

TEST REPORT

Applicant: SHENZHEN 8BITDO TECH CO., LTD.
Address: Room 210, Building 1, Nanhai Ecool, No.6 Xinghua Road, Shekou, Nanshan District, Shenzhen, China
Equipment Type: 8BitDo Ultimate 3-mode Controller for Xbox
Model Name: 81HB
Brand Name: 8BITDO
FCC ID: 2AOWF-ULT3MX
ISED Number: 29401-ULT3MX
Test Standard: 47 CFR Part 15 Subpart C
RSS-Gen Issue 5
RSS-247 Issue 3
(refer to section 3.1)
Sample Arrival Date: Mar. 06, 2024
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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 30, 2024</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	☒ 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. The laboratory has been listed by Industry Canada to perform electromagnetic emission measurements. The recognition numbers of test site are 11524A.

2 PRODUCT INFORMATION

2.1 Applicant Information

Applicant	SHENZHEN 8BITDO TECH CO., LTD.
Address	Room 210, Building 1, Nanhai Ecool, No.6 Xinghua Road, Shekou, Nanshan District, Shenzhen, China

2.2 Manufacturer Information

Manufacturer	SHENZHEN ONEBITDO TECH CO., LTD.
Address	Room 203, Building 1, Huajian Building, Xinghua Road, Shekou, Shuiwan Community, Zhaoshang Street, Nanshan District, Shenzhen, China

2.3 General Description for Equipment under Test (EUT)

EUT Name	8BitDo Ultimate 3-mode Controller for Xbox
Model Name Under Test	81HB
Series Model Name	N/A
Description of Model name differentiation	N/A
Serial Number	81HB01024618000127
Hardware Version	V12
Software Version	V2.2.2
Dimensions (Approx.)	N/A
Weight (Approx.)	N/A

2.4 Technical Information

Network and Wireless connectivity	Bluetooth (BLE), 2.4G ISM Band
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The requirement for the following technical information of the EUT was tested in this report:

Modulation Technology	FHSS
Modulation Type	GFSK
Product Type	☐ Mobile ☒ Portable ☐ Fix Location
Transfer Rate	1 Mbps
Frequency Range	The frequency range used is 2402 MHz – 2480 MHz; The frequency block is 2400 MHz to 2483.5 MHz.
Number of Channel	40 (at intervals of 2 MHz)
Tested Channel	Low (2402 MHz), Middle (2440 MHz), High (2480 MHz)
Antenna Type	FPC Antenna
Antenna Gain	0.18 dBi
The Max RF Output power	-0.66 dBm
Adaptive or non-adaptive	non-adaptive

All Channel List:

Channel	Frequency	Channel	Frequency	Channel	Frequency
CH0	2402 MHz	CH14	2430 MHz	CH28	2458 MHz
CH1	2404 MHz	CH15	2432 MHz	CH29	2460 MHz
CH2	2406 MHz	CH16	2434 MHz	CH30	2462 MHz
CH3	2408 MHz	CH17	2436 MHz	CH31	2464 MHz
CH4	2410 MHz	CH18	2438 MHz	CH32	2466 MHz
CH5	2412 MHz	CH19	2440 MHz	CH33	2468 MHz
CH6	2414 MHz	CH20	2442 MHz	CH34	2470 MHz
CH7	2416 MHz	CH21	2444 MHz	CH35	2472 MHz
CH8	2418 MHz	CH22	2446 MHz	CH36	2474 MHz
CH9	2420 MHz	CH23	2448 MHz	CH37	2476 MHz
CH10	2422 MHz	CH24	2450 MHz	CH38	2478 MHz
CH11	2424 MHz	CH25	2452 MHz	CH39	2480 MHz
CH12	2426 MHz	CH26	2454 MHz		
CH13	2428 MHz	CH27	2456 MHz		

Note: The modulation is GFSK with FHSS, there are total 40 channels (frequency range is 2402-2480 MHz, channel step is 2 MHz, totally 40 channels), when this part works, it will choose 40 channels, each channel band width is 1 MHz, if one channel is chosen, adjacent two channels cannot be chosen to make sure step of working channels is more than 2 MHz. the equipment select the lowest, middle and highest channel from 40 channels, Which are 2402 MHz, 2440 MHz and 2480 MHz. The more information please refer to the manufacturer's instructions.

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	RSS-Gen Issue 5	General Requirements for Compliance of Radio Apparatus
3	RSS-247 Issue 3	Digital Transmission Systems (DTSS), Frequency Hopping Systems(FHSs) and Licence-Exemp Local Area Network (LE-LAN) Devices
4	ANSI C63.10-2013	American National Standard for Testing Unlicensed Wireless Devices
5	KDB 558074 D01 15.247 Meas Guidance v05r02	Guidance for compliance measurements on digital transmission system, frequency hopping spread spectrum system, and hybrid system devices operating under section 15.247 of the FCC rules

3.2 Verdict

No.	Description	FCC Part No.	ISED Part No.	Test Result	Verdict
1	Antenna Requirement	15.203	RSS-247, 5.4 (6)	--	Pass ^{Note 1}
2	Number of Hopping Frequency	15.247(a)	RSS-247, 5.1 (4)	ANNEX A.1	Pass
3	Peak Output Power and E.I.R.P	15.247(b)	RSS-247, 5.4 (2)	ANNEX A.2	Pass
4	Occupied Bandwidth	15.247(a)	RSS-247, 5.1 (1)	ANNEX A.3	Pass
5	Hopping Frequency Separation	15.247(a)	RSS-247, 5.1 (2)	ANNEX A.4	Pass
6	Time of Occupancy (Dwell time)	15.247(a)	RSS-247, 5.1 (4)	ANNEX A.5	Pass
7	Conducted Spurious Emission& Authorized-band band-edge	15.247(d)	RSS-247, 5.5	ANNEX A.6	Pass
8	Conducted Emission	15.207	RSS-GEN, 8.8	ANNEX A.7	Pass
9	Radiated Spurious Emission	15.209 15.247(d)	RSS-247, 5.5	ANNEX A.8	Pass
10	Band Edge (Restricted-band band-edge)	15.209 15.247(d)	RSS-247, 5.5	ANNEX A.9	Pass
11	Receiver Spurious Emissions	--	RSS-Gen, 7.1.2	--	N/A ^{Note 2}

Note ¹: The EUT has a permanently and irreplaceable attached antenna, which complies with the requirement FCC 15.203.

Note ²: Only radio communication receivers operating in stand-alone mode within the band 30-960 MHz, as well as scanner receivers, are subject to Industry Canada requirements, so this test is not applicable.

4 GENERAL TEST CONFIGURATIONS

4.1 Test Environments

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

Relative Humidity	47% to 70%	
Atmospheric Pressure	100 kPa to 102 kPa	
Temperature	NT (Normal Temperature)	+19.5°C to +24.1°C
Working Voltage of the EUT	NV (Normal Voltage)	3.7 V

4.1 Test Equipment List

Description	Manufacturer	Model	Serial No.	Cal. Date	Cal. Due
Spectrum Analyzer	KEYSIGHT	N9020A	MY46471071	2023.07.25	2024.07.24
Spectrum Analyzer	KEYSIGHT	N9020A	MY52510065	2023.09.05	2024.09.04
Test Antenna-Horn	SCHWARZBECK	BBHA 9120D	01631	2022.02.23	2025.02.22
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
Amplifier	COM-MV	LSCX_LNA1-12G-01	180602	2023.09.05	2024.09.04
Amplifier	COM-MV	XKu_LNA7-18G-01	180601	2023.09.05	2024.09.04
Amplifier	COM-MV	KA LNA18 40G-01	18050001	2023.12.06	2024.12.05
EMI Receiver	ROHDE&SCHWARZ	ESRP	101036	2023.09.05	2024.09.04
Test Antenna-Bi-Log	SCHWARZBECK	VULB 9168	9168-01162	2023.08.04	2024.08.03
Test Antenna-Loop	SCHWARZBECK	FMZB 1519	1519-037	2024.01.23	2025.01.22
Amplifier	COM-MV	ZT30-1000M	B2018054558	2023.12.05	2024.12.04
Anechoic Chamber	EMC Electronic Co., Ltd	20.10*11.60*7.35m	130	2021.08.15	2024.08.14
EMI Receiver	KEYSIGHT	N9010B	MY57110309	2023.09.05	2024.09.04
LISN	SCHWARZBECK	NSLK 8127	8127-687	2023.05.16	2024.05.15
Shielded Enclosure	YiHeng Electronic Co., Ltd	3.5m*3.1m*2.8 m	112	2022.02.19	2025.02.18

4.2 Test Software List

Description	Manufacturer	Software Version	Serial No.	Applicable test Setup
BL410R	BALUN	V2.1.1.488	N/A	The section 4.5.1
BL410E	BALUN	V22.930	N/A	The section 4.5.2&4.5.3&4.5.4&4.5.5

4.2 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%

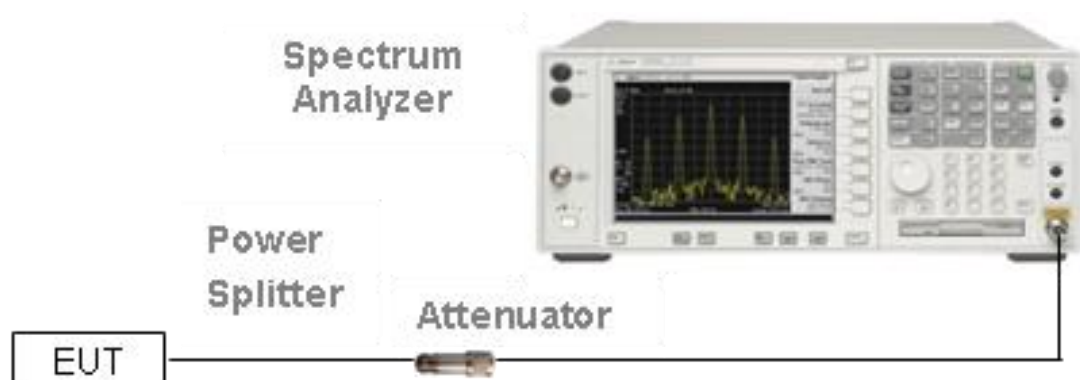
4.3 Description of Test Setup

4.4.1 For Antenna Port Test

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

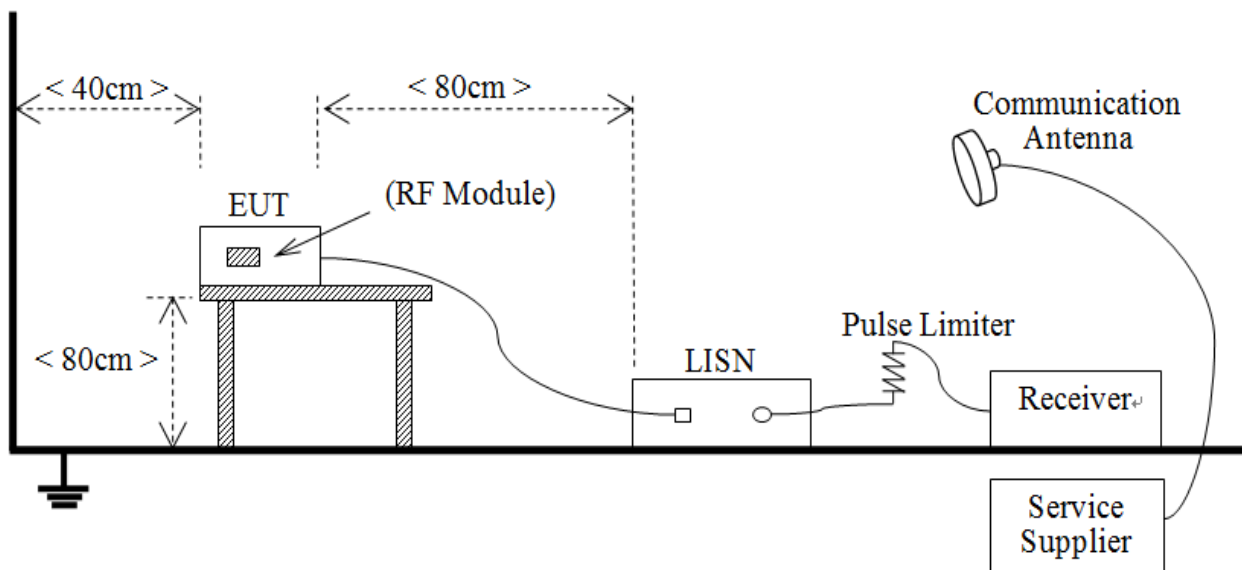
For example: the measurement value is 10 dBm and the cable 0.5dBm used, then the final result of EUT:

