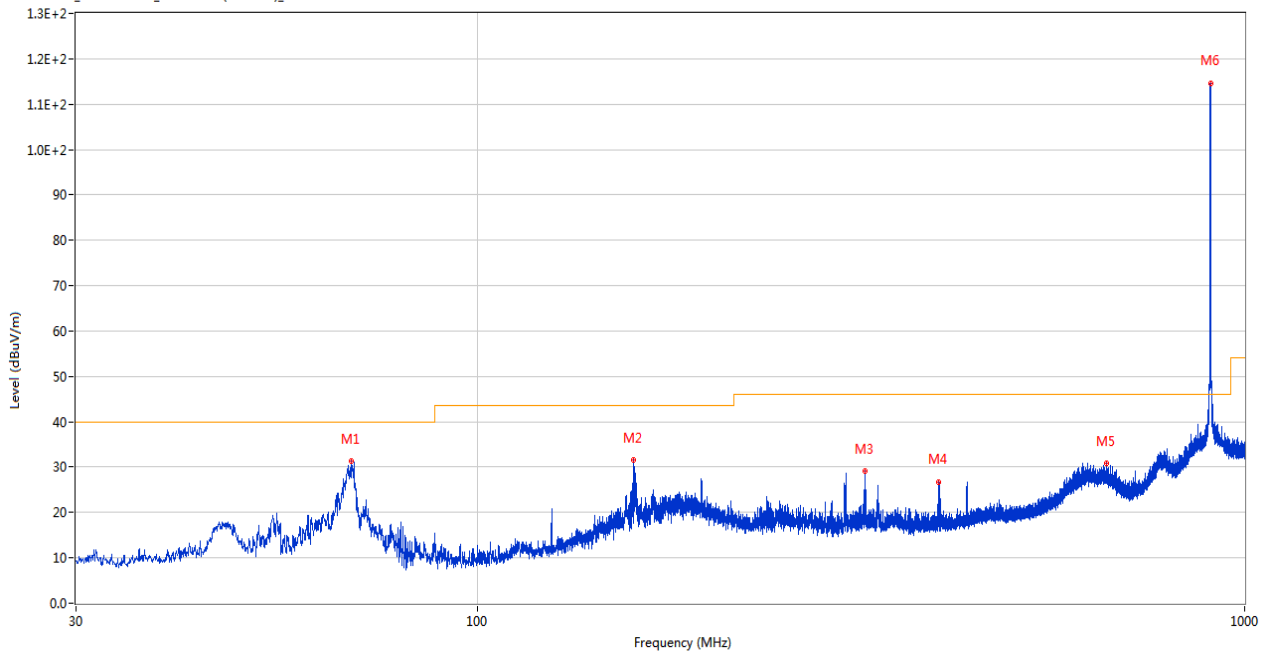
Note ³: The low frequency, which started from 9 kHz to 30 MHz, was pre-scanned and the result which was 20 dB lower than the limit line per 15.31(o) was not reported.

Note ⁴: The worst configurations is below 1 GHz, only the worst configuration (Low Channel) shown here.

Test Data and Plots

30 MHz to 1 GHz, ANT H

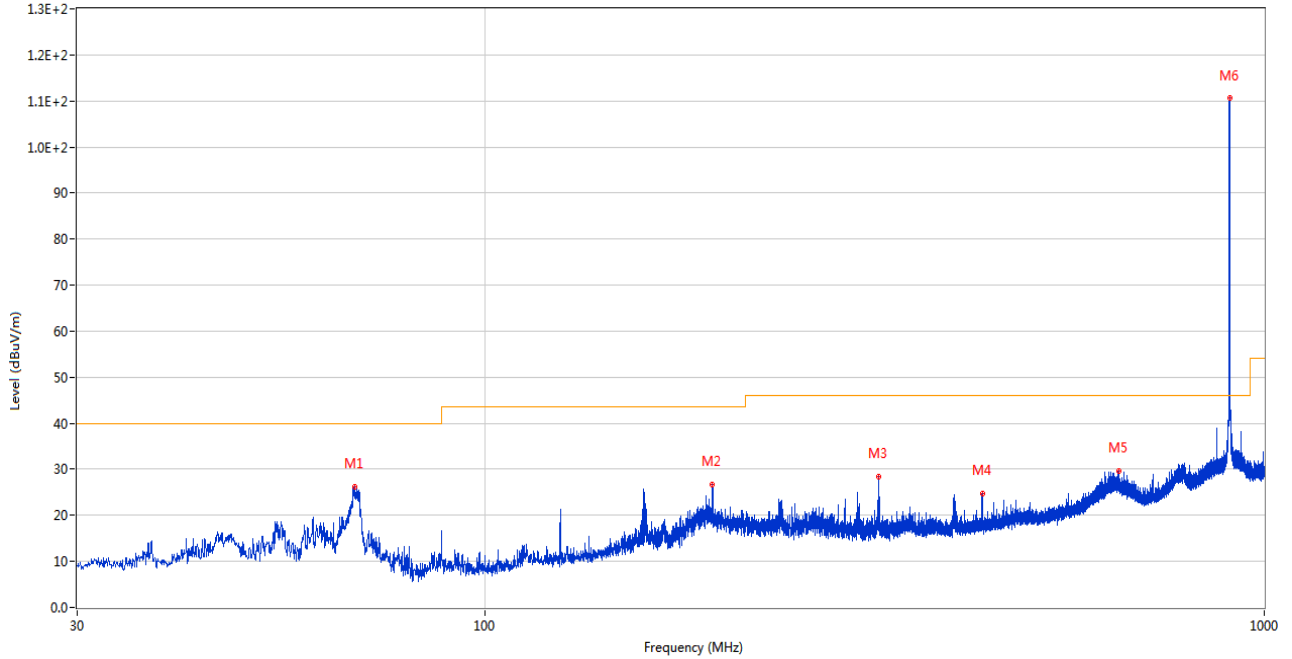
RE Test case_FCC Part 15C_FCC 15.231(433MHz)_30MHz-1GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	68.606	31.29	-28.14	40.0	8.71	Peak	131.00	200	Horizontal	Pass
2	160.028	31.46	-24.32	43.5	12.04	Peak	316.00	100	Horizontal	Pass
3	320.030	29.12	-22.92	46.0	16.88	Peak	198.00	200	Horizontal	Pass
4	399.425	26.72	-21.21	46.0	19.28	Peak	192.00	200	Horizontal	Pass
5	659.773	30.83	-13.30	46.0	15.17	Peak	20.00	100	Horizontal	Pass
6	902.321	114.61	-7.59	46.0	-68.61	Peak	69.00	200	Horizontal	N/A

