TEST REPORT

Applicant:	TELON TECHNOLOGY CO., LTD
Address:	No. 1, Aly. 14, Ln. 26, Shuren Rd., Guishan Dist., Taoyuan City 333, Taiwan (R.O.C.)
Equipment Type:	Mechanical Keyboard
Model Name:	MKey PRO
Brand Name:	MONTECH
FCC ID:	2BKOF-MKEYPRO
Test Standard:	47 CFR Part 15 Subpart C (refer to section 3.1)
Sample Arrival Date:	Aug. 15, 2024
Test Date:	Aug. 19, 2024 - Sep. 12, 2024
Date of Issue:	Sep. 25, 2024

ISSUED BY:

Shenzhen BALUN Technology Co., Ltd.

Tested by: Li Ganming **Checked by:** Ye Hongji **Approved by:** Sunny Zou (Technical Director)

Revision History

Version	Issue Date	Revisions
Rev. 01	Sep. 25, 2024	Initial Issue

TABLE OF CONTENTS

1 GENERAL INFORMATION 4

1.1 Test Laboratory 4

1.2 Test Location 4

2 PRODUCT INFORMATION 5

2.1 Applicant Information 5

2.2 Manufacturer Information 5

2.3 General Description for Equipment under Test (EUT) 5

2.4 Technical Information 6

3 SUMMARY OF TEST RESULTS 7

3.1 Test Standards 7

3.2 Verdict 7

4 GENERAL TEST CONFIGURATIONS 8

4.1 Test Environments 8

4.2 Test Equipment List 8

4.3 Test Software List 9

4.4 Measurement Uncertainty 9

4.5 Description of Test Setup 10

4.6 Measurement Results Explanation Example 13

5 TEST ITEMS 14

5.1 Antenna Requirements 14

5.2 Number of Hopping Frequency 15

5.3 Peak Output Power 16

5.4 Occupied Bandwidth 17

5.5 Carrier Frequency Separation 18

5.6 Time of Occupancy (Dwell time) 19
5.7 Conducted Spurious Emission & Authorized-band band-edge 20
5.8 Conducted Emission 21
5.9 Radiated Spurious Emission 22
5.10 Band Edge (Restricted-band band-edge) 24
ANNEX A TEST RESULT 25
A.1 Number of Hopping Frequency 25
A.2 Peak Output Power 26
A.3 Occupied Bandwidth 28
A.4 Hopping Frequency Separation 30
A.5 Time of Occupancy (Dwell time) 31
A.6 Conducted Spurious Emissions & Authorized-band band-edge 32
A.7 Conducted Emissions 36
A.8 Radiated Emission 38
A.9 Band Edge (Restricted-band band-edge) 46
ANNEX B TEST SETUP PHOTOS 48
ANNEX C EUT EXTERNAL PHOTOS 48
ANNEX D EUT INTERNAL PHOTOS 48

1 GENERAL INFORMATION

1.1 Test Laboratory

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

1.2 Test Location

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

2 PRODUCT INFORMATION

2.1 Applicant Information

Applicant	TELON TECHNOLOGY CO., LTD
Address	No. 1, Aly. 14, Ln. 26, Shuren Rd., Guishan Dist., Taoyuan City 333, Taiwan (R.O.C.)

2.2 Manufacturer Information

Manufacturer	DONGGUAN WANMIAN ELECTRONICS CO., LTD.
Address	Room 101, No. 7, East 3rd Street, Keji Road, Qingxi Town, Dongguan City, Guangdong

2.3 General Description for Equipment under Test (EUT)

EUT Name	Mechanical Keyboard
Model Name Under Test	MKey PRO
Series Model Name	N/A
Description of Model name differentiation	N/A
Hardware Version	VER1.2
Software Version	V1.0.0
Dimensions (Approx.)	N/A
Weight (Approx.)	N/A

2.4 Technical Information

Network and Wireless connectivity	Bluetooth (BLE) 2.4G ISM Band

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
Tested Channel	Low (2402 MHz), Middle (2440 MHz), High (2480 MHz)
Antenna Type	PCB Antenna
Antenna Gain	1.87 dBi
Adaptive or non-adaptive	non-adaptive
The Max RF Output power	3.77 dBm
About the Product	The equipment is Mechanical Keyboard, it contains Bluetooth and 2.4G ISM Band Modules operating at 2.4 GHz ISM band. Only the 2.4G ISM Band (GFSK modulation) was tested in this report.

All channel was listed on the following table:

Channel Number	Frequency (MHz)	Channel Number	Frequency (MHz)	Channel Number	Frequency (MHz)	Channel Number	Frequency (MHz)
1	**2402**	11	2422	21	2442	31	2462
2	2404	12	2424	22	2444	32	2464
3	2406	13	2426	23	2446	33	2466
4	2408	14	2428	24	2448	34	2468
5	2410	15	2430	25	2450	35	2470
6	2412	16	2432	26	2452	36	2472
7	2414	17	2434	27	2454	37	2474
8	2416	18	2436	28	2456	38	2476
9	2418	19	2438	29	2458	39	2478
10	2420	**20**	**2440**	30	2460	**40**	**2480**

Note: The modulation is GFSK with FHSS, there are total 40 channels (frequency range is 2402-2480MHz, channel step is 2MHz, totally 40 channels), when this part works, it will choose 40 channels, each channel band width is 2MHz, if one channel is chosen, adjacent two channels cannot be chosen to make sure step of working channels is more than 2MHz.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	ANSI C63.10-2013	American National Standard for Testing Unlicensed Wireless Devices
3	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.	Test Result	Verdict
1	Antenna Requirement	15.203	--	Pass Note 1
2	Number of Hopping Frequency	15.247(a)	ANNEX A.1	Pass
3	Peak Output Power	15.247(b)	ANNEX A.2	Pass
4	Occupied Bandwidth	15.247(a)	ANNEX A.3	Pass
5	Hopping Frequency Separation	15.247(a)	ANNEX A.4	Pass
6	Time of Occupancy (Dwell time)	15.247(a)	ANNEX A.5	Pass
7	Conducted Spurious Emission& Authorized-band band-edge	15.247(d)	ANNEX A.6	Pass
8	Conducted Emission	15.207	ANNEX A.7	Pass
9	Radiated Spurious Emission	15.209 15.247(d)	ANNEX A.8	Pass
10	Band Edge (Restricted-band band-edge)	15.209 15.247(d)	ANNEX A.9	Pass
Note [1]: The EUT has a permanently and irreplaceable attached antenna, which complies with the requirement FCC 15.203.				

4 GENERAL TEST CONFIGURATIONS

4.1 Test Environments

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

Relative Humidity	40% to 67%	
Atmospheric Pressure	100 kPa to 102 kPa	
Temperature	NT (Normal Temperature)	20.1℃ to +25.9℃
Working Voltage of the EUT	NV (Normal Voltage)	3.7 V

4.2 Test Equipment List

Description	Manufacturer	Model	Serial No.	Cal. Date	Cal. Due
Spectrum Analyzer	ROHDE&SCHWARZ	FSV-40	101544	2023.12.27	2024.12.26
Spectrum Analyzer	KEYSIGHT	N9020A	MY50330200	2024.05.08	2025.05.07
Signaling Unit	ROHDE&SCHWARZ	CMW500	142028	2024.05.08	2025.05.07
Power Sensor	KEYSIGHT	U2063XA	MY58000247	2024.07.04	2025.07.03
Spectrum Analyzer	KEYSIGHT	N9020A	MY50531259	2024.08.01	2025.07.31
Test Antenna-Horn	SCHWARZBECK	BBHA 9120D	02460	2024.05.16	2027.05.15
Test Antenna-Horn	A-INFO	LB-180400KF	J211060273	2024.06.15	2027.06.14
Anechoic Chamber	RAINFORD	9m*6m*6m	140	2024.07.28	2027.07.27
Amplifier	COM-MV	LSCX_LNA1-12G-01	7210214	2024.08.01	2025.07.31
Amplifier	COM-MV	XKu_LNA7-18G-01	7210209	2024.08.01	2025.07.31
Amplifier	COM-MV	KA LNA18 40G-01	18050001	2023.12.06	2024.12.05
EMI Receiver	Agilent	N9038A	MY55330120	2024.08.01	2025.07.31
Test Antenna-Bi-Log	SCHWARZBECK	VULB 9168	9168-00867	2022.04.12	2025.04.11
Test Antenna-Loop	SCHWARZBECK	FMZB 1519	1519-037	2024.01.23	2025.01.22
Amplifier	COM-MV	ZT30-1000M	B2017119081	2023.12.05	2024.12.04
Anechoic Chamber	YiHeng	9m*6m*6m	142	2024.07.21	2027.07.20
EMI Receiver	KEYSIGHT	N9010B	MY57110309	2024.08.01	2025.07.31
LISN	SCHWARZBECK	NSLK 8127	8127-687	2024.05.09	2025.05.08
Shielded Enclosure	YiHeng Electronic Co., Ltd	3.5m*3.1m*2.8m	112	2022.02.19	2025.02.18
EMI Receiver	ROHDE&SCHWARZ	ESRP	101036	2024.08.01	2025.07.31
Test Antenna-Bi-Log	SCHWARZBECK	VULB 9168	9168-01162	2023.08.04	2026.08.03
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	2024.07.13	2027.07.12

4.3 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	V19.8.28.435	N/A	The section 4.5.2&4.5.3&4.5.4&4.5.5

4.4 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.

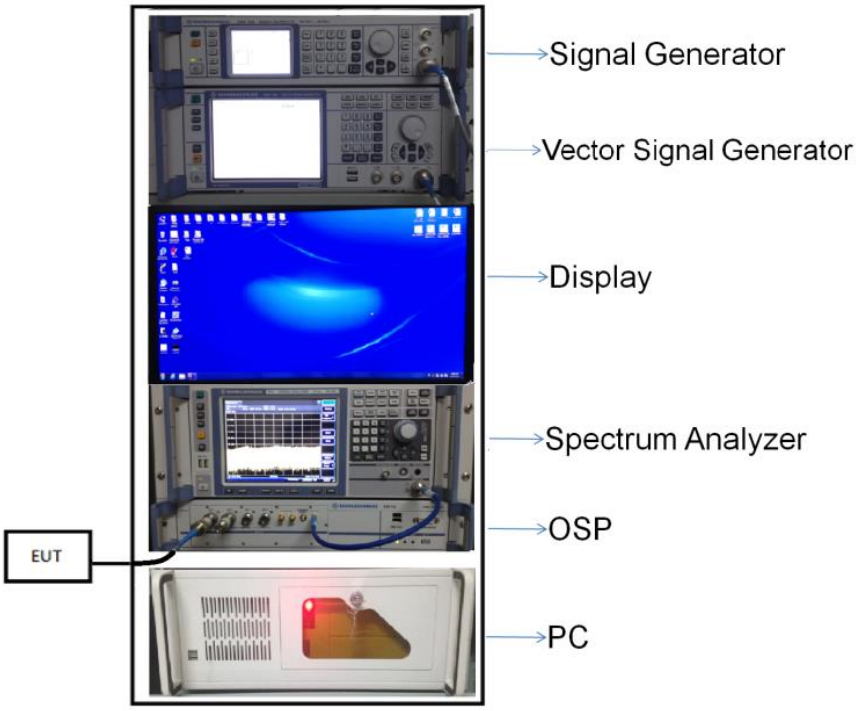
Parameters	Uncertainty
Occupied Channel Bandwidth	2.8%
RF output power, conducted	1.28 dB
Power Spectral Density, conducted	1.30 dB
Unwanted Emissions, conducted	1.84 dB
All emissions, radiated	5.36 dB
Temperature	0.8°C
Humidity	4%

