FCC/ISED - TEST REPORT

Report Number	:	**68.710.24.0270.01**	Date of Issue:	2024-09-05
Model/HVIN	:	**Q10**		
Product Type	:	Robot Vacuum Cleaner		
Applicant	:	Shenzhen Tunnu Innovation Co., Ltd.		
Address	:	4 Floor, Tsinghua University Research Institute, Yuehai Street, NanShan district, 518000 Shenzhen, Guangdong Province, PEOPLE'S REPUBLIC OF CHINA		
Manufacturer	:	Shenzhen Tunnu Innovation Co., Ltd.		
Address	:	4 Floor, Tsinghua University Research Institute, Yuehai Street, NanShan district, 518000 Shenzhen, Guangdong Province, PEOPLE'S REPUBLIC OF CHINA		
Test Result	:	■ **Positive** ☐ **Negative**		
Total pages including Appendices	:	**64**		

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2 Details about the Test Laboratory

Details about the Test Laboratory
Test Site 1

Company name:	TÜV SÜD Certification and Testing (China) Co., Ltd. Shenzhen Branch Building 12 & 13, Zhiheng Wisdomland Business Park, Guankou Erlu, Nantou, Nanshan District, Shenzhen, Guangdong, China
Telephone:	86 755 8828 6998
Fax:	86 755 8828 5299
FCC Registration No.:	514049
FCC Designation Number:	CN5009
ISED CAB identifier:	CN0077
IC Registration No.:	10320A

3 Description of the Equipment Under Test

Product:	Robot Vacuum Cleaner
Model no.:	Q10
Product Marketing Name (PMN):	Robot Vacuum Cleaner
Hardware Version Identification No. (HVIN):	Q10
FCC ID:	2BELS-Q10
IC:	32336-Q10
Options and accessories:	Base station Manufacturer: Shenzhen Topband Co., Ltd. Model: Q10-S Input: 120VAC, 60Hz, 24W for Charging, 80W for Drying, 800W for Heating water, 1000W for Collecting dust Output: DC23.65V, 2.5A
Ratings:	Input: DC23.65V, 2.5A (for charging only) Battery: 14.4V, 5000mAh
RF Transmission Frequency:	2402MHz - 2480MHz for BR/EDR
No. of Operated Channel:	79 for BR/EDR
Modulation:	GFSK, Pi/4DQPSK, 8DPSK
Antenna Type:	Integrated FPC antenna
Antenna Gain:	4.2 dBi for Bluetooth
Description of the EUT:	The EUT is a Robot Vacuum Cleaner supports Wi-Fi and Bluetooth functions: 2412MHz - 2462MHz for 2.4GHz Wi-Fi; 2402MHz - 2480MHz for BLE (1Mbps); 2402MHz - 2480MHz for BR/EDR.
Remark:	This report is only for BR/EDR.

NOTE 1: The above EUT's information is declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.

4 Summary of Test Standards

Test Standards	
FCC Part 15 Subpart C 10-1-2023 Edition	PART 15 - RADIO FREQUENCY DEVICES Subpart C - Intentional Radiators
RSS-Gen Issue 5 April 2018 + Amendment 1 March 2019 + Amendment 2 February 2021	General Requirements for Compliance of Radio Apparatus
RSS-247 Issue 3 August 2023	Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSS) and License-Exempt Local Area Network (LE-LAN) Devices

All the test methods were according to KDB 558074 D01 15.247 Meas Guidance v05r02 Measurement Guidance and ANSI C63.10-2020.

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5 Summary of Test Results

Technical Requirements						
FCC Part 15 Subpart C/ RSS-247 Issue 3/RSS-Gen Issue 5						
Test Condition		Test Site	Test Result			Test Environment
			Pass	Fail	N/A	
§15.207& RSS-Gen 8.8	Conducted emission AC power port	Site 1	☒	☐	☐	T: 22.4℃ H: 53.2%
§15.247(b)(1)	Conducted peak output power	Site 1	☒	☐	☐	T: 23.2℃ H: 51.5%
RSS-247 5.4(b)	Conducted peak output power and Equivalent Isotropic Radiated Power	Site 1	☒	☐	☐	T: 23.2℃ H: 51.5%
§15.247(a)(1) & RSS-247 5.1(a) & RSS-Gen 6.7	20dB bandwidth and 99% occupied bandwidth	Site 1	☒	☐	☐	T: 23.2℃ H: 51.5%
§15.247(a)(1) & RSS-247 5.1(b)	Carrier channel frequency separation	Site 1	☒	☐	☐	T: 23.2℃ H: 51.5%
§15.247(a)(1)(iii) & RSS-247 5.1(d)	Number of hopping frequencies	Site 1	☒	☐	☐	T: 23.2℃ H: 51.5%
§15.247(a)(1)(iii) & RSS-247 5.1(d)	Dwell Time - Average Time of Occupancy	Site 1	☒	☐	☐	T: 23.2℃ H: 51.5%
§15.247(d) & RSS-247 5.5	Spurious RF conducted emissions	Site 1	☒	☐	☐	T: 24.7℃ H: 49.3%
§15.247(d) & RSS-247 5.5	Band edge	Site 1	☒	☐	☐	T: 22.4℃ H: 53.2%
§15.247(d) & §15.209 &§15.205 &RSS-247 5.5 & RSS-Gen 6.13	Spurious radiated emissions for transmitter	Site 1	☒	☐	☐	T: 23.2℃ H: 51.5%
§15.203 & RSS-Gen 6.8	Antenna requirement	See note 2	☒	☐	☐	---

Note 1: N/A=Not Applicable.
Note 2: The EUT uses an Integrated FPC antenna, which gains are 4.2dBi for Bluetooth. In accordance with §15.203 and RSS-Gen 6.8, it is considered sufficiently to comply with the provisions of this section.
Note 3: T: Temperature, H: Humidity.

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6 General Remarks

The conducted emissions of Q10 were tested with a Base station, and the input voltage is 120VAC/60Hz; The RF tests of Q10 were tested with battery operation, the battery voltage is 14.4VDC.

This submittal(s) (test report) is intended for FCC ID: 2BELS-Q10, complies with Section 15.207, 15.209, 15.205, 15.247 of the FCC Part 15, Subpart C rules.

This submittal(s) (test report) is intended for IC: 32336-Q10, complies with RSS-247 and RSS-Gen.

SUMMARY:

All tests according to the regulations cited on page 5 were

■ - Performed

☐ - **Not** Performed

The Equipment Under Test

■ - **Fulfills** the general approval requirements.

☐ - **Does not** fulfill the general approval requirements.

Sample Received Date: 2024-07-09

Testing Start Date: 2024-07-17

Testing End Date: 2024-08-09

- TÜV SÜD Certification and Testing (China) Co., Ltd. Shenzhen Branch -

Reviewed by:	Prepared by:	Tested by:
Jessie He	Myron Yu	Carry Cai
Project Manager	Project Engineer	Test Engineer

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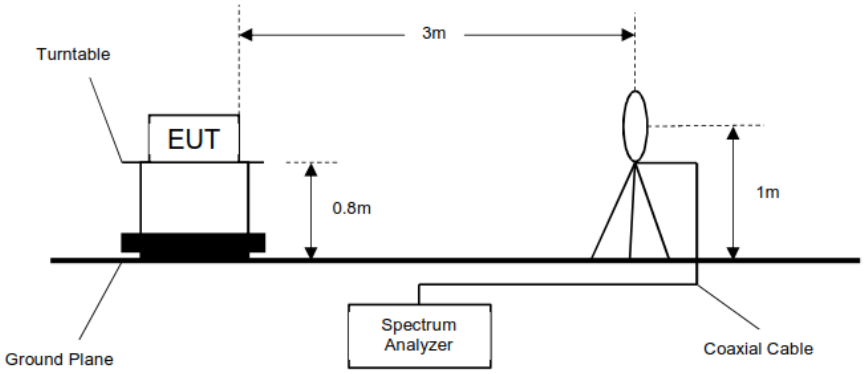
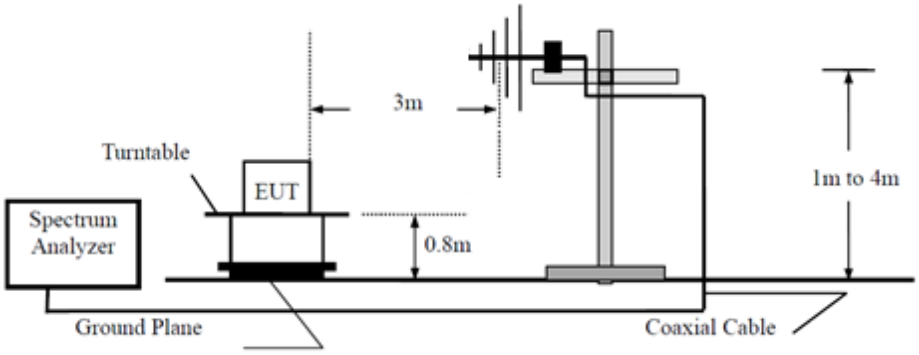
7 Test Setups