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



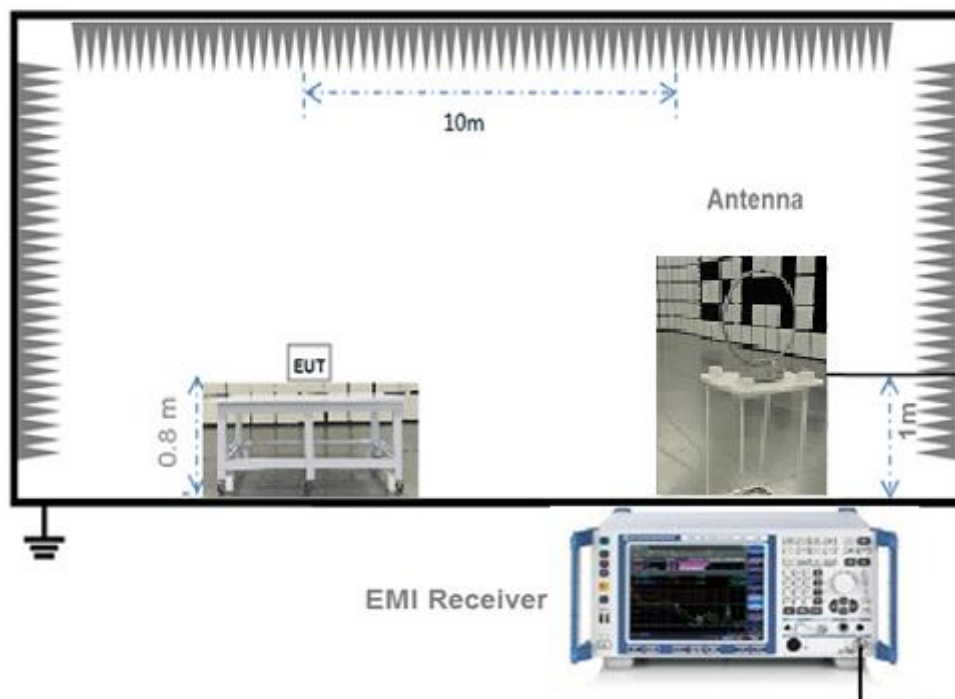
(Diagram 1)

4.4.2 For AC Power Supply Port Test



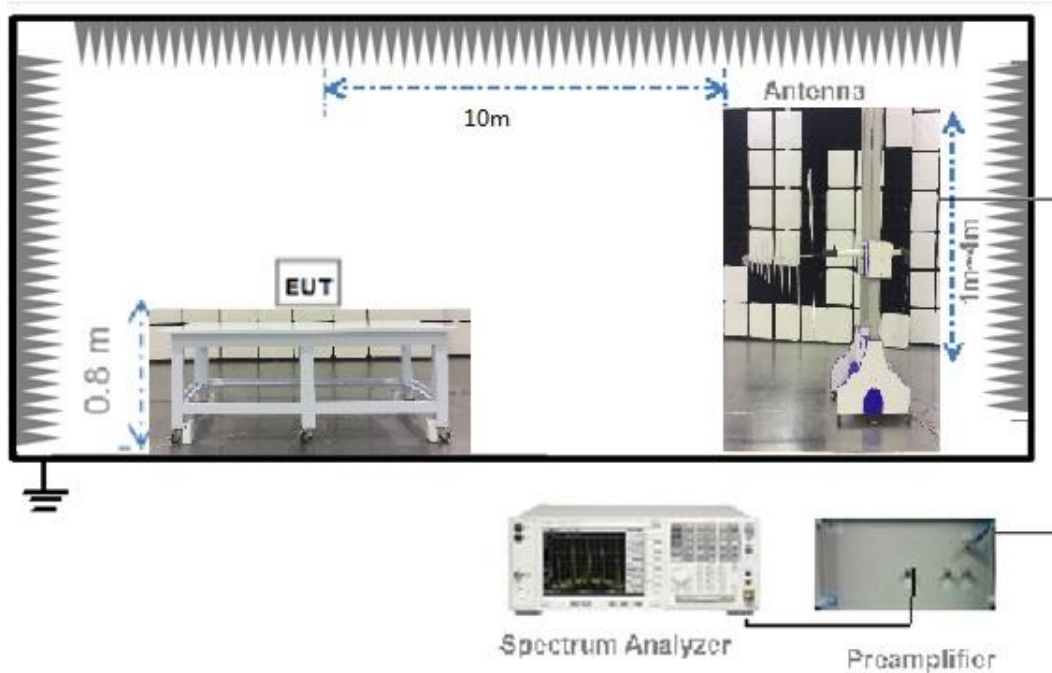
(Diagram 2)

4.4.3 For Radiated Test (Below 30 MHz)



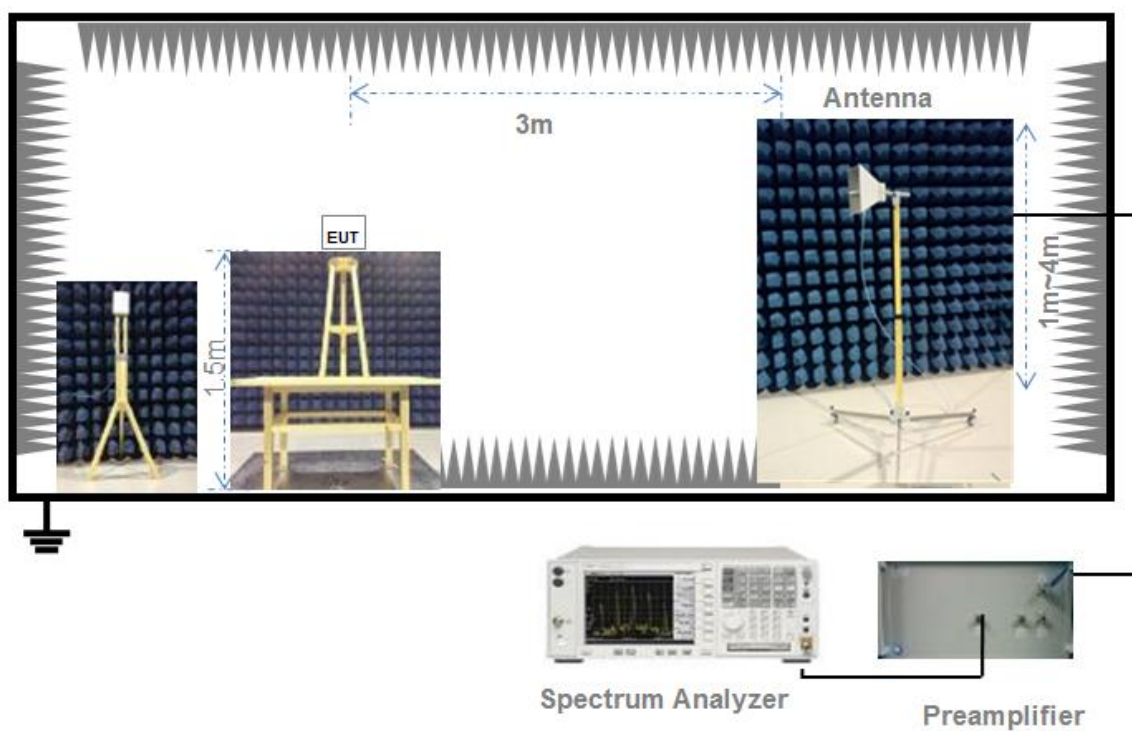
(Diagram 3)

4.4.4 For Radiated Test (30 MHz-1 GHz)



(Diagram 4)

4.4.5 For Radiated Test (Above 1 GHz)



(Diagram 5)

4.4 Measurement Results Explanation Example

4.5.1 For conducted test items:

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

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

Offset = RF cable loss + attenuator factor.

4.5.2 For radiated band edges and spurious emission test:

Per part 15.35(c), the EUT Bluetooth average emission level could be determined by the peak emission level applying duty cycle correction factor, to represent averaging over the whole pulse train.

The average level is derived from the peak level corrected with "Duty cycle correction factor".

Average Emission Level (dBuV/m) = Peak Emission Level (dBuV/m) + Duty cycle correction factor (dB)

Duty cycle correction factor (dB) = $20 * \log (\text{Duty cycle})$.

Duty cycle = on time / 100 milliseconds

On time = dwell time * hopping number in 100 ms

For example: bluetooth with dwell time 2.9 ms and 3 hops in 100 ms, then

Duty cycle correction factor (dB) = $20 * \log ((2.9 * 3) / 100) = -21.21 \text{ dB}$

Following shows an average computation example with duty cycle correction factor = -21.21 dB, and the peak emission level is 45.61 dBuV/m.

Example:

Average Emission Level (dBuV/m) = Peak Emission Level (dBuV/m) + duty cycle correction factor (dB)
= $45.61 + (-21.21) = 24.4 \text{ (dBuV/m)}$

5 TEST ITEMS

5.1 Antenna Requirements

5.1.1 Relevant Standards

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

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

If directional gain of transmitting antennas is greater than 6 dBi, the power shall be reduced by the same level in dB comparing to gain minus 6 dBi. For the fixed point-to-point operation, the power shall be reduced by one dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the FCC rule.

5.1.2 Antenna Anti-Replacement Construction

The Antenna Anti-Replacement as following method:

Protected Method	Description
The antenna is embedded in the product.	An embedded-in antenna design is used.

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

5.1.1Antenna 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 Frequency

5.2.1 Limit

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

Frequency hopping systems operating in the 2400 MHz to 2483.5 MHz bands shall use at least 15 hopping frequencies.

5.2.2 Test Setup

See section 4.5.1 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 and E.I.R.P

5.3.1 Test Limit

FCC § 15.247(b)

For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

RSS-247, 5.4 (2)

For FHSs operating in the band 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W and the e.i.r.p. shall not exceed 4 W if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W and the e.i.r.p. shall not exceed 0.5 W if the hopset uses less than 75 hopping channels (see Section 5.4(5) for exceptions).

5.3.2 Test Setup

See section 4.5.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.3.3 Test Procedure

The Bluetooth 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.

EIRP= Maximum peak conducted output power +Antenna Gain.

5.3.4 Test Result

Please refer to ANNEX A.2.

5.4 Occupied Bandwidth

5.4.1 Limit

FCC §15.247(a); RSS-247, 5.1 (1)

Measurement of the 20dB bandwidth of the modulated signal.

5.4.2 Test Setup

See section 4.5.1 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 $\geq$ 1% of the 20 dB bandwidth

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); RSS-247, 5.1 (2)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

5.5.2 Test Setup

See section 4.5.1 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); RSS-247, 5.1 (4)

Frequency hopping systems in the 2400 MHz - 2483.5 MHz band shall use at least 15 non-overlapping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

5.6.2 Test Setup

See section 4.5.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.6.3 Test Procedure

The average time of occupancy on any channel within the Period can be calculated with formulas:

$$\{\text{Total of Dwell}\} = \{\text{Pulse Time}\} * \{\text{Number of Hopping Frequency in Period}\}$$

$$\{\text{Period}\} = 0.4s * \{\text{Number of Hopping Frequency}\}$$

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

5.6.4 Test Result

Please refer to ANNEX A.5

5.7 Conducted Spurious Emission & Authorized-band band-edge

5.7.1 Limit

FCC §15.247(d); RSS-247, 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement.

5.7.2 Test Setup

See section 4.5.1 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.

5.8 Conducted Emission

5.8.1 Limit

FCC §15.207; RSS-GEN, 8.8

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 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 4.5.2 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.

5.8.4 Test Result

Please refer to ANNEX A.7.