30 MHz to 1 GHz, ANT V

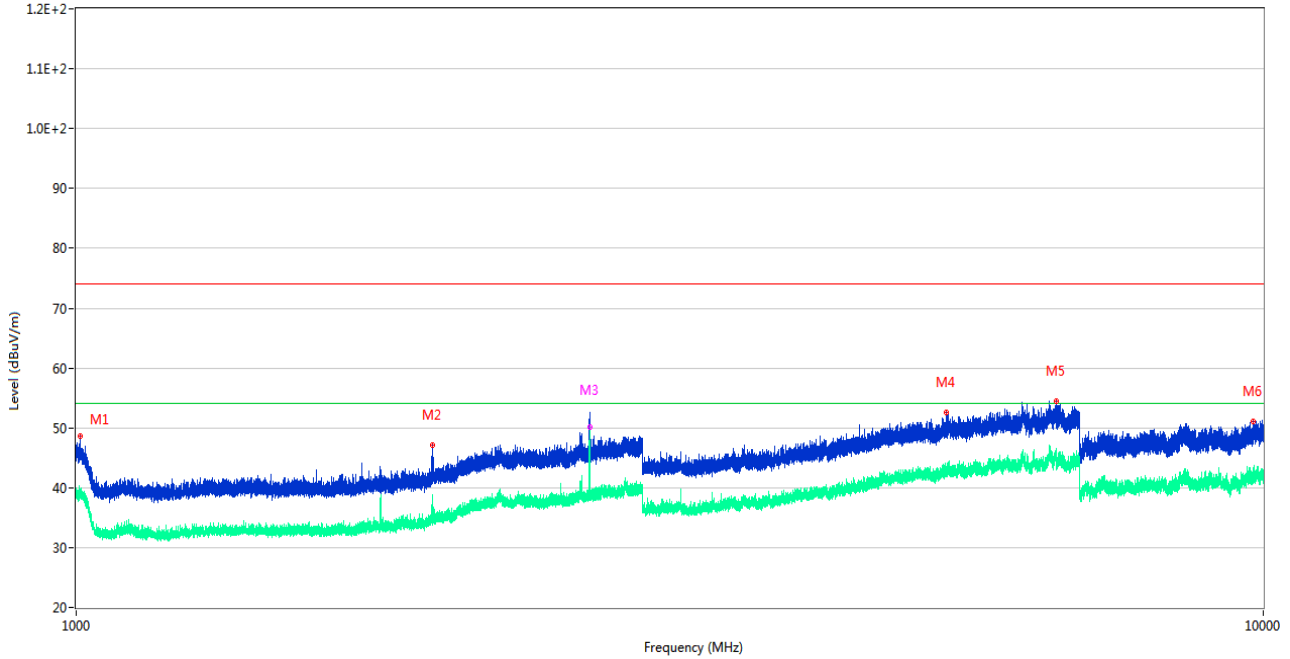
RE Test case_FCC Part 15C_FCC 15.231(433MHz)_30MHz-1GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	68.170	26.23	-28.05	40.0	13.77	Peak	210.00	100	Vertical	Pass
2	196.016	26.73	-27.83	43.5	16.77	Peak	300.00	200	Vertical	Pass
3	320.030	28.49	-22.92	46.0	17.51	Peak	38.00	200	Vertical	Pass
4	434.587	24.81	-19.87	46.0	21.19	Peak	164.00	100	Vertical	Pass
5	650.315	29.70	-13.15	46.0	16.30	Peak	111.00	200	Vertical	Pass
6	902.370	110.56	-7.58	46.0	-64.56	Peak	277.00	200	Vertical	N/A