7.1 Radiated test setups

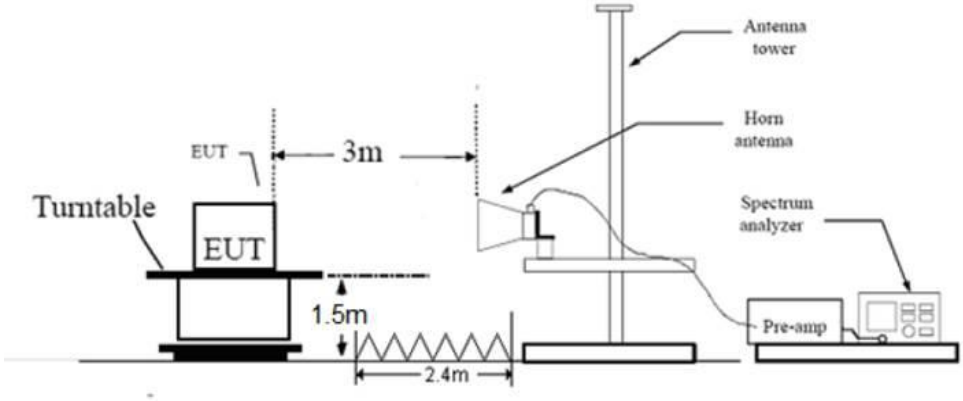
9kHz - 30MHz



Below 1GHz



Above 1GHz



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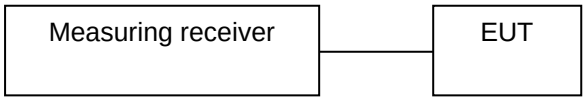
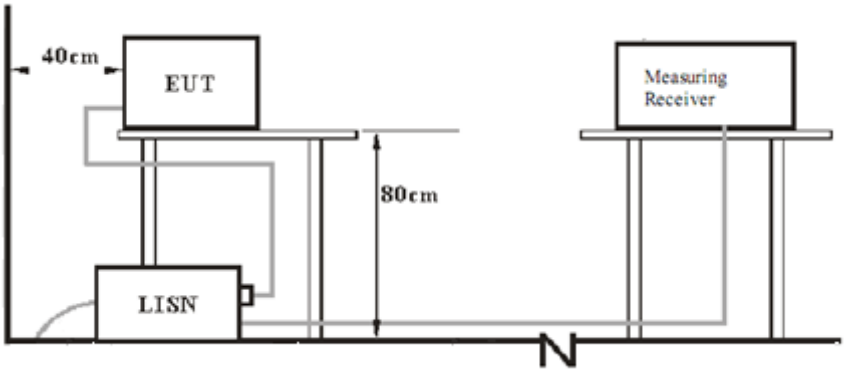
7.2 Conducted RF test setups



7.3 AC Power Line Conducted Emission test setups



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8 Systems Test Configuration

Auxiliary Equipment Used during Test:

DESCRIPTION	MODEL NO.	MANUFACTURER	S/N
Laptop	X220	ThinkPad	EMC-158

Test software information:

Test Software Version	Adb tool	
Modulation	Setting TX Power	Packet Type
GFSK	Default parameters	PRBS9
π/4-DQPSK	Default parameters	PRBS9
8DPSK	Default parameters	PRBS9

The system was configured to hopping mode and non-hopping mode.

Hopping mode: typical working mode (normal hopping status)

Non-hopping mode: The system was configured to operate at a signal channel transmitting. The test software allows the configuration and operation at the worst-case duty and the highest transmit power.

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9 Technical Requirement

9.1 Conducted Emission

Test Method

1. The EUT was placed 0.4 meter from the conducting wall of the shielding room was kept at least 80 centimeters from any other grounded conducting surface.
2. Connect EUT to the power mains through a line impedance stabilization network (LISN).
3. All the support units are connecting to the other LISN.
4. The LISN provides 50 ohm coupling impedance for the measuring instrument.
5. Both sides of AC line were checked for maximum conducted interference.
6. The frequency range from 150 kHz to 30 MHz was searched.
7. Set the test-receiver system to Peak Detect Function and specified bandwidth (IF Bandwidth = 9kHz) with Maximum Hold Mode. Then measurement is also conducted by Average Detector and Quasi-Peak Detector Function respectively.

Limit

Frequency MHz	QP Limit dBµV	AV Limit dBµV
0.150-0.500	66-56*	56-46*
0.500-5	56	46
5-30	60	50

Remark: “*” Decreasing linearly with logarithm of the frequency

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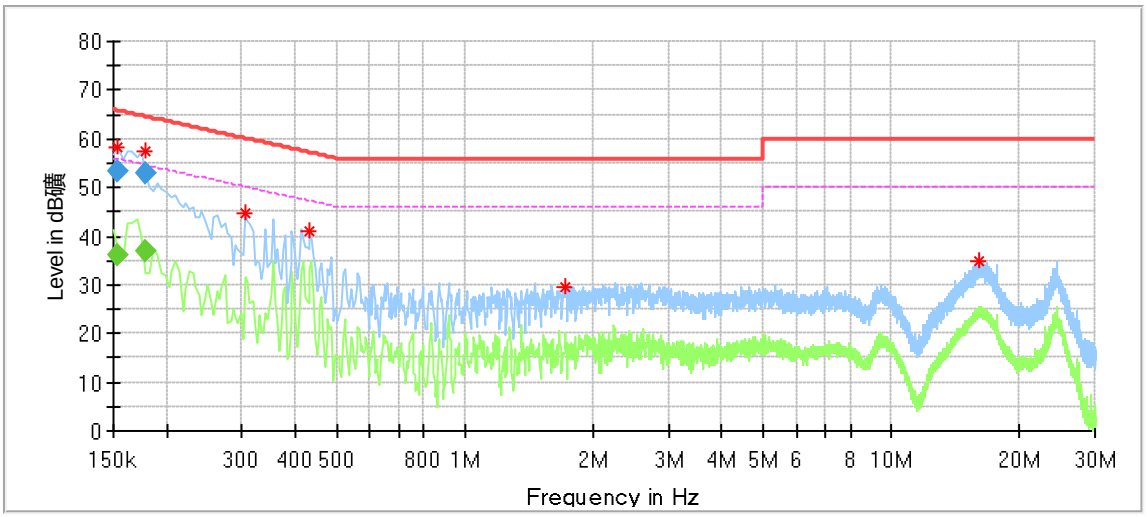
Conducted Emission

Product Type	:	Robot Vacuum Cleaner
M/N	:	Q10
Operating Condition	:	Charging + BT Transmitting
Test Specification	:	Line
Comment	:	AC 120V/60Hz



Critical_Freqs

Frequency (MHz)	MaxPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	Corr. (dB)
0.154000	58.45	---	65.78	7.33	L1	9.67
0.177500	57.44	---	64.77	7.33	L1	9.67
0.306000	44.58	---	60.08	15.50	L1	9.67
0.434000	41.05	---	57.18	16.13	L1	9.68
1.718000	29.61	---	56.00	26.39	L1	9.73
16.126000	34.68	---	60.00	25.32	L1	9.99

Final_Result

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	Corr. (dB)
0.154000	53.35	---	65.78	12.43	L1	9.67
0.154000	---	35.96	55.78	19.82	L1	9.67
0.177500	---	37.01	54.60	17.59	L1	9.67
0.177500	53.05	---	64.60	11.55	L1	9.67