5.9 Radiated Spurious Emission

5.9.1 Limit

FCC §15.209&15.247(d); RSS-247, 5.5

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

According to FCC section 15.209 (a), except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength (μV/m)	Measurement Distance (m)
0.009 - 0.490	2400/F(kHz)	300
0.490 - 1.705	24000/F(kHz)	30
1.705 - 30.0	30	30
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

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 4.5.3 to 4.5.5 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); RSS-247, 5.5

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

5.10.2 Test Setup

See section 4.5.3 to 4.5.5 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

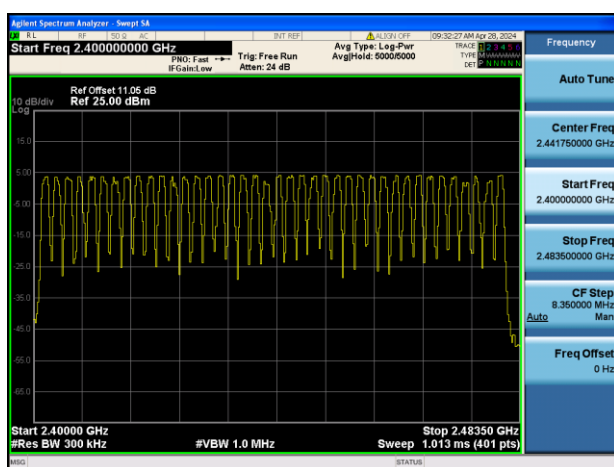
A.1 Number of Hopping Frequency

Test Data

Test Mode	Frequency Block (MHz)	Measured Channel Numbers	Min. Limit	Verdict
GFSK	2400 - 2483.5	40	15	Pass

Test Plots

GFSK 2.4 GHz ~ 2.4835 GHz



A.2 Peak Output Power and E.I.R.P

Peak Power Test Data

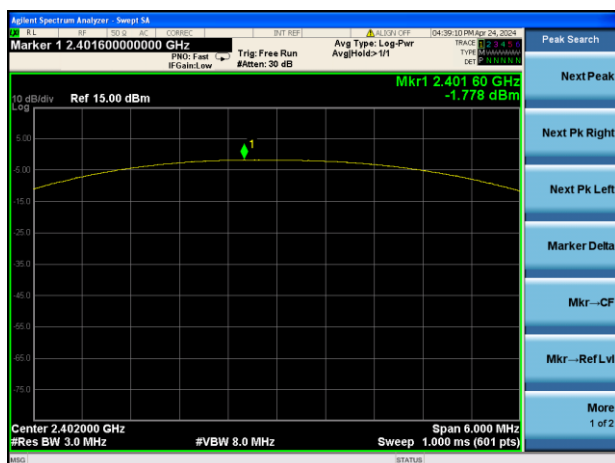
Channel	Measured Output Peak Power		Limit		Verdict
	dBm	mW	dBm	mW	
Low	-1.78	0.66	30	1000	Pass
Middle	-1.08	0.78			Pass
High	-0.66	0.86			Pass

E.I.R.P Test Data (For ISSED)

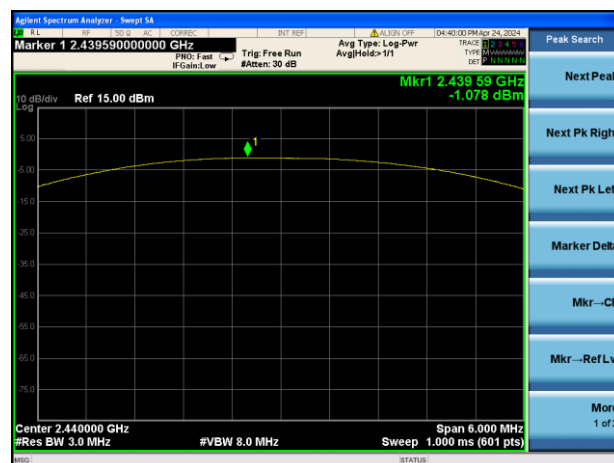
Channel	E.I.R.P		Limit		Verdict
	dBm	mW	dBm	mW	
Low	-1.60	0.69	36	4000	Pass
Middle	-0.90	0.81			Pass
High	-0.48	0.89			Pass

Test Plots

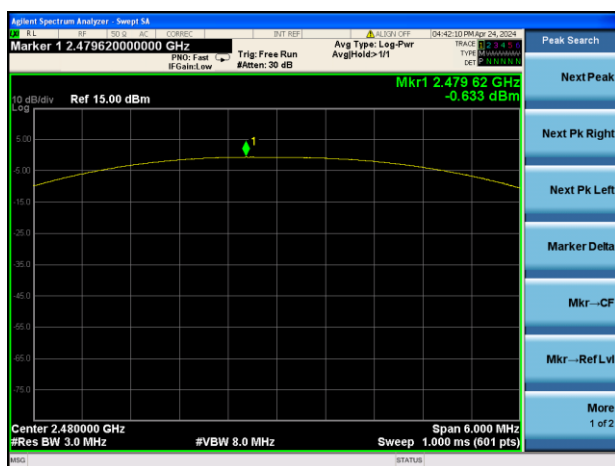
GFSK LOW CHANNEL



GFSK MIDDLE CHANNEL



GFSK HIGH CHANNEL



A.3 Occupied Bandwidth

Test Data

Test Mode	GFSK	
Channel	20 dB Bandwidth (MHz)	99% Bandwidth (MHz)
Low Channel	1.064900	1.012900
Middle Channel	1.064900	1.013800
High Channel	1.072500	1.016100

Test Plots

20 dB Bandwidth

GFSK LOW CHANNEL



GFSK MIDDLE CHANNEL

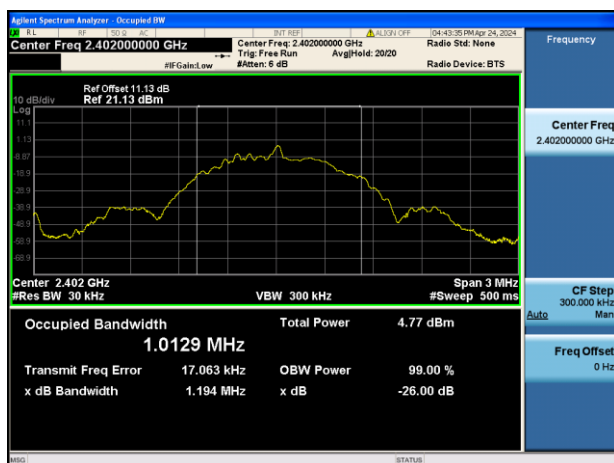


GFSK HIGH CHANNEL

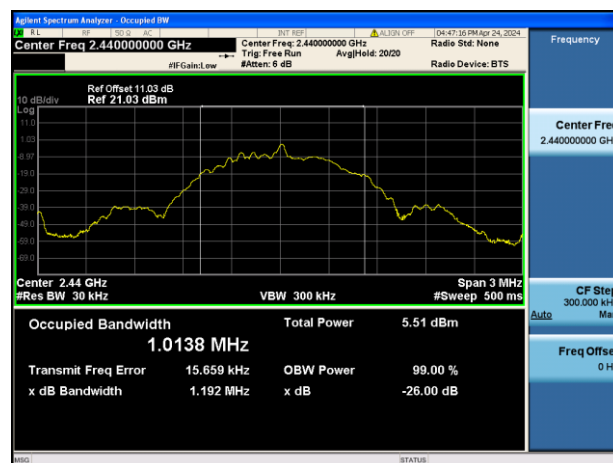


99% Bandwidth

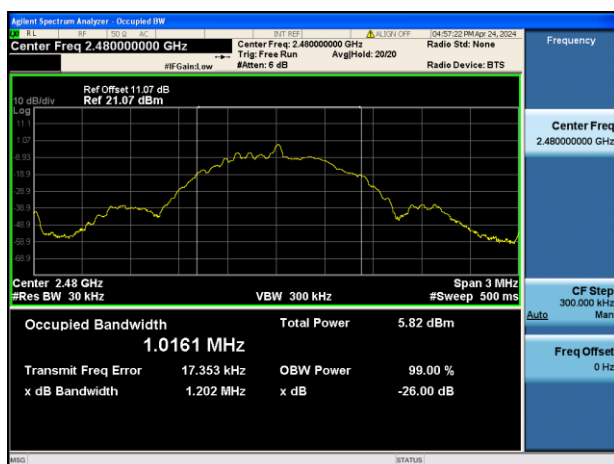
GFSK LOW CHANNEL



GFSK MIDDLE CHANNEL



GFSK HIGH CHANNEL



A.4 Hopping Frequency Separation

Test Data

Mode	Frequency separation (MHz)	2/3 of the 20 dB Bandwidth (MHz)	Verdict
GFSK	2.000	0.715	Pass

Test Plots

GFSK



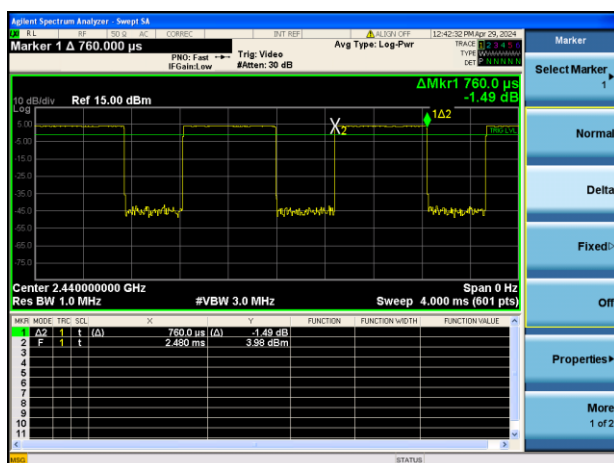
A.5 Time of Occupancy (Dwell time)

Test Data

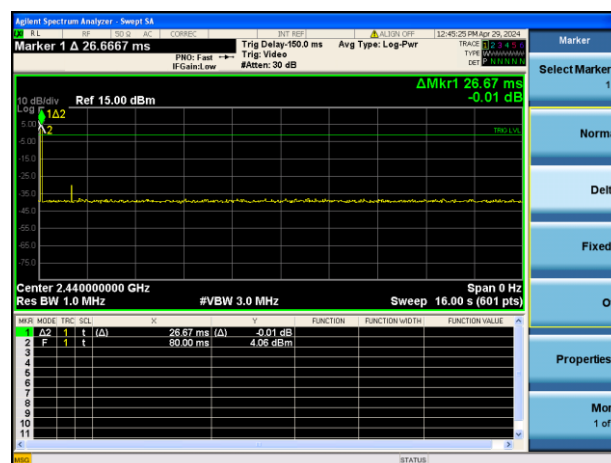
GFSK			
Pulse Width (ms)	Total of Dwell (ms)	Limit (sec)	Verdict
0.760	26.670	0.4	Pass

Test Plots

Pulse Width



Total of Dwell



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

Test Data

GFSK Mode:

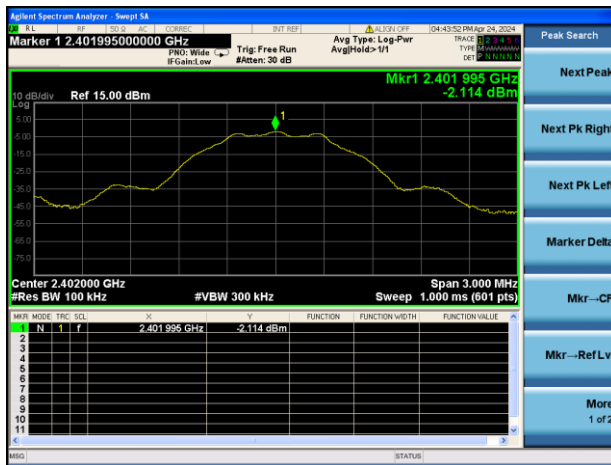
GFSK				
Channel	Measured Max. Out of Band Emission (dBm)	Limit (dBm)		Verdict
		Carrier Level	Calculated 20 dBc Limit	
Low	-35.64	-2.11	-22.11	Pass
Middle	-35.69	-1.39	-21.39	Pass
High	-35.92	-1.00	-21.00	Pass

Hopping Mode:

