

TEST REPORT

Reference No...... : WTX23X08177364W001
FCC ID : 2ASIVIPGH123A
Applicant : PIN GENIE, INC. DBA LOCKLY
Address : 676 Transfer Rd., St. Paul, MN 55114
Manufacturer : Smart Electronic Industrial (Dong Guan) Co., Ltd.
Address : Qing Long Road, Long Jian Tian Village, Huang Jiang Town, Dong Guan,
Guang Dong, China
Product Name : VISION CONNECT
Model No...... : PGH123
Standards : FCC Part 15.247
Date of Receipt sample : 2023-08-14
Date of Test..... : 2023-08-14 to 2023-08-21
Date of Issue : 2023-08-21
Test Report Form No. : WTX_Part 15_247W
Test Result..... : **Pass**

Remarks:

The results shown in this test report refer only to the sample(s) tested, this test report cannot be reproduced, except in full, without prior written permission of the company. The report would be invalid without specific stamp of test institute and the signatures of approver.

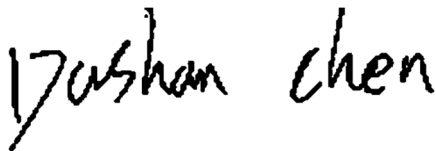
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Report version

Version No.	Date of issue	Description
Rev.00	2023-08-21	Original
/	/	/

1. GENERAL INFORMATION

1.1 Product Description for Equipment Under Test (EUT)

General Description of EUT	
Product Name:	VISION CONNECT
Trade Name:	LOCKLY
Model No.:	PGH123
Adding Model(s):	/
Rated Voltage:	DC5V
Power Adapter:	Model:617058 Input:AC100~240V-50/60Hz 0.15A Output:DC5V,1A
<i>Note: The test data is gathered from a production sample, provided by the manufacturer.</i>	

Technical Characteristics of EUT	
Frequency Range:	2403.01-2471.01MHz
RF Output Power:	18.25dBm (Conducted)
Modulation:	GFSK
Quantity of Channels:	18
Channel Separation:	4MHz
Type of Antenna:	External Antenna
Antenna Gain:	0.78dBi
<i>Note: The Antenna Gain is provided by the customer and can affect the validity of results.</i>	

1.2 Test Standards

The tests were performed according to following standards:

FCC Rules Part 15.247: Frequency Hopping, Direct Spread Spectrum and Hybrid Systems that are in operation within the bands of 902-928MHz, 2400-2483.5MHz, and 5725-5850MHz.

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.

ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices.

Maintenance of compliance is the responsibility of the manufacturer. Any modification of the product, which result in lowering the emission, should be checked to ensure compliance has been maintained.

1.3 Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013, The equipment under test (EUT) was configured to measure its highest possible emission level. The test modes were adapted accordingly in reference to the Operating Instructions.

1.4 Test Facility

Address of the test laboratory

Laboratory: Waltek Testing Group (Shenzhen) Co., Ltd.

Address: 1/F., Room 101, Building 1, Hongwei Industrial Park, Liuxian 2nd Road, Block 70 Bao'an District, Shenzhen, Guangdong, China

FCC – Registration No.: 125990

Waltek Testing Group (Shenzhen) Co., Ltd. EMC Laboratory has been registered and fully described in a report filed with the FCC (Federal Communications Commission). The acceptance letter from the FCC is maintained in our files. The Designation Number is CN5010, and Test Firm Registration Number is 125990.

Industry Canada (IC) Registration No.: 11464A

The 3m Semi-anechoic chamber of Waltek Testing Group (Shenzhen) Co., Ltd. has been registered by Certification and Engineering Bureau of Industry Canada for radio equipment testing with Registration No.: 11464A and the CAB identifier is CN0057.

1.5 EUT Setup and Test Mode

The EUT was operated in the engineering mode to fix the Tx frequency that was for the purpose of the measurements. All testing shall be performed under maximum output power condition, and to measure its highest possible emissions level, more detailed description as follows:

Test Mode List		
Test Mode	Description	Remark
TM1	Low Channel	2403.01MHz
TM2	Middle Channel	2439.01MHz
TM3	High Channel	2471.01MHz
TM4	Hopping	2403.01-2471.01MHz

Test Conditions	
Temperature:	22~25 °C
Relative Humidity:	45~55 %
ATM Pressure:	1019 mbar

EUT Cable List and Details			
Cable Description	Length (m)	Shielded/Unshielded	With / Without Ferrite
DC Cable	1.0	Unshielded	With Ferrite
Network cable	1.0	Unshielded	Without Ferrite

Special Cable List and Details			
Cable Description	Length (m)	Shielded/Unshielded	With / Without Ferrite
/	/	/	/

Auxiliary Equipment List and Details			
Description	Manufacturer	Model	Serial Number
Router	TP-LINK	TL-WR842N	/
Notebook	Lenovo	TianYi 100-14IBD	PF0F4ABV

1.6 Measurement Uncertainty

Measurement uncertainty		
Parameter	Conditions	Uncertainty
RF Output Power	Conducted	$\pm 0.42\text{dB}$
Occupied Bandwidth	Conducted	$\pm 1.5\%$
Conducted Spurious Emission	Conducted	$\pm 2.17\text{dB}$
Conducted Emissions	Conducted	9-150kHz $\pm 3.74\text{dB}$
		0.15-30MHz $\pm 3.34\text{dB}$
Transmitter Spurious Emissions	Radiated	30-200MHz $\pm 4.52\text{dB}$
		0.2-1GHz $\pm 5.56\text{dB}$
		1-6GHz $\pm 3.84\text{dB}$
		6-26GHz $\pm 3.92\text{dB}$

1.7 Test Equipment List and Details

Fixed asset Number	Description	Manufacturer	Model	Serial No.	Cal Date	Due. Date
WTXE1041A 1001	Communication Tester	Rohde & Schwarz	CMW500	148650	2023-02-25	2024-02-24
WTXE1022A 1002	GSM Tester	Rohde & Schwarz	CMU200	114403	2023-02-25	2024-02-24
WTXE1005A 1005	Spectrum Analyzer	Agilent	N9020A	US471401 02	2023-02-25	2024-02-24
WTXE1084A 1001	Spectrum Analyzer	Agilent	N9020A	MY543205 48	2023-02-25	2024-02-24
WTXE1044A 1001	Signal Generator	Agilent	83752A	3610A014 53	2023-02-25	2024-02-24
WTXE1045A 1001	Vector Signal Generator	Agilent	N5182A	MY470702 02	2023-02-25	2024-02-24
WTXE1018A 1001	Power Divider	Weinschel	1506A	PM204	2023-02-25	2024-02-24
WTXE1045A 1001	Power Divider	RF-Lambda	RFLT4W5M18G	14110400 027	2023-02-25	2024-02-24
☐ Chamber A: Below 1GHz						
WTXE1005A 1003	Spectrum Analyzer	Rohde & Schwarz	FSP30	836079/03 5	2023-02-25	2024-02-24
WTXE1007A 1001	EMI Test Receiver	Rohde & Schwarz	ESVB	825471/00 5	2023-02-25	2024-02-24
WTXE1007A 1001	Amplifier	HP	8447F	2805A034 75	2023-02-25	2024-02-24
WTXE1010A 1007	Loop Antenna	Schwarz beck	FMZB 1516	9773	2021-03-20	2024-03-19
WTXE1010A 1006	Broadband Antenna	Schwarz beck	VULB9163	9163-333	2023-03-20	2026-03-19
☐ Chamber A: Above 1GHz						
WTXE1005A 1003	Spectrum Analyzer	Rohde & Schwarz	FSP30	836079/03 5	2023-02-25	2024-02-24
WTXE1007A 1001	EMI Test Receiver	Rohde & Schwarz	ESVB	825471/00 5	2023-02-25	2024-02-24
WTXE1065A 1001	Amplifier	C&D	PAP-1G18	14918	2023-02-25	2024-02-24
WTXE1010A 1005	Horn Antenna	ETS	3117	00086197	2021-03-19	2024-03-18
WTXE1010A 1010	DRG Horn Antenna	A.H. SYSTEMS	SAS-574	571	2021-03-19	2024-03-18

WTXE1003A 1001	Pre-amplifier	Schwarzbeck	BBV 9721	9721-031	2023-02-25	2024-02-24
☐ Chamber B:Below 1GHz						
WTXE1010A 1006	Trilog Broadband Antenna	Schwarz beck	VULB9163(B)	9163-635	2021-04-09	2024-04-08
WTXE1038A 1001	Amplifier	Agilent	8447D	2944A101 79	2023-02-25	2024-02-24
WTXE1001A 1002	EMI Test Receiver	Rohde & Schwarz	ESPI	101391	2023-02-25	2024-02-24
☒ Chamber C:Below 1GHz						
WTXE1093A 1001	EMI Test Receiver	Rohde & Schwarz	ESIB 26	100401	2023-02-25	2024-02-24
WTXE1010A 1013-1	Trilog Broadband Antenna	Schwarz beck	VULB 9168	1194	2021-05-28	2024-05-27
WTXE1010A 1007	Loop Antenna	Schwarz beck	FMZB 1516	9773	2021-03-20	2024-03-19
WTXE1007A 1002	Amplifier	HP	8447F	2944A038 69	2023-02-25	2024-02-24
☒ Chamber C: Above 1GHz						
WTXE1093A 1001	EMI Test Receiver	Rohde & Schwarz	ESIB 26	100401	2023-02-25	2024-02-24
WTXE1103A 1005	Horn Antenna	POAM	RTF-11A	LP228060 221	2023-03-10	2026-03-09
WTXE1103A 1006	Amplifier	Tonscend	TAP01018050	AP22E806 235	2023-02-25	2024-02-24
WTXE1010A 1010	DRG Horn Antenna	A.H. SYSTEMS	SAS-574	571	2021-03-19	2024-03-18
WTXE1003A 1001	Pre-amplifier	Schwarzbeck	BBV 9721	9721-031	2023-02-25	2024-02-24
☒ Conducted Room 1#						
WTXE1001A 1001	EMI Test Receiver	Rohde & Schwarz	ESPI	101611	2023-02-25	2024-02-24
WTXE1002A 1001	Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100911	2023-02-25	2024-02-24
WTXE1003A 1001	AC LISN	Schwarz beck	NSLK8126	8126-224	2023-02-25	2024-02-24
☐ Conducted Room 2#						
WTXE1001A 1004	EMI Test Receiver	Rohde & Schwarz	ESPI	101259	2023-02-25	2024-02-24
WTXE1003A	LISN	Rohde &	ENV 216	100097	2023-02-25	2024-02-24

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1003		Schwarz				
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Software List			
Description	Manufacturer	Model	Version
EMI Test Software (Radiated Emission)*	Farad	EZ-EMC	RA-03A1
EMI Test Software (Conducted Emission)*	Farad	EZ-EMC	RA-03A1

*Remark: indicates software version used in the compliance certification testing.