4.5 Description of Test Setup

4.5.1 For Antenna Port Test

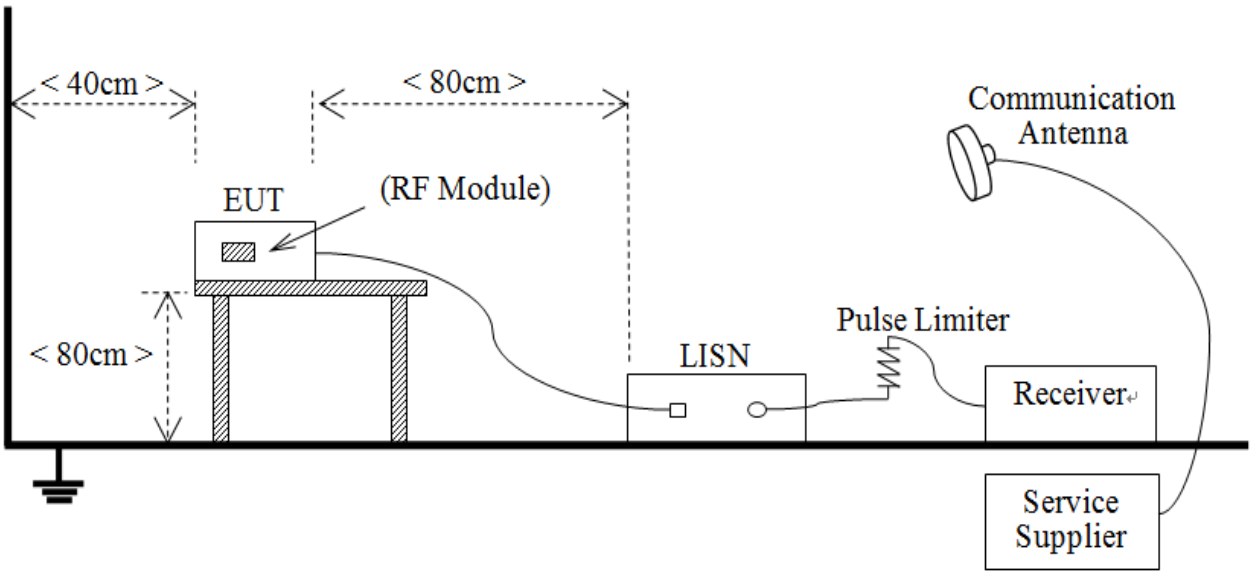
Conducted value (dBm) = Measurement value (dBm) + cable loss (dB)

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



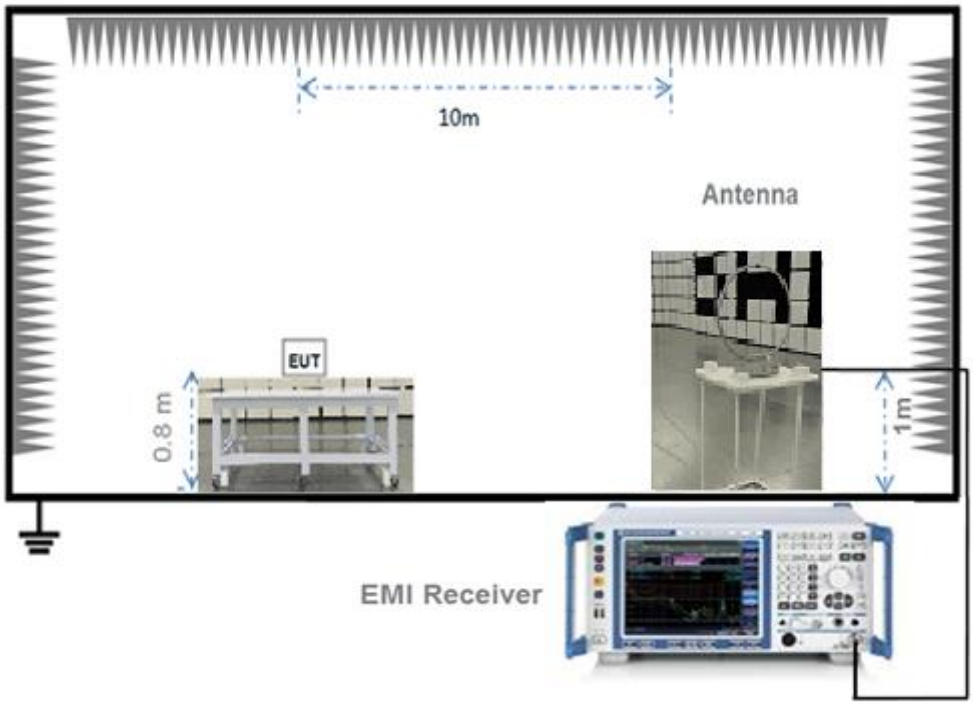
(Diagram 1)

4.5.2 For AC Power Supply Port Test



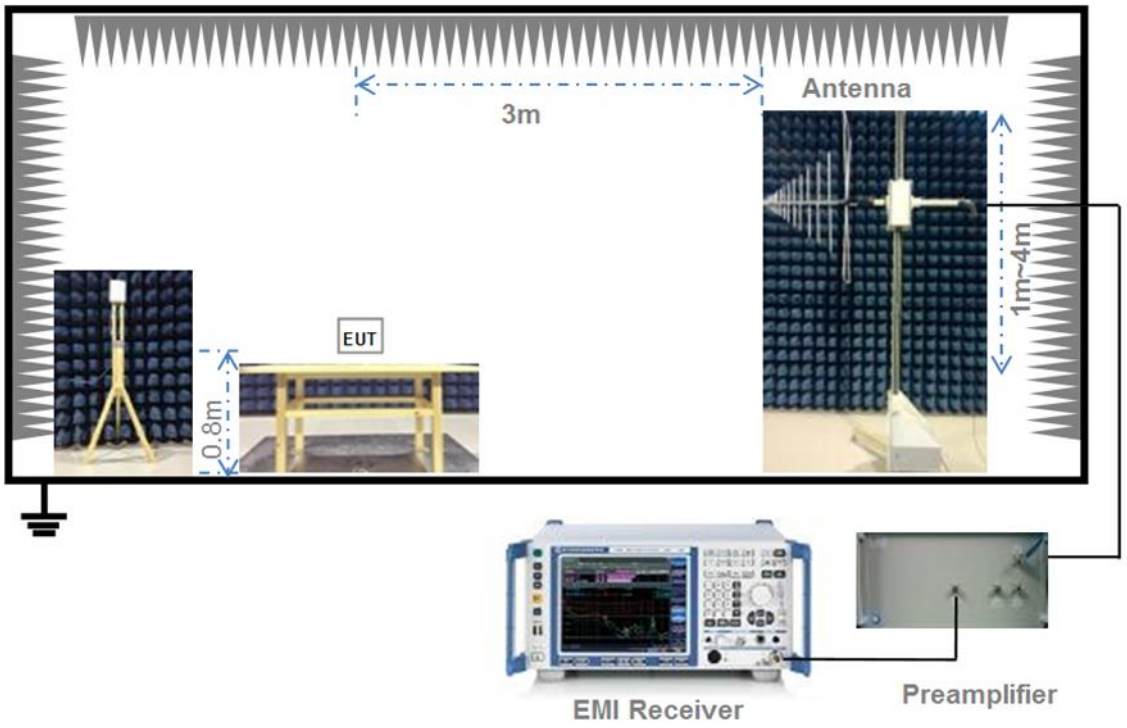
(Diagram 2)

4.5.3 For Radiated Test (Below 30 MHz)



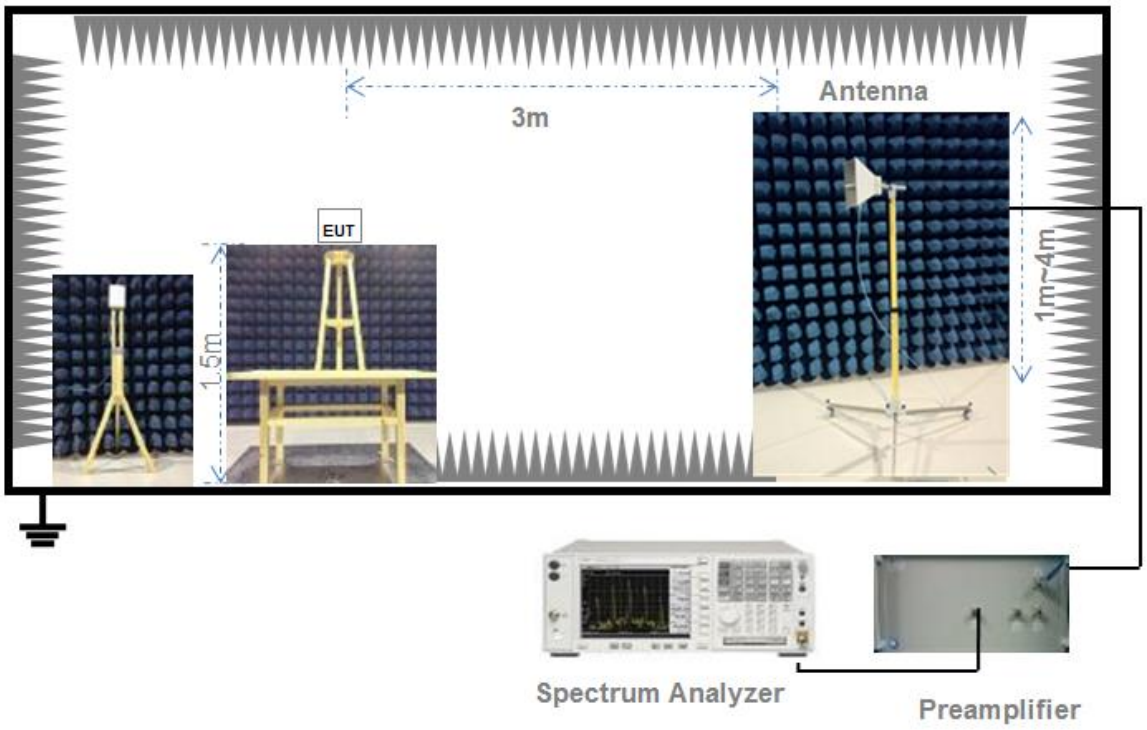
(Diagram 3)

4.5.4 For Radiated Test (30 MHz-1 GHz)



(Diagram 4)

4.5.5 For Radiated Test (Above 1 GHz)



(Diagram 5)

4.6 Measurement Results Explanation Example

4.6.1 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.

4.6.2 For radiated band edges and spurious emission test:

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

5 TEST ITEMS

5.1 Antenna Requirements

5.1.1 Relevant Standards

FCC §15.203 & 15.247(b)

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 Frequency

5.2.1 Limit

FCC §15.247(a) (1) (iii)

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 ≥ 1% of the span

VBW ≥ 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 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.

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 ≥ 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)

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 ≥ 1% of the 20 dB bandwidth

VBW ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

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

5.4.4 Test Result

Please refer to ANNEX A.3.

5.5 Carrier Frequency Separation

5.5.1 Limit

FCC §15.247(a)

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) ≥ 1% of the span

Video (or Average) Bandwidth (VBW) ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

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

5.5.4 Test Result

Please refer to ANNEX A.4.

5.6 Time of Occupancy (Dwell time)

5.6.1 Limit

FCC §15.247(a)

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:

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

{Period} = 0.4s * {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)

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 ≥ 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

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

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

5.8.2 Test Setup

See section 4.5.2 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)

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 ≥ 1 GHz, 100 kHz for f < 1 GHz
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold
For measurement below 1GHz, If the emission level of the EUT measured by the peak detector is 3 dB lower than the applicable limit, the peak emission level will be reported, Otherwise, the emission measurement will be repeated using the quasi-peak detector and reported.

5.9.4 Test Result

Please refer to ANNEX A.8.

5.10 Band Edge (Restricted-band band-edge)

5.10.1 Limit

FCC §15.209&15.247(d)

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

5.10.2 Test Setup

See section 4.5.3 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 ≥ 1 GHz, 100 kHz for f < 1 GHz
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

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

5.10.4 Test Result

Please refer to ANNEX A.9.