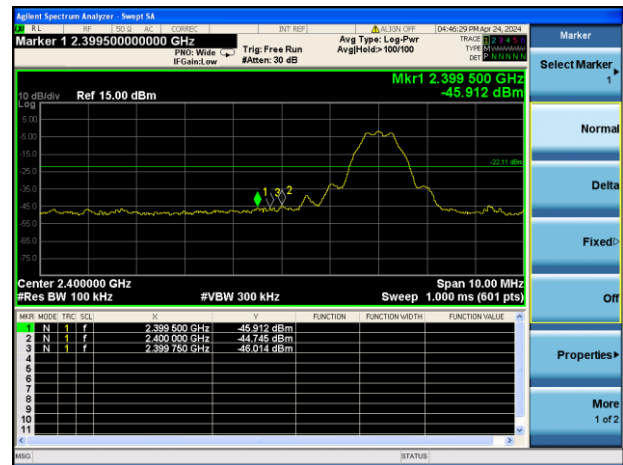
GFSK				
Channel	Measured Max. Out of Band Emission (dBm)	Limit (dBm)		Verdict
		Carrier Level	Calculated 20 dBc Limit	
GFSK	-35.04	1.59	-18.41	Pass

Test Plots

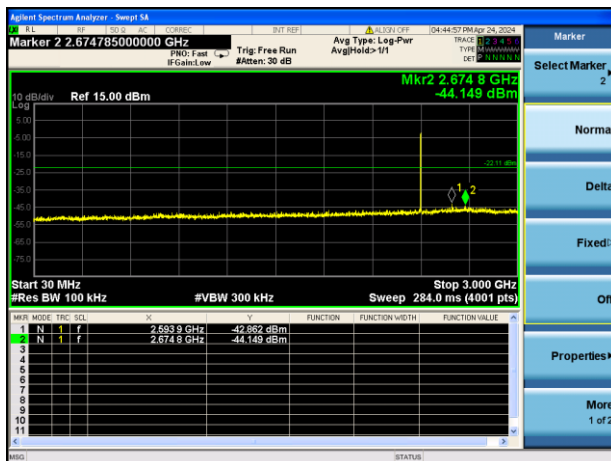
GFSK LOW CHANNEL, CARRIER LEVEL



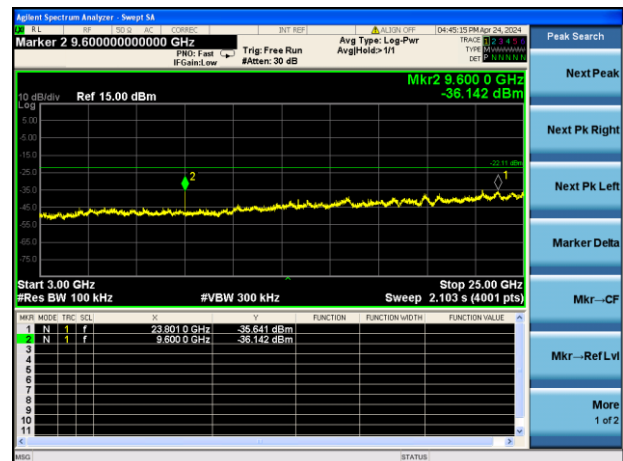
GFSK LOW CHANNEL, BAND EDGE



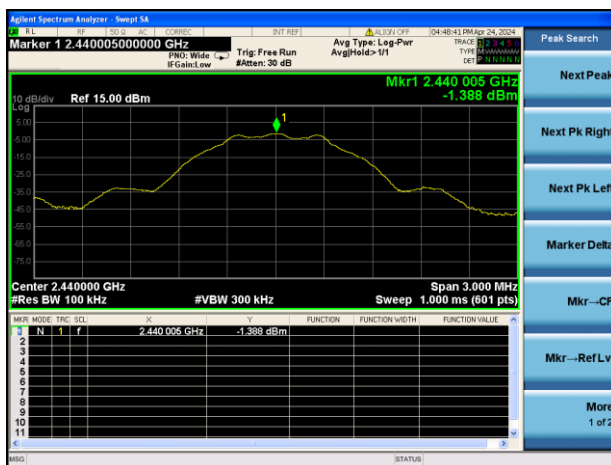
GFSK LOW CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



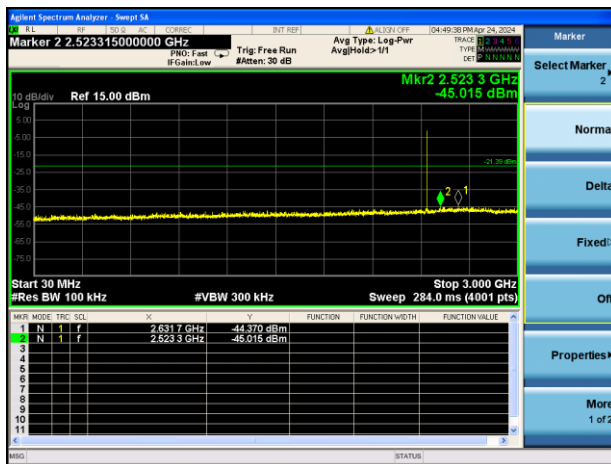
GFSK LOW CHANNEL, SPURIOUS 3 GHz ~ 25 GHz



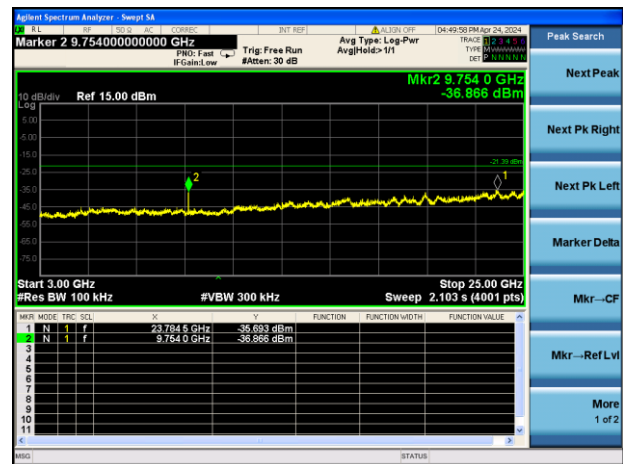
GFSK MIDDLE CHANNEL, CARRIER LEVEL



GFSK MIDDLE CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



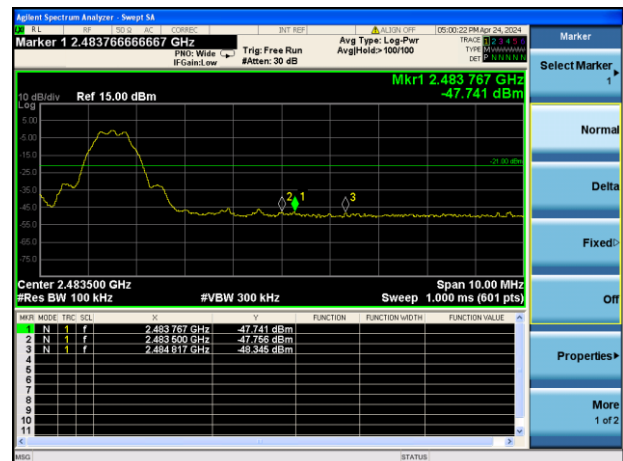
GFSK MIDDLE CHANNEL, SPURIOUS 3 GHz ~ 25 GHz



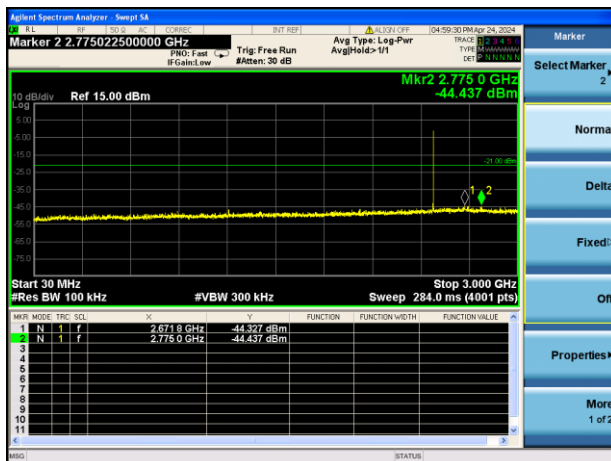
GFSK HIGH CHANNEL, CARRIER LEVEL



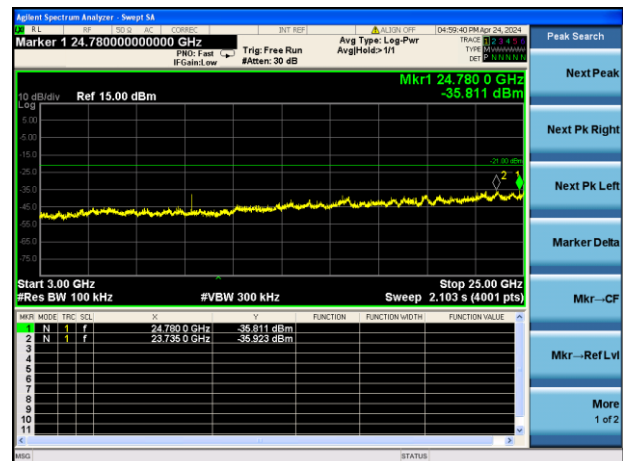
GFSK HIGH CHANNEL, BAND EDGE



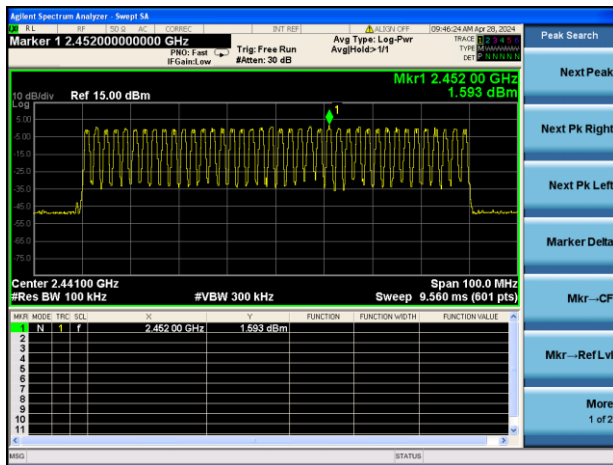
GFSK HIGH CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



GFSK HIGH CHANNEL, SPURIOUS 3 GHz ~ 25 GHz



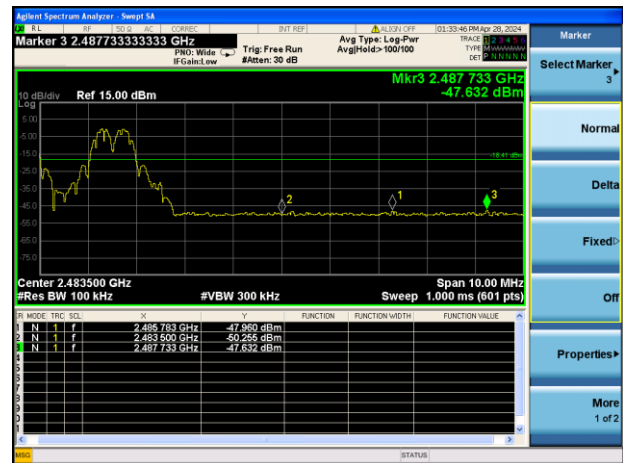
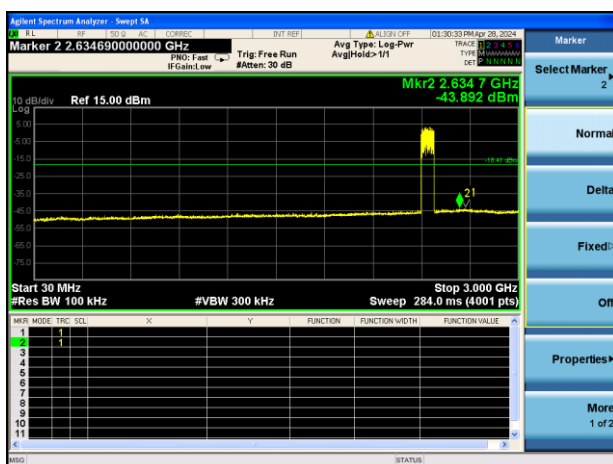
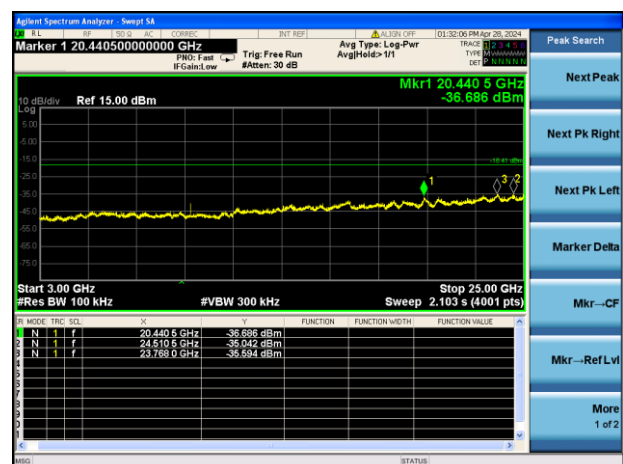
GFSK HOPPING, CARRIER LEVEL