2. SUMMARY OF TEST RESULTS

FCC Rules	Description of Test Item	Result
§15.203; §15.247(b)(4)(i)	Antenna Requirement	Compliant
§15.205	Restricted Band of Operation	Compliant
§15.207(a)	Conducted Emission	N/A
§15.209(a)	Radiated Spurious Emissions	Compliant
§15.247(a)(1)(iii)	Quantity of Hopping Channel	Compliant
§15.247(a)(1)	Channel Separation	Compliant
§15.247(a)(1)(iii)	Time of Occupancy (Dwell time)	Compliant
§15.247(a)	20dB Bandwidth	Compliant
§15.247(b)(1)	RF Power Output	Compliant
§15.247(d)	Band Edge (Out of Band Emissions)	Compliant
§15.247(a)(1)	Frequency Hopping Sequence	Compliant
§15.247(g), (h)	Frequency Hopping System	Compliant

N/A: Not applicable.

3 Antenna Requirement

3.1 Standard Applicable

According to FCC Part 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

3.2 Evaluation Information

This product has an External Antenna, fulfill the requirement of this section.

4. Frequency Hopping System Requirements

4.1 Standard Applicable

According to FCC Part 15.247(a)(1), the system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(g) Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

(h) The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

4.2 Frequency Hopping System

This transmitter device is frequency hopping device, and complies with FCC part 15.247 rule.

This device uses transmitter radio which operates in 2400-2483.5MHz band. It uses a radio technology called frequency-hopping spread spectrum, which chops up the data being sent and transmits chunks of it on up to 18 bands (4MHz each; centred from 2403.01 to 2471.0MHz) in the range 2,400-2,483.5MHz.

This device was tested with a system receiver to check that the device maintained hopping synchronization, and the device complied with these requirements for 558074 D01 15.247 Meas Guidance v05r02 and FCC Part 15.247 rule.

4.3 EUT Pseudorandom Frequency Hopping Sequence

Pseudorandom Frequency Hopping Sequence Table as below:

Channel: 4, 10, 14, 15, 16, 14, 11, 15, 6, 8, 4, 1, 3, 13, 14, 17, 6, 14, 7, 18, 11, 6, 13, 12, 2, 11, 5, 3, 17, 11, 12, 18, 13, 7, 5, 2, 7, 6, 13, 14, 8, 10, 14, 15, 17, 4, 1, 11, 10, 11, 18, 6, 17, 11, 1, 4, 18, 5, 11, 12, 16, 15, 2, 17, 13, 9, 10, 15, 5, 1, 18, 12, 1, 6 etc.

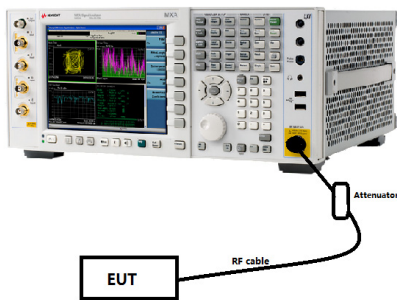
The system receiver have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchronization with the transmitted signals.

5. Quantity of Hopping Channels and Channel Separation

5.1 Standard Applicable

According to FCC 15.247(a)(1), frequency hopping systems operating in the 2400-2483.5MHz band may have hopping channel carrier frequencies that are separated by 25kHz or two-thirds of the 20dB bandwidth of the hopping channel, and frequency hopping systems in the 2400-2483.5MHz band shall use at least 15 channels.

5.2 Test Setup Block Diagram



5.3 Test Procedure

According to KDB 558074 D01 v05r02 Subclause 9 and ANSI C63.10-2013 section 7.8.3, the number of hopping frequencies test method as follows.

- a) Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
- b) RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- c) VBW $\geq$ RBW.
- d) Sweep: Auto.
- e) Detector function: Peak.
- f) Trace: Max hold.
- g) Allow the trace to stabilize.

According to KDB 558074 D01 v05r02 Subclause 9 and ANSI C63.10-2013 section 7.8.2, the EUT shall have its hopping function enabled, the Carrier frequency separation test method as follows:

- a) Span: Wide enough to capture the peaks of two adjacent channels.
- b) RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
- c) Video (or average) bandwidth (VBW) $\geq$ RBW.
- d) Sweep: Auto.

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e) Detector function: Peak.

f) Trace: Max hold.

g) Allow the trace to stabilize.

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

5.4 Summary of Test Results/Plots

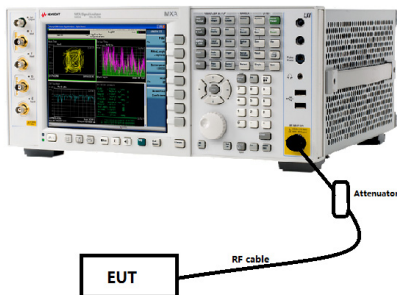
Please refer to Appendix A

6. Dwell Time of Hopping Channel

6.1 Standard Applicable

According to 15.247(a)(1)(iii), frequency hopping systems in the 2400–2483.5MHz band shall use at least 15 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.

6.2 Test Setup Block Diagram



6.3 Test Procedure

According to KDB 558074 D01 v05r02 Subclause 9 and ANSI C63.10-2013 section 7.8.4, the dwell time of a hopping channel test method as follows.

- Span: Zero span, centered on a hopping channel.
- RBW shall be $\leq$ channel spacing and where possible RBW should be set $\gg 1/T$, where T is the expected dwell time per channel.
- Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
- Detector function: Peak.
- Trace: Max hold.

Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time.

Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements. Determine the number of hops over the sweep time and calculate the total number of hops in the period specified in the requirements, using the following equation:

$$(\text{Number of hops in the period specified in the requirements}) = (\text{number of hops on spectrum analyzer}) \times (\text{period specified in the requirements} / \text{analyzer sweep time})$$

The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops

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in the period specified in the requirements. If the number of hops in a specific time varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation.

The measured transmit time and time between hops shall be consistent with the values described in the operational description for the EUT.

6.4 Summary of Test Results/Plots

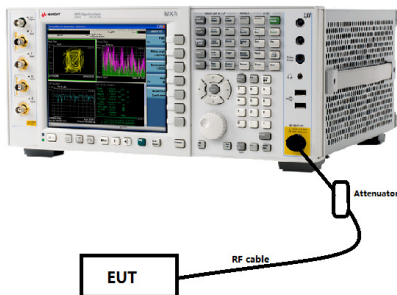
Please refer to Appendix B

7. 20dB Bandwidth

7.1 Standard Applicable

According to 15.247(a) and 15.215(c), 20dB bandwidth is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

7.2 Test Setup Block Diagram



7.3 Test Procedure

According to KDB 558074 D01 v05r02 Subclause 9 and ANSI C63.10-2013 section 6.9.2, the 20dB bandwidth test method as follows.

- The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The span range for the EMI receiver or spectrum analyzer shall be between two times and five times the OBW.
- The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW and video bandwidth (VBW) shall be approximately three times RBW, unless otherwise specified by the applicable requirement.
- Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than $[10 \log (\text{OBW}/\text{RBW})]$ below the reference level.
- Steps a) through c) might require iteration to adjust within the specified tolerances.
- The dynamic range of the instrument at the selected RBW shall be more than 10 dB below the target “-xx dB down” requirement; that is, if the requirement calls for measuring the -20 dB OBW, the instrument noise floor at the selected RBW shall be at least 30 dB below the reference value.
- Set detection mode to peak and trace mode to max hold.
- Determine the reference value: Set the EUT to transmit an unmodulated carrier or modulated signal, as applicable. Allow the trace to stabilize. Set the spectrum analyzer marker to the highest level of the displayed trace (this is the reference value).
- Determine the “-xx dB down amplitude” using $[(\text{reference value}) - \text{xx}]$. Alternatively, this calculation may be made by using the marker-delta function of the instrument.
- If the reference value is determined by an unmodulated carrier, then turn the EUT modulation ON, and either clear the existing trace or start a new trace on the spectrum analyzer and allow the new trace to

stabilize. Otherwise, the trace from step g) shall be used for step j).

j) Place two markers, one at the lowest frequency and the other at the highest frequency of the envelope of the spectral display, such that each marker is at or slightly below the “-xx dB down amplitude” determined in step h). If a marker is below this “-xx dB down amplitude” value, then it shall be as close as possible to this value. The occupied bandwidth is the frequency difference between the two markers. Alternatively, set a marker at the lowest frequency of the envelope of the spectral display, such that the marker is at or slightly below the “-xx dB down amplitude” determined in step h). Reset the marker-delta function and move the marker to the other side of the emission until the delta marker amplitude is at the same level as the reference marker amplitude. The marker-delta frequency reading at this point is the specified emission bandwidth.

k) The occupied bandwidth shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

7.4 Summary of Test Results/Plots

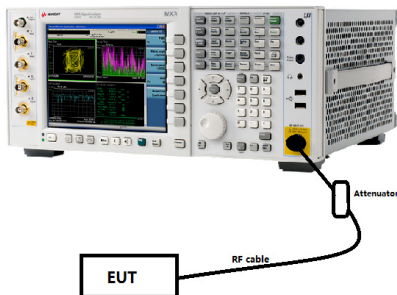
Please refer to Appendix C

8. RF Output Power

8.1 Standard Applicable

According to 15.247(b)(1), for frequency hopping systems operating in the 2400–2483.5MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725–5850MHz band: 1 watt. For all other frequency hopping systems in the 2400–2483.5MHz band: 0.125 watts.

8.2 Test Setup Block Diagram



8.3 Test Procedure

According to KDB 558074 D01 v05r02 Subclause 9 and ANSI C63.10-2013 section 7.8.5, the output power test method as follows.

Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.

This is an RF-conducted test to evaluate maximum peak output power. Use a direct connection between the antenna port of the unlicensed wireless device and the spectrum analyzer, through suitable attenuation. The hopping shall be disabled for this test:

- a) Use the following spectrum analyzer settings:
 - 1) Span: Approximately five times the 20dB bandwidth, centered on a hopping channel.
 - 2) RBW > 20dB bandwidth of the emission being measured.
 - 3) VBW $\geq$ RBW.
 - 4) Sweep: Auto.
 - 5) Detector function: Peak.
 - 6) Trace: Max hold.
- b) Allow trace to stabilize.
- c) Use the marker-to-peak function to set the marker to the peak of the emission.
- d) The indicated level is the peak output power, after any corrections for external attenuators and cables.
- e) A plot of the test results and setup description shall be included in the test report.