ANNEX A TEST RESULT

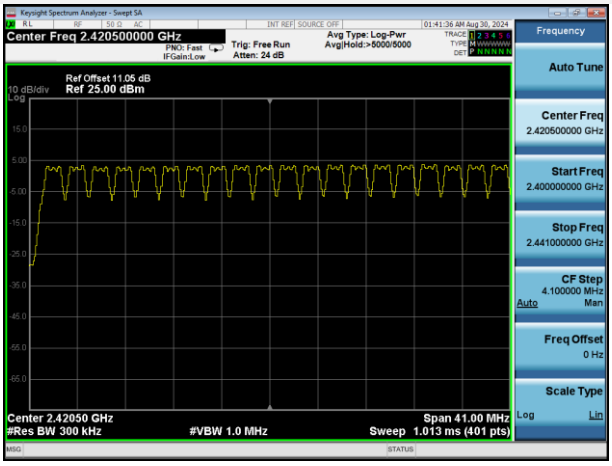
A.1 Number of Hopping Frequency

Test Data

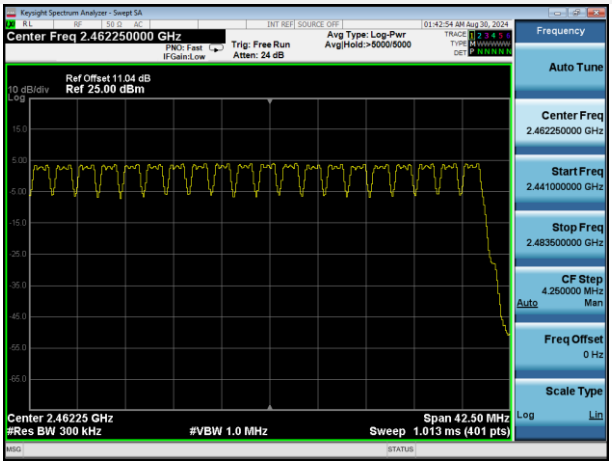
Test Mode	Frequency Block (MHz)	Measured Channel Numbers	Min. Limit	Verdict
GFSK	2400 - 2483.5	40	15	Pass

Test Plots

GFSK 2.4 GHz ~ 2.4835 GHz



GFSK 2.4 GHz ~ 2.4835 GHz



A.2 Peak Output Power

Peak Power Test Data

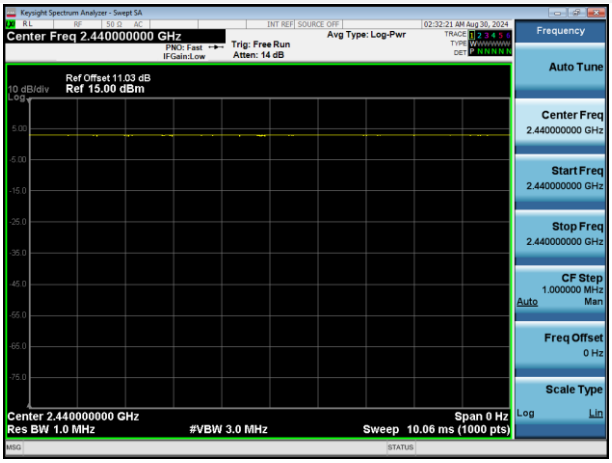
Channel	Measured Output Peak Power		Limit		Verdict
	dBm	mW	dBm	mW	
Low	3.40	2.19	30	1000	Pass
Middle	3.48	2.23			Pass
High	3.77	2.38			Pass

Duty Cycle Test Data

Band	On Time (ms)	On+Off Time (ms)	Duty Cycle (%)
GFSK	10.06	10.06	100

Test Plots

GFSK



A.3 Occupied Bandwidth

Test Data

Test Mode	GFSK	
Channel	20 dB Bandwidth (kHz)	99% Bandwidth (kHz)
Low Channel	2.347400	2.025800
Middle Channel	2.377700	2.039200
High Channel	2.362500	2.029100

Test Plots

20 dB Bandwidth

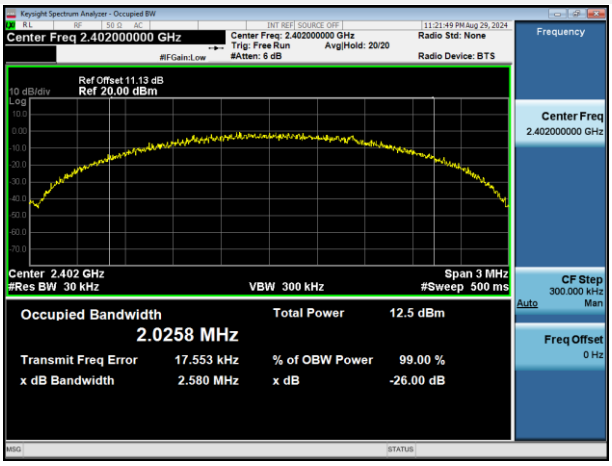
GFSK LOW CHANNEL

GFSK MIDDLE CHANNEL

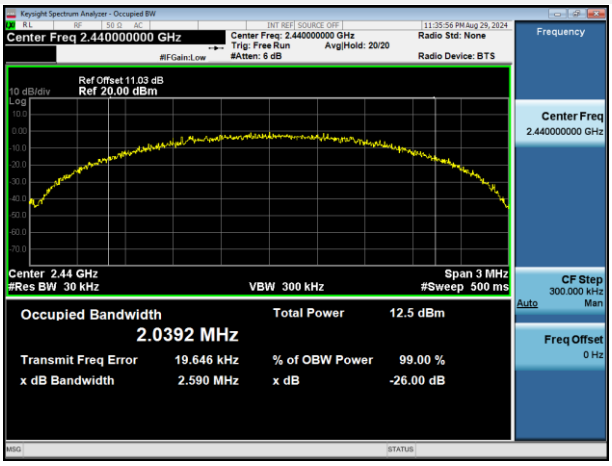
GFSK HIGH CHANNEL

99% Bandwidth

GFSK LOW CHANNEL



GFSK MIDDLE CHANNEL



GFSK HIGH CHANNEL

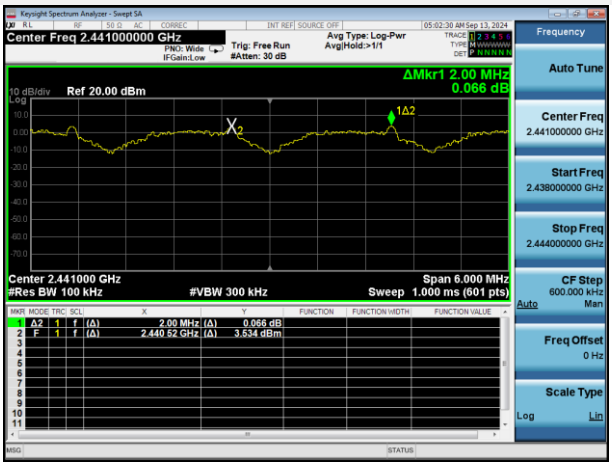
A.4 Hopping Frequency Separation

Test Data

Mode	Frequency separation (MHz)	2/3 of the 20 dB Bandwidth (MHz)	Verdict
GFSK	2.000	1.585	Pass

Test Plots

GFSK



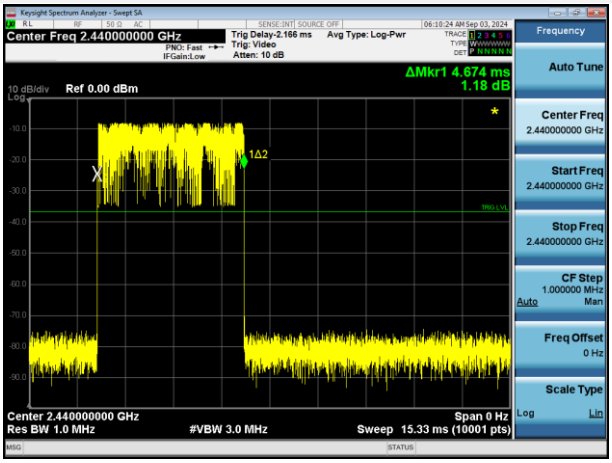
A.5 Time of Occupancy (Dwell time)

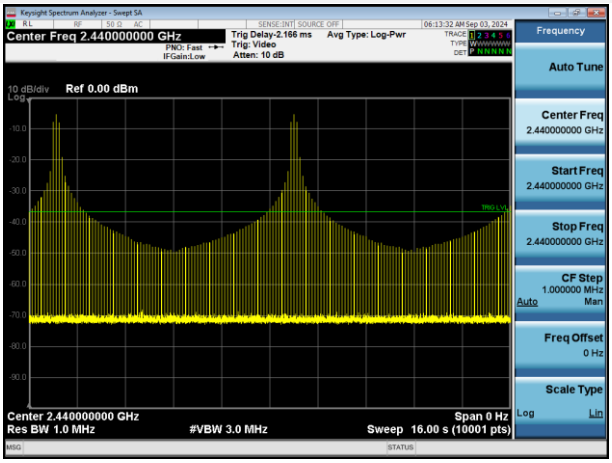
Test Data

GFSK			
Pulse Width (ms)	Total of Dwell (ms)	Limit (sec)	Verdict
4.67400	9.348	0.4	Pass

Test Plots

GFSK





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

Test Data

GFSK Mode:

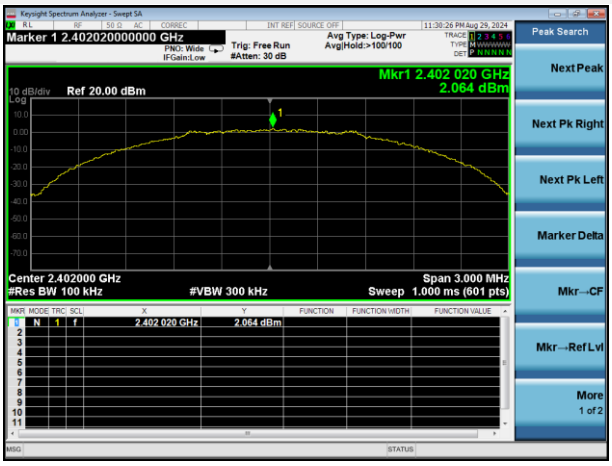
GFSK				
Channel	Measured Max. Out of Band Emission (dBm)	Limit (dBm)		Verdict
		Carrier Level	Calculated 20 dBc Limit	
Low	-31.51	2.06	-17.94	Pass
Middle	-32.08	2.14	-17.87	Pass
High	-33.74	3.65	-16.35	Pass

Hopping Mode:

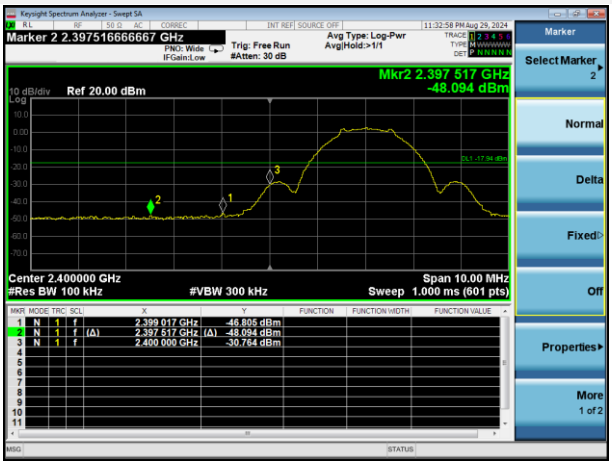
GFSK				
Channel	Measured Max. Out of Band Emission (dBm)	Limit (dBm)		Verdict
		Carrier Level	Calculated 20 dBc Limit	
GFSK	-28.67	4.07	-15.93	Pass