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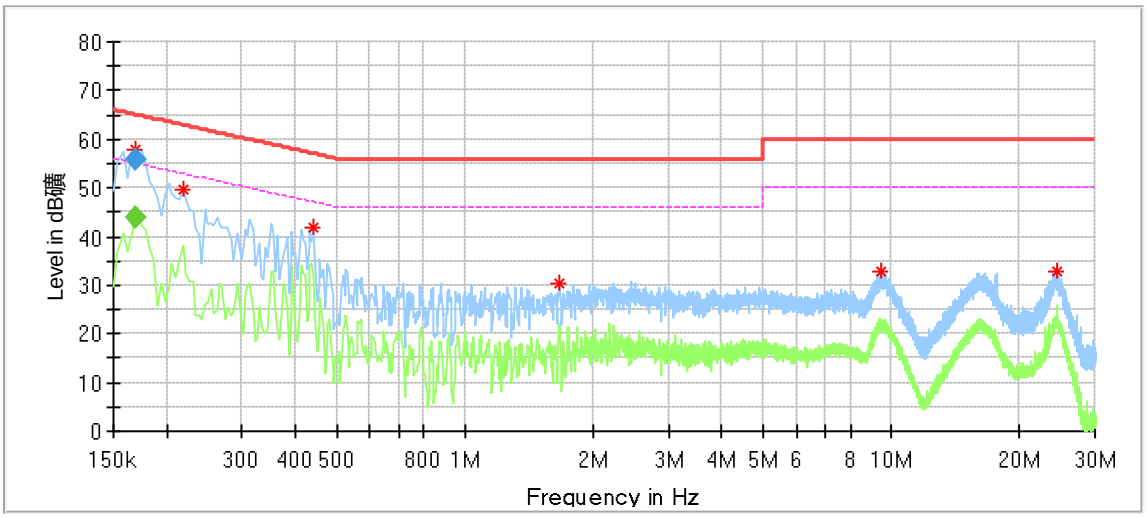
Conducted Emission

Product Type	:	Robot Vacuum Cleaner
M/N	:	Q10
Operating Condition	:	Charging + BT Transmitting
Test Specification	:	Neutral
Comment	:	AC 120V/60Hz



Critical_Freqs

Frequency (MHz)	MaxPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	Corr. (dB)
0.169500	57.93	---	64.77	6.83	N	9.67
0.218000	49.83	---	62.90	13.06	N	9.67
0.442000	41.66	---	57.02	15.37	N	9.67
1.670000	30.52	---	56.00	25.48	N	9.70
9.462000	32.69	---	60.00	27.31	N	9.91
24.430000	32.99	---	60.00	27.01	N	10.22

Final_Result

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	Corr. (dB)
0.169500	---	43.81	54.99	11.18	N	9.67
0.169500	55.68	---	64.99	9.30	N	9.67

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9.2 Conducted Peak Output Power & EIRP

Test Method

1. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit continuously
3. Use the following test receiver settings:
   Span = approximately 5 times the 20dB bandwidth, centered on a hopping channel
   RBW > the 20dB bandwidth of the emission being measured, VBW≥RBW,
   Sweep = auto, Detector function = peak, Trace = max hold
4. Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. The indicated level is the peak output power and record the results in the test report.
5. Repeat above procedures until all frequencies measured were complete.

Limits

According to §15.247 (b) (1) & RSS-247 5.4(b), conducted peak output power limit as below:

Frequency Range MHz	Limit W	Limit dBm
2400-2483.5	≤1	≤30

According to & RSS-247 5.4(b), EIRP limit as below:

Frequency Range MHz	Limit W	Limit dBm
2400-2483.5	≤4	≤36

Test Results

Mode	Frequency (MHz)	Gain (dBi)	Conducted Output Power (dBm)	EIRP (dBm)	Conducted Output Power Limit (dBm)	EIRP Limit (dBm)	Verdict
GFSK	2402	4.2	0.51	4.71	<=30	<=36	Pass
	2441	4.2	0.14	4.34	<=30	<=36	Pass
	2480	4.2	0.26	4.46	<=30	<=36	Pass
Pi/4DQPSK	2402	4.2	1.98	6.18	<=30	<=36	Pass
	2441	4.2	2.44	6.64	<=30	<=36	Pass
	2480	4.2	2.71	6.91	<=30	<=36	Pass
8DPSK	2402	4.2	3.28	7.48	<=30	<=36	Pass
	2441	4.2	2.97	7.17	<=30	<=36	Pass
	2480	4.2	3.30	7.50	<=30	<=36	Pass
Note1: E.I.R.P = Measured Power + Antenna Gain							

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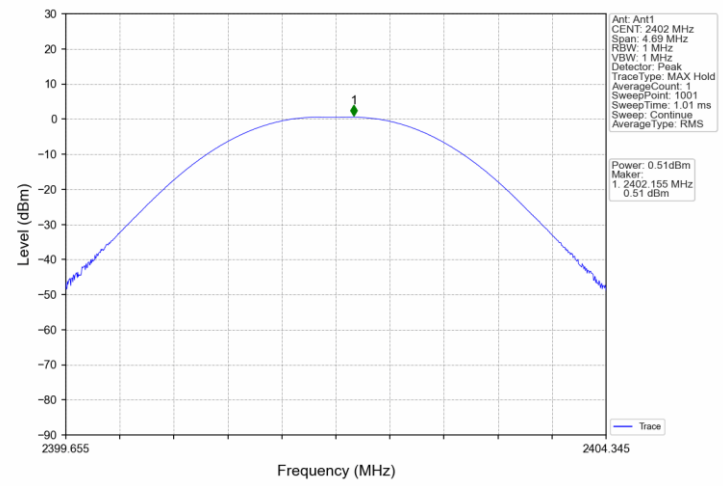
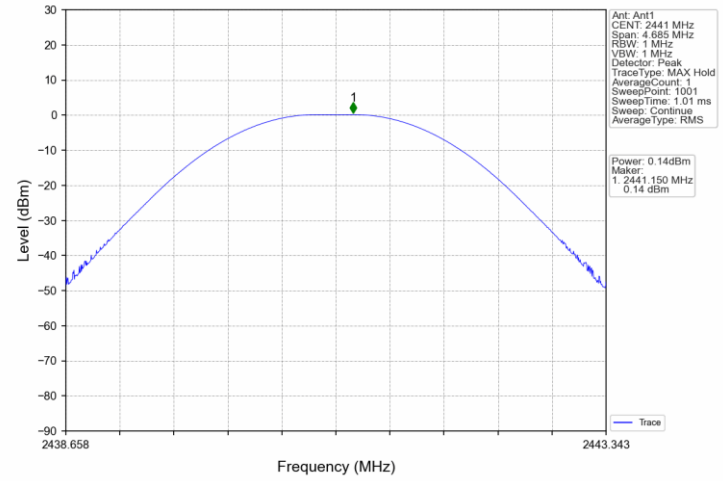
Test Graphs