8.4 Summary of Test Results/Plots

Please refer to Appendix D

9. Field Strength of Spurious Emissions

9.1 Standard Applicable

According to §15.247(d), in any 100kHz 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 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30dB instead of 20dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a).

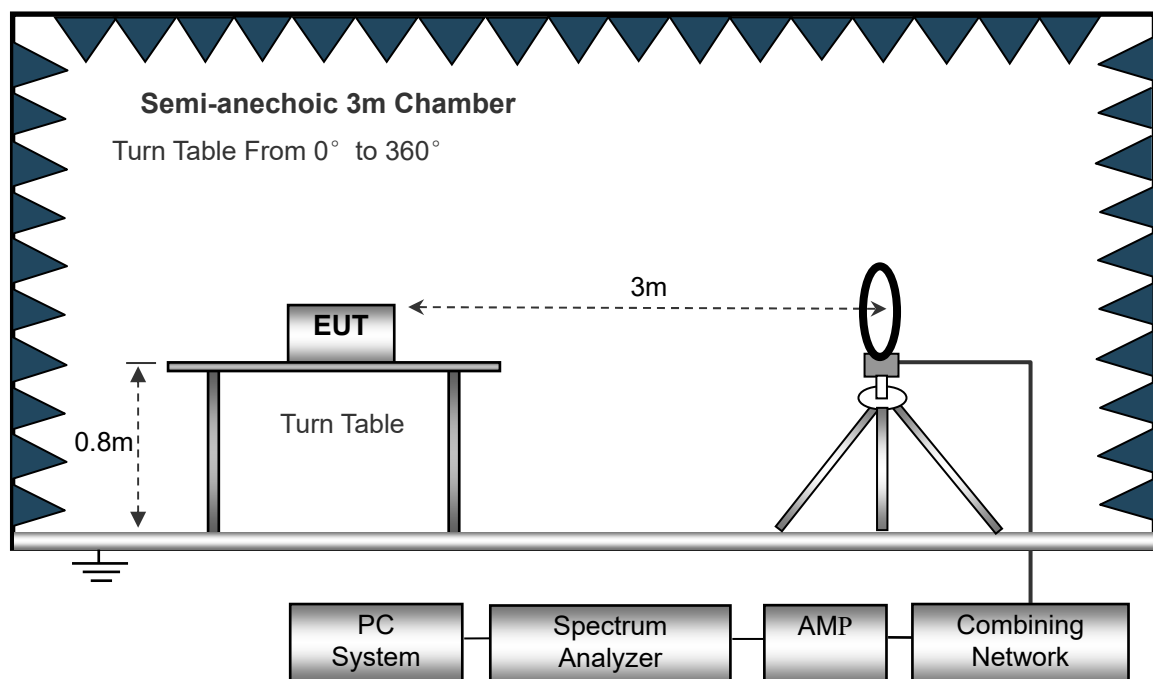
The emission limit in this paragraph is based on measurement instrumentation employing an average detector. The provisions in §15.35 for limiting peak emissions apply. Spurious Radiated Emissions measurements starting below or at the lowest crystal frequency.

9.2 Test Procedure

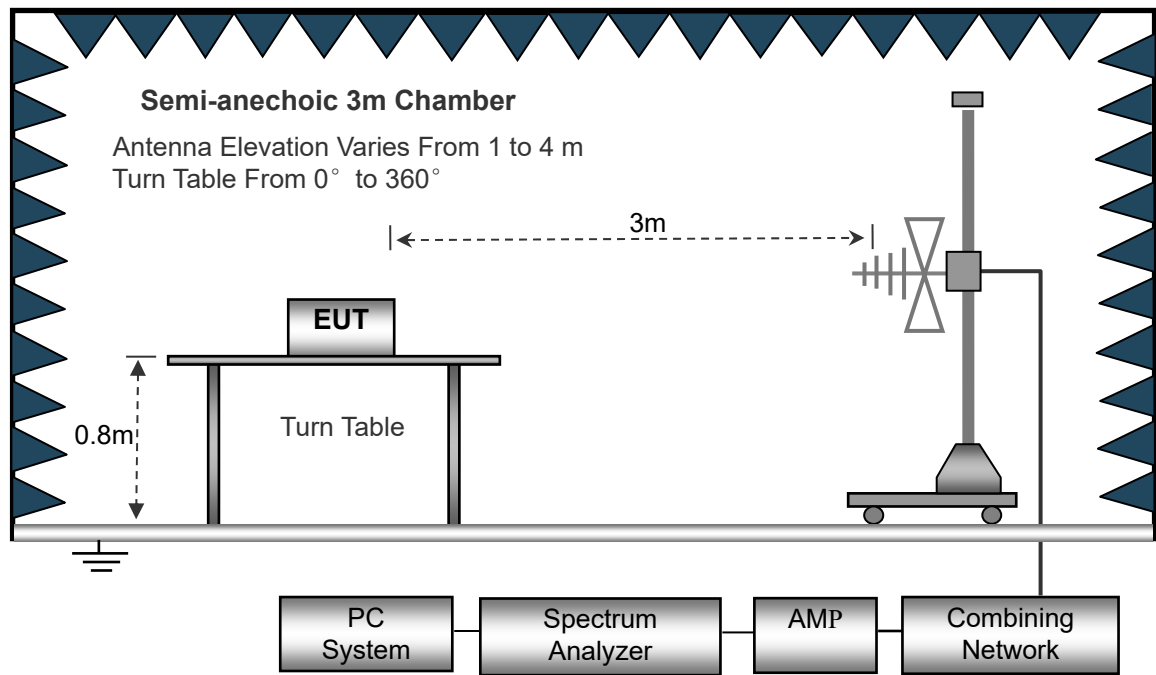
The setup of EUT is according with per ANSI C63.10-2013 measurement procedure. The specification used was with the FCC Part 15.205 15.247(a) and FCC Part 15.209 Limit.

The external I/O cables were draped along the test table and formed a bundle 30 to 40cm long in the middle. The spacing between the peripherals was 10cm.

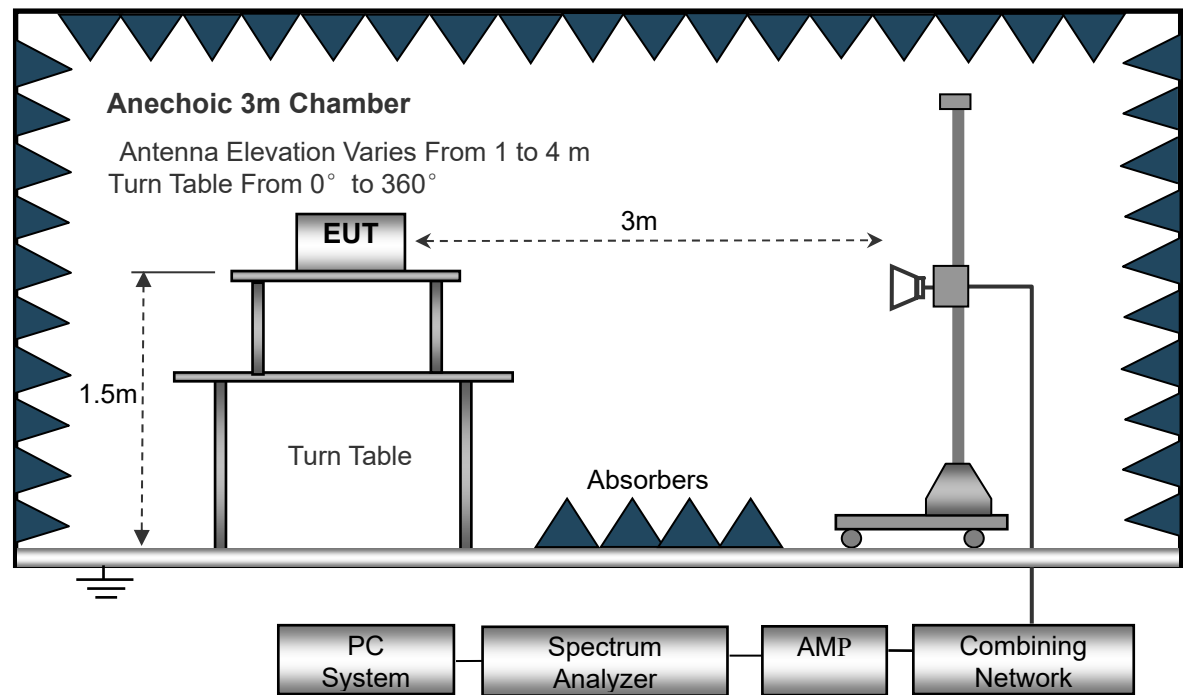
The test setup for emission measurement below 30MHz.



The test setup for emission measurement from 30MHz to 1GHz.



The test setup for emission measurement above 1GHz.



Frequency :9kHz-30MHz
RBW=10KHz,
VBW =30KHz
Sweep time= Auto
Trace = max hold
Detector function = peak

Frequency :30MHz-1GHz
RBW=120KHz,
VBW=300KHz
Sweep time= Auto
Trace = max hold
Detector function = peak, QP

Frequency :Above 1GHz
RBW=1MHz,
VBW=3MHz(Peak), 10Hz(AV)
Sweep time= Auto
Trace = max hold
Detector function = peak, AV

9.3 Corrected Amplitude & Margin Calculation

The Corrected Amplitude is calculated by adding the Antenna Factor and the Cable Factor, and subtracting the Amplifier Gain from the Amplitude reading. The basic equation is as follows:

$$\begin{aligned}\text{Corr. Ampl.} &= \text{Indicated Reading} + \text{Correct} \\ \text{Correct} &= \text{Ant. Factor} + \text{Cable Loss} - \text{Ampl. Gain}\end{aligned}$$