Test Plots

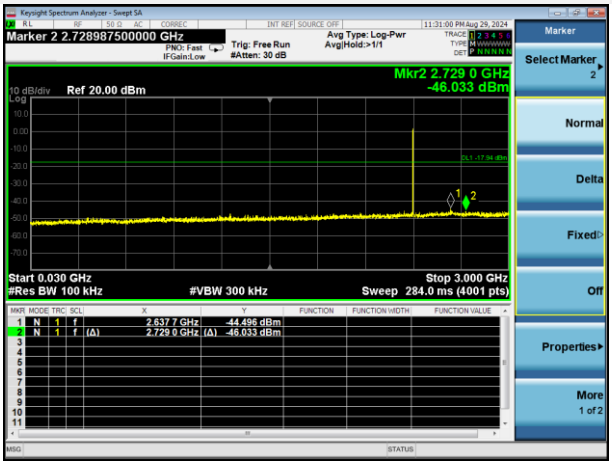
GFSK LOW CHANNEL, CARRIER LEVEL



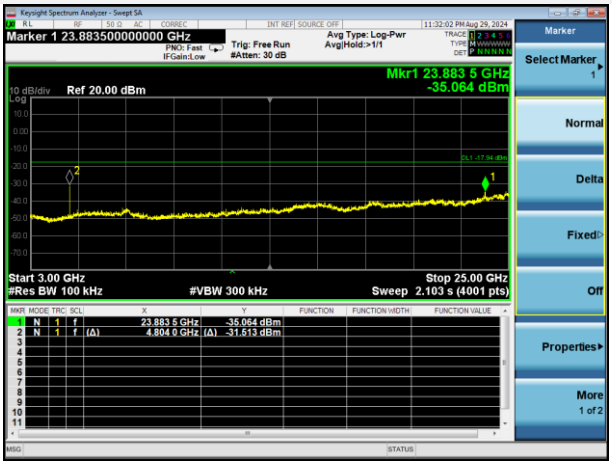
GFSK LOW CHANNEL, BAND EDGE



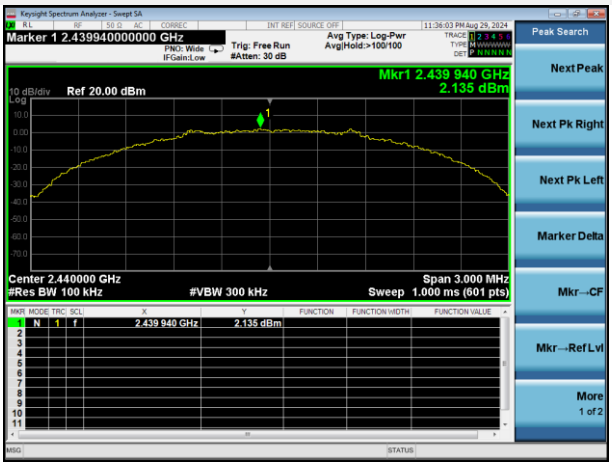
GFSK LOW CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



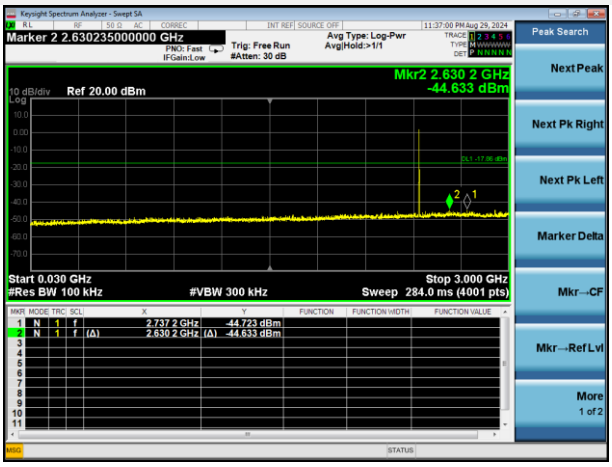
GFSK LOW CHANNEL, SPURIOUS 3 GHz ~ 25 GHz



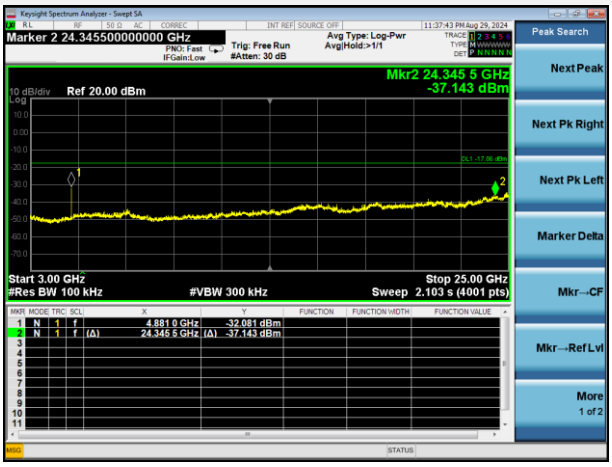
GFSK MIDDLE CHANNEL, CARRIER LEVEL



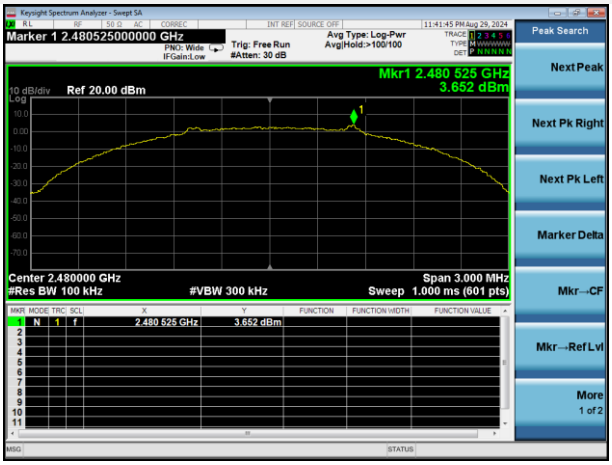
GFSK MIDDLE CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



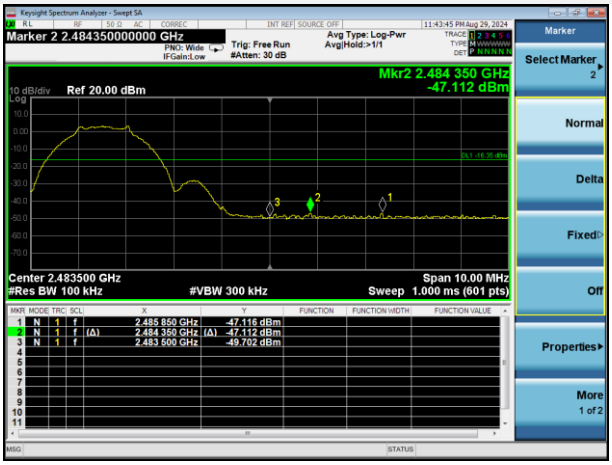
GFSK MIDDLE CHANNEL, SPURIOUS 3 GHz ~ 25 GHz



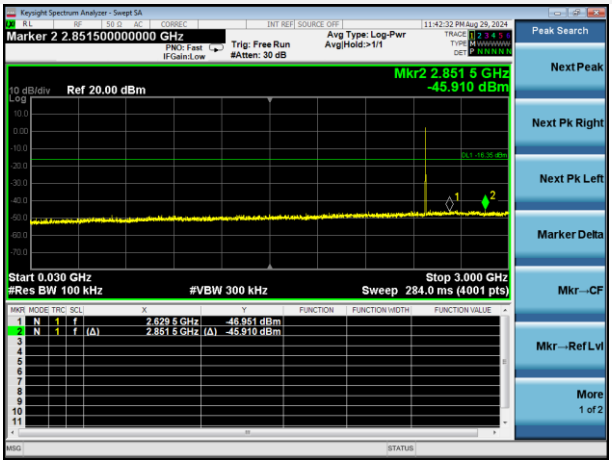
GFSK HIGH CHANNEL, CARRIER LEVEL



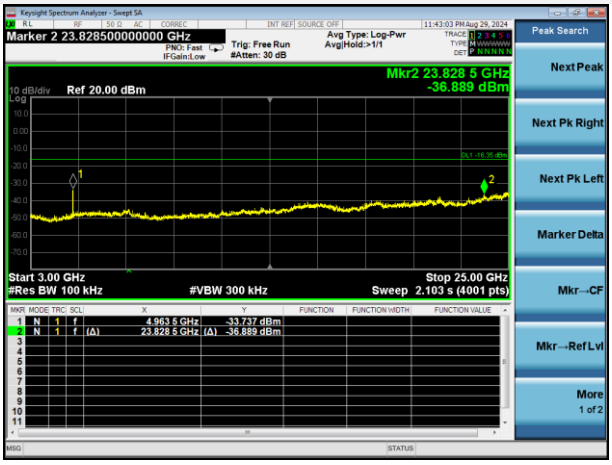
GFSK HIGH CHANNEL, BAND EDGE



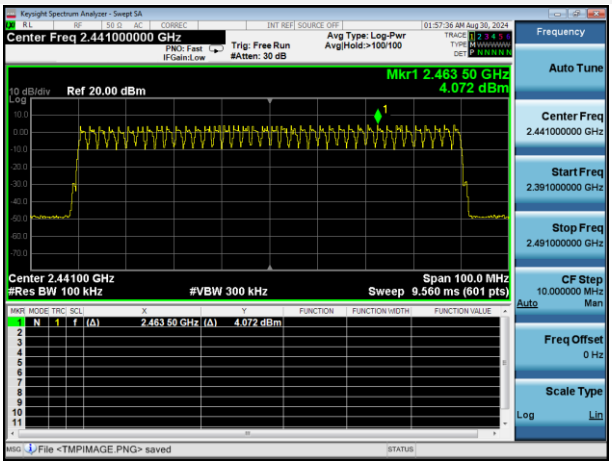
GFSK HIGH CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



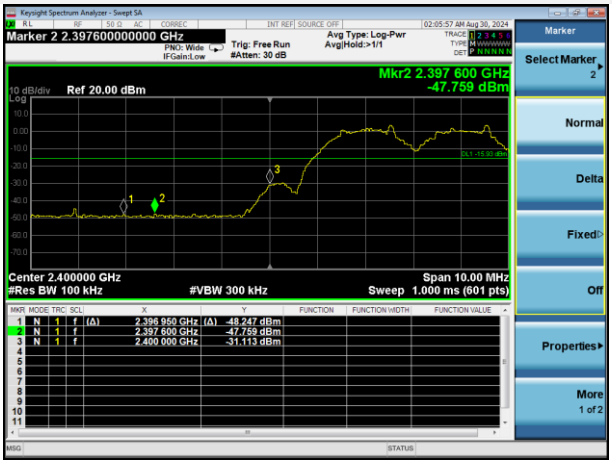
GFSK HIGH CHANNEL, SPURIOUS 3 GHz ~ 25 GHz



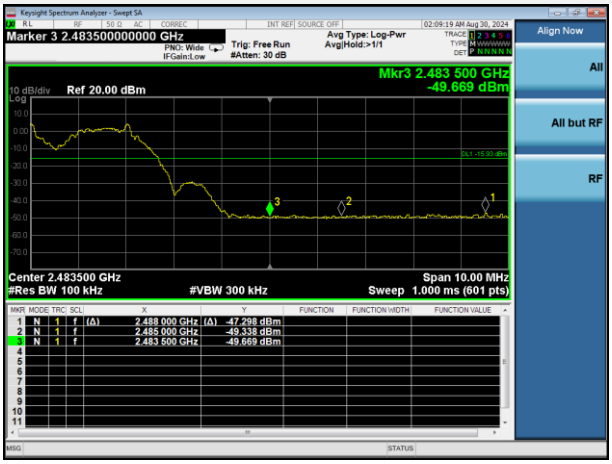
GFSK HOPPING, CARRIER LEVEL



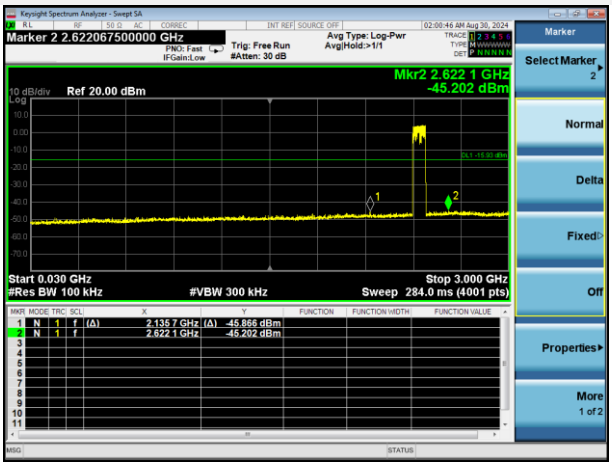
GFSK HOPPING BAND EDGE (LOW)