GFSK HOPPING BAND EDGE (LOW)



GFSK HOPPING BAND EDGE (HIGH)

GFSK Hopping Mode, SPURIOUS
30 MHz ~ 3 GHzGFSK Hopping Mode, SPURIOUS
3GHz ~ 25 GHz

A.7 Conducted Emissions

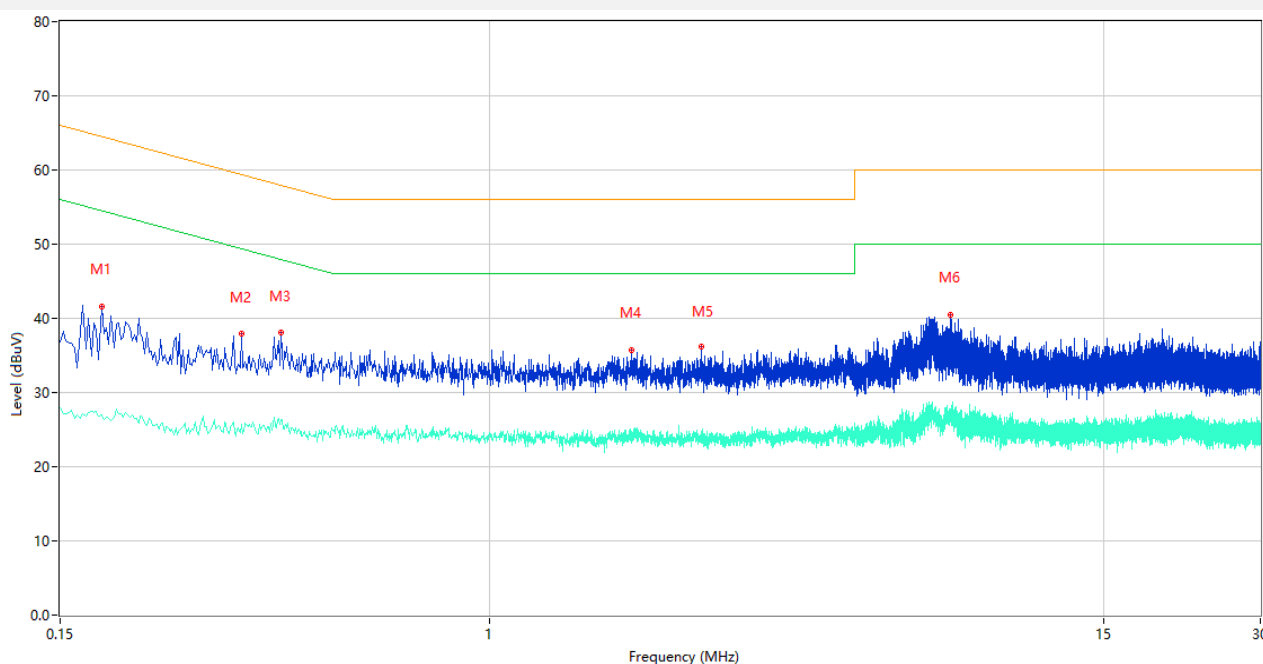
Note ¹: The EUT is working in the Normal link mode. All modes have been tested and normal link mode is worst.

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)

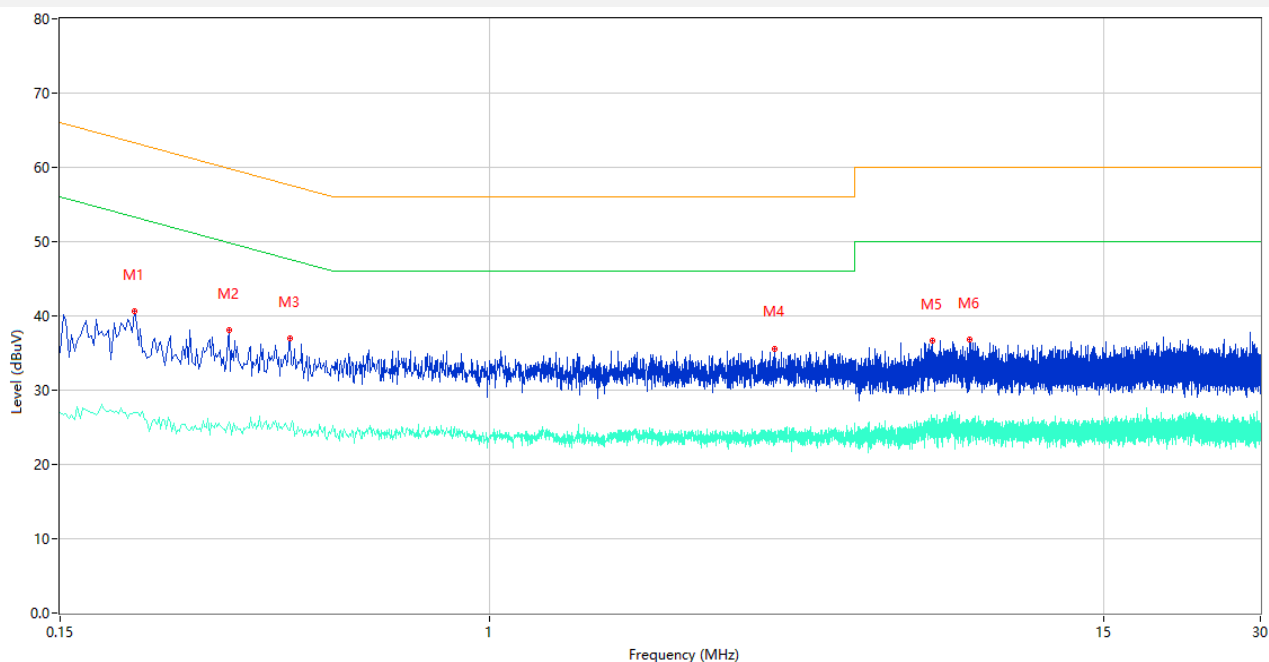
Test Data and Plots

PHASE L



No.	Frequency (MHz)	Results (dBuV)	Factor (dB)	Limit (dBuV)	Margin (dB)	Detector	Line	Verdict
1	0.180	41.54	9.78	64.49	22.95	Peak	L	Pass
1**	0.180	26.93	9.78	54.49	27.56	AV	L	Pass
2	0.334	37.86	10.44	59.35	21.49	Peak	L	Pass
2**	0.334	25.76	10.44	49.35	23.59	AV	L	Pass
3	0.398	38.08	10.56	57.90	19.82	Peak	L	Pass
3**	0.398	26.32	10.56	47.90	21.58	AV	L	Pass
4	1.870	35.75	10.38	56.00	20.25	Peak	L	Pass
4**	1.870	23.17	10.38	46.00	22.83	AV	L	Pass
5	2.548	36.14	10.09	56.00	19.86	Peak	L	Pass
5**	2.548	24.10	10.09	46.00	21.90	AV	L	Pass
6	7.650	40.54	10.35	60.00	19.46	Peak	L	Pass
6**	7.650	27.54	10.35	50.00	22.46	AV	L	Pass

PHASE N



No.	Frequency (MHz)	Results (dBuV)	Factor (dB)	Limit (dBuV)	Margin (dB)	Detector	Line	Verdict
1	0.208	40.61	9.77	63.28	22.67	Peak	N	Pass
1**	0.208	26.95	9.77	53.28	26.33	AV	N	Pass
2	0.316	38.04	10.08	59.81	21.77	Peak	N	Pass
2**	0.316	25.78	10.08	49.81	24.03	AV	N	Pass
3	0.414	36.92	10.41	57.57	20.65	Peak	N	Pass
3**	0.414	24.53	10.41	47.57	23.04	AV	N	Pass
4	3.520	35.60	10.14	56.00	20.40	Peak	N	Pass
4**	3.520	23.95	10.14	46.00	22.05	AV	N	Pass
5	7.066	36.64	10.41	60.00	23.36	Peak	N	Pass
5**	7.066	25.29	10.41	50.00	24.71	AV	N	Pass
6	8.292	36.78	10.29	60.00	23.22	Peak	N	Pass
6**	8.292	24.62	10.29	50.00	25.38	AV	N	Pass

A.8 Radiated Emission

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

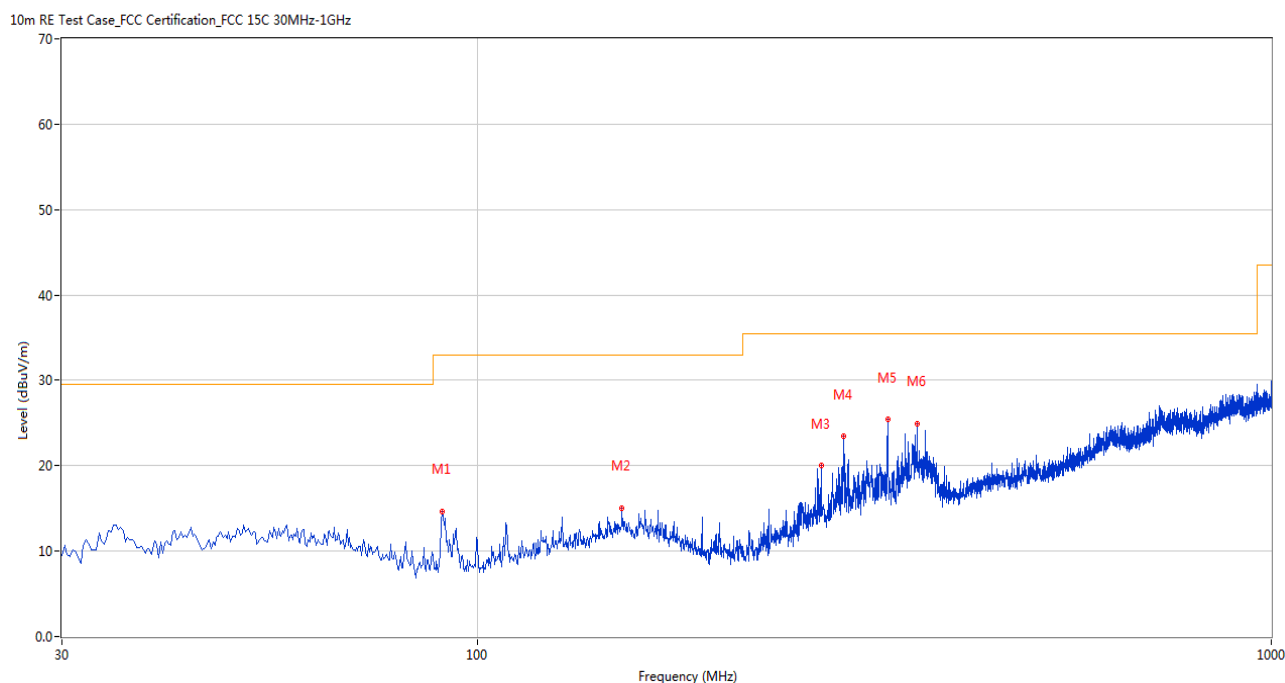
Note ²: For the test data above 1 GHz, according the ANSI C63.10-2013, where limits are specified for both average and peak (or quasi-peak) detector functions, if the peak (or quasi-peak) measured value complies with the average limit, it is unnecessary to perform an average measurement.