LOW CHANNEL 1 GHz to 10 GHz, ANT H

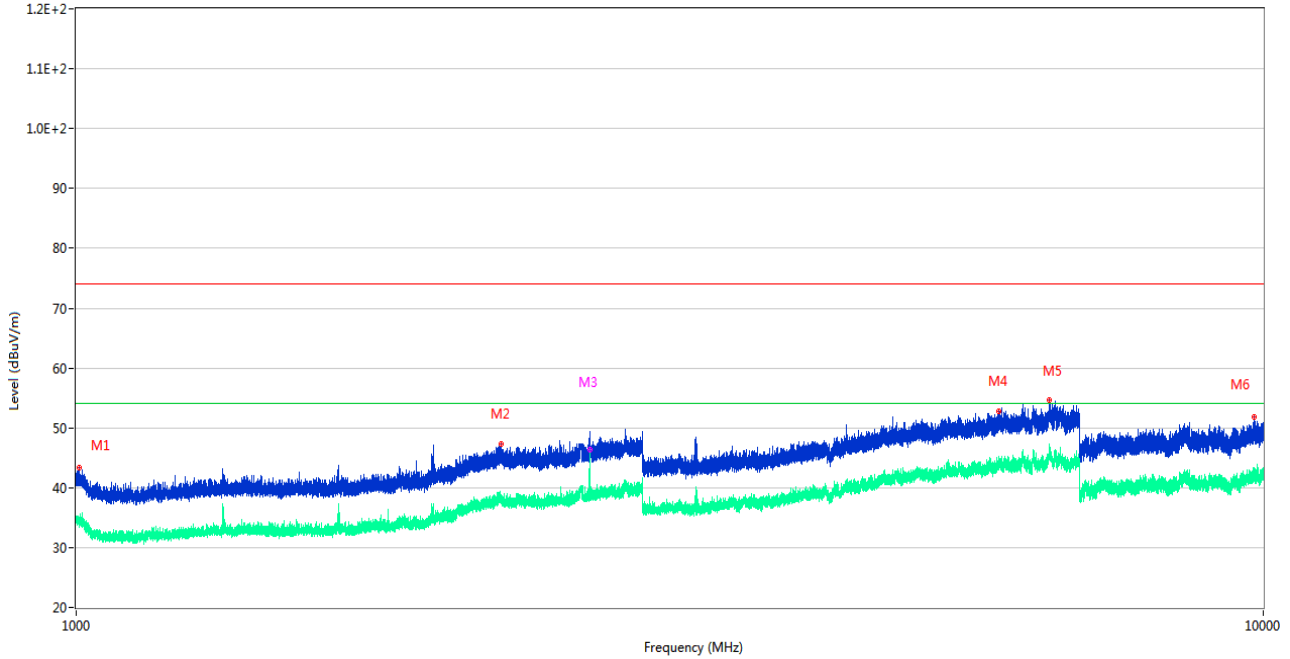
RE Test case_FCC Part 15C_FCC 15.249_1GHz-10GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1008.500	48.65	-12.98	74.0	25.35	Peak	28.00	400	Horizontal	Pass
1**	1008.500	39.21	-12.98	54.0	14.79	AV	28.00	400	Horizontal	Pass
2	1996.500	47.20	-11.92	74.0	26.80	Peak	82.00	300	Horizontal	Pass
2**	1996.500	36.03	-11.92	54.0	17.97	AV	82.00	300	Horizontal	Pass
3	2706.900	52.64	-7.22	74.0	21.36	Peak	360.00	100	Horizontal	Pass
3**	2706.900	50.22	-7.22	54.0	3.78	AV	360.00	100	Horizontal	Pass
4	5406.200	52.61	-2.11	74.0	21.39	Peak	303.00	300	Horizontal	Pass
4**	5406.200	43.25	-2.11	54.0	10.75	AV	303.00	300	Horizontal	Pass
5	6689.000	54.54	-0.18	74.0	19.46	Peak	272.00	100	Horizontal	Pass
5**	6689.000	44.97	-0.18	54.0	9.03	AV	272.00	100	Horizontal	Pass
6	9814.300	51.13	-0.03	74.0	22.87	Peak	151.00	300	Horizontal	Pass
6**	9814.300	42.73	-0.03	54.0	11.27	AV	151.00	300	Horizontal	Pass