GFSK HOPPING BAND EDGE (HIGH)



GFSK Hopping Mode, SPURIOUS 30 MHz ~ 3 GHz



GFSK Hopping Mode, SPURIOUS 3GHz ~ 25 GHz

A.7 Conducted Emissions

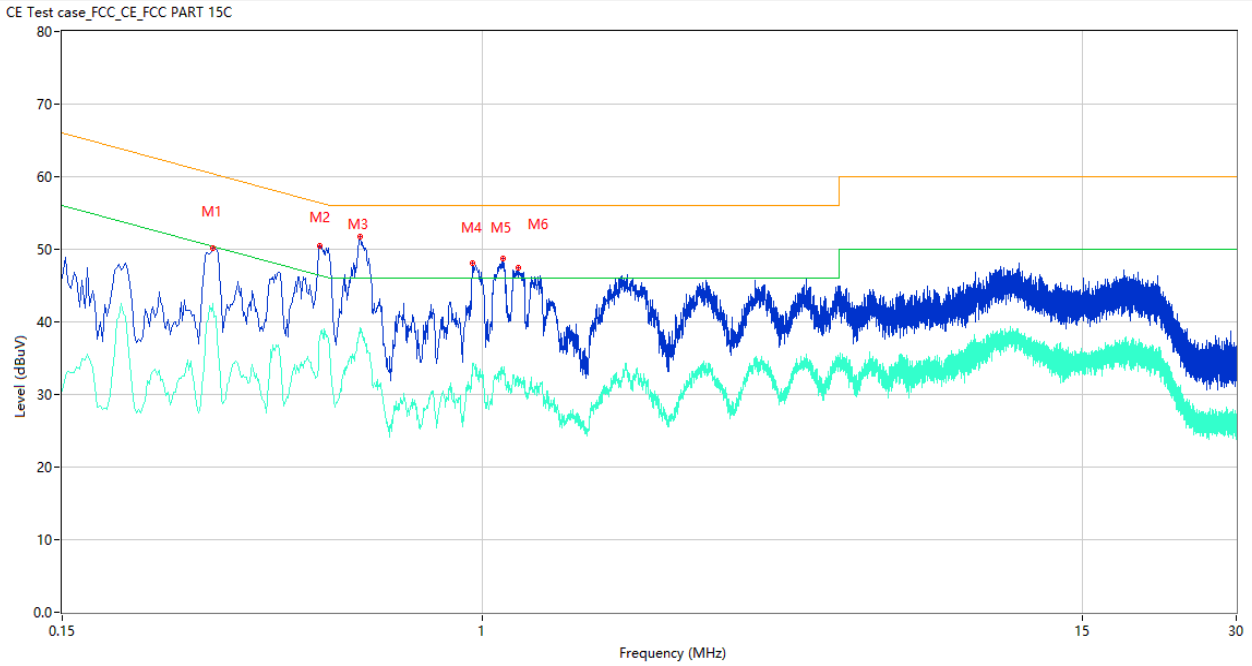
Note [1]: The EUT is working in the Normal link mode. All modes have been tested and normal link mode is worst.

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)

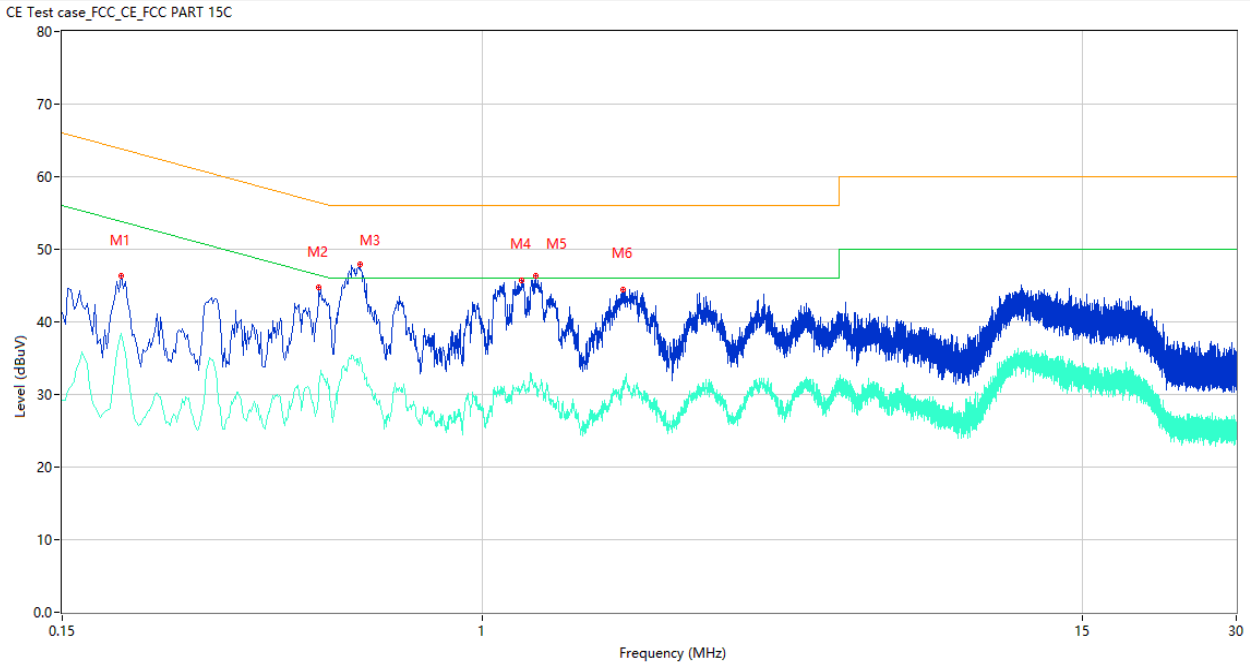
Test Data and Plots

PHASE L



No.	Frequency (MHz)	Results (dBuV)	Factor (dB)	Limit (dBuV)	Margin (dB)	Detector	Line	Verdict
1	0.296	50.17	9.76	60.35	10.18	Peak	L	Pass
1**	0.296	42.47	9.76	50.35	7.88	AV	L	Pass
2	0.480	50.50	10.00	56.34	5.84	Peak	L	Pass
2**	0.480	37.60	10.00	46.34	8.74	AV	L	Pass
3	0.574	51.80	10.09	56.00	4.20	Peak	L	Pass
3**	0.574	38.36	10.09	46.00	7.64	AV	L	Pass
4	0.956	48.05	10.05	56.00	7.95	Peak	L	Pass
4**	0.956	34.32	10.05	46.00	11.68	AV	L	Pass
5	1.098	48.66	10.00	56.00	7.34	Peak	L	Pass
5**	1.098	32.80	10.00	46.00	13.20	AV	L	Pass
6	1.174	47.52	10.15	56.00	8.48	Peak	L	Pass
6**	1.174	31.12	10.15	46.00	14.88	AV	L	Pass

PHASE N



No.	Frequency (MHz)	Results (dBuV)	Factor (dB)	Limit (dBuV)	Margin (dB)	Detector	Line	Verdict
1	0.196	46.29	9.77	63.78	17.49	Peak	N	Pass
1**	0.196	38.35	9.77	53.78	15.43	AV	N	Pass
2	0.478	44.69	10.00	56.37	11.68	Peak	N	Pass
2**	0.478	31.30	10.00	46.37	15.07	AV	N	Pass
3	0.574	47.87	10.09	56.00	8.13	Peak	N	Pass
3**	0.574	35.07	10.09	46.00	10.93	AV	N	Pass
4	1.192	45.64	9.97	56.00	10.36	Peak	N	Pass
4**	1.192	30.66	9.97	46.00	15.34	AV	N	Pass
5	1.270	46.43	10.47	56.00	9.57	Peak	N	Pass
5**	1.270	31.50	10.47	46.00	14.50	AV	N	Pass
6	1.888	44.48	10.63	56.00	11.52	Peak	N	Pass
6**	1.888	31.02	10.63	46.00	14.98	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.

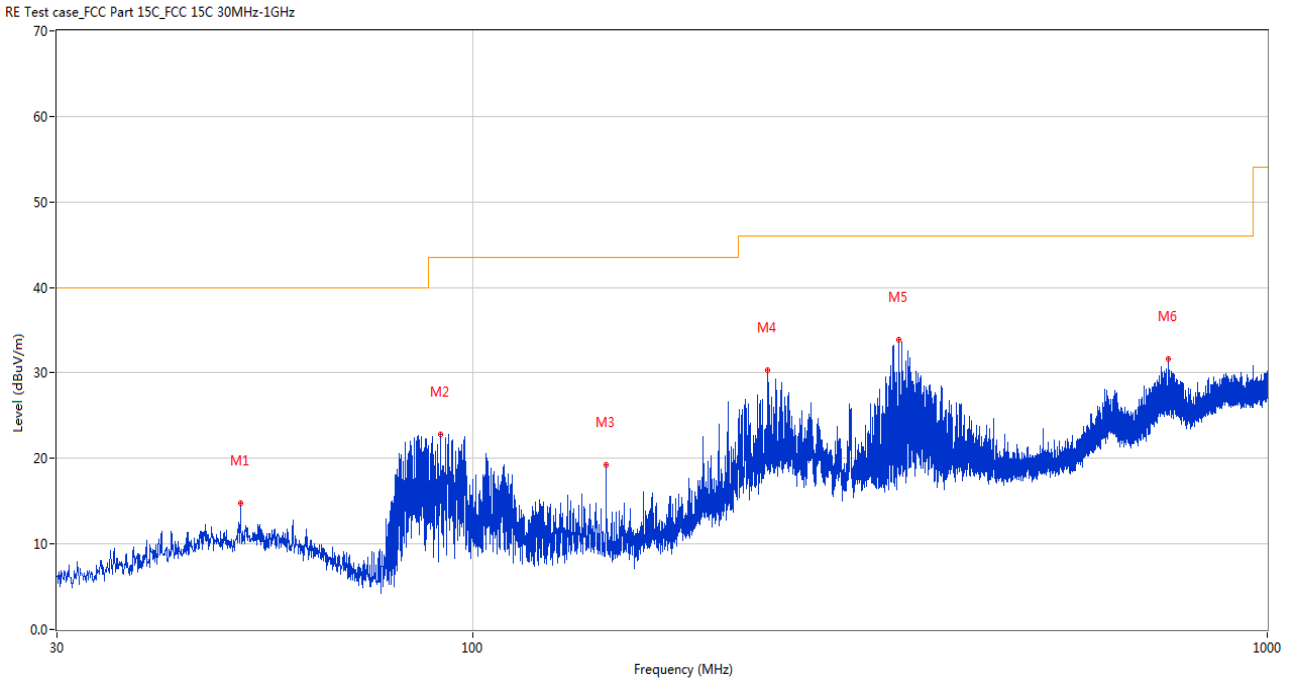
Note [3]: The EUT is working in the Normal link mode below 1 GHz. All modes have been tested and DH5-Hopping mode is the worst.

Note [4]: Results (dBuV/m) = Original reading level of Spectrum Analyzer (dBuV/m) + Factor (dB)

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.