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: Results (dBuV/m) = Original reading level of Spectrum Analyzer (dBuV/m) + Factor (dB)

Test Data and Plots

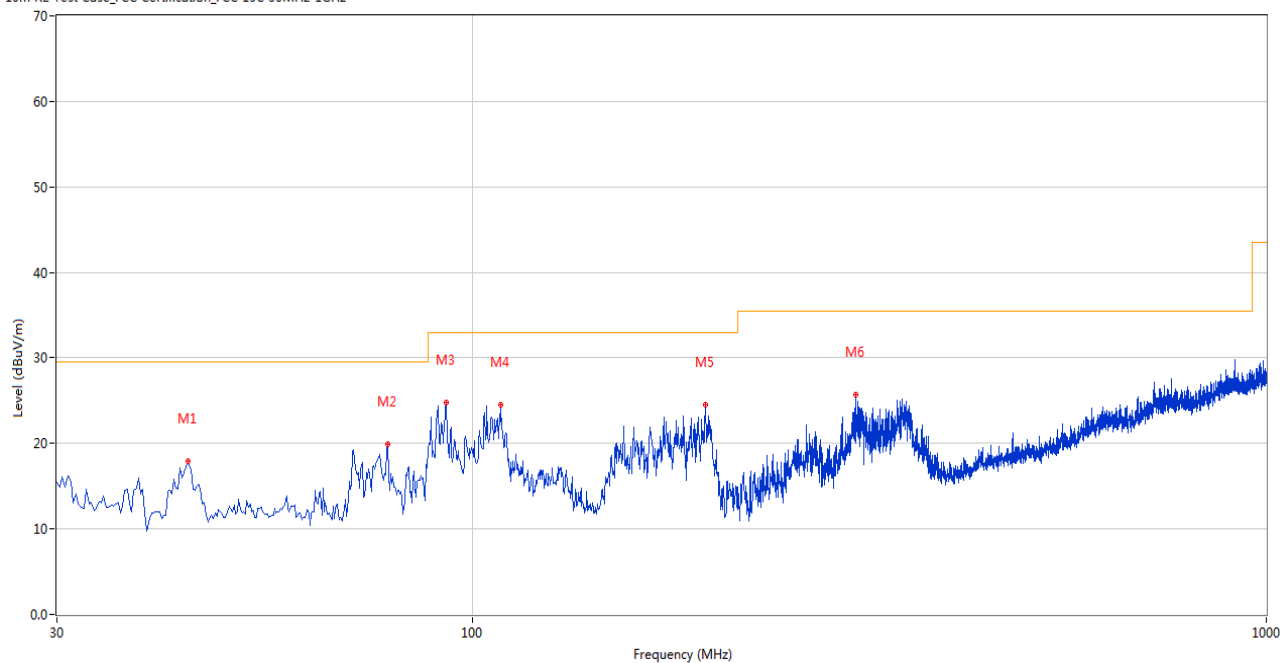
30 MHz to 1 GHz, ANT H



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	90.367	14.62	-31.55	33.0	18.38	Peak	16.00	200	Horizontal	Pass
2	152.189	15.00	-25.67	33.0	18.00	Peak	248.00	200	Horizontal	Pass
3	270.985	19.98	-25.93	35.5	15.52	Peak	115.00	200	Horizontal	Pass
4	289.410	23.45	-24.91	35.5	12.05	Peak	288.00	200	Horizontal	Pass
5	328.928	25.38	-24.07	35.5	10.12	Peak	273.00	200	Horizontal	Pass
6	358.263	24.87	-23.50	35.5	10.63	Peak	289.00	100	Horizontal	Pass

30 MHz to 1 GHz, ANT V

10m RE Test Case_FCC Certification_FCC 15C 30MHz-1GHz



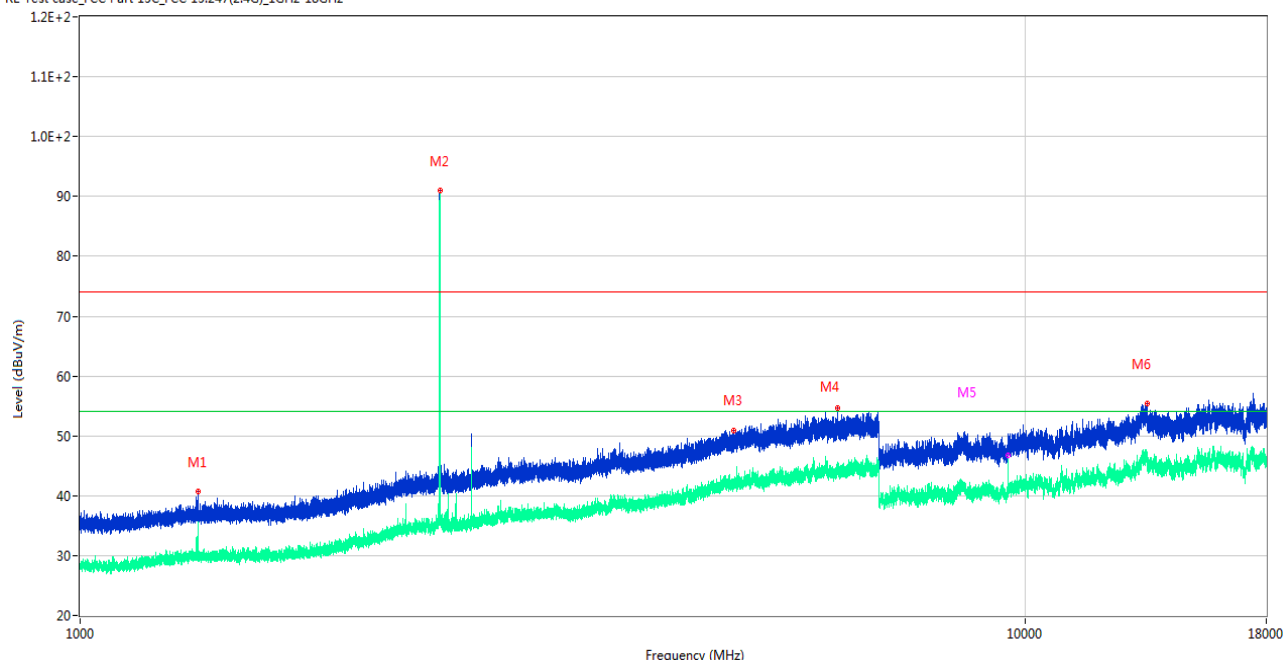
No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	43.819	17.88	-26.25	29.5	11.62	Peak	68.00	200	Vertical	Pass
2	78.245	19.87	-30.01	29.5	9.63	Peak	149.00	200	Vertical	Pass
3	92.792	24.80	-31.57	33.0	8.20	Peak	134.00	100	Vertical	Pass
4	108.793	24.47	-29.06	33.0	8.53	Peak	360.00	200	Vertical	Pass
5	196.798	24.58	-28.93	33.0	8.42	Peak	273.00	200	Vertical	Pass
6	304.199	25.76	-24.84	35.5	9.74	Peak	146.00	100	Vertical	Pass

Note 1: The marked spikes near 2400 MHz with circle should be ignored because they are Fundamental signal.

Note 2: The spurious from 18GHz-25GHz is noise only, do not show on the report.

GFSK LOW CHANNEL 1 GHz to 18 GHz, ANT H

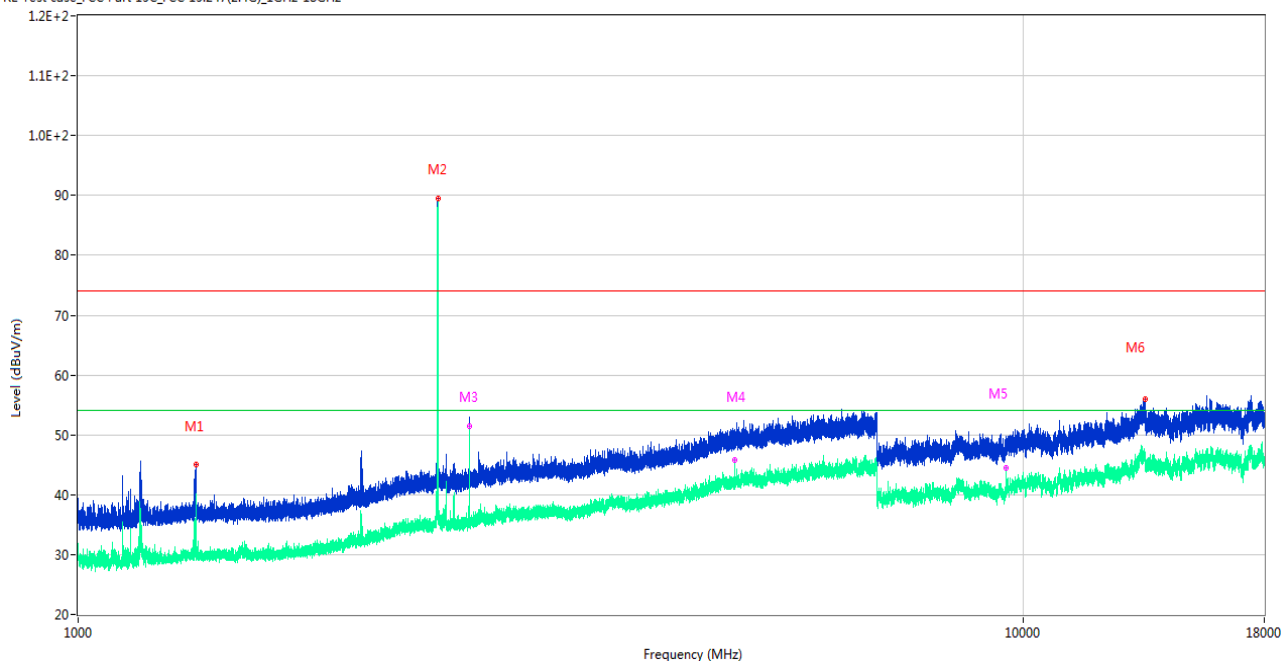
RE Test case_FCC Part 15C_FCC 15.247(2.4G)_1GHz-18GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1332.400	40.71	-17.12	74.0	33.29	Peak	148.00	100	Horizontal	Pass
1**	1332.400	35.57	-17.12	54.0	18.43	AV	148.00	100	Horizontal	Pass
2	2401.900	90.91	-9.75	74.0	-16.91	Peak	277.00	200	Horizontal	N/A
2**	2401.900	90.19	-9.75	54.0	-36.19	AV	277.00	200	Horizontal	N/A
3	4912.400	50.88	-2.84	74.0	23.12	Peak	135.00	100	Horizontal	Pass
3**	4912.400	41.36	-2.84	54.0	12.64	AV	135.00	100	Horizontal	Pass
4	6331.200	54.60	-0.75	74.0	19.40	Peak	124.00	100	Horizontal	Pass
4**	6331.200	43.88	-0.75	54.0	10.12	AV	124.00	100	Horizontal	Pass
5	9602.450	48.85	0.03	74.0	25.15	Peak	6.00	200	Horizontal	Pass
5**	9602.450	46.80	0.03	54.0	7.20	AV	6.00	200	Horizontal	Pass
6	13454.026	55.35	0.63	74.0	18.65	Peak	147.00	150	Horizontal	Pass
6**	13454.026	45.80	0.63	54.0	8.20	AV	147.00	150	Horizontal	Pass