LOW CHANNEL 1 GHz to 10 GHz, ANT V

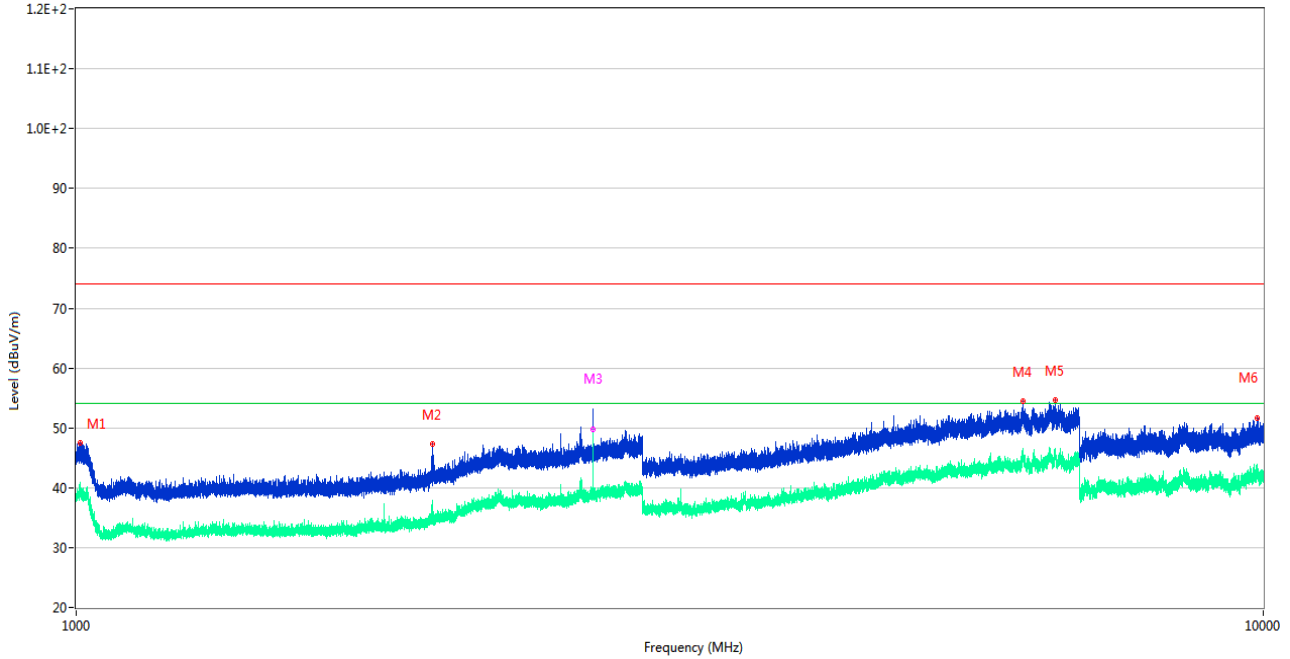
RE Test case_FCC Part 15C_FCC 15.249_1GHz-10GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1005.200	43.44	-12.86	74.0	30.56	Peak	14.00	400	Vertical	Pass
1**	1005.200	34.07	-12.86	54.0	19.93	AV	14.00	400	Vertical	Pass
2	2280.900	47.34	-8.18	74.0	26.66	Peak	193.00	100	Vertical	Pass
2**	2280.900	37.45	-8.18	54.0	16.55	AV	193.00	100	Vertical	Pass
3	2707.000	49.44	-7.21	74.0	24.56	Peak	355.00	100	Vertical	Pass
3**	2707.000	46.44	-7.21	54.0	7.56	AV	355.00	100	Vertical	Pass
4	5987.200	52.83	-1.11	74.0	21.17	Peak	64.00	300	Vertical	Pass
4**	5987.200	43.79	-1.11	54.0	10.21	AV	64.00	300	Vertical	Pass
5	6606.400	54.62	1.42	74.0	19.38	Peak	240.00	100	Vertical	Pass
5**	6606.400	45.46	1.42	54.0	8.54	AV	240.00	100	Vertical	Pass
6	9820.151	51.85	0.03	74.0	22.15	Peak	76.00	400	Vertical	Pass
6**	9820.151	42.24	0.03	54.0	11.76	AV	76.00	400	Vertical	Pass

MIDDLE CHANNEL 1 GHz to 10 GHz, ANT H

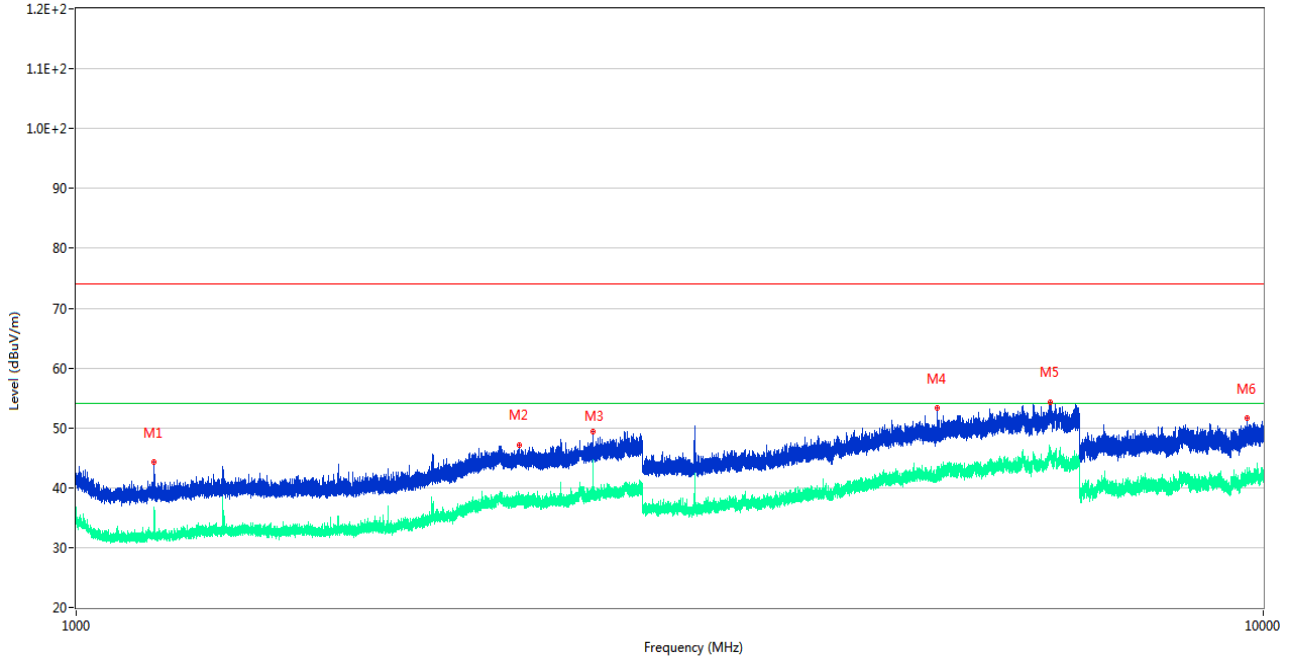
RE Test case_FCC Part 15C_FCC 15.249_1GHz-10GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1007.800	47.44	-13.01	74.0	26.56	Peak	10.00	400	Horizontal	Pass
1**	1007.800	40.96	-13.01	54.0	13.04	AV	10.00	400	Horizontal	Pass
2	1995.800	47.24	-11.94	74.0	26.76	Peak	80.00	100	Horizontal	Pass
2**	1995.800	34.56	-11.94	54.0	19.44	AV	80.00	100	Horizontal	Pass
3	2725.400	51.75	-6.68	74.0	22.25	Peak	87.00	100	Horizontal	Pass
3**	2725.400	49.80	-6.68	54.0	4.20	AV	87.00	100	Horizontal	Pass
4	6272.400	54.46	0.56	74.0	19.54	Peak	70.00	100	Horizontal	Pass
4**	6272.400	46.17	0.56	54.0	7.83	AV	70.00	100	Horizontal	Pass
5	6677.600	54.57	0.28	74.0	19.43	Peak	31.00	400	Horizontal	Pass
5**	6677.600	45.15	0.28	54.0	8.85	AV	31.00	400	Horizontal	Pass
6	9876.250	51.55	-0.86	74.0	22.45	Peak	47.00	100	Horizontal	Pass
6**	9876.250	42.10	-0.86	54.0	11.90	AV	47.00	100	Horizontal	Pass