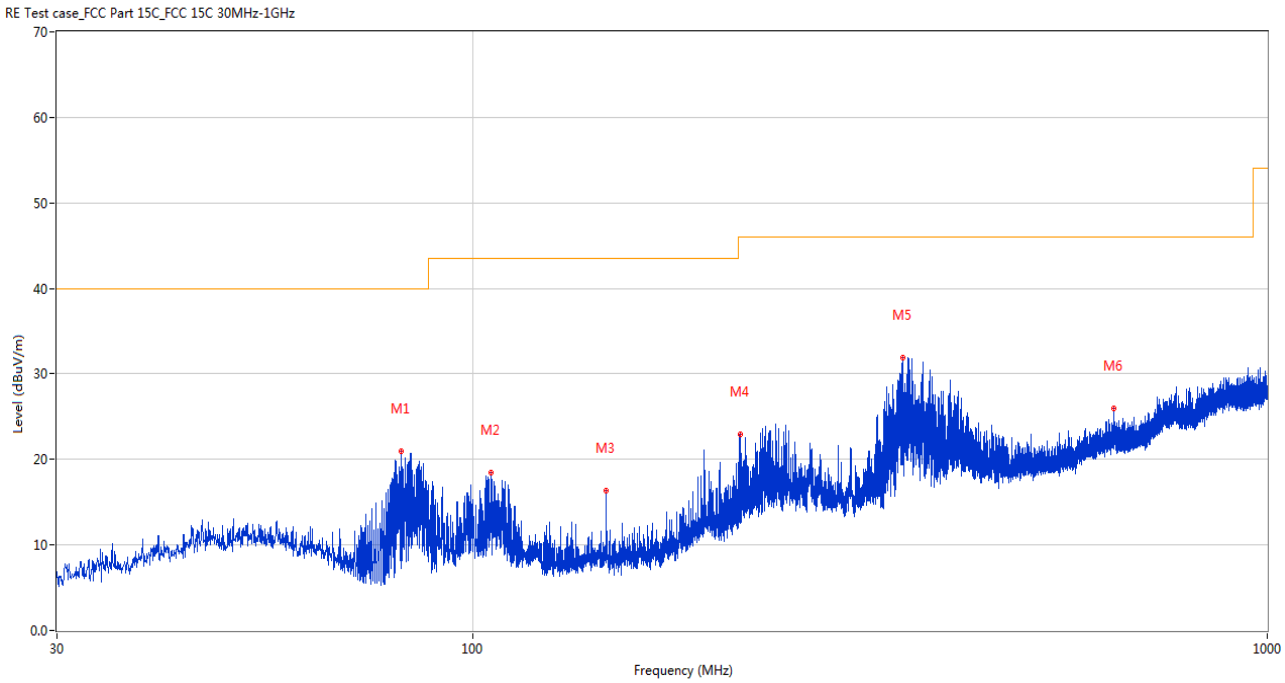
Test Data and Plots

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	51.097	14.80	-24.73	40.0	25.20	Peak	62.30	200	Horizontal	Pass
2	91.159	22.85	-28.20	43.5	20.65	Peak	84.60	200	Horizontal	Pass
3	147.322	19.30	-29.49	43.5	24.20	Peak	87.00	100	Horizontal	Pass
4	235.155	30.35	-24.80	46.0	15.65	Peak	87.00	100	Horizontal	Pass
5	343.552	33.83	-21.61	46.0	12.17	Peak	123.50	100	Horizontal	Pass
6	750.856	31.68	-12.15	46.0	14.32	Peak	130.90	100	Horizontal	Pass

30 MHz to 1 GHz, ANT V

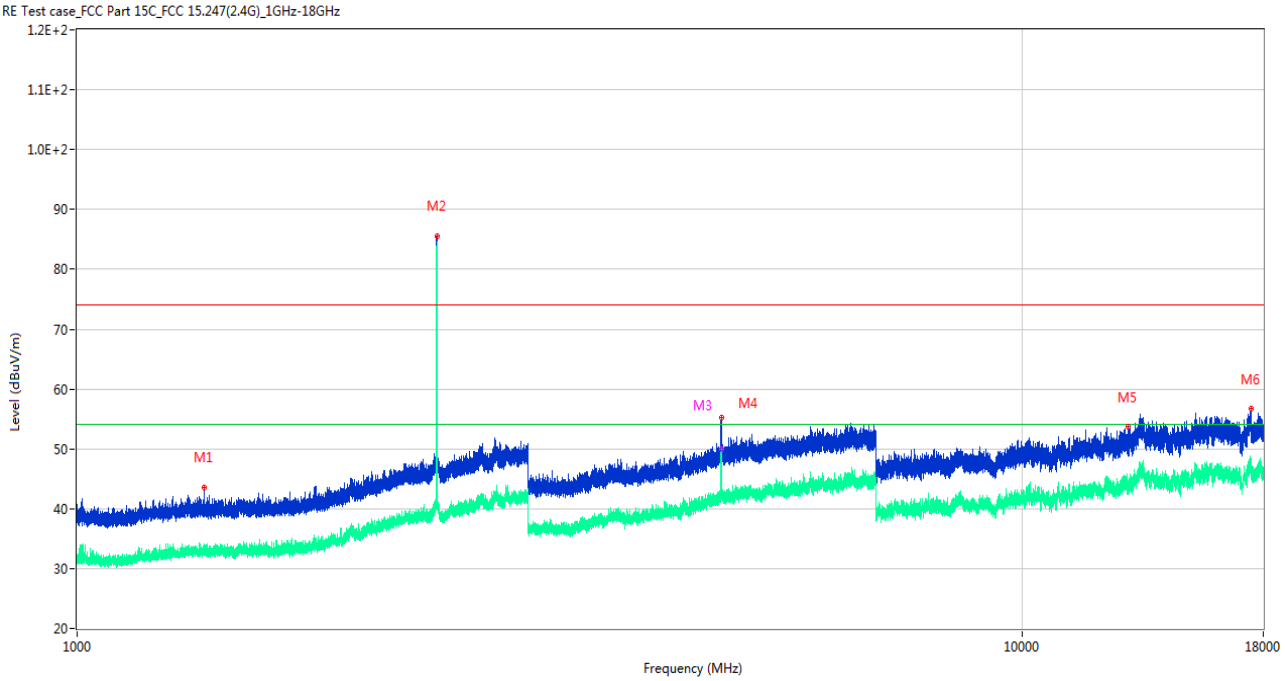


No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	81.362	20.99	-31.64	40.0	19.01	Peak	65.80	100	Vertical	Pass
2	105.466	18.44	-26.78	43.5	25.06	Peak	352.90	100	Vertical	Pass
3	147.273	16.36	-29.49	43.5	27.14	Peak	14.40	100	Vertical	Pass
4	216.968	22.93	-25.81	46.0	23.07	Peak	4.20	200	Vertical	Pass
5	347.966	31.95	-21.35	46.0	14.05	Peak	148.20	100	Vertical	Pass
6	641.100	25.99	-14.38	46.0	20.01	Peak	277.40	100	Vertical	Pass

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

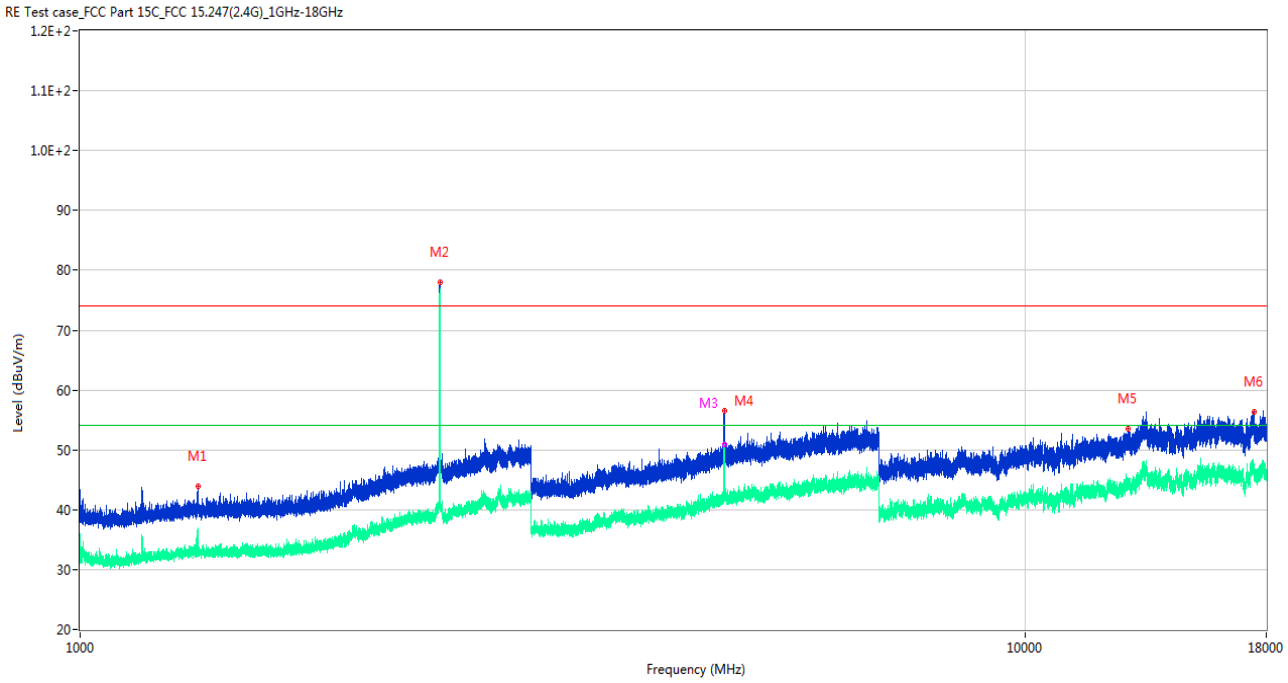
Note [2]: The spurious from 18GHz-25GHz is noise only, do not show on the report.

GFSK LOW CHANNEL 1 GHz to 18 GHz, ANT H



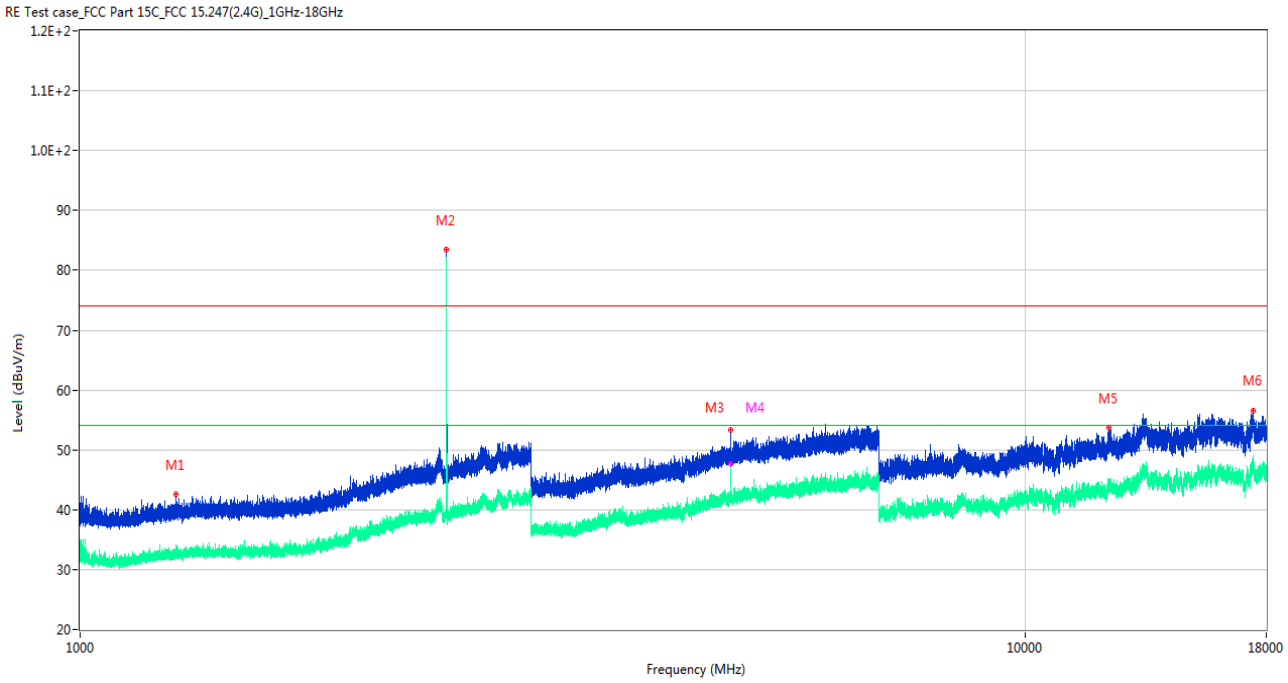
No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1361.800	43.56	-17.14	74.0	30.44	Peak	156.00	400	Horizontal	Pass
1**	1361.800	32.81	-17.14	54.0	21.19	AV	156.00	400	Horizontal	Pass
2	2402.500	85.63	-9.73	74.0	-11.63	Peak	208.00	150	Horizontal	N/A
2**	2402.500	84.14	-9.73	54.0	-30.14	AV	208.00	150	Horizontal	N/A
3	4803.400	54.16	-2.91	74.0	19.84	Peak	258.00	150	Horizontal	Pass
3**	4803.400	50.02	-2.91	54.0	3.98	AV	258.00	150	Horizontal	Pass
4	4805.200	55.24	-2.68	74.0	18.76	Peak	289.00	150	Horizontal	Pass
4**	4805.200	49.15	-2.68	54.0	4.85	AV	289.00	150	Horizontal	Pass
5	12950.813	53.63	0.91	74.0	20.37	Peak	33.00	400	Horizontal	Pass
5**	12950.813	42.70	0.91	54.0	11.30	AV	33.00	400	Horizontal	Pass
6	17480.511	56.64	2.72	74.0	17.36	Peak	168.00	200	Horizontal	Pass
6**	17480.511	47.01	2.72	54.0	6.99	AV	168.00	200	Horizontal	Pass