GFSK LOW CHANNEL 1 GHz to 18 GHz, ANT V

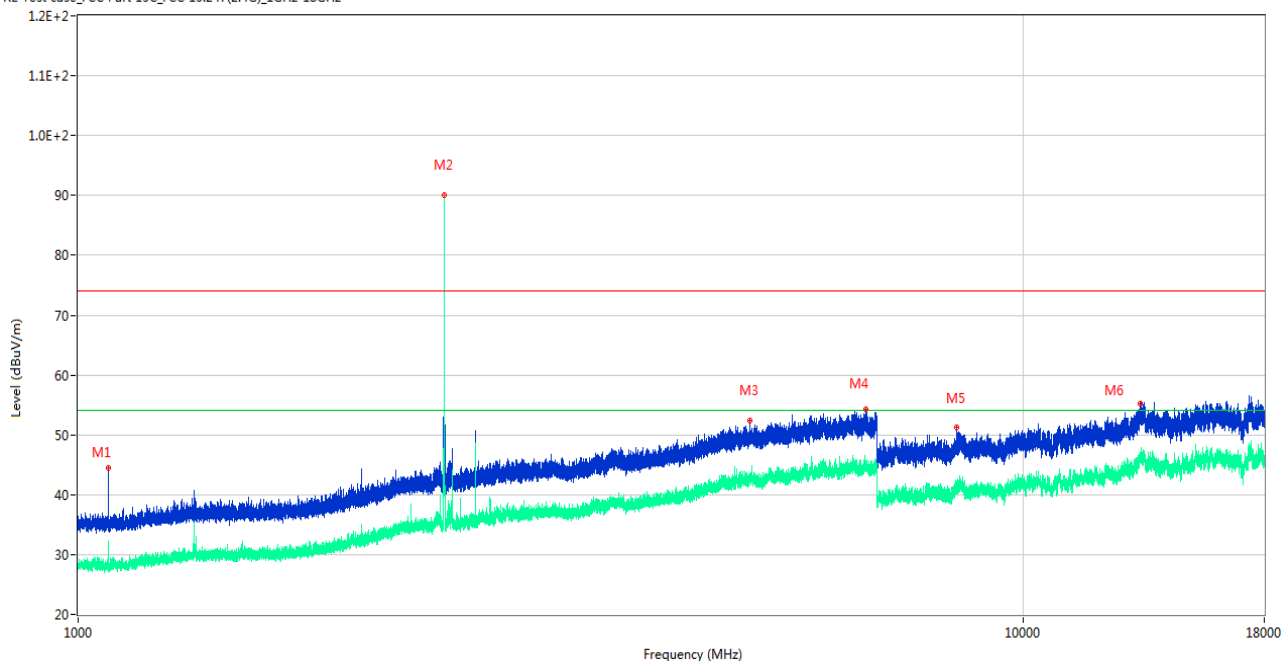
RE Test case_FCC Part 15C_FCC 15.247(2.4G)_1GHz-18GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1331.900	45.03	-17.08	74.0	28.97	Peak	219.00	100	Vertical	Pass
1**	1331.900	35.04	-17.08	54.0	18.96	AV	219.00	100	Vertical	Pass
2	2401.900	89.41	-9.75	74.0	-15.41	Peak	288.00	200	Vertical	N/A
2**	2401.900	88.68	-9.75	54.0	-34.68	AV	288.00	200	Vertical	N/A
3	2594.200	52.28	-11.51	74.0	21.72	Peak	288.00	150	Vertical	Pass
3**	2594.200	51.38	-11.51	54.0	2.62	AV	288.00	150	Vertical	N/A
4	4953.200	49.76	-2.89	74.0	24.24	Peak	230.00	100	Vertical	Pass
4**	4953.200	45.78	-2.89	54.0	8.22	AV	230.00	100	Vertical	Pass
5	9602.162	49.47	0.03	74.0	24.53	Peak	331.00	200	Vertical	Pass
5**	9602.162	44.57	0.03	54.0	9.43	AV	331.00	200	Vertical	Pass
6	13452.188	55.91	0.62	74.0	18.09	Peak	15.00	150	Vertical	Pass
6**	13452.188	46.29	0.62	54.0	7.71	AV	15.00	150	Vertical	Pass

GFSK MIDDLE CHANNEL 1 GHz to 18 GHz, ANT H

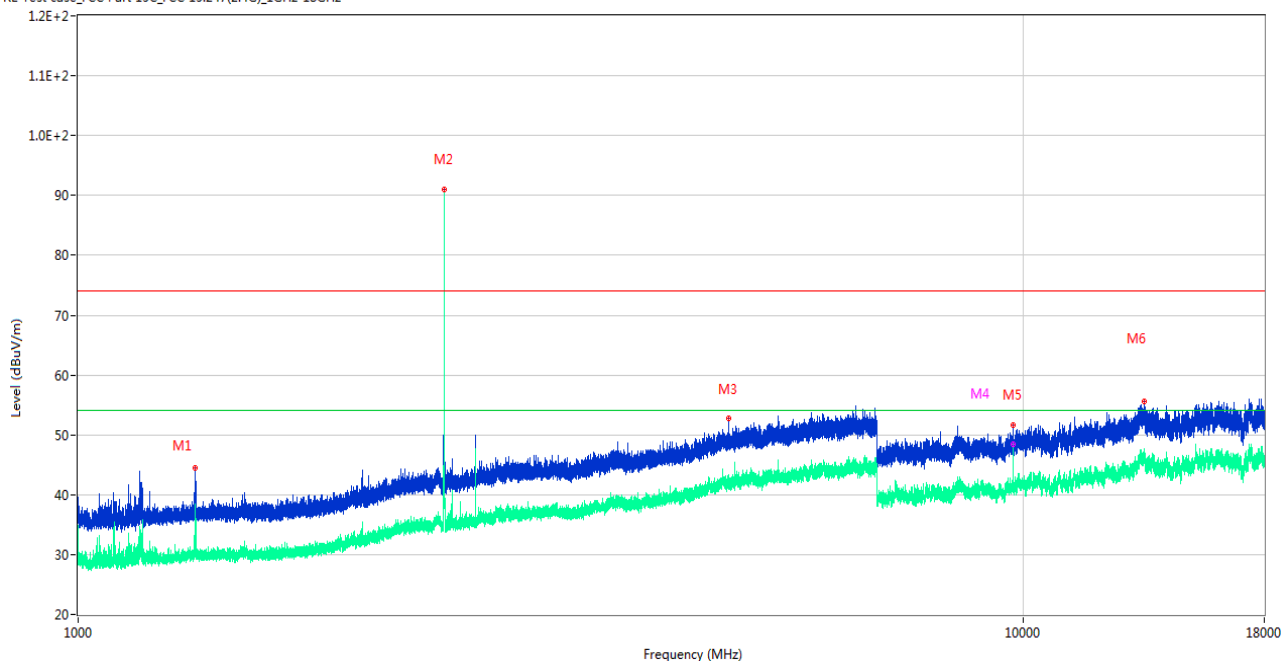
RE Test case_FCC Part 15C_FCC 15.247(2.4G)_1GHz-18GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1076.100	44.56	-18.28	74.0	29.44	Peak	9.00	100	Horizontal	Pass
1**	1076.100	32.24	-18.28	54.0	21.76	AV	9.00	100	Horizontal	Pass
2	2440.300	90.06	-12.38	74.0	-16.06	Peak	320.00	200	Horizontal	N/A
2**	2440.300	89.42	-12.38	54.0	-35.42	AV	320.00	200	Horizontal	N/A
3	5133.400	52.40	-1.82	74.0	21.60	Peak	283.00	150	Horizontal	Pass
3**	5133.400	42.54	-1.82	54.0	11.46	AV	283.00	150	Horizontal	Pass
4	6814.800	54.35	0.62	74.0	19.65	Peak	237.00	100	Horizontal	Pass
4**	6814.800	44.83	0.62	54.0	9.17	AV	237.00	100	Horizontal	Pass
5	8510.525	51.20	-1.44	74.0	22.80	Peak	0.00	200	Horizontal	Pass
5**	8510.525	40.72	-1.44	54.0	13.28	AV	0.00	200	Horizontal	Pass
6	13318.050	55.23	0.90	74.0	18.77	Peak	37.00	150	Horizontal	Pass
6**	13318.050	46.30	0.90	54.0	7.70	AV	37.00	150	Horizontal	Pass

GFSK MIDDLE CHANNEL 1 GHz to 18 GHz, ANT V

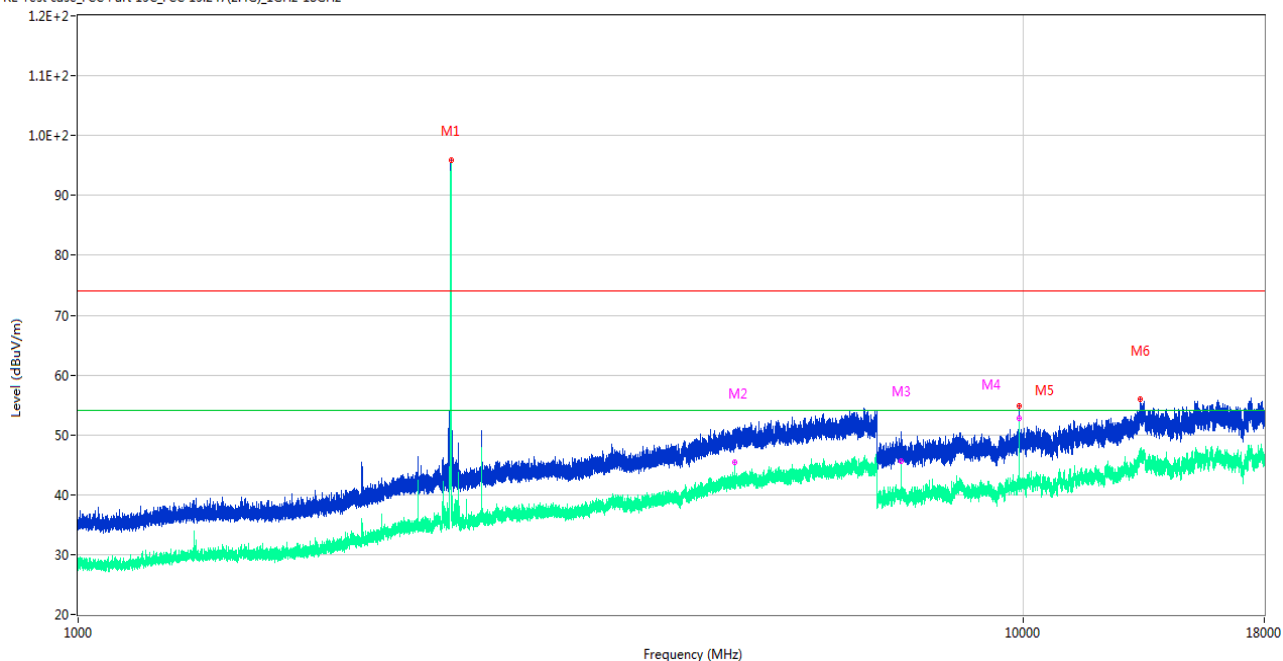
RE Test case_FCC Part 15C_FCC 15.247(2.4G)_1GHz-18GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1331.300	44.48	-17.03	74.0	29.52	Peak	119.00	100	Vertical	Pass
1**	1331.300	35.70	-17.03	54.0	18.30	AV	119.00	100	Vertical	Pass
2	2439.900	91.06	-12.38	74.0	-17.06	Peak	84.00	200	Vertical	N/A
2**	2439.900	90.34	-12.38	54.0	-36.34	AV	84.00	200	Vertical	N/A
3	4878.600	52.69	-2.71	74.0	21.31	Peak	131.00	150	Vertical	Pass
3**	4878.600	41.67	-2.71	54.0	12.33	AV	131.00	150	Vertical	Pass
4	9758.562	49.03	-0.39	74.0	24.97	Peak	360.00	200	Vertical	Pass
4**	9758.562	48.44	-0.39	54.0	5.56	AV	360.00	200	Vertical	Pass
5	9758.276	51.65	-0.39	74.0	22.35	Peak	274.00	150	Vertical	Pass
5**	9758.276	47.93	-0.39	54.0	6.07	AV	274.00	150	Vertical	Pass
6	13424.625	55.65	0.40	74.0	18.35	Peak	16.00	150	Vertical	Pass
6**	13424.625	45.90	0.40	54.0	8.10	AV	16.00	150	Vertical	Pass