MIDDLE CHANNEL 1 GHz to 10 GHz, ANT V

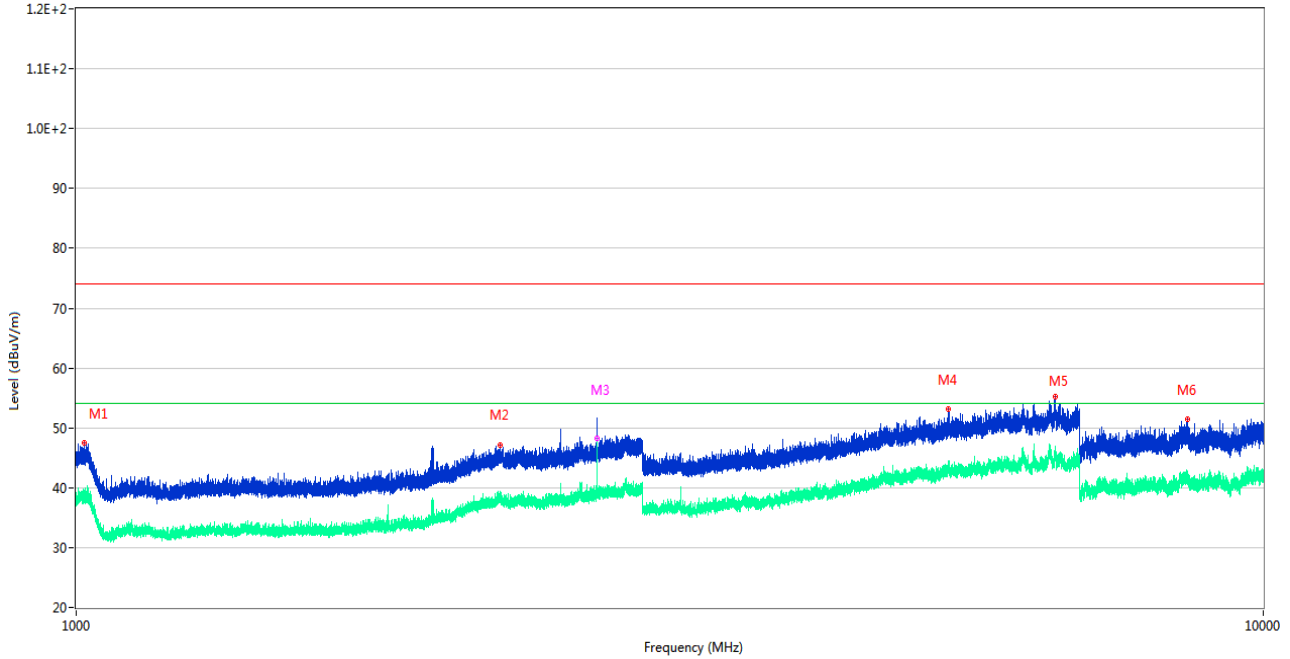
RE Test case_FCC Part 15C_FCC 15.249_1GHz-10GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1162.100	44.28	-13.92	74.0	29.72	Peak	14.00	200	Vertical	Pass
1**	1162.100	32.39	-13.92	54.0	21.61	AV	14.00	200	Vertical	Pass
2	2362.700	47.19	-8.32	74.0	26.81	Peak	0.00	200	Vertical	Pass
2**	2362.700	37.79	-8.32	54.0	16.21	AV	0.00	200	Vertical	Pass
3	2725.800	49.37	-6.72	74.0	24.63	Peak	9.00	100	Vertical	Pass
3**	2725.800	44.23	-6.72	54.0	9.77	AV	9.00	100	Vertical	Pass
4	5317.000	57.30	-2.54	74.0	16.70	Peak	27.00	400	Vertical	Pass
4**	5317.000	41.79	-2.54	54.0	12.21	AV	27.00	400	Vertical	Pass
5	6616.000	54.30	0.84	74.0	19.70	Peak	102.00	200	Vertical	Pass
5**	6616.000	45.64	0.84	54.0	8.36	AV	102.00	200	Vertical	Pass
6	9699.849	51.63	0.01	74.0	22.37	Peak	108.00	200	Vertical	Pass
6**	9699.849	41.99	0.01	54.0	12.01	AV	108.00	200	Vertical	Pass