The “**Margin**” column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of -6dB μ V means the emission is 6dB μ V below the maximum limit. The equation for margin calculation is as follows:

$$\text{Margin} = \text{Corr. Ampl.} - \text{FCC Part 15 Limit}$$

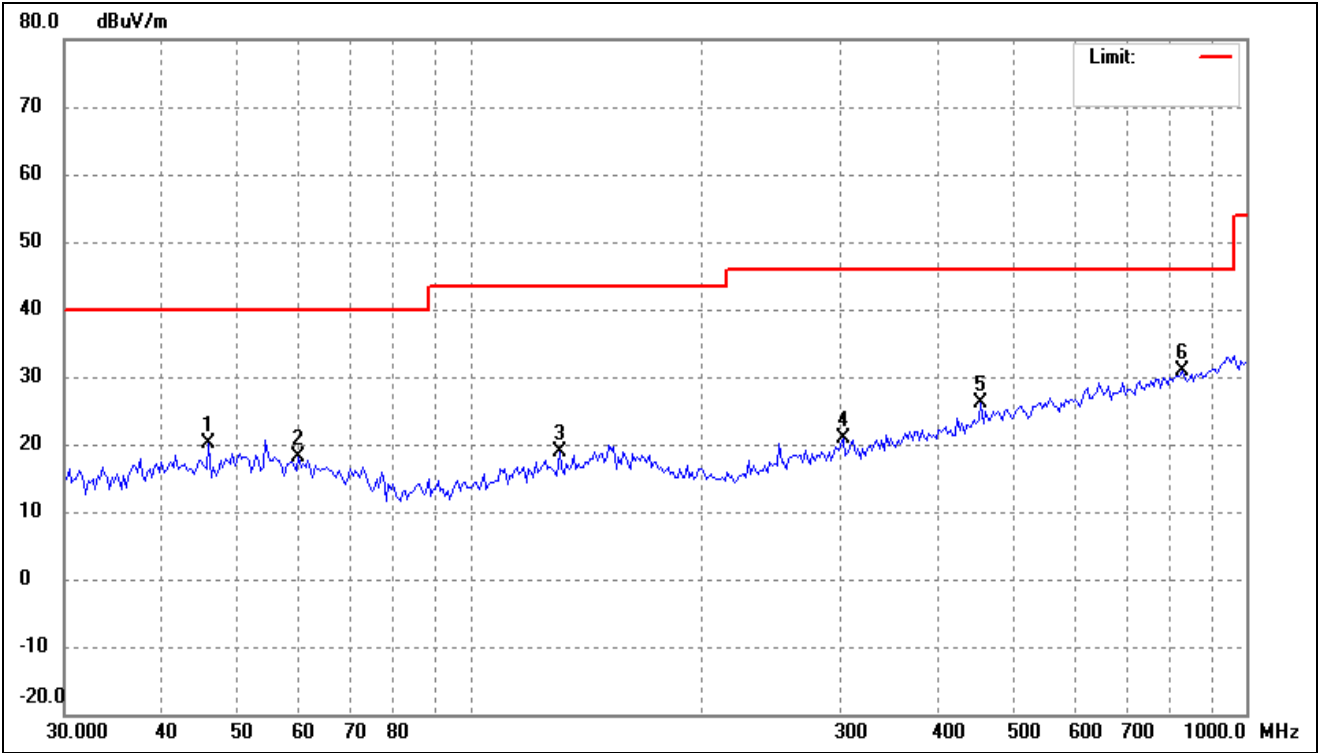
9.4 Summary of Test Results/Plots

Note: this EUT was tested in 3 orthogonal positions and the worst case position data was reported.

All test modes (different data rate and different modulation) are performed, but only the worst case (GFSK) is recorded in this report.

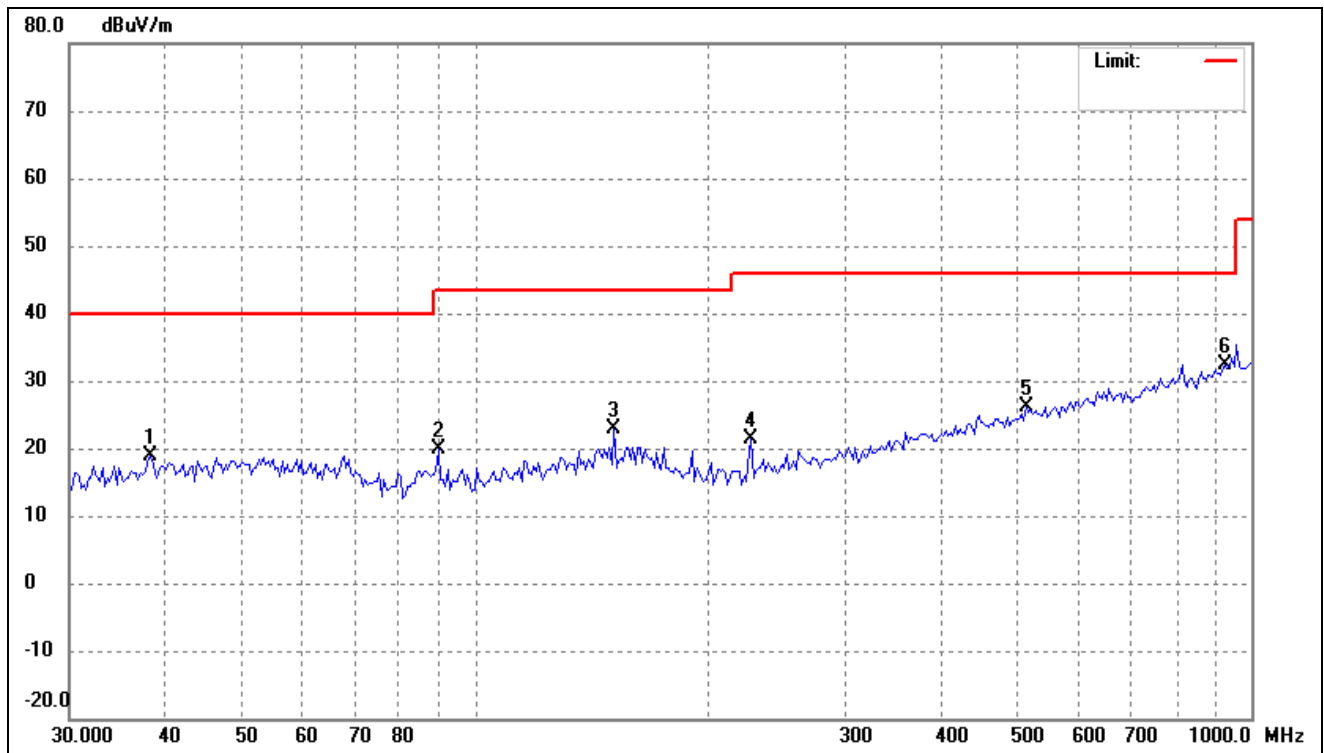
➤ Spurious Emissions Below 1GHz

Test Channel	2.4G Hopping	Polarity:	Horizontal
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No.	Frequency (MHz)	Reading (dBuV/m)	Correct dB/m	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Degree ()	Height (cm)	Remark
1	46.0558	28.39	-8.38	20.01	40.00	-19.99	-	-	QP
2	60.1528	27.19	-8.97	18.22	40.00	-21.78	-	-	QP
3	130.3048	28.76	-9.84	18.92	43.50	-24.58	-	-	QP
4	302.8193	29.07	-8.18	20.89	46.00	-25.11	-	-	QP
5	455.1888	30.55	-4.52	26.03	46.00	-19.97	-	-	QP
6	827.1795	30.35	0.54	30.89	46.00	-15.11	-	-	QP

Test Channel	2.4G Hopping	Polarity:	Vertical
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No.	Frequency (MHz)	Reading (dBuV/m)	Correct dB/m	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Degree ()	Height (cm)	Remark
1	38.0965	27.85	-8.89	18.96	40.00	-21.04	-	-	QP
2	89.7866	33.07	-13.10	19.97	43.50	-23.53	-	-	QP
3	151.0252	31.37	-8.61	22.76	43.50	-20.74	-	-	QP
4	227.0164	33.10	-11.76	21.34	46.00	-24.66	-	-	QP
5	512.9478	29.78	-3.70	26.08	46.00	-19.92	-	-	QP
6	925.6132	30.67	1.74	32.41	46.00	-13.59	-	-	QP

Remark: '-' Means the test Degree and Height are not recorded by the test software and only show the worst case in the test report.

➤ Spurious Emissions Above 1GHz

Frequency (MHz)	Reading (dBuV/m)	Correct dB	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Polar H/V	Detector
Low Channel-2403.01MHz							
4787.883	69.90	-16.47	53.43	74.00	-20.57	H	PK
7200.782	60.95	-12.01	48.94	74.00	-25.06	H	PK
9581.752	62.51	-9.87	52.64	74.00	-21.36	H	PK
12054.251	59.69	-8.17	51.52	74.00	-22.48	H	PK
4812.370	63.53	-16.45	47.08	74.00	-26.92	V	PK
7200.782	65.38	-12.01	53.37	74.00	-20.63	V	PK
9581.752	62.37	-9.87	52.50	74.00	-21.50	V	PK
12054.251	60.61	-8.17	52.44	74.00	-21.56	V	PK
Middle Channel-2439.01MHz							
4861.719	66.90	-16.38	50.52	74.00	-23.48	H	PK
7311.828	63.95	-11.83	52.12	74.00	-21.88	H	PK
9729.517	61.91	-9.81	52.10	74.00	-21.90	H	PK
12240.145	60.52	-8.03	52.49	74.00	-21.51	H	PK
4861.719	63.83	-16.38	47.45	74.00	-26.55	V	PK
7311.828	63.91	-11.83	52.08	74.00	-21.92	V	PK
9729.517	62.33	-9.81	52.52	74.00	-21.48	V	PK
12240.145	60.85	-8.03	52.82	74.00	-21.18	V	PK
High Channel-2471.01MHz							
4936.694	68.58	-16.28	52.30	74.00	-21.70	H	PK
7386.809	61.26	-11.71	49.55	74.00	-24.45	H	PK
9879.560	60.29	-9.75	50.54	74.00	-23.46	H	PK
12365.665	57.84	-7.95	49.89	74.00	-24.11	H	PK
4936.694	62.80	-16.28	46.52	74.00	-27.48	V	PK
7386.809	64.41	-11.71	52.70	74.00	-21.30	V	PK
9879.560	60.67	-9.75	50.92	74.00	-23.08	V	PK
12365.665	61.66	-7.95	53.71	74.00	-20.29	V	PK

Note: Testing is carried out with frequency rang 9kHz to the tenth harmonics, other than listed in the table above are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.

10. Out of Band Emissions

10.1 Standard Applicable

According to §15.247 (d), in any 100kHz 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 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30dB instead of 20dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a).

10.2 Test Procedure

According to ANSI C63.10-2013 section 7.8.6, the Band-edge measurements for RF conducted emissions test method as follows.