GFSK HIGH CHANNEL 1 GHz to 18 GHz, ANT H

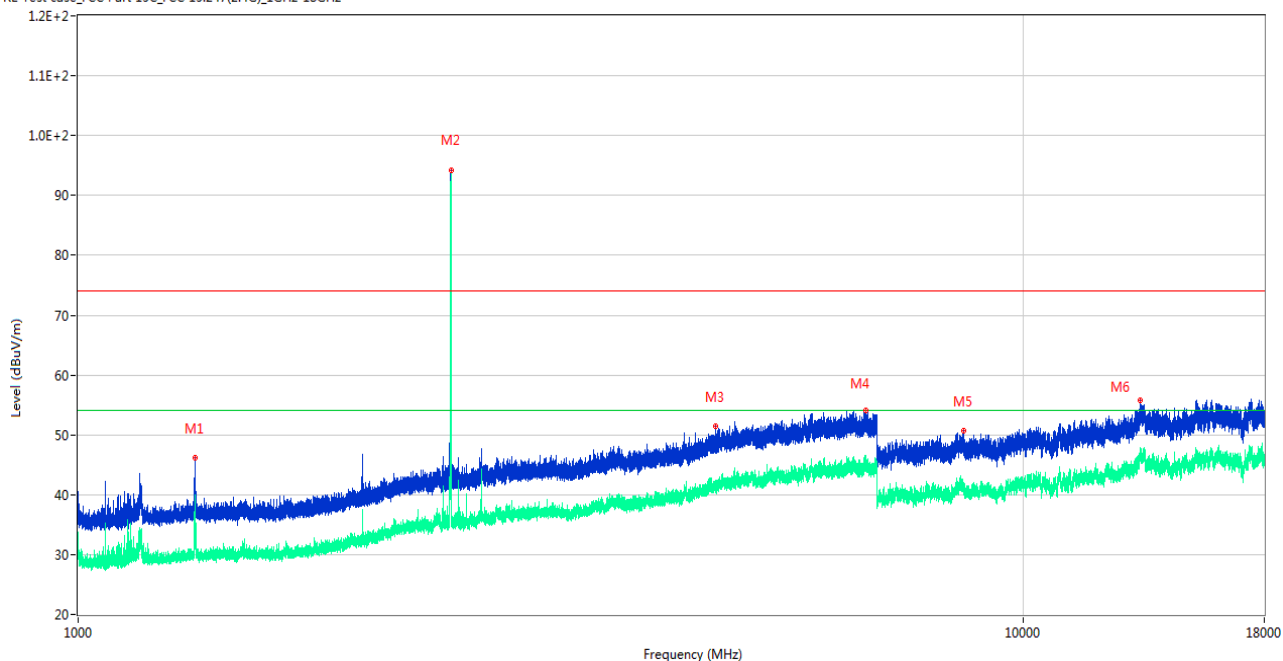
RE Test case_FCC Part 15C_FCC 15.247(2.4G)_1GHz-18GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	2479.900	95.86	-11.32	74.0	-21.86	Peak	312.00	100	Horizontal	N/A
1**	2479.900	95.25	-11.32	54.0	-41.25	AV	312.00	100	Horizontal	N/A
2	4953.200	50.81	-2.89	74.0	23.19	Peak	340.00	200	Horizontal	Pass
2**	4953.200	45.35	-2.89	54.0	8.65	AV	340.00	200	Horizontal	Pass
3	7434.413	48.78	-3.41	74.0	25.22	Peak	348.00	100	Horizontal	Pass
3**	7434.413	45.54	-3.41	54.0	8.46	AV	348.00	100	Horizontal	Pass
4	9914.387	53.94	-0.99	74.0	20.06	Peak	32.00	200	Horizontal	Pass
4**	9914.387	52.76	-0.99	54.0	1.24	AV	32.00	200	Horizontal	N/A
5	9914.100	54.78	-0.99	74.0	19.22	Peak	32.00	150	Horizontal	Pass
5**	9914.100	51.08	-0.99	54.0	2.92	AV	32.00	150	Horizontal	N/A
6	13314.375	55.95	0.88	74.0	18.05	Peak	179.00	150	Horizontal	Pass
6**	13314.375	46.57	0.88	54.0	7.43	AV	179.00	150	Horizontal	Pass

GFSK HIGH CHANNEL 1 GHz to 18 GHz, ANT V

RE Test case_FCC Part 15C_FCC 15.247(2.4G)_1GHz-18GHz



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1329.700	46.14	-17.02	74.0	27.86	Peak	222.00	150	Vertical	Pass
1**	1329.700	35.70	-17.02	54.0	18.30	AV	222.00	150	Vertical	Pass
2	2479.800	94.23	-11.33	74.0	-20.23	Peak	253.00	100	Vertical	N/A
2**	2479.800	92.31	-11.33	54.0	-38.31	AV	253.00	100	Vertical	N/A
3	4728.600	51.41	-3.45	74.0	22.59	Peak	62.00	200	Vertical	Pass
3**	4728.600	41.32	-3.45	54.0	12.68	AV	62.00	200	Vertical	Pass
4	6809.800	54.12	1.52	74.0	19.88	Peak	174.00	100	Vertical	Pass
4**	6809.800	44.99	1.52	54.0	9.01	AV	174.00	100	Vertical	Pass
5	8643.063	50.62	-1.84	74.0	23.38	Peak	329.00	200	Vertical	Pass
5**	8643.063	41.15	-1.84	54.0	12.85	AV	329.00	200	Vertical	Pass
6	13302.825	55.72	0.87	74.0	18.28	Peak	344.00	150	Vertical	Pass
6**	13302.825	46.01	0.87	54.0	7.99	AV	344.00	150	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.

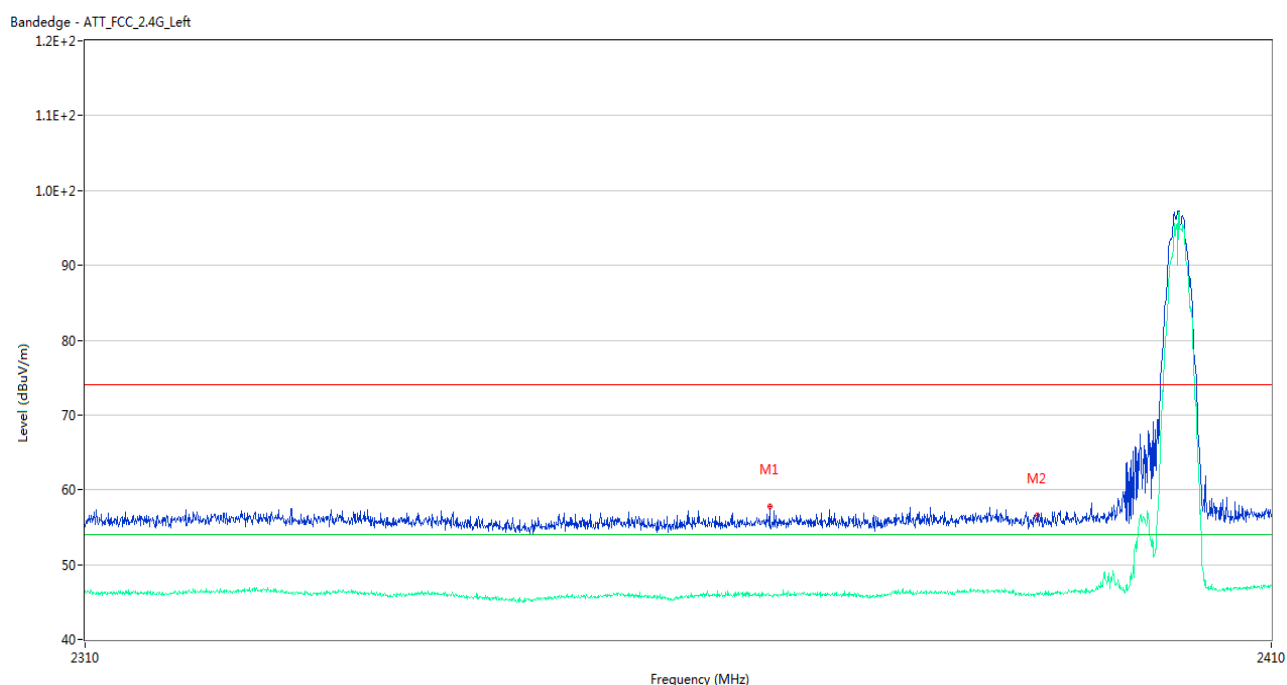
Note ²: The test data all are tested in the vertical and horizontal antenna which the trace is max hold. So these plots have shown the worst case.

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

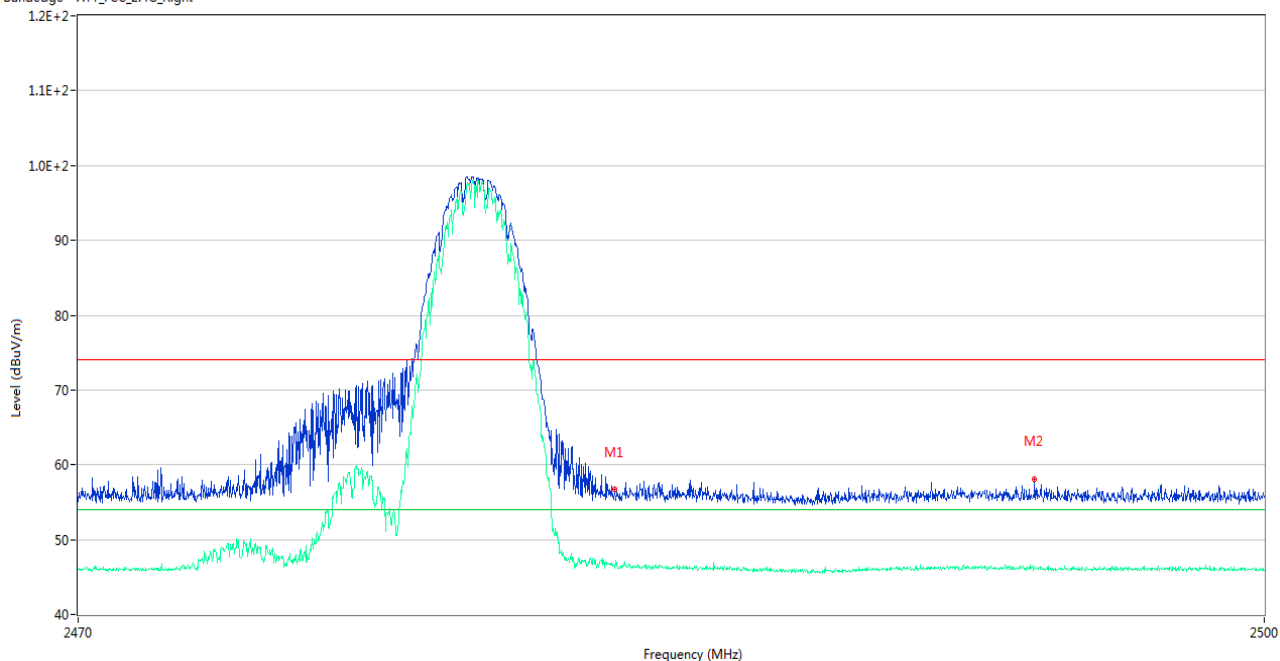
GFSK LOW CHANNEL



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	2367.200	57.73	1.73	74.0	16.27	Peak	41.00	100	Horizontal	Pass
1**	2367.200	45.86	1.73	54.0	8.14	AV	41.00	100	Horizontal	Pass
2	2389.950	56.57	1.92	74.0	17.43	Peak	232.00	200	Horizontal	Pass
2**	2389.950	46.03	1.92	54.0	7.97	AV	232.00	200	Horizontal	Pass

GFSK HIGH CHANNEL

Bandedge - ATT_FCC_2.4G_Right



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	2483.530	56.76	2.11	74.0	17.24	Peak	184.00	150	Horizontal	Pass
1**	2483.530	46.19	2.11	54.0	7.81	AV	184.00	150	Horizontal	Pass
2	2494.165	58.14	1.80	74.0	15.86	Peak	296.00	100	Horizontal	Pass
2**	2494.165	46.26	1.80	54.0	7.74	AV	296.00	100	Horizontal	Pass

ANNEX B TEST SETUP PHOTOS

Please refer the document “BL-SZ2430058-AR.PDF”.

ANNEX C EUT EXTERNAL PHOTOS

Please refer the document “BL-SZ2430058-AW.PDF”.

ANNEX D EUT INTERNAL PHOTOS

Please refer the document “BL-SZ2430058-AI.PDF”.

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--END OF REPORT--