HIGH CHANNEL 1 GHz to 10 GHz, ANT H

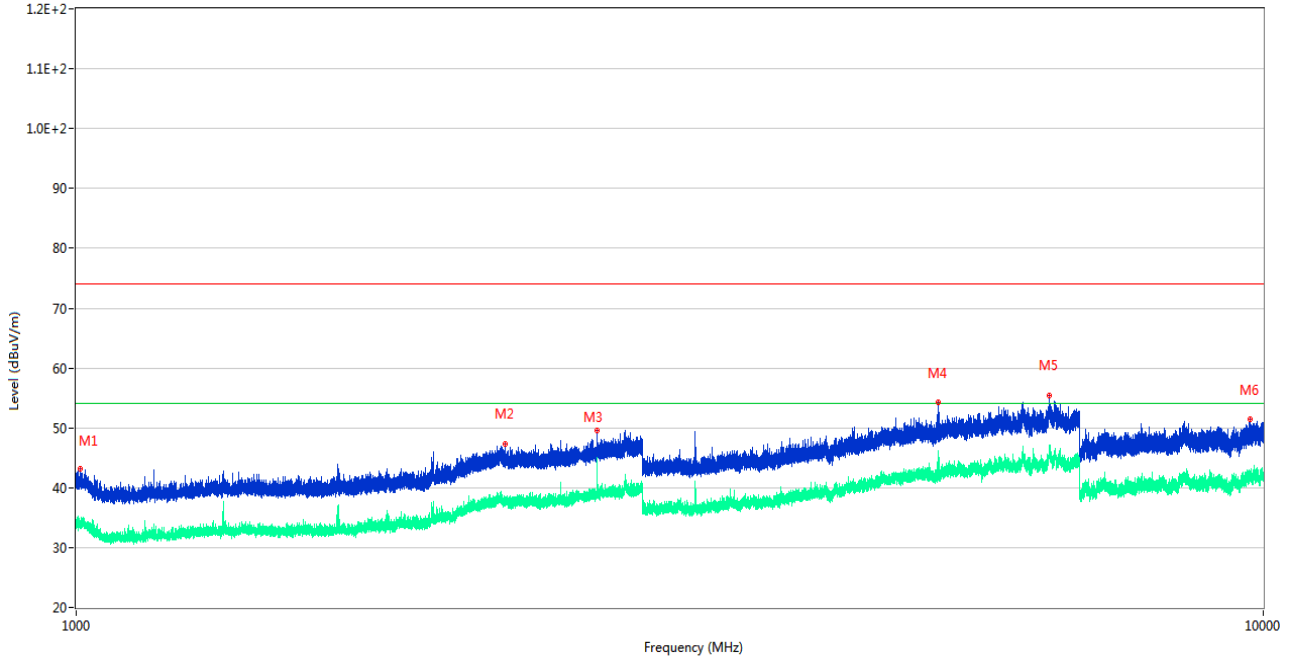
RE Test case_FCC Part 15C_FCC 15.249_1GHz-10GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1016.700	47.58	-13.19	74.0	26.42	Peak	10.00	400	Horizontal	Pass
1**	1016.700	39.04	-13.19	54.0	14.96	AV	10.00	400	Horizontal	Pass
2	2274.400	47.16	-7.33	74.0	26.84	Peak	73.00	200	Horizontal	Pass
2**	2274.400	38.12	-7.33	54.0	15.88	AV	73.00	200	Horizontal	Pass
3	2744.900	51.16	-6.86	74.0	22.84	Peak	328.00	100	Horizontal	Pass
3**	2744.900	48.34	-6.86	54.0	5.66	AV	328.00	100	Horizontal	Pass
4	5433.400	53.09	-1.57	74.0	20.91	Peak	167.00	100	Horizontal	Pass
4**	5433.400	43.52	-1.57	54.0	10.48	AV	167.00	100	Horizontal	Pass
5	6677.400	55.28	0.29	74.0	18.72	Peak	294.00	100	Horizontal	Pass
5**	6677.400	45.74	0.29	54.0	8.26	AV	294.00	100	Horizontal	Pass
6	8631.400	51.43	-1.88	74.0	22.57	Peak	310.00	300	Horizontal	Pass
6**	8631.400	42.49	-1.88	54.0	11.51	AV	310.00	300	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	1007.300	43.23	-13.01	74.0	30.77	Peak	62.00	100	Vertical	Pass
1**	1007.300	33.78	-13.01	54.0	20.22	AV	62.00	100	Vertical	Pass
2	2299.700	47.40	-8.59	74.0	26.60	Peak	136.00	300	Vertical	Pass
2**	2299.700	37.34	-8.59	54.0	16.66	AV	136.00	300	Vertical	Pass
3	2744.300	49.48	-6.93	74.0	24.52	Peak	4.00	100	Vertical	Pass
3**	2744.300	43.83	-6.93	54.0	10.17	AV	4.00	100	Vertical	Pass
4	5320.400	54.20	-2.80	74.0	19.80	Peak	42.00	300	Vertical	Pass
4**	5320.400	42.43	-2.80	54.0	11.57	AV	42.00	300	Vertical	Pass
5	6608.800	55.42	1.60	74.0	18.58	Peak	360.00	200	Vertical	Pass
5**	6608.800	45.35	1.60	54.0	8.65	AV	360.00	200	Vertical	Pass
6	9752.800	51.40	-0.41	74.0	22.60	Peak	200.00	400	Vertical	Pass
6**	9752.800	41.99	-0.41	54.0	12.01	AV	200.00	400	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.