- a) Connect the EMI receiver or spectrum analyzer to the EUT using an appropriate RF cable connected to the EUT output. Configure the spectrum analyzer settings as described in step e) (be sure to enter all losses between the unlicensed wireless device output and the spectrum analyzer).
- b) Set the EUT to the lowest frequency channel (for the hopping on test, the hopping sequence shall include the lowest frequency channel).
- c) Set the EUT to operate at maximum output power and 100% duty cycle, or equivalent “normal mode of operation” as specified in 6.10.3.
- d) If using the radiated method, then use the applicable procedure(s) of 6.4, 6.5, or 6.6, and orient the EUT and measurement antenna positions to produce the highest emission level.
- e) Perform the test as follows:
 - 1) Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products that fall outside of the authorized band of operation.
 - 2) Reference level: As required to keep the signal from exceeding the maximum instrument input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than $[10 \log (OBW/RBW)]$ below the reference level. Specific guidance is given in 4.1.5.2.
 - 3) Attenuation: Auto (at least 10 dB preferred).
 - 4) Sweep time: Coupled.
 - 5) Resolution bandwidth: 100kHz.
 - 6) Video bandwidth: 300kHz.
 - 7) Detector: Peak.
 - 8) Trace: Max hold.
- f) Allow the trace to stabilize. For the test with the hopping function turned ON, this can take several minutes

to achieve a reasonable probability of intercepting any emissions due to oscillator overshoot.

g) Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.

h) Repeat step c) through step e) for every applicable modulation.

i) Set the EUT to the highest frequency channel (for the hopping on test, the hopping sequence shall include the highest frequency channel) and repeat step c) through step d).

j) The band-edge measurement shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

Restricted-band band-edge test method please refers to ANSI C63.10-2013 section 6.10.5. The emission must comply with the 15.209 limit for fall in the restricted bands listed in section 15.205. Note that the method of measurement KDB publication number: 913591 may be used for the radiated band-edge measurements.

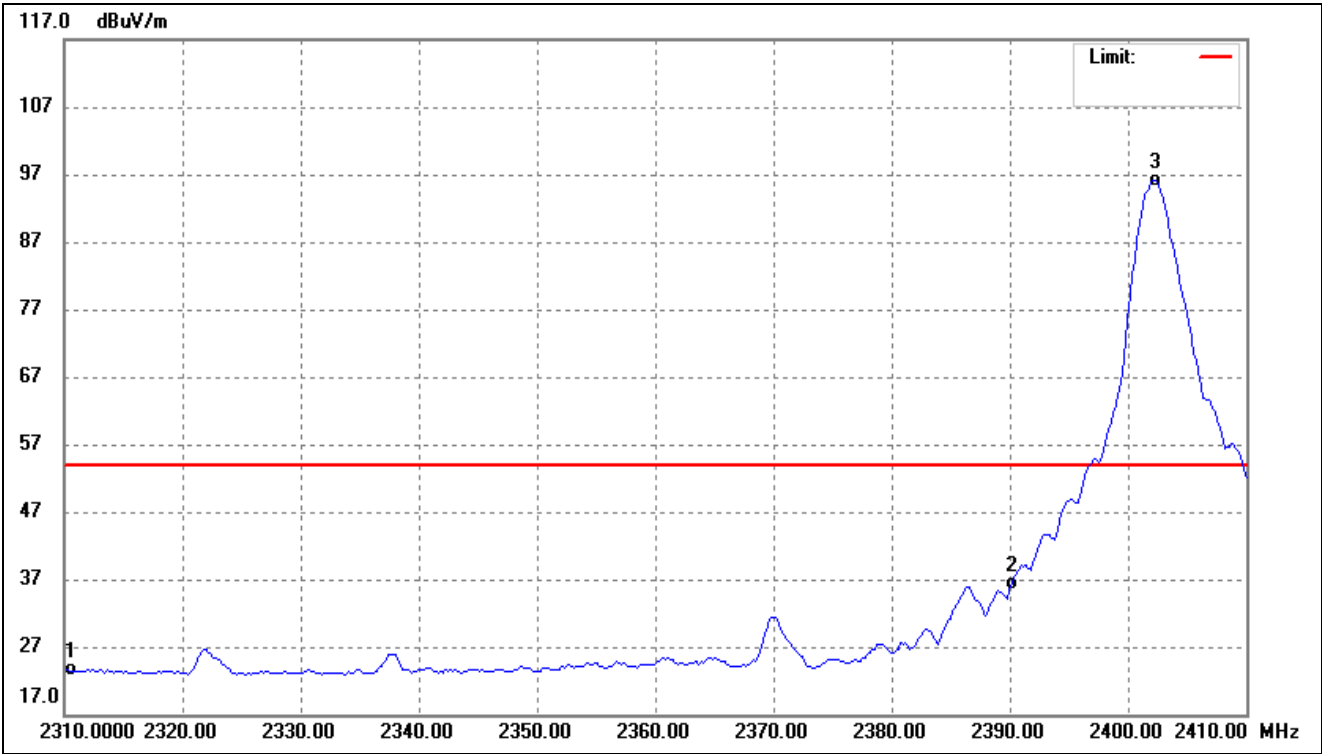
According to ANSI C63.10-2013 section 7.8.8, Conducted spurious emissions shall be measured for the transmit frequency, per 5.5 and 5.6, and at the maximum transmit powers.

Connect the primary antenna port through an attenuator to the spectrum analyzer input; in the results, account for all losses between the unlicensed wireless device output and the spectrum analyzer. The instrument shall span 30MHz to 10 times the operating frequency in GHz, with a resolution bandwidth of 100kHz, video bandwidth of 300kHz, and a coupled sweep time with a peak detector. The band 30MHz to the highest frequency may be split into smaller spans, as long as the entire spectrum is covered.

10.3 Summary of Test Results/Plots

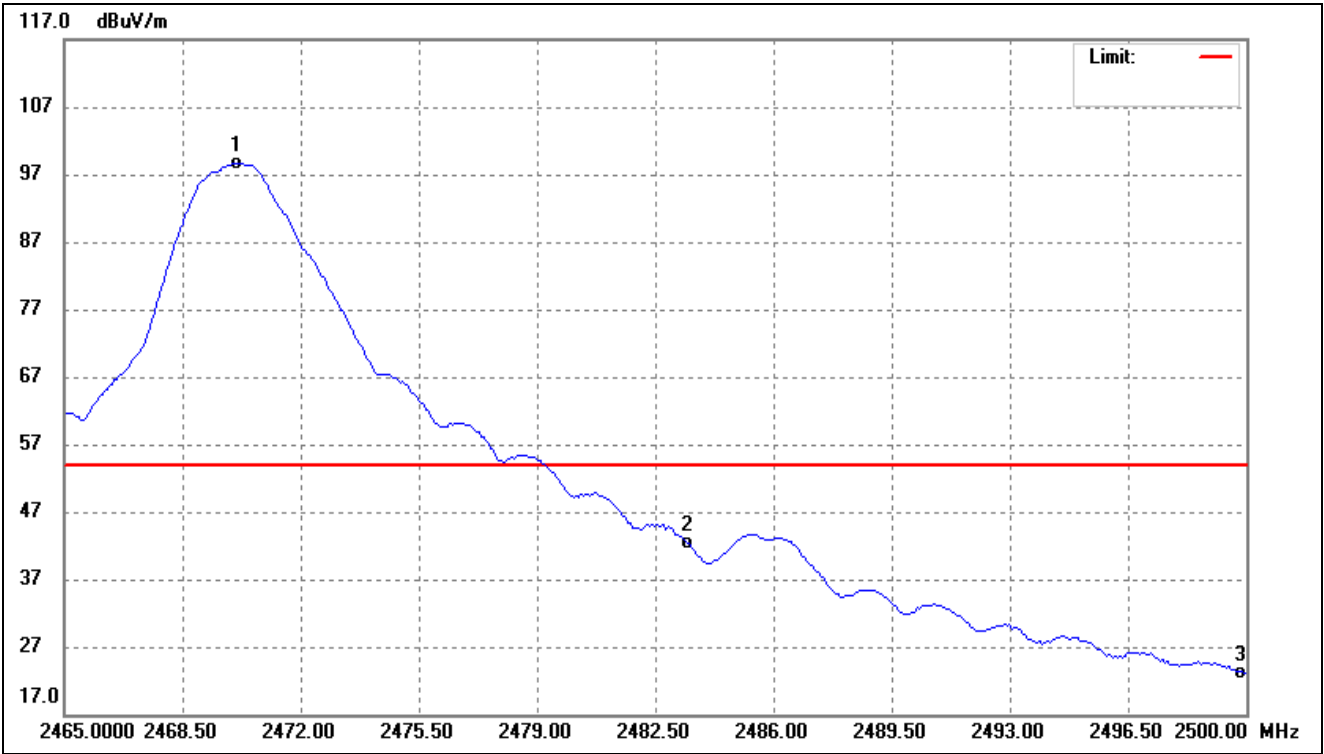
Note: All test modes (different data rate and different modulation) are performed, but only the worst case (GFSK) is recorded in this report.

Test Channel	Low	Polarity:	Horizontal (Worst case)
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No.	Frequency (MHz)	Reading (dBuV/m)	Correct Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	2310.000	45.86	-22.24	23.62	54.00	-30.38	Average Detector
	2310.000	57.57	-22.24	35.33	74.00	-38.67	Peak Detector
2	2390.000	58.54	-22.10	36.44	54.00	-17.56	Average Detector
	2390.000	72.20	-22.10	50.10	74.00	-23.90	Peak Detector
3	2402.385	118.22	-22.07	96.15	Fundamental		Average Detector
	2403.988	123.30	-22.07	101.23			Peak Detector

Test Channel	High	Polarity:	Horizontal (Worst case)
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No.	Frequency (MHz)	Reading (dBuV/m)	Correct Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	2470.120	120.69	-21.96	98.73	Fundamental		Average Detector
	2469.559	124.74	-21.96	102.78			Peak Detector
2	2483.500	64.23	-21.93	42.30	54.00	-11.70	Average Detector
	2483.500	80.75	-21.93	58.82	74.00	-15.18	Peak Detector
3	2500.000	45.08	-21.90	23.18	54.00	-30.82	Average Detector
	2500.000	57.96	-21.90	36.06	74.00	-37.94	Peak Detector

➤ Conducted test

Please refer to Appendix E

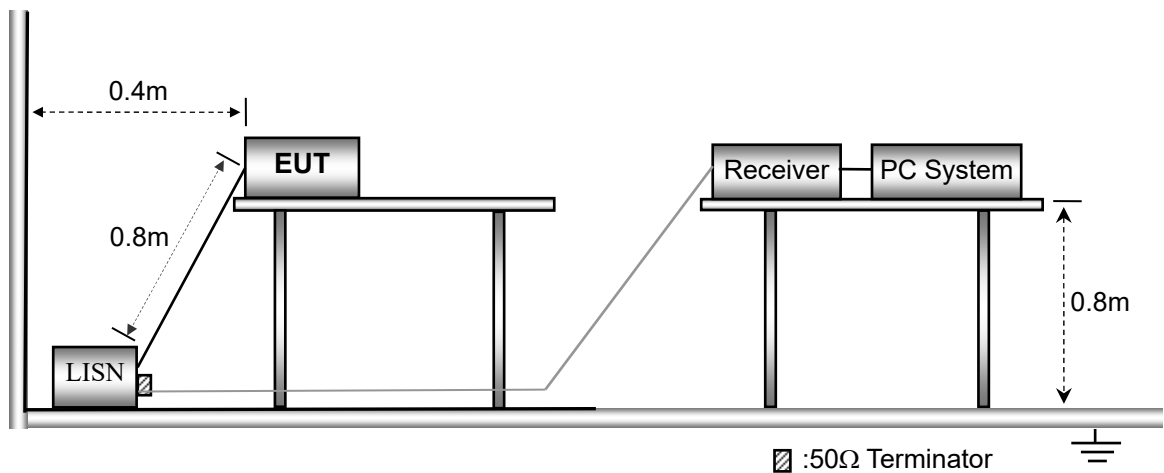
11. Conducted Emissions

11.1 Test Procedure

The setup of EUT is according with per ANSI C63.10-2013 measurement procedure. The specification used was with the FCC Part 15.207 Limit.