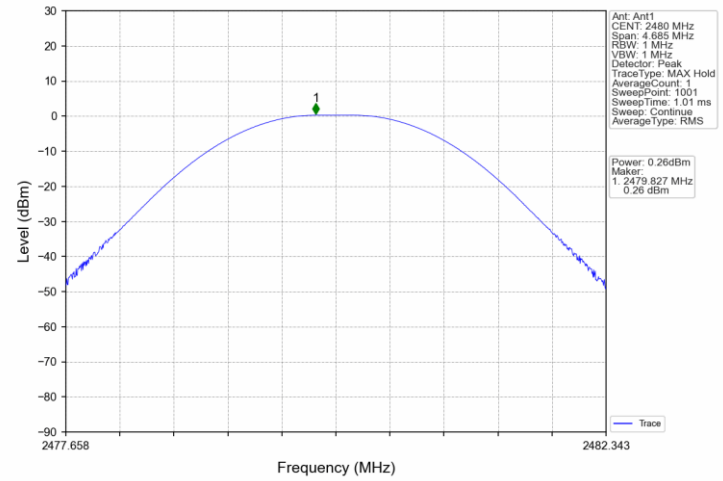
GFSK_DH5_LCH_2402MHz_Ant1_NTNV

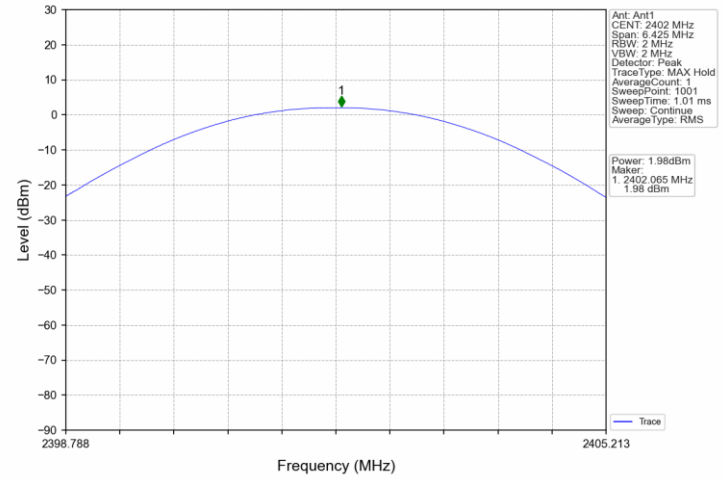


GFSK_DH5_MCH_2441MHz_Ant1_NTNV



GFSK_DH5_HCH_2480MHz_Ant1_NTNV



Pi/4DQPSK_2DH5_LCH_2402MHz_Ant1_NTNV

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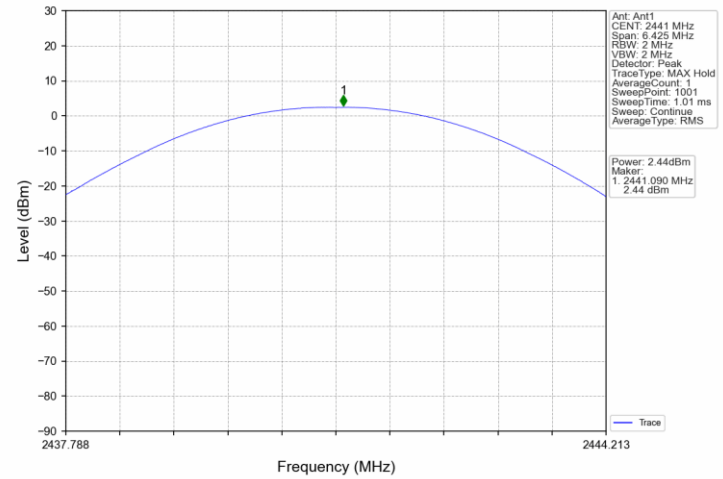
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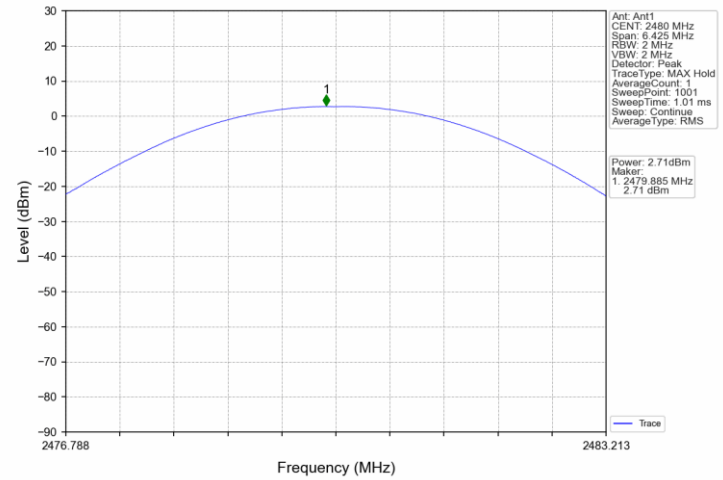
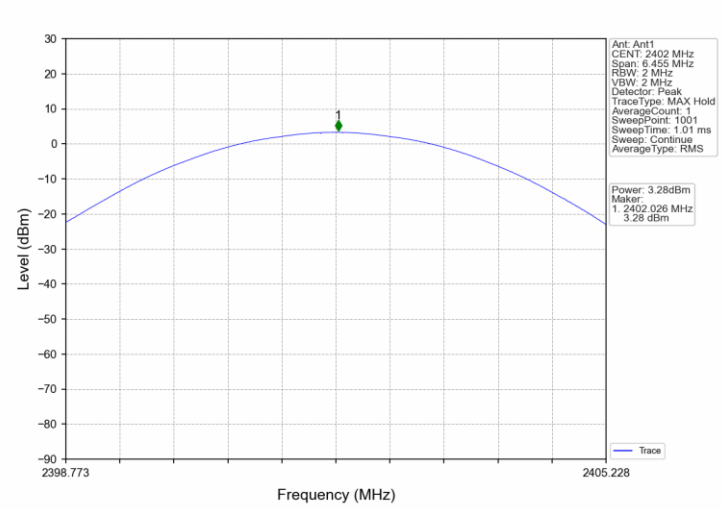
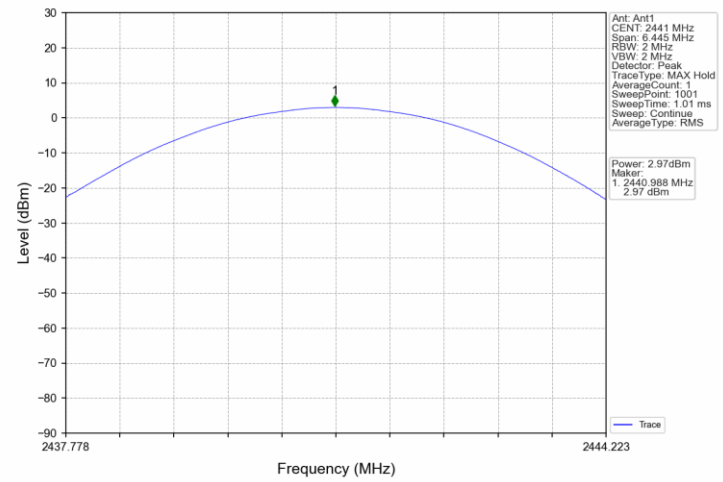


8DPSK_3DH5_LCH_2402MHz_Ant1_NTNV

8DPSK_3DH5_MCH_2441MHz_Ant1_NTNV

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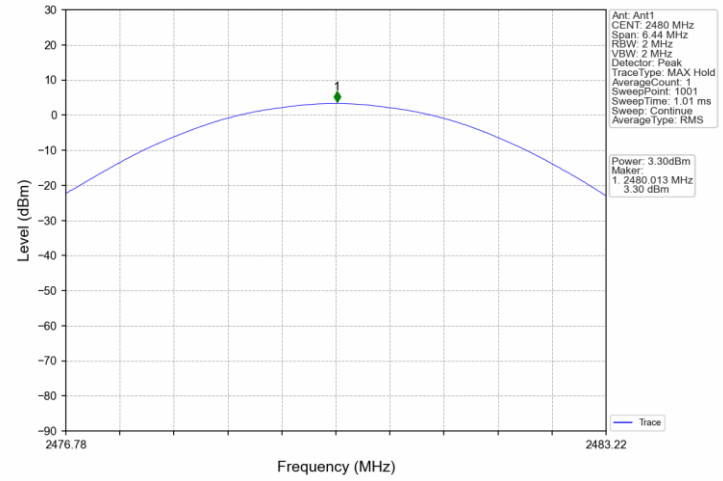

9.3 20 dB Bandwidth and 99% Occupied Bandwidth

Test Method

1. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit continuously.
3. Use the following test receiver settings:
   Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel
   RBW ≥ 1% to 5% of the 20 dB bandwidth/99% OBW, VBW≥3RBW,
   Sweep = auto, Detector function = peak, Trace = max hold
4. Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. Measure the frequency difference of two frequencies that were attenuated 20 dB/99% OBW from the reference level. Record the frequency difference as the emission bandwidth. Record the results.
5. Repeat above procedures until all frequencies measured were complete.

Limit

Limit [kHz]
N/A

Test Results

20dB bandwidth

Mode	Frequency (MHz)	Packet Type	20dB Bandwidth (MHz)		Verdict
			Result	Limit	
GFSK	2402	DH5	0.938	/	Pass
	2441	DH5	0.937	/	Pass
	2480	DH5	0.937	/	Pass
Pi/4DQPSK	2402	2DH5	1.285	/	Pass
	2441	2DH5	1.285	/	Pass
	2480	2DH5	1.285	/	Pass
8DPSK	2402	3DH5	1.291	/	Pass
	2441	3DH5	1.289	/	Pass
	2480	3DH5	1.288	/	Pass

99% Occupied Bandwidth

Mode	Frequency (MHz)	Packet Type	99% Occupied Bandwidth (MHz)		Verdict
			Result	Limit	
GFSK	2402	DH5	0.852	/	Pass
	2441	DH5	0.850	/	Pass
	2480	DH5	0.849	/	Pass
Pi/4DQPSK	2402	2DH5	1.183	/	Pass
	2441	2DH5	1.185	/	Pass
	2480	2DH5	1.183	/	Pass
8DPSK	2402	3DH5	1.170	/	Pass
	2441	3DH5	1.169	/	Pass
	2480	3DH5	1.170	/	Pass