GFSK LOW CHANNEL 1 GHz to 18 GHz, ANT V



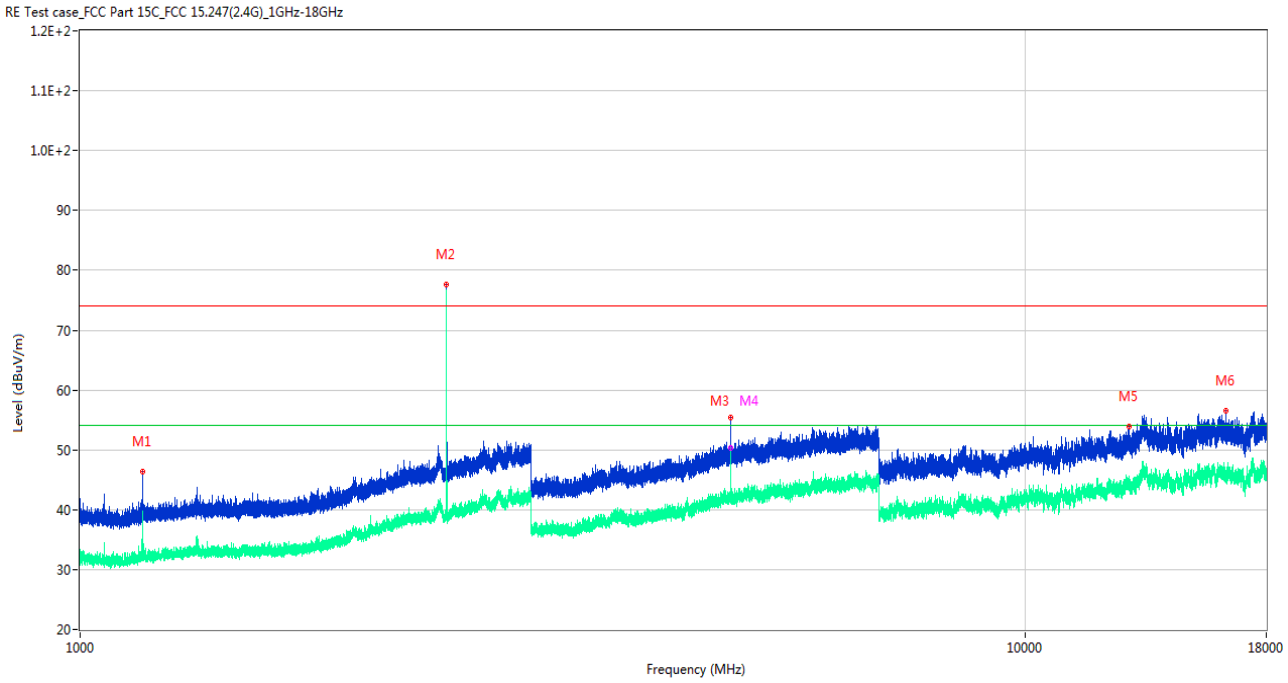
No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1331.900	43.98	-17.08	74.0	30.02	Peak	236.00	400	Vertical	Pass
1**	1331.900	33.52	-17.08	54.0	20.48	AV	236.00	400	Vertical	Pass
2	2402.500	78.01	-9.73	74.0	-4.01	Peak	8.00	100	Vertical	N/A
2**	2402.500	76.30	-9.73	54.0	-22.30	AV	8.00	100	Vertical	N/A
3	4803.400	54.63	-2.91	74.0	19.37	Peak	206.00	150	Vertical	Pass
3**	4803.400	50.85	-2.91	54.0	3.15	AV	206.00	150	Vertical	Pass
4	4805.000	56.50	-2.72	74.0	17.50	Peak	206.00	150	Vertical	Pass
4**	4805.000	50.60	-2.72	54.0	3.40	AV	206.00	150	Vertical	Pass
5	12841.088	53.58	1.33	74.0	20.42	Peak	69.00	400	Vertical	Pass
5**	12841.088	43.79	1.33	54.0	10.21	AV	69.00	400	Vertical	Pass
6	17472.901	56.34	2.86	74.0	17.66	Peak	218.00	300	Vertical	Pass
6**	17472.901	47.10	2.86	54.0	6.90	AV	218.00	300	Vertical	Pass

GFSK MIDDLE CHANNEL 1 GHz to 18 GHz, ANT H



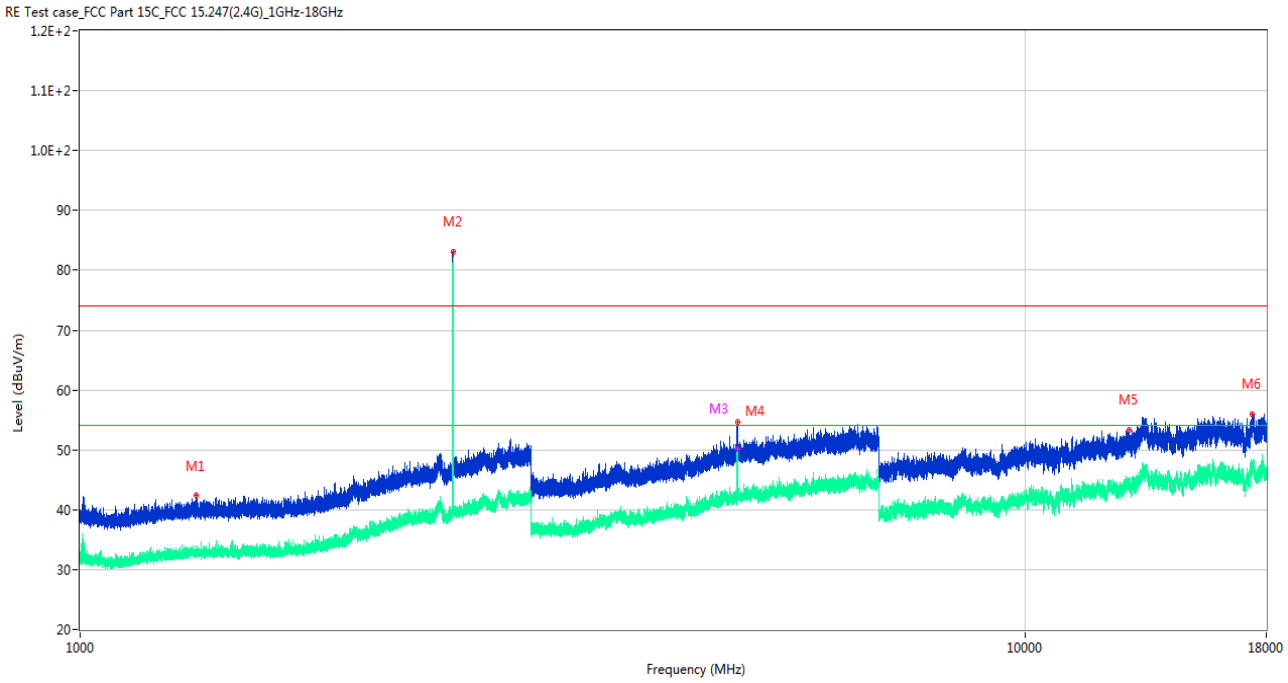
No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1263.500	42.55	-17.07	74.0	31.45	Peak	290.00	100	Horizontal	Pass
1**	1263.500	32.34	-17.07	54.0	21.66	AV	290.00	100	Horizontal	Pass
2	2441.500	83.39	-12.38	74.0	-9.39	Peak	191.00	100	Horizontal	N/A
2**	2441.500	81.70	-12.38	54.0	-27.70	AV	191.00	100	Horizontal	N/A
3	4881.000	53.35	-2.67	74.0	20.65	Peak	276.00	200	Horizontal	Pass
3**	4881.000	47.17	-2.67	54.0	6.83	AV	276.00	200	Horizontal	Pass
4	4882.800	52.97	-2.55	74.0	21.03	Peak	276.00	150	Horizontal	Pass
4**	4882.800	47.60	-2.55	54.0	6.40	AV	276.00	150	Horizontal	Pass
5	12276.775	53.64	1.68	74.0	20.36	Peak	253.00	400	Horizontal	Pass
5**	12276.775	43.67	1.68	54.0	10.33	AV	253.00	400	Horizontal	Pass
6	17448.749	56.55	2.83	74.0	17.45	Peak	349.00	300	Horizontal	Pass
6**	17448.749	47.61	2.83	54.0	6.39	AV	349.00	300	Horizontal	Pass

GFSK MIDDLE CHANNEL 1 GHz to 18 GHz, ANT V



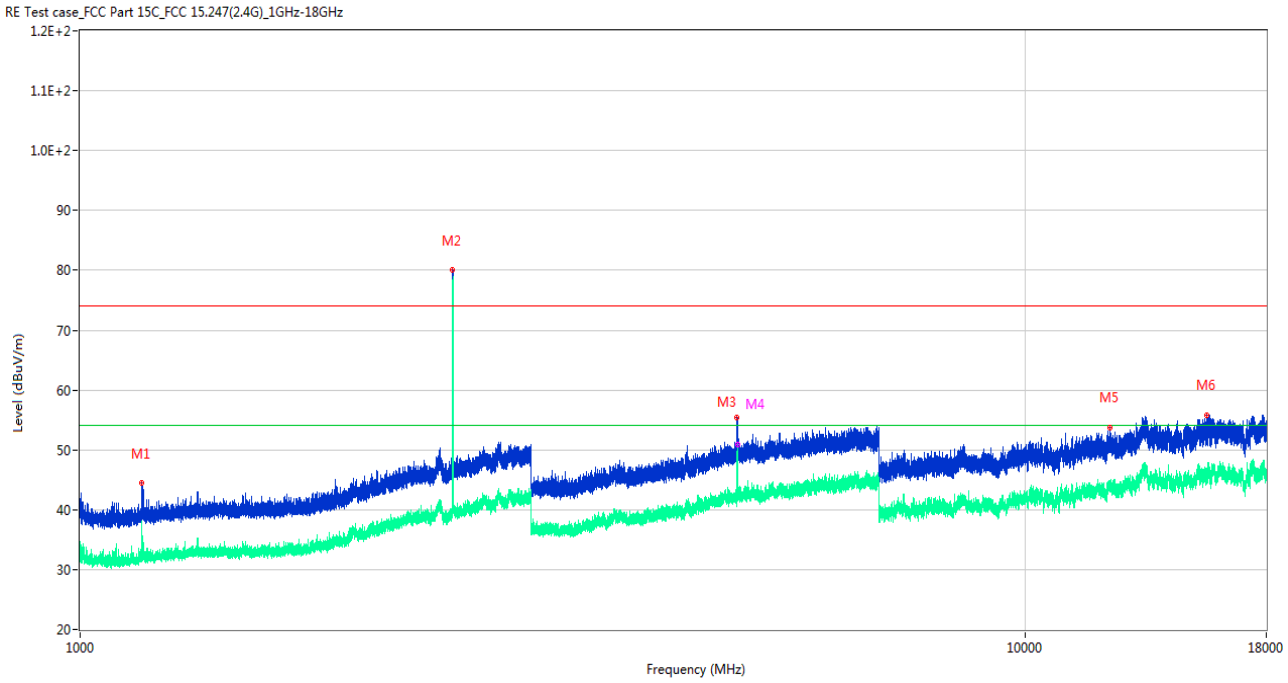
No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1165.800	46.37	-17.61	74.0	27.63	Peak	42.00	400	Vertical	Pass
1**	1165.800	35.82	-17.61	54.0	18.18	AV	42.00	400	Vertical	Pass
2	2440.600	77.66	-12.39	74.0	-3.66	Peak	186.00	200	Vertical	N/A
2**	2440.600	75.58	-12.39	54.0	-21.58	AV	186.00	200	Vertical	N/A
3	4881.000	55.48	-2.67	74.0	18.52	Peak	204.00	150	Vertical	Pass
3**	4881.000	49.05	-2.67	54.0	4.95	AV	204.00	150	Vertical	Pass
4	4881.400	53.17	-2.65	74.0	20.83	Peak	204.00	150	Vertical	Pass
4**	4881.400	50.26	-2.65	54.0	3.74	AV	204.00	150	Vertical	Pass
5	12898.050	53.91	1.51	74.0	20.09	Peak	164.00	200	Vertical	Pass
5**	12898.050	44.58	1.51	54.0	9.42	AV	164.00	200	Vertical	Pass
6	16312.388	56.56	1.31	74.0	17.44	Peak	314.00	200	Vertical	Pass
6**	16312.388	45.48	1.31	54.0	8.52	AV	314.00	200	Vertical	Pass