The external I/O cables were draped along the test table and formed a bundle 30 to 40cm long in the middle. The spacing between the peripherals was 10cm.

11.2 Basic Test Setup Block Diagram



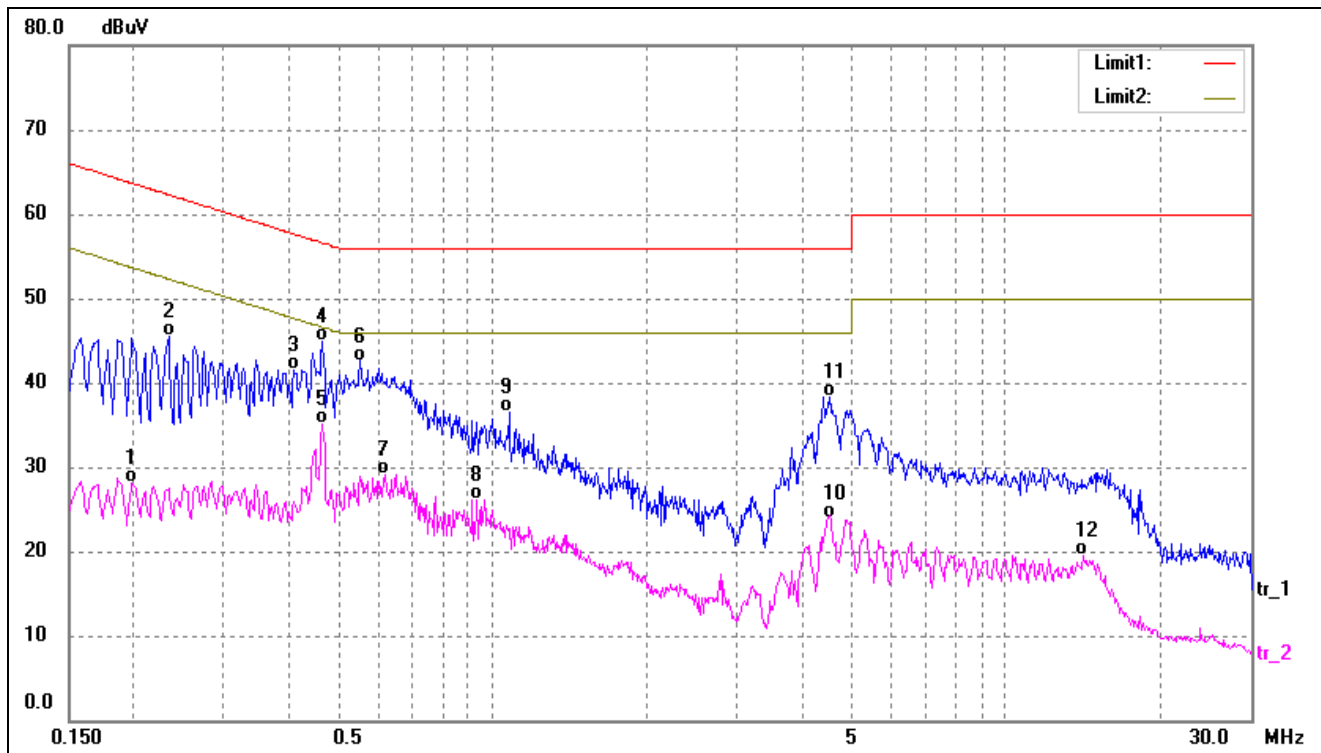
11.3 Test Receiver Setup

During the conducted emission test, the test receiver was set with the following configurations:

Start Frequency	150kHz
Stop Frequency	30MHz
Sweep Speed	Auto
IF Bandwidth.....	10kHz
Quasi-Peak Adapter Bandwidth	9kHz
Quasi-Peak Adapter Mode	Normal

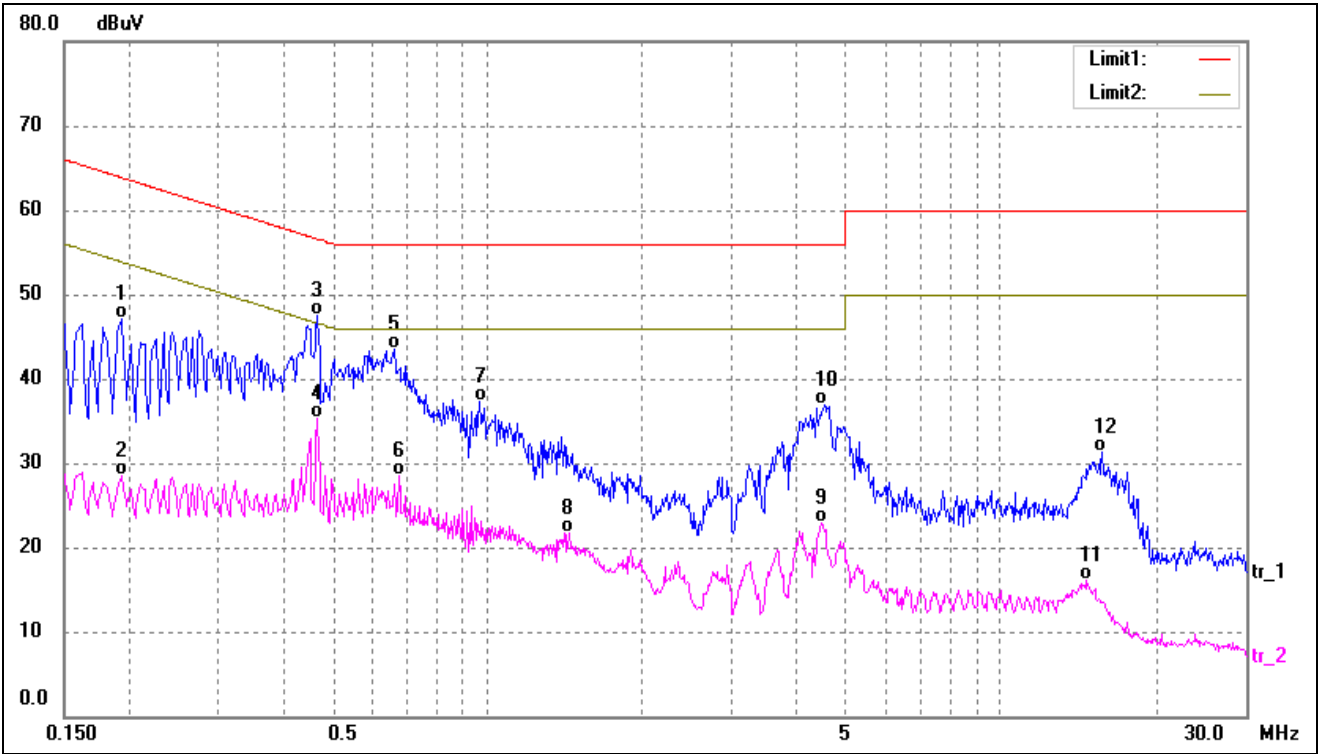
11.4 Summary of Test Results/Plots

Test Mode	Communication	AC120V 60Hz	Polarity:	Neutral
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No.	Frequency (MHz)	Reading (dBuV)	Correct (dB)	Result (dBuV)	Limit (dBuV)	Margin (dB)	Detector
1	0.1980	17.75	10.39	28.14	53.69	-25.55	AVG
2	0.2340	35.20	10.35	45.55	62.30	-16.75	QP
3	0.4099	31.26	10.26	41.52	57.65	-16.13	QP
4	0.4660	34.68	10.25	44.93	56.58	-11.65	QP
5*	0.4660	24.79	10.25	35.04	46.58	-11.54	AVG
6	0.5540	32.38	10.22	42.60	56.00	-13.40	QP
7	0.6179	18.97	10.21	29.18	46.00	-16.82	AVG
8	0.9340	15.98	10.15	26.13	46.00	-19.87	AVG
9	1.0820	26.42	10.16	36.58	56.00	-19.42	QP
10	4.5140	13.54	10.37	23.91	46.00	-22.09	AVG
11	4.5300	27.96	10.37	38.33	56.00	-17.67	QP
12	14.1859	9.25	10.25	19.50	50.00	-30.50	AVG

Test Mode	Communication	AC120V 60Hz	Polarity:	Line
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No.	Frequency (MHz)	Reading (dBuV)	Correct (dB)	Result (dBuV)	Limit (dBuV)	Margin (dB)	Detector
1	0.1940	36.68	10.39	47.07	63.86	-16.79	QP
2	0.1940	18.17	10.39	28.56	53.86	-25.30	AVG
3*	0.4660	37.28	10.25	47.53	56.58	-9.05	QP
4	0.4660	24.97	10.25	35.22	46.58	-11.36	AVG
5	0.6580	33.24	10.20	43.44	56.00	-12.56	QP
6	0.6740	18.32	10.20	28.52	46.00	-17.48	AVG
7	0.9660	27.14	10.14	37.28	56.00	-18.72	QP
8	1.4460	11.56	10.22	21.78	46.00	-24.22	AVG
9	4.4580	12.44	10.37	22.81	46.00	-23.19	AVG
10	4.5380	26.47	10.37	36.84	56.00	-19.16	QP
11	14.6860	5.82	10.23	16.05	50.00	-33.95	AVG
12	15.7620	21.06	10.25	31.31	60.00	-28.69	QP