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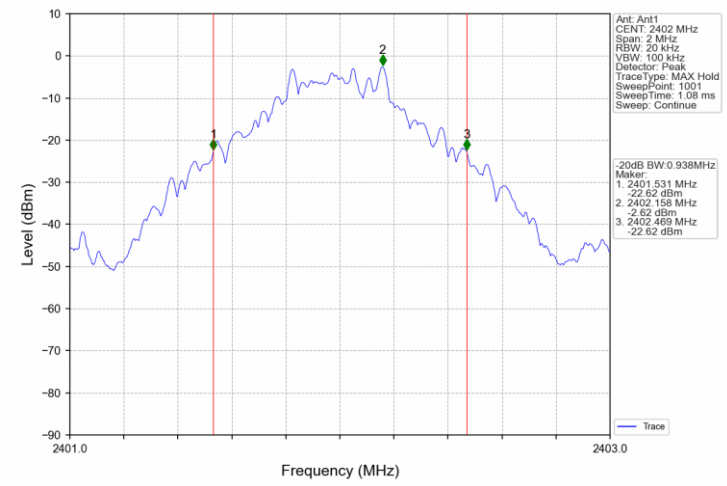
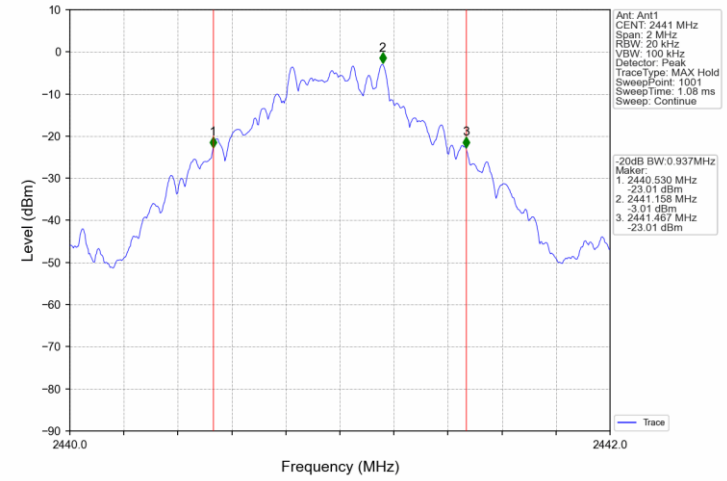
Test Graphs of 20dB Bandwidth

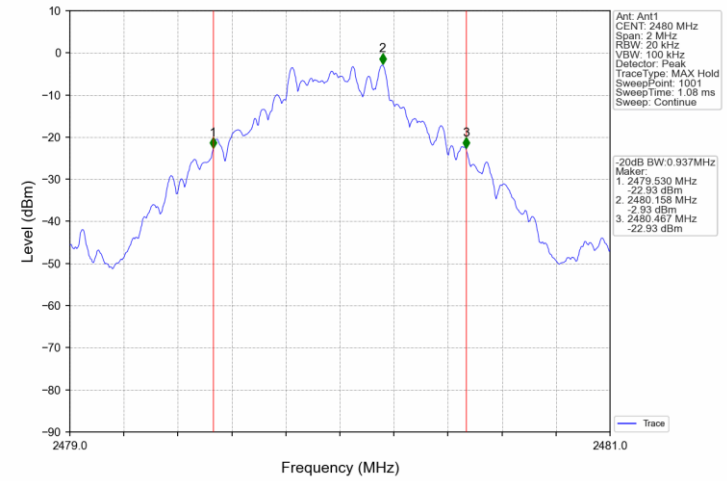
GFSK_DH5_LCH_2402MHz_Ant1_NTNV



GFSK_DH5_MCH_2441MHz_Ant1_NTNV



GFSK_DH5_HCH_2480MHz_Ant1_NTNV



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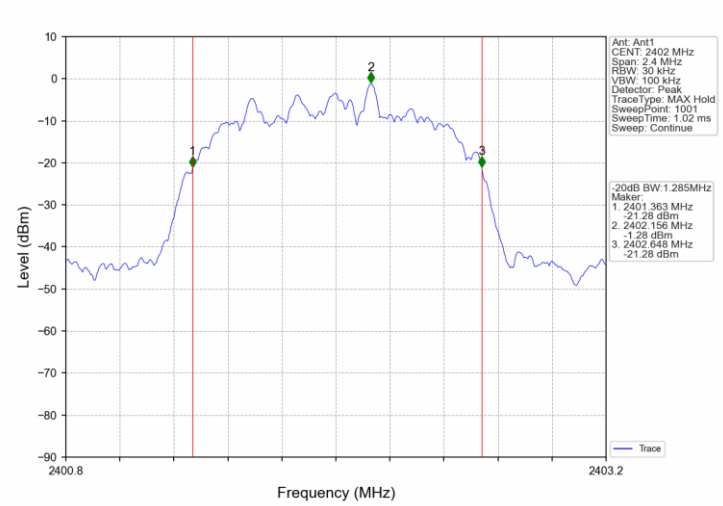
Pi/4DQPSK_2DH5_LCH_2402MHz_Ant1_NTNV

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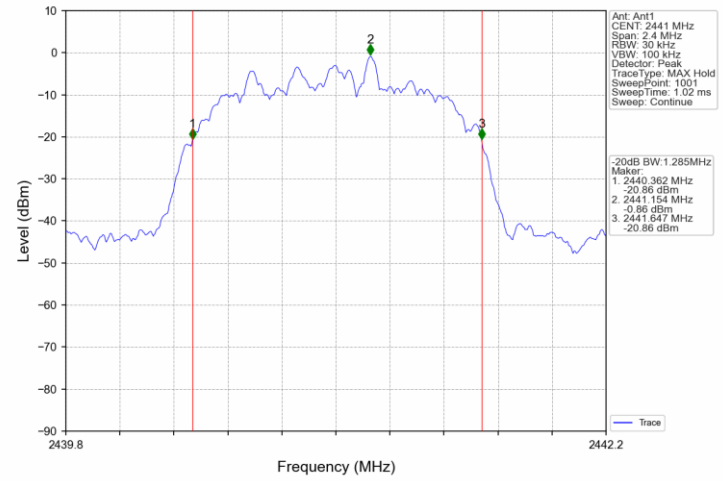
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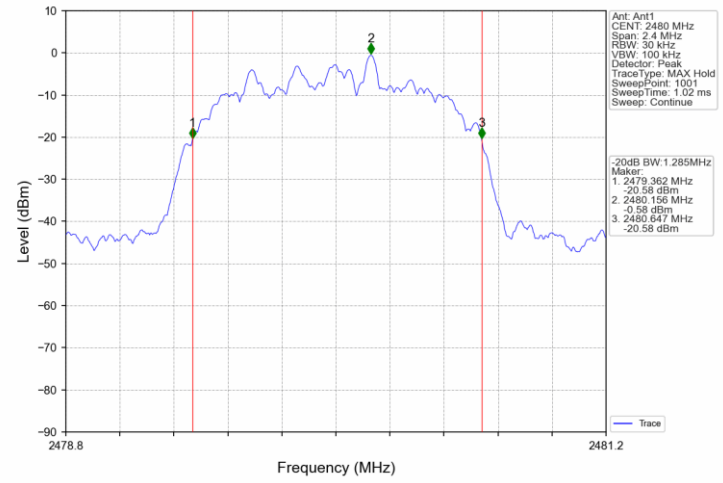
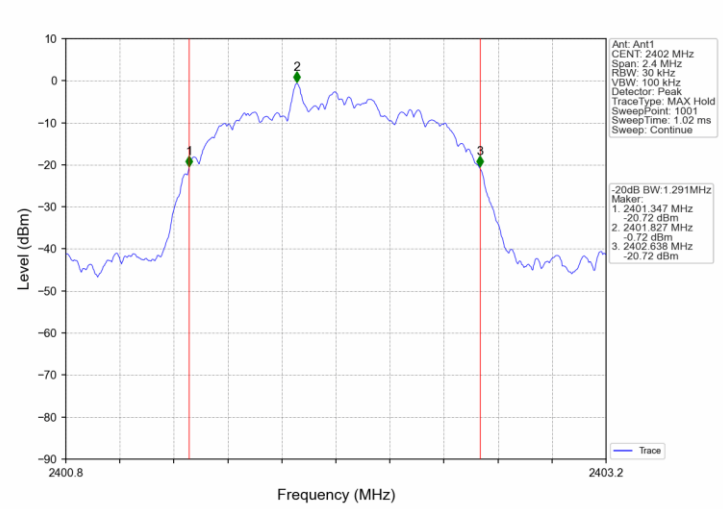