GFSK HIGH CHANNEL 1 GHz to 18 GHz, ANT H



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1327.800	42.37	-17.08	74.0	31.63	Peak	108.00	200	Horizontal	Pass
1**	1327.800	32.89	-17.08	54.0	21.11	AV	108.00	200	Horizontal	Pass
2	2480.500	83.17	-11.30	74.0	-9.17	Peak	195.00	200	Horizontal	N/A
2**	2480.500	81.05	-11.30	54.0	-27.05	AV	195.00	200	Horizontal	N/A
3	4959.400	53.57	-2.25	74.0	20.43	Peak	269.00	150	Horizontal	Pass
3**	4959.400	50.19	-2.25	54.0	3.81	AV	269.00	150	Horizontal	Pass
4	4961.000	54.61	-2.37	74.0	19.39	Peak	280.00	150	Horizontal	Pass
4**	4961.000	49.76	-2.37	54.0	4.24	AV	280.00	150	Horizontal	Pass
5	12874.951	53.38	1.50	74.0	20.62	Peak	270.00	300	Horizontal	Pass
5**	12874.951	44.22	1.50	54.0	9.78	AV	270.00	300	Horizontal	Pass
6	17398.614	55.99	3.13	74.0	18.01	Peak	360.00	300	Horizontal	Pass
6**	17398.614	47.85	3.13	54.0	6.15	AV	360.00	300	Horizontal	Pass

GFSK HIGH CHANNEL 1 GHz to 18 GHz, ANT V



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	1162.500	44.41	-17.60	74.0	29.59	Peak	83.00	200	Vertical	Pass
1**	1162.500	37.51	-17.60	54.0	16.49	AV	83.00	200	Vertical	Pass
2	2479.500	79.98	-11.38	74.0	-5.98	Peak	31.00	150	Vertical	N/A
2**	2479.500	77.66	-11.38	54.0	-23.66	AV	31.00	150	Vertical	N/A
3	4959.000	55.43	-2.29	74.0	18.57	Peak	195.00	100	Vertical	Pass
3**	4959.000	48.16	-2.29	54.0	5.84	AV	195.00	100	Vertical	Pass
4	4961.400	52.98	-2.43	74.0	21.02	Peak	9.00	150	Vertical	Pass
4**	4961.400	50.81	-2.43	54.0	3.19	AV	9.00	150	Vertical	Pass
5	12303.799	53.71	1.41	74.0	20.29	Peak	32.00	200	Vertical	Pass
5**	12303.799	43.51	1.41	54.0	10.49	AV	32.00	200	Vertical	Pass
6	15564.787	55.84	1.33	74.0	18.16	Peak	253.00	100	Vertical	Pass
6**	15564.787	45.55	1.33	54.0	8.45	AV	253.00	100	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.

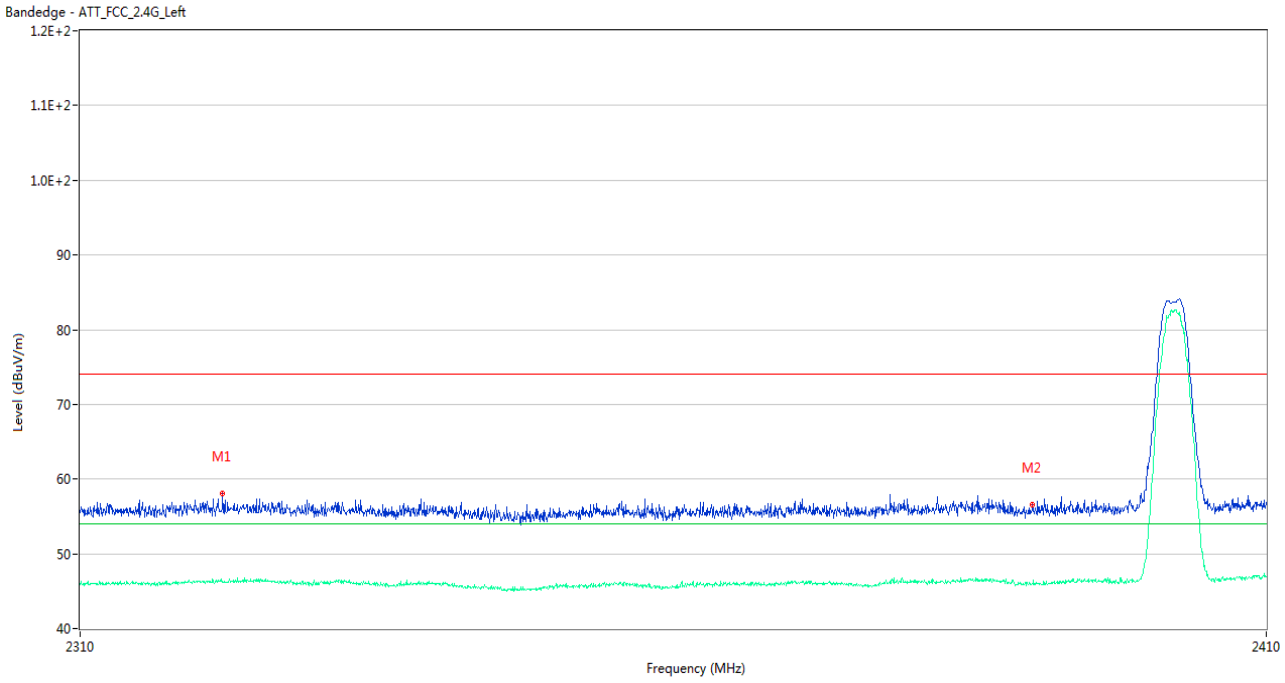
Note [2]: The test data all are tested in the vertical and horizontal antenna which the trace is max hold. So these plots have shown the worst case.

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.

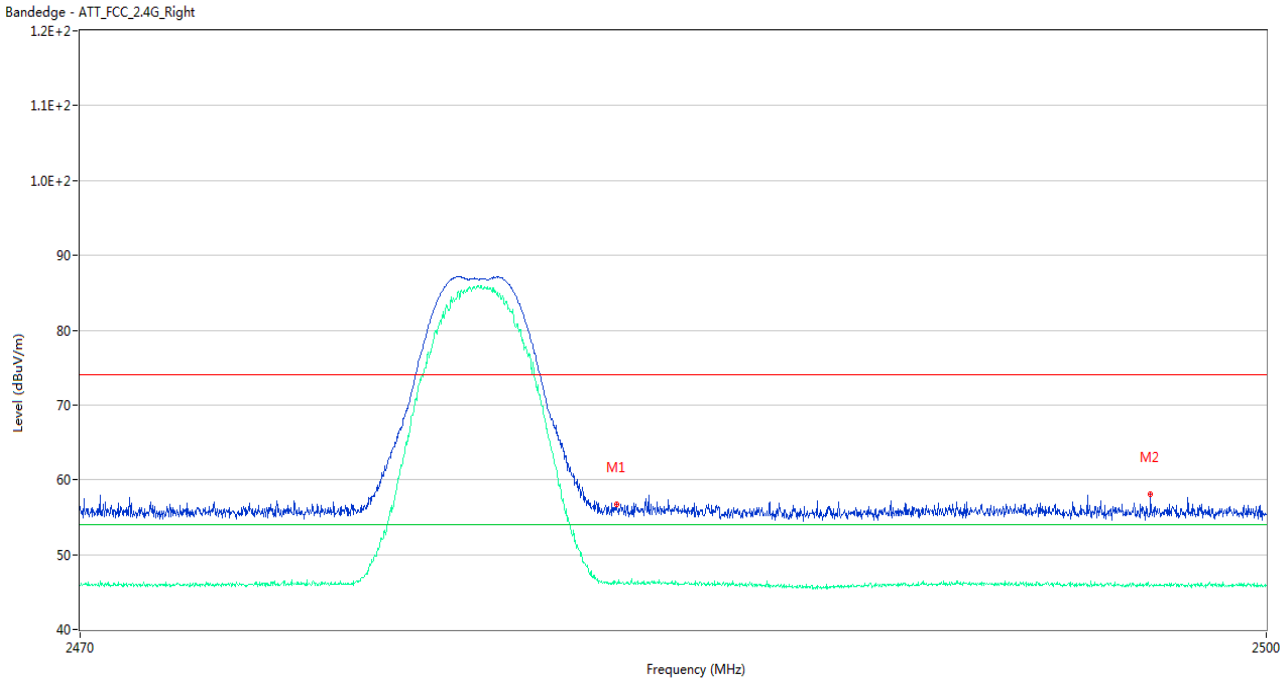
Test Data and Plots

GFSK LOW CHANNEL



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	2321.800	58.05	1.62	74.0	15.95	Peak	360.00	100	Horizontal	Pass
1**	2321.800	46.27	1.62	54.0	7.73	AV	360.00	100	Horizontal	Pass
2	2389.950	56.53	1.92	74.0	17.47	Peak	112.00	200	Horizontal	Pass
2**	2389.950	45.96	1.92	54.0	8.04	AV	112.00	200	Horizontal	Pass

GFSK HIGH CHANNEL



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (Degree)	Height (cm)	Antenna	Verdict
1	2483.515	56.66	2.11	74.0	17.34	Peak	265.00	200	Horizontal	Pass
1**	2483.515	46.23	2.11	54.0	7.77	AV	265.00	200	Horizontal	Pass
2	2497.060	58.06	1.69	74.0	15.94	Peak	55.00	200	Horizontal	Pass
2**	2497.060	45.95	1.69	54.0	8.05	AV	55.00	200	Horizontal	Pass

ANNEX B TEST SETUP PHOTOS

Please refer the document “BL-SZ2480794-AR.PDF”.

ANNEX C EUT EXTERNAL PHOTOS

Please refer the document “BL-SZ2480794-AW.PDF”.

ANNEX D EUT INTERNAL PHOTOS

Please refer the document “BL-SZ2480794-AI.PDF”.

Statement

1. The laboratory guarantees the scientificity, accuracy and impartiality of the test, and is responsible for all the information in the report, except the information provided by the customer. The customer is responsible for the impact of the information provided on the validity of the results.
2. The report without China inspection body and laboratory Mandatory Approval (CMA) mark has no effect of proving to the society.
3. For the report with CNAS mark or A2LA mark, the items marked with "☆" are not within the accredited scope.
4. This report is invalid if it is altered, without the signature of the testing and approval personnel, or without the “inspection and testing dedicated stamp” or test report stamp.
5. The test data and results are only valid for the tested samples provided by the customer.
6. This report shall not be partially reproduced without the written permission of the laboratory.
7. Any objection shall be raised to the laboratory within 30 days after receiving the report.

--END OF REPORT--