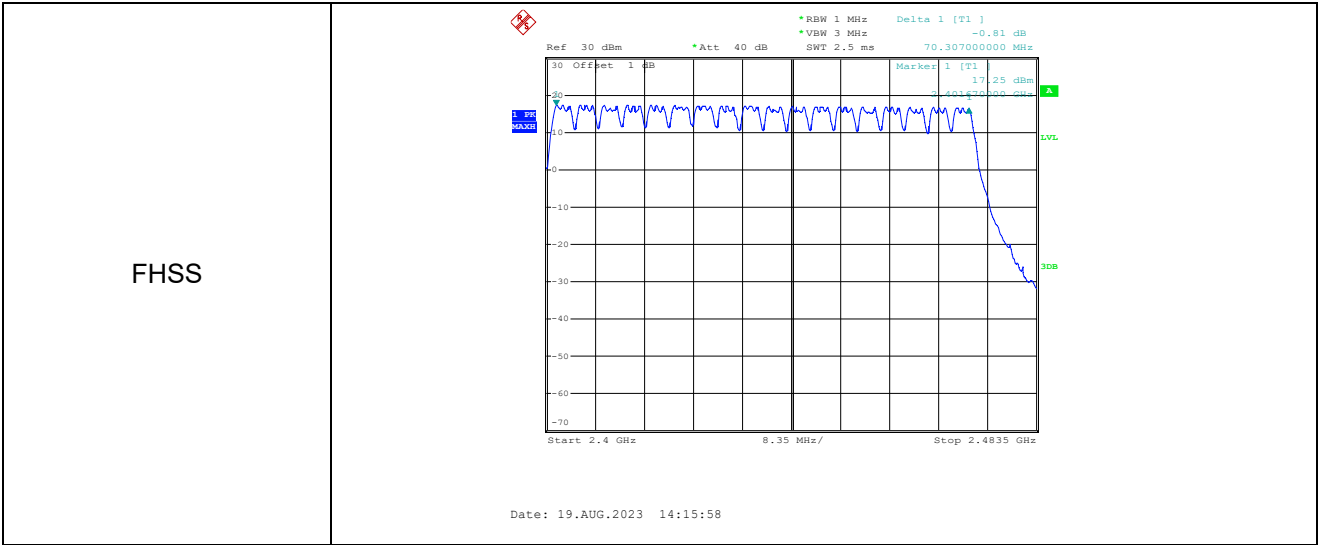
APPENDIX SUMMARY

Project No.	WTX23X08177364W	Test Engineer	Elin Su
Start date	2023/8/18	Finish date	2023/8/19
Temperature	24.3℃	Humidity	69%
RF specifications	2.4GHz-FHSS		

APPENDIX	Description of Test Item	Result
A	Hopping Channels and Channel Separation	Compliant
B	Dwell Time of Hopping Channel	Compliant
C	20dB Bandwidth	Compliant
D	RF Output Power	Compliant
E	Conducted Out of Band Emissions	Compliant

APPENDIX A

Hopping Channels Number			
Mode	Test Result	Limit	Result
FHSS	18	≥15	Pass



Channel Separation			
Mode	Channel	Carrier Frequencies Separation (MHz)	Result
FHSS	Low	4.00	Pass
	Middle	4.00	Pass
	High	4.00	Pass

Low

Ref 30 dBm Att 40 dB RBW 1 MHz VBW 3 MHz Delta 1 [T1] -0.04 dB
SWT 2.5 ms 4.00000000 MHz

Marker 1 [T1] 15.07 dB
2.40500000 GHz

Center 2.40501 GHz 1 MHz/ Span 10 MHz

Date: 19.AUG.2023 14:24:29

Middle

Ref 30 dBm Att 40 dB RBW 1 MHz VBW 3 MHz Delta 1 [T1] -0.12 dB
SWT 2.5 ms 4.00000000 MHz

Marker 1 [T1] 15.87 dB
2.44100000 GHz

Center 2.44101 GHz 1 MHz/ Span 10 MHz

Date: 19.AUG.2023 14:21:48

High

Ref 30 dBm Att 40 dB RBW 1 MHz VBW 3 MHz Delta 1 [T1] -0.07 dB
SWT 2.5 ms 4.00000000 MHz

Marker 1 [T1] 15.47 dB
2.46900000 GHz

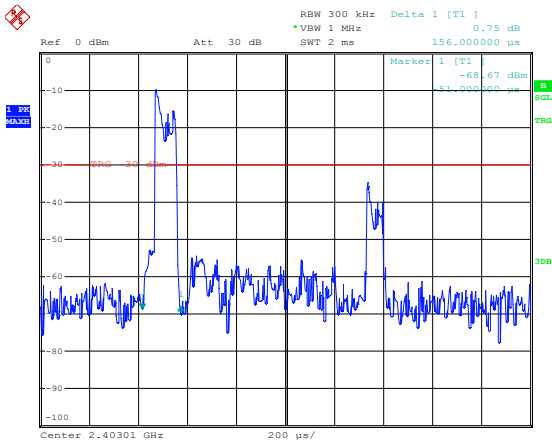
Center 2.46901 GHz 1 MHz/ Span 10 MHz

Date: 19.AUG.2023 14:23:07

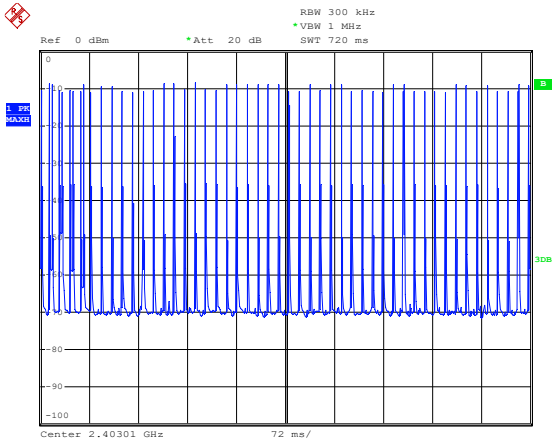
APPENDIX B

Test Channel	Time Slot Length (ms)	Dwell time (ms)	Limit (ms)
Low	0.156	76.44	400
Middle	0.148	74.00	400
High	0.148	71.04	400

Low

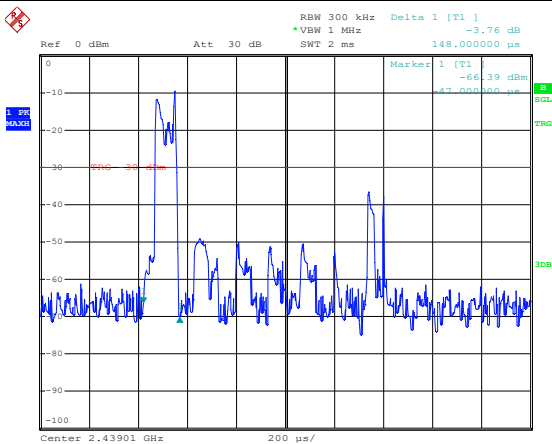


Date: 18.AUG.2023 16:17:43

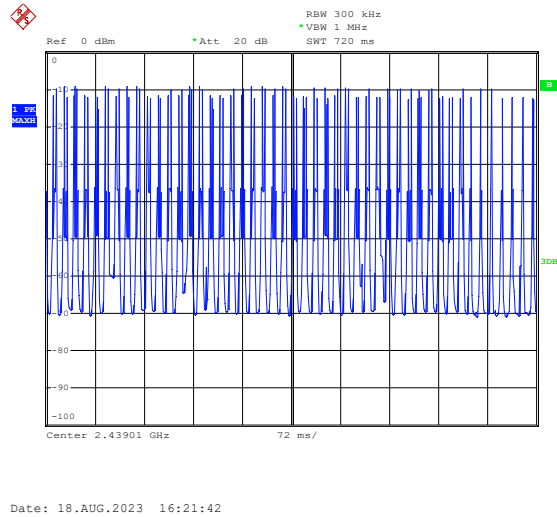


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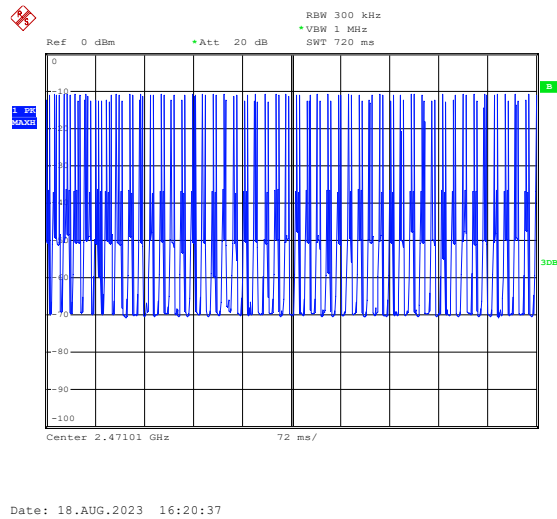
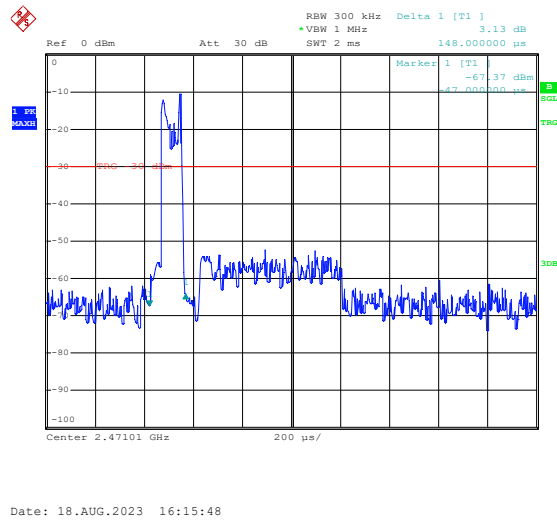
Middle



Date: 18.AUG.2023 16:14:38



High

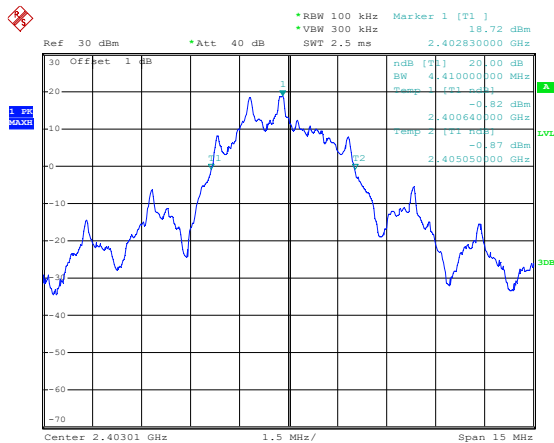


APPENDIX C

20 dB Bandwidth			
Test Mode	Test Channel MHz	20 dB Bandwidth MHz	Result
FHSS	Low	4.410	Pass
	Middle	4.380	Pass
	High	4.410	Pass