8DPSK_3DH5_LCH_2402MHz_Ant1_NTNV

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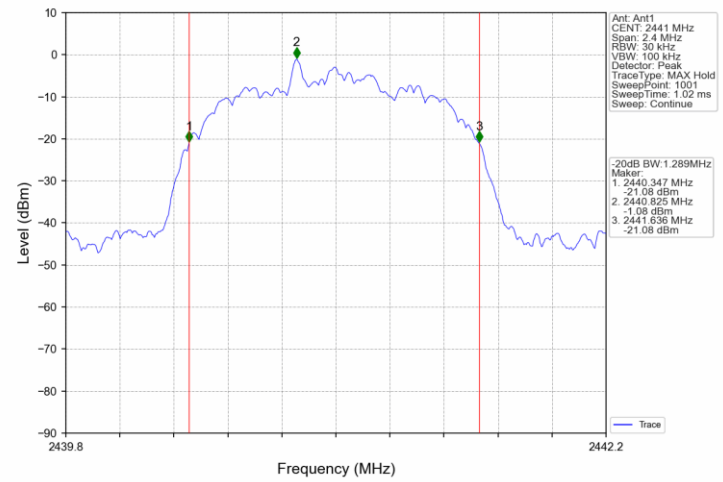
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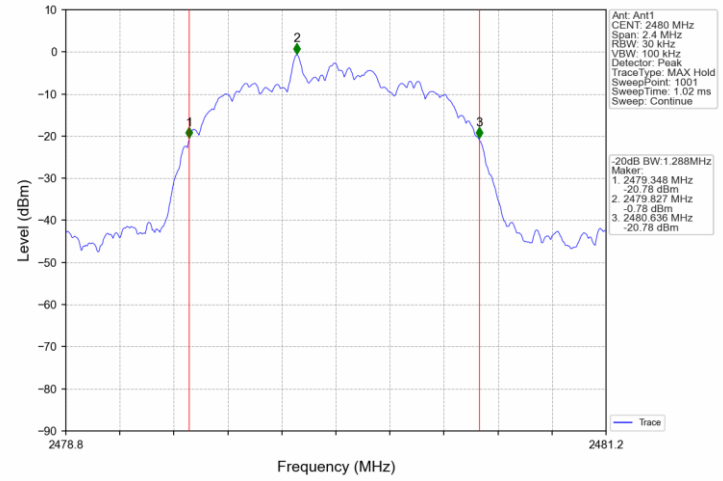
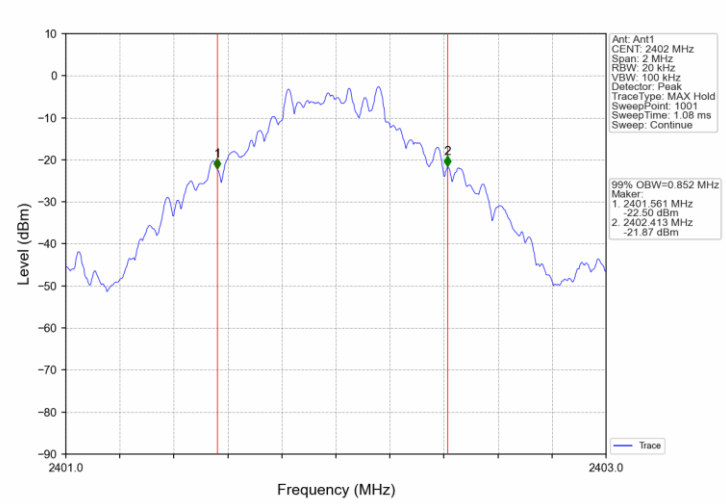
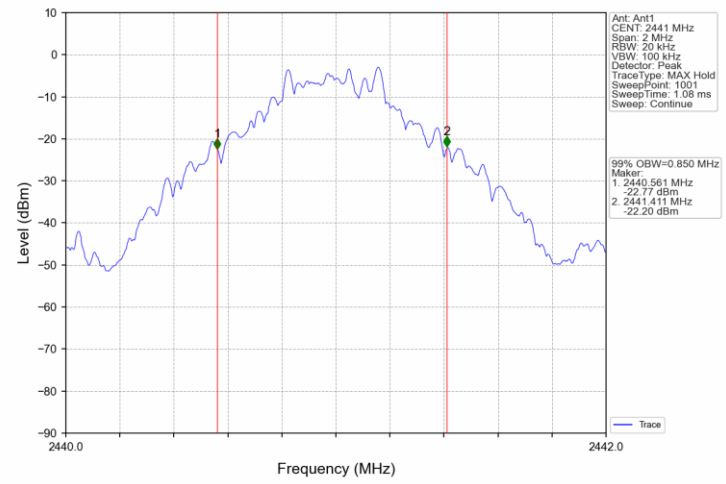
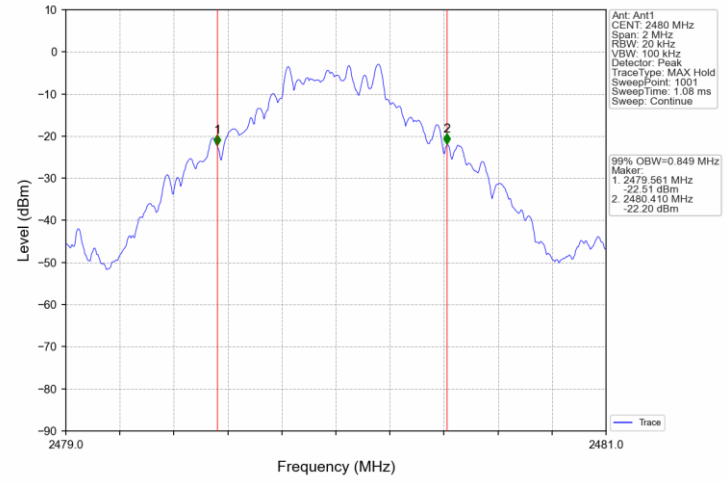
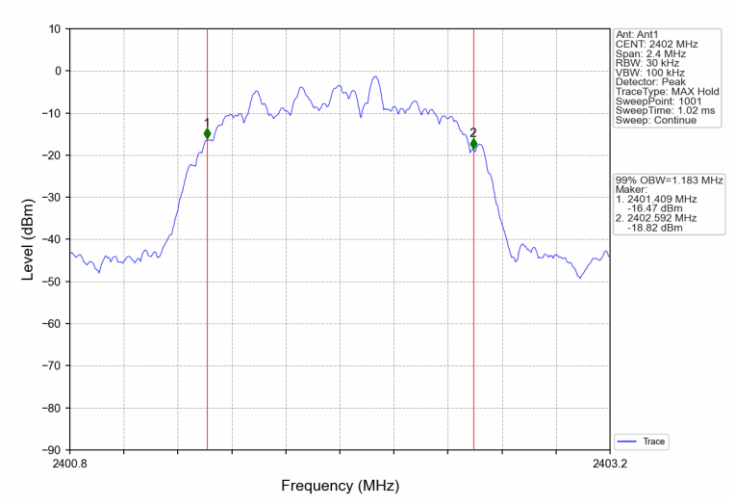
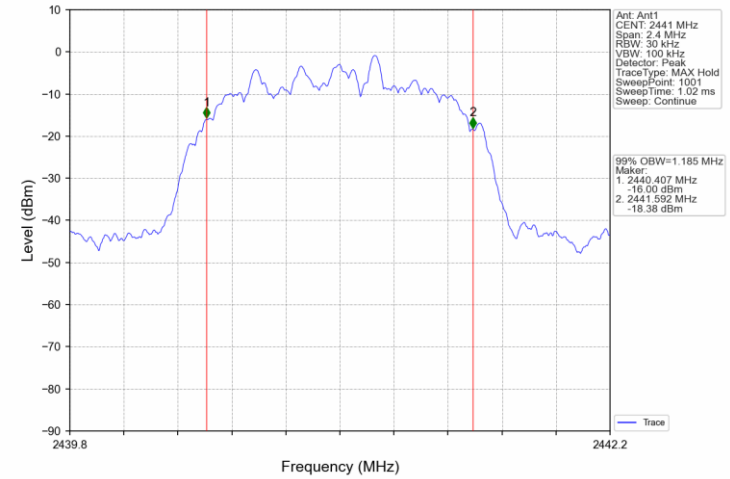