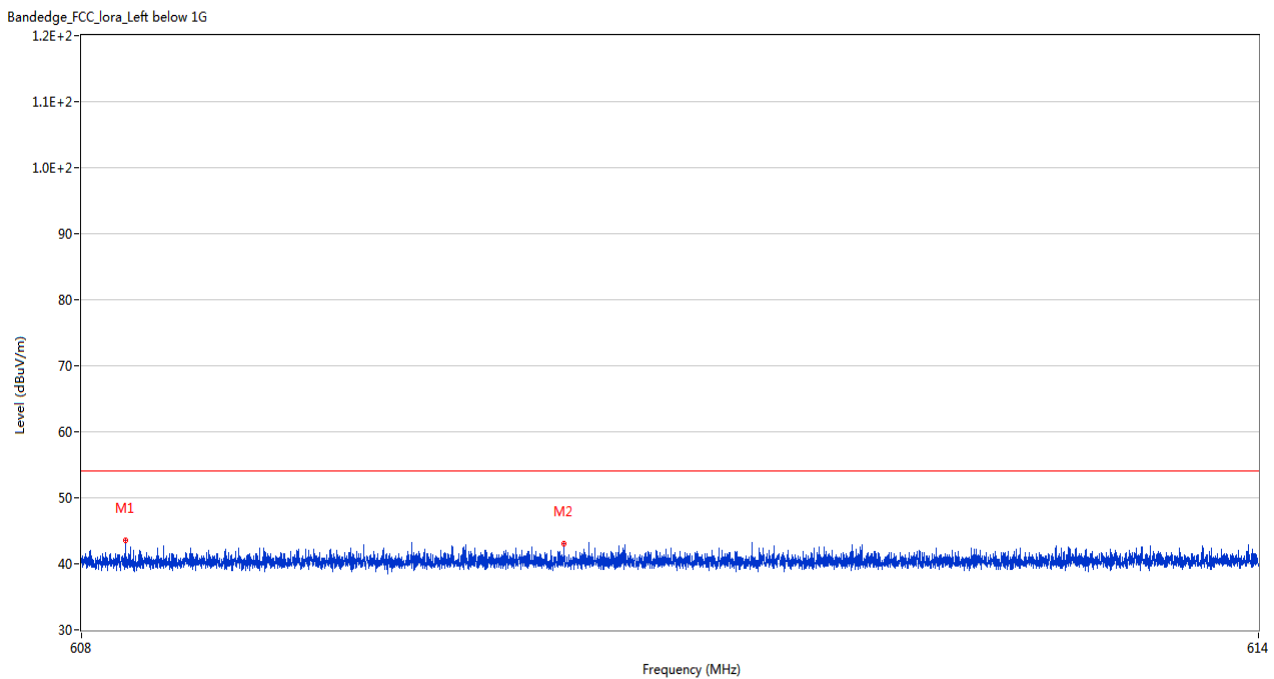
Note ²: The test data all are tested in the vertical and horizontal antenna which the trace is max hold. So these plots have shown the worst case.