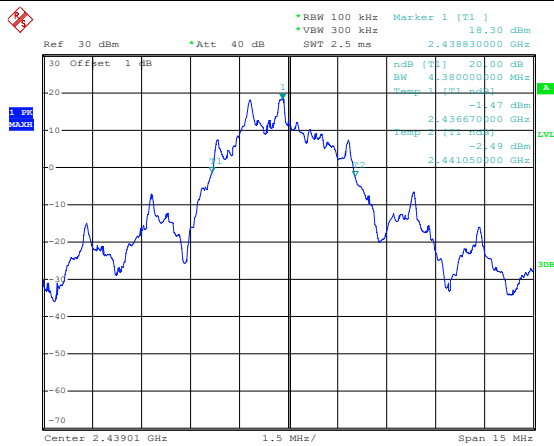
20 dB Bandwidth

Low



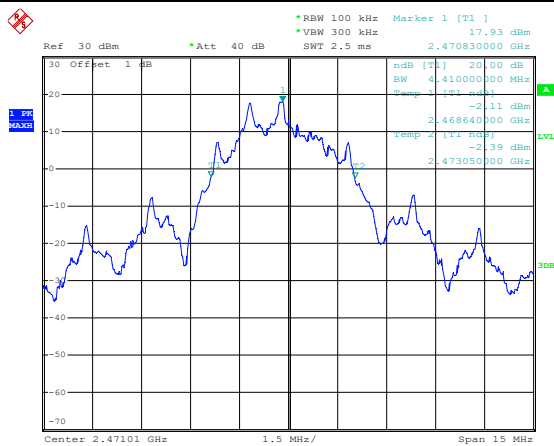
Date: 19.AUG.2023 14:05:01

Middle



Date: 19.AUG.2023 14:07:38

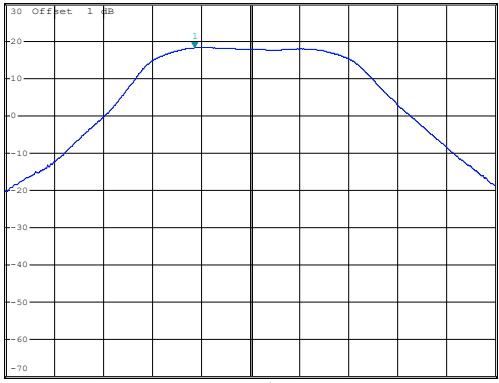
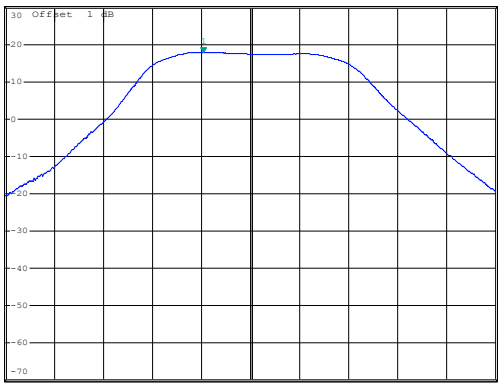
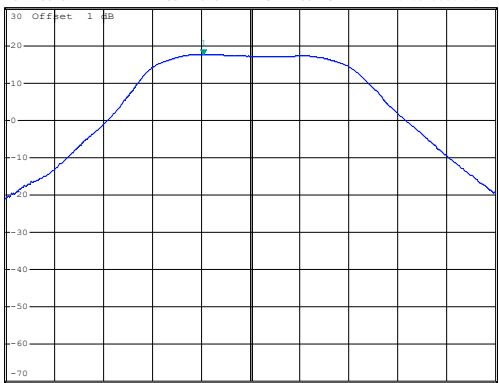
High



Date: 19.AUG.2023 14:09:18

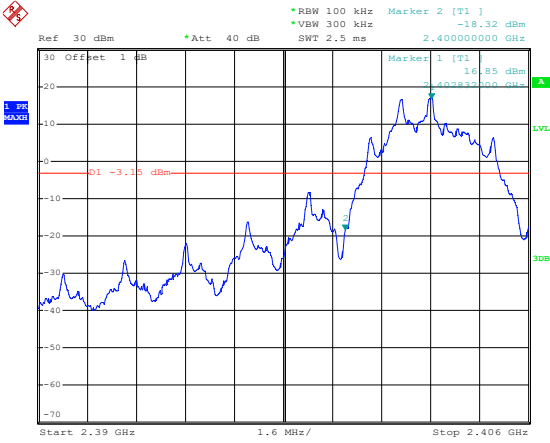
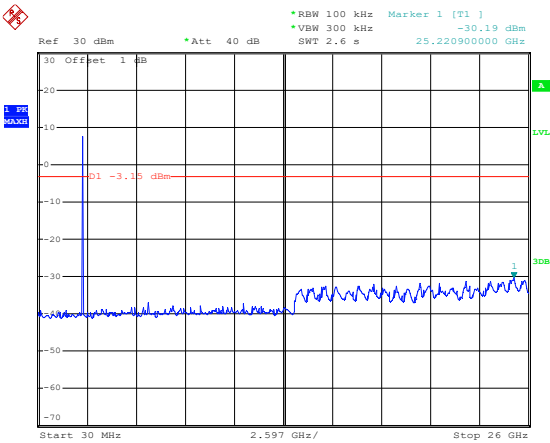
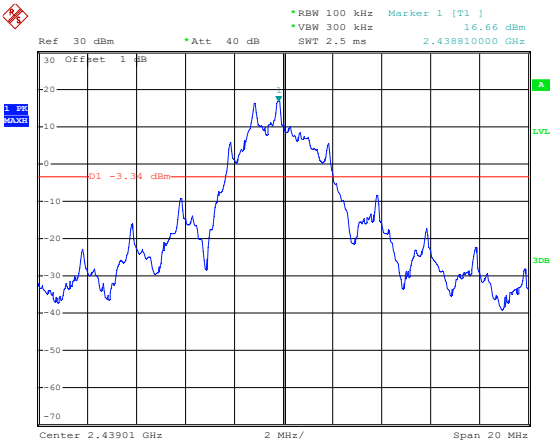
APPENDIX D

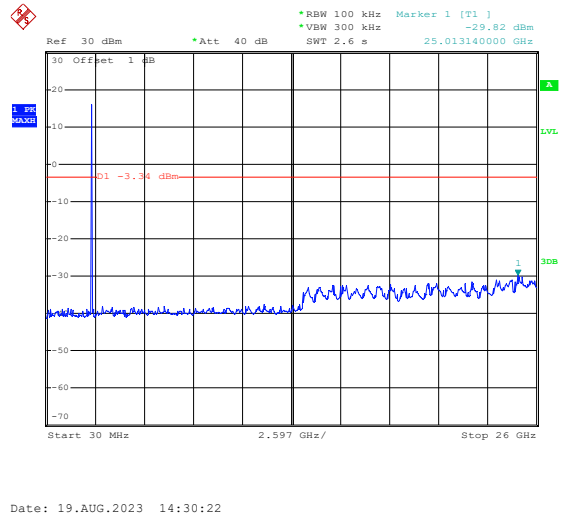
RF Output Power					
Modulation type	Channel	Output power (dBm)	Output power (mW)	Limit (dBm)	Result
FHSS	Low	18.25	66.83	30.00	Pass
	Middle	17.91	61.80		
	High	17.61	57.68		

Low	 Ref 30 dBm *Att 40 dB RBW 10 MHz Marker 1 [T1] 18.25 dBm VBW 10 MHz 2.399590000 GHz SWT 2.5 ms Center 2.40301 GHz 3 MHz/ Span 30 MHz Date: 19.AUG.2023 14:12:08
Middle	 Ref 30 dBm *Att 40 dB RBW 10 MHz Marker 1 [T1] 17.91 dBm VBW 10 MHz 2.436130000 GHz SWT 2.5 ms Center 2.43901 GHz 3 MHz/ Span 30 MHz Date: 19.AUG.2023 14:12:53
High	 Ref 30 dBm *Att 40 dB RBW 10 MHz Marker 1 [T1] 17.61 dBm VBW 10 MHz 2.468130000 GHz SWT 2.5 ms Center 2.47101 GHz 3 MHz/ Span 30 MHz Date: 19.AUG.2023 14:11:36

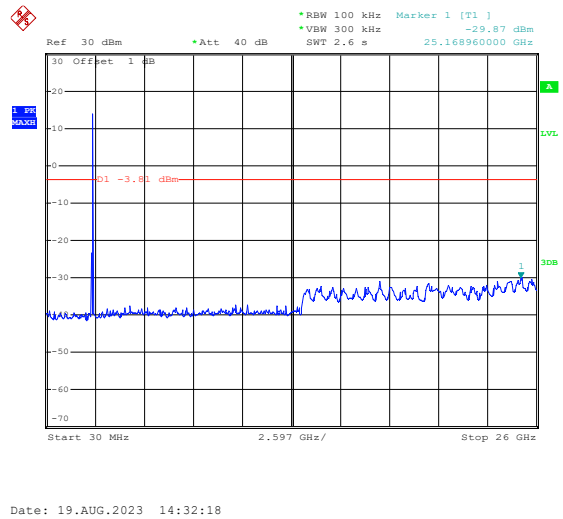
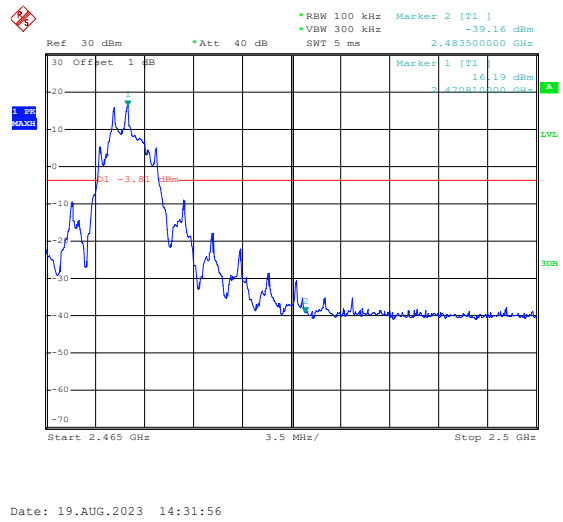
APPENDIX E

Conducted Out of Band Emissions

Low	 Date: 19.AUG.2023 14:28:14
	 Date: 19.AUG.2023 14:28:35
Middle	 Date: 19.AUG.2023 14:30:02



High



APPENDIX PHOTOGRAPHS

Please refer to “ANNEX”

***** END OF REPORT *****