Test Graphs of 99% Occupied Bandwidth

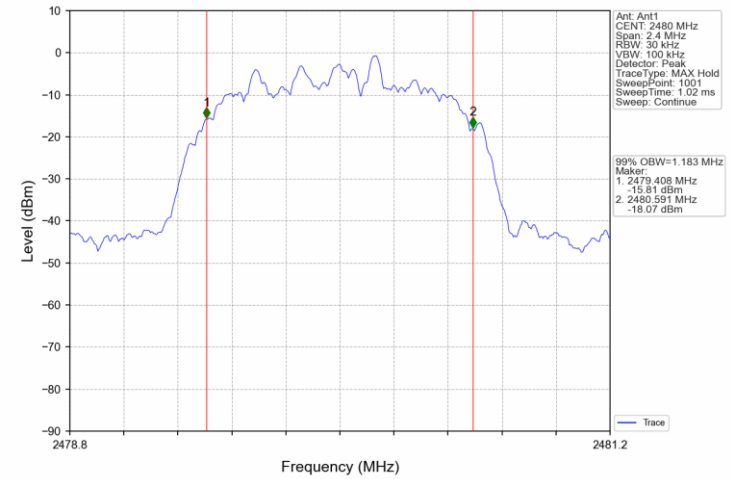
GFSK_DH5_LCH_2402MHz_Ant1_NTNV

GFSK_DH5_MCH_2441MHz_Ant1_NTNV

GFSK_DH5_HCH_2480MHz_Ant1_NTNV

Pi/4DQPSK_2DH5_LCH_2402MHz_Ant1_NTNV

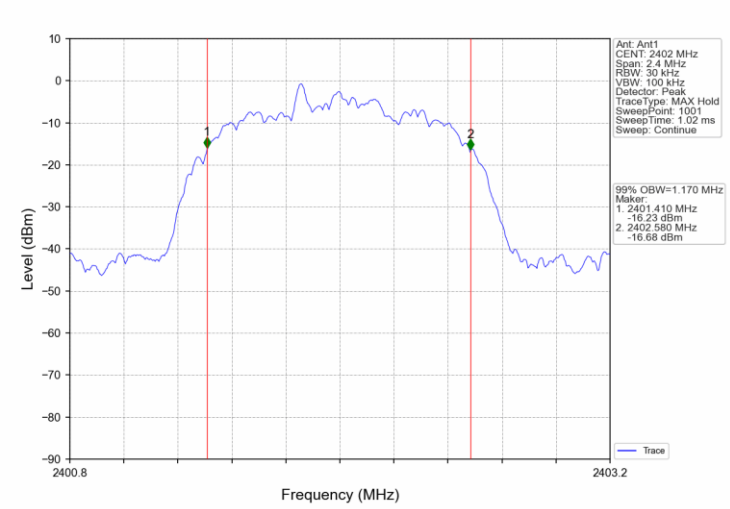
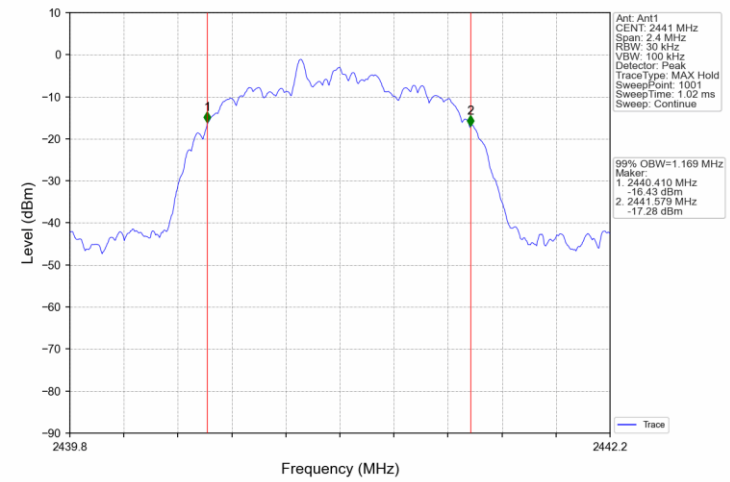
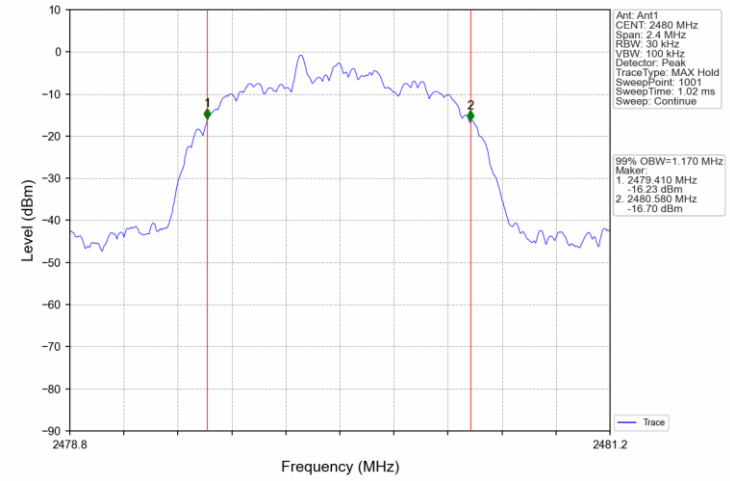


Pi/4DQPSK_2DH5_MCH_2441MHz_Ant1_NTNV



Pi/4DQPSK_2DH5_HCH_2480MHz_Ant1_NTNV



8DPSK_3DH5_LCH_2402MHz_Ant1_NTNV

8DPSK_3DH5_MCH_2441MHz_Ant1_NTNV

8DPSK_3DH5_HCH_2480MHz_Ant1_NTNV


9.4 Carrier Frequency Separation

Test Method

1. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit to hopping mode.
3. Use the following spectrum analyzer settings:
   Span = wide enough to capture the peaks of two adjacent channels, 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. VBW ≥RBW, Sweep = auto, Detector function = peak.
4. By using the Max-Hold function record the separation of two adjacent channels.
5. Measure the frequency difference of these two adjacent channels by spectrum analyzer marker function. Record the results.
6. Repeat above procedures until all frequencies measured were complete.

Limits

Limit kHz
⩾25KHz or 2/3 of the 20 dB bandwidth which is greater

Test Results

Mode	Frequency (MHz)	Packet Type	Channel Separation (MHz)	20dB Bandwidth (MHz)	Limit (MHz)	Verdict
GFSK	HOPP	DH5	0.768	0.938	>=0.625	Pass
Pi/4DQPSK	HOPP	2DH5	0.998	1.285	>=0.857	Pass
8DPSK	HOPP	3DH5	1.001	1.291	>=0.861	Pass

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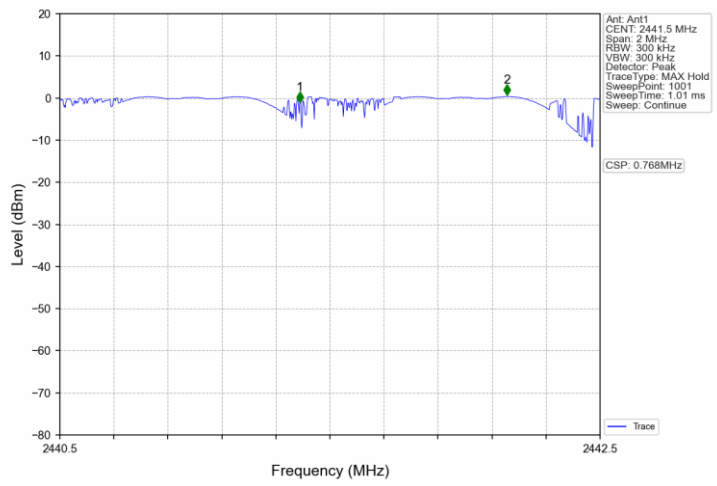
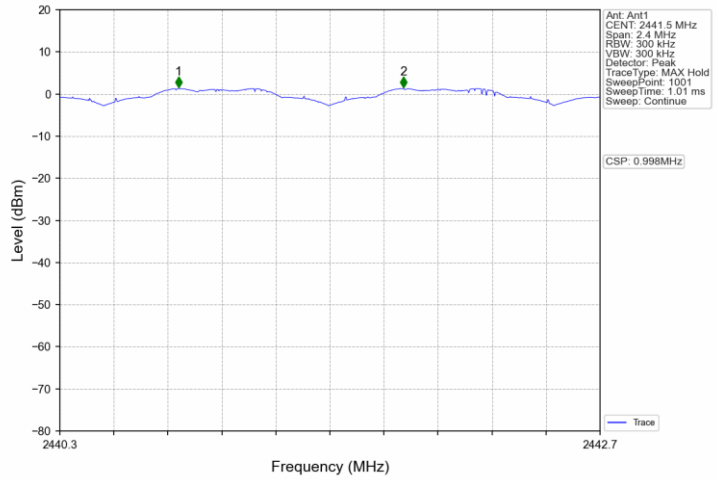
Test Graphs