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

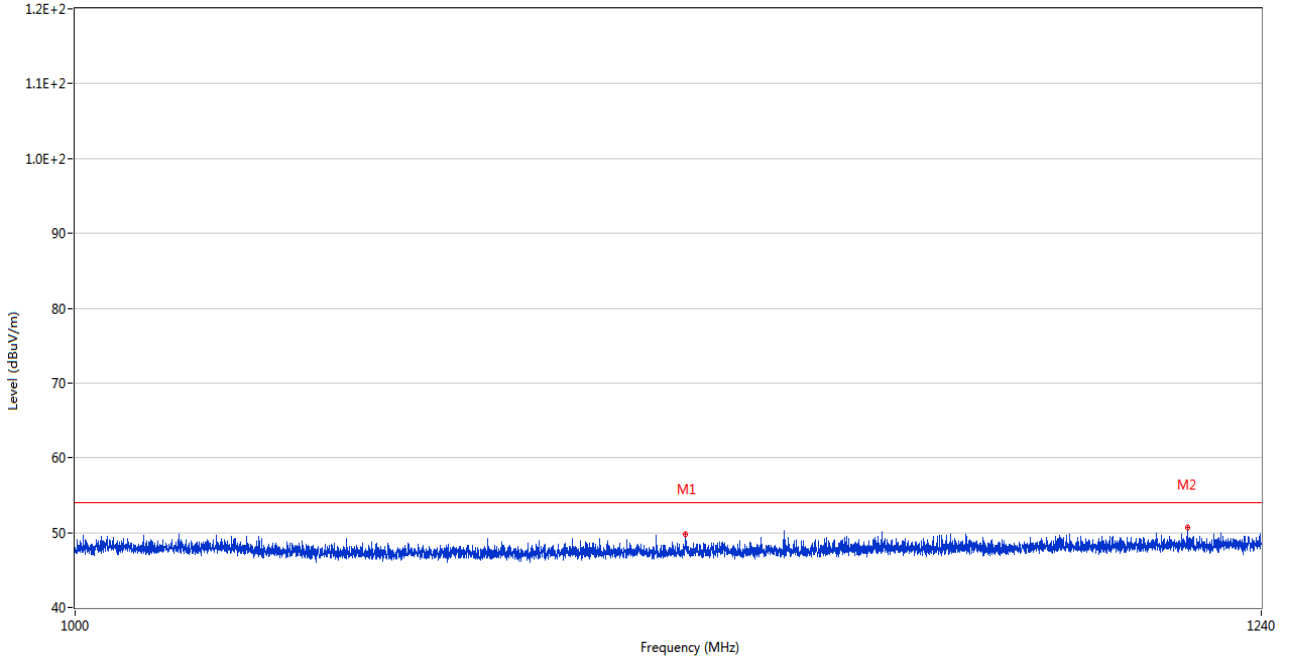
LOW CHANNEL



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	608.223	43.51	2.99	54.0	10.49	Peak	259.00	100	Horizontal	Pass
2	610.451	43.00	3.09	54.0	11.00	Peak	75.00	100	Horizontal	Pass

HIGH CHANNEL

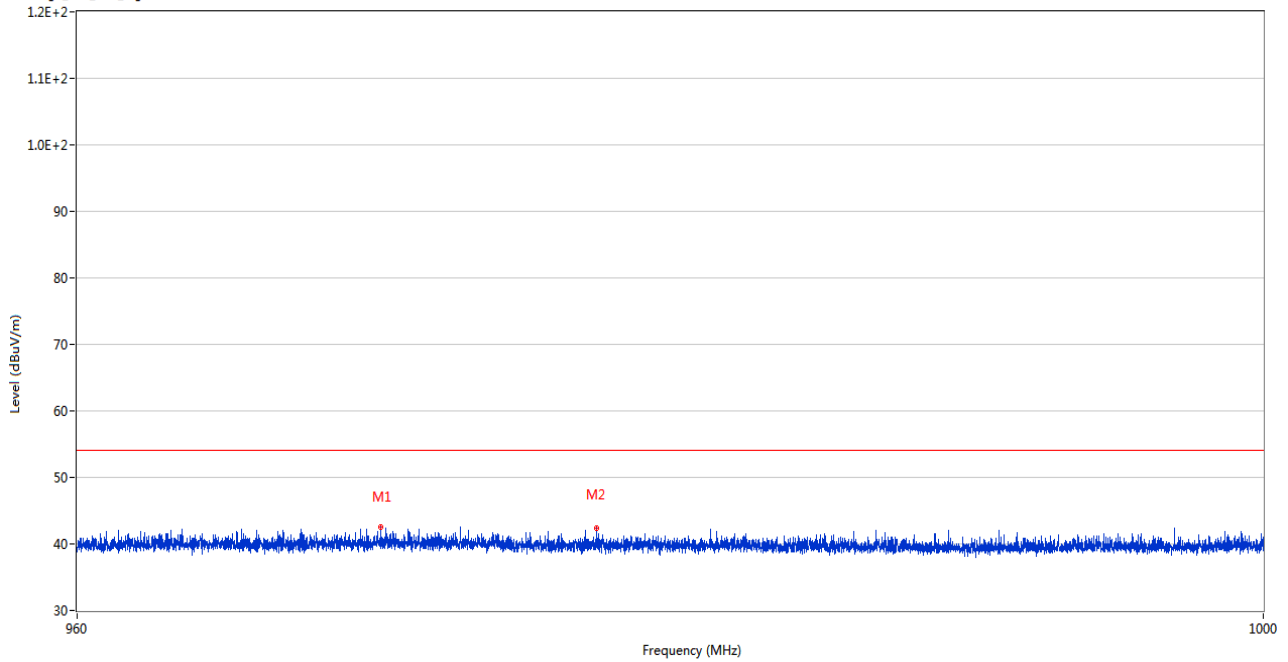
Bandedge_FCC_lora_Right above 1G



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1116.960	49.72	-6.42	54.0	4.28	Peak	141.00	100	Horizontal	Pass
2	1223.560	50.70	-5.82	54.0	3.30	Peak	311.00	100	Horizontal	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	970.100	42.63	-3.34	54.0	11.37	Peak	114.00	200	Horizontal	Pass
2	977.307	42.35	-3.46	54.0	11.65	Peak	125.00	100	Horizontal	Pass

ANNEX B TEST SETUP PHOTOS

Please refer the document “BL-SZ2340268-AR.PDF”.

ANNEX C EUT EXTERNAL PHOTOS

Please refer the document “BL-SZ2340268-AW.PDF”.

ANNEX D EUT INTERNAL PHOTOS

Please refer the document “BL-SZ2340268-AI.PDF”.

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--END OF REPORT--