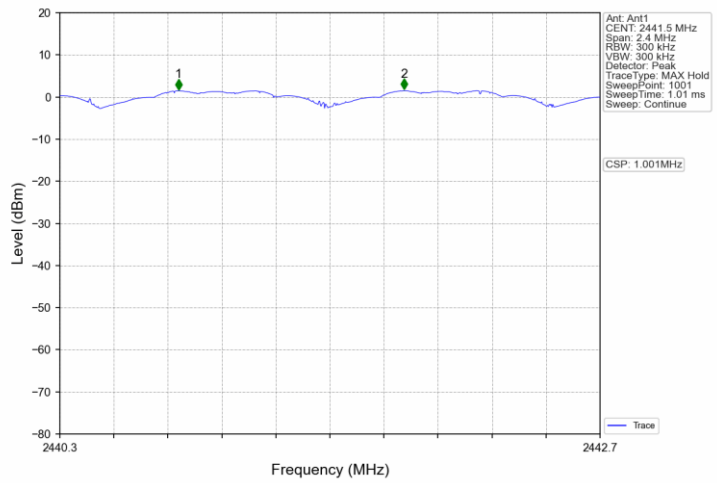
GFSK_DH5_HOPP_Ant1_NTNV



Pi/4DQPSK_2DH5_HOPP_Ant1_NTNV



8DPSK_3DH5_HOPP_Ant1_NTNV



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9.5 Number of Hopping Frequencies

Test Method

1. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit to hopping mode.
3. Use the following spectrum analyzer settings:
   Span = the frequency band of operation, 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, VBW ≥RBW, Sweep = auto, Detector function = peak, Trace=Max hold.
4. Allow the trace to stabilize. It may prove necessary to break the span up to sections, in order to clearly show all of the hopping frequencies. The limit is specified in one of the subparagraphs of this Section. Submit this plot(s).

Limit

Limit number
⩾ 15

Test Results

Mode	Frequency (MHz)	Packet Type	Num of Hopping Frequencies		Verdict
			Result	Limit	
GFSK	HOPP	DH5	79	>=15	Pass
Pi/4DQPSK	HOPP	2DH5	79	>=15	Pass
8DPSK	HOPP	3DH5	79	>=15	Pass

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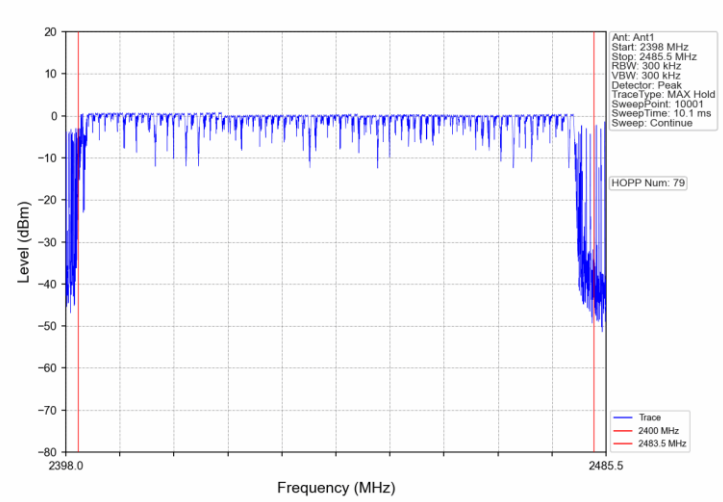
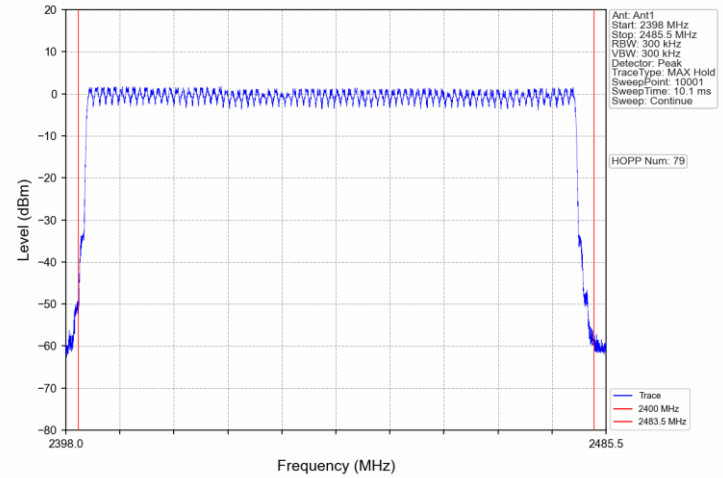
Test Graphs

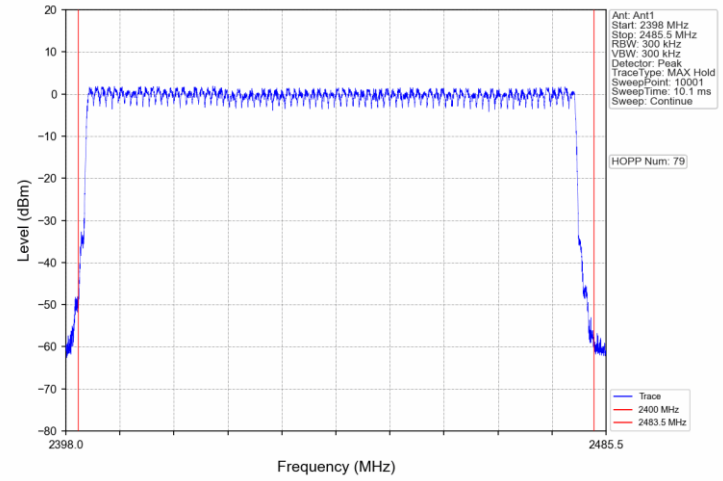
GFSK_DH5_HOPP_Ant1_NTNV



Pi/4DQPSK_2DH5_HOPP_Ant1_NTNV



8DPSK_3DH5_HOPP_Ant1_NTNV



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9.6 Dwell Time

Test Method

1. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit to hopping mode.
3. Span: Zero span, centered on a hopping channel.
4. RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
5. 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.
6. Detector function: Peak.
7. 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.

Limit

The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

Test Results

Mode	Frequency (MHz)	Packet Type	Duration of Single Pulse (ms)	Observation Period (s)	Num of Pulse in Observation Period	Dwell Time (ms)	Limit (ms)	Verdict
GFSK	HOPP	DH1	0.392	31.600	320	125.440	<=400	Pass
		DH3	1.648	31.600	160	263.680	<=400	Pass
		DH5	2.898	31.600	108	312.984	<=400	Pass
Pi/4DQPSK	HOPP	2DH1	0.398	31.600	320	127.360	<=400	Pass
		2DH3	1.648	31.600	162	266.976	<=400	Pass
		2DH5	2.904	31.600	101	293.304	<=400	Pass
8DPSK	HOPP	3DH1	0.396	31.600	320	126.720	<=400	Pass
		3DH3	1.646	31.600	161	265.006	<=400	Pass
		3DH5	2.906	31.600	115	334.190	<=400	Pass

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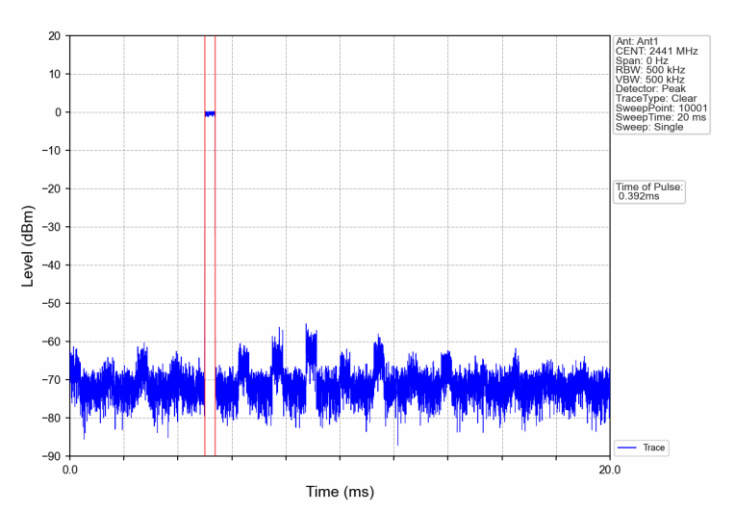
Test Graphs

GFSK_DH1_HOPP_Ant1_NTNV

GFSK_DH1_HOPP_Ant1_NTNV