

TEST REPORT

Applicant Name : Leotec Electronics Co. LTD
Address : No.174 Wenzhou Road, Dongcheng District, Dongguan,
Guangdong, China
Report Number : RA230717-41157E-RF-00A
FCC ID: 2BABOLT-BT2311

Test Standard (s)

FCC PART 15.247

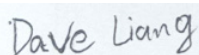
Sample Description

Product Type: Barbie Collection Wireless Speaker
Model No.: LT-BT2311
Multiple Model(s) No.: N/A
Trade Mark: LEOTEC, MINISO
Date Received: 2023/07/17
Report Date: 2023/07/27

Test Result:	Pass*
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* In the configuration tested, the EUT complied with the standards above.

Prepared and Checked By:



Dave Liang
EMC Engineer

Approved By:



Candy Li
EMC Engineer

Note: This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk "★".

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	RA230717-41157E-RF-00A	Original Report	2023-07-27

GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Frequency Range	Bluetooth: 2402~2480MHz
Maximum conducted Peak output power	Bluetooth: 0.28dBm
Modulation Technique	Bluetooth: GFSK, $\pi/4$ -DQPSK, 8DPSK
Antenna Specification*	1.9dBi (provided by the applicant)
Voltage Range	DC 3.7V from battery or DC 5V from type-c port
Sample serial number	28CW-1 for Conducted and Radiated Emissions Test 28CW-2 for RF Conducted Test (Assigned by ATC)
Sample/EUT Status	Good condition

Objective

This test report is in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commission rules.

The tests were performed in order to determine compliance with FCC Part 15, Subpart C, section 15.203, 15.205, 15.207, 15.209 and 15.247 rules.

Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.

All emissions measurement was performed at Shenzhen Accurate Technology Co., Ltd. The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

Measurement Uncertainty

Parameter		Uncertainty
Occupied Channel Bandwidth		5%
RF Frequency		0.082×10^{-7}
RF output power, conducted		0.71dB
Unwanted Emission, conducted		1.6dB
AC Power Lines Conducted Emissions	9k-30MHz	2.74dB, k=2
Emissions, Radiated	9kHz - 30MHz	2.06dB
	30MHz - 1GHz	5.08dB
	1GHz - 18GHz	4.96dB
	18GHz - 26.5GHz	5.16dB
	26.5GHz - 40GHz	4.64dB
Temperature		1°C
Humidity		6%
Supply voltages		0.4%

Note: The extended uncertainty given in this report is obtained by combining the standard uncertainty times the coverage factor K with the 95% confidence interval. Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.

Test Facility

The test site used by Shenzhen Accurate Technology Co., Ltd. to collect test data is located on the Floor 1, KuMaKe Building, Dongzhou Community, Guangming Street, Guangming District, Shenzhen, Guangdong, China.

The test site has been approved by the FCC under the KDB 974614 D01 and is listed in the FCC Public Access Link (PAL) database, FCC Registration No.: 708358, the FCC Designation No.: CN1189. Accredited by American Association for Laboratory Accreditation (A2LA) The Certificate Number is 429 7.01.

The lab has been recognized by Innovation, Science and Economic Development Canada to test to Canadian radio equipment requirements, the CAB identifier: CN0016. The Registration Number is 30241.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

The system was configured for testing in an engineering mode.

Channel list:

Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2402	40	2442
1	2403	41	2443
2	2404	42	2444
...	...	...	...
...	...	...	...
36	2438	75	2477
37	2439	76	2478
38	2440	77	2479
39	2441	78	2480

EUT was tested with Channel 0, 39 and 78.

EUT Exercise Software

“BT_Tool *” exercise software was used and the power level is 7*. The software and power level was provided by the manufacturer.

Special Accessories

No special accessory.

Equipment Modifications

No modification was made to the EUT tested.

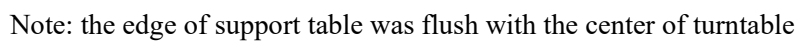
Support Equipment List and Details

Manufacturer	Description	Model	Serial Number
Honor	Mobile phone	TFY-AN00	A00000E76E0FD2
Xiaomi	Mobile phone	M7	2356U2589
Switching	adapter	TPA-46B050100UU	/

External I/O Cable

Cable Description	Length (m)	From Port	To
Un-shielding Detachable DC Cable	0.8	socket	Adapter
Un-shielding Detachable USB Cable	1.0	Mobile phone	EUT

For Conducted Emissions:



SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
FCC§15.247 (i), §1.1307 (b) (3) &§2.1091	MPE-Based Exemption	Compliant
§15.203	Antenna Requirement	Compliant
§15.207(a)	AC Line Conducted Emissions	Compliant
§15.205, §15.209 & §15.247(d)	Radiated Emissions	Compliant
§15.247(a)(1)	20 dB Emission Bandwidth & 99% Occupied Bandwidth	Compliant
§15.247(a)(1)	Channel Separation Test	Compliant
§15.247(a)(1)(iii)	Time of Occupancy (Dwell Time)	Compliant
§15.247(a)(1)(iii)	Quantity of hopping channel Test	Compliant
§15.247(b)(1)	Peak Output Power Measurement	Compliant
§15.247(d)	Band edges	Compliant

TEST EQUIPMENT LIST

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Conducted Emissions Test					
Rohde& Schwarz	EMI Test Receiver	ESCI	100784	2022/11/25	2023/11/24
Rohde & Schwarz	L.I.S.N.	ENV216	101314	2022/11/25	2023/11/24
Anritsu Corp	50 Coaxial Switch	MP59B	6100237248	2022/12/07	2023/12/06
Unknown	RF Coaxial Cable	No.18	N0850	2022/11/25	2023/11/24
Conducted Emission Test Software: e3 191218 (V9)					
Radiated Emissions Test					
Rohde& Schwarz	Test Receiver	ESR	102725	2022/11/25	2023/11/24
Rohde&Schwarz	Spectrum Analyzer	FSV40	101949	2022/11/25	2023/11/24
SONOMA INSTRUMENT	Amplifier	310 N	186131	2022/11/08	2023/11/07
A.H. Systems, inc.	Preamplifier	PAM-0118P	135	2022/11/08	2023/11/07
Quinstar	Amplifier	QLW-18405536-J0	15964001002	2022/11/08	2023/11/07
Schwarzbeck	Bilog Antenna	VULB9163	9163-323	2021/07/06	2024/07/06
Schwarzbeck	Horn Antenna	BBHA9120D	837	2023/02/22	2026/02/21
Schwarzbeck	HORN ANTENNA	BBHA9170	9170-359	2022/12/26	2025/12/25
Radiated Emission Test Software:e3 191218 (V9)					
Unknown	RF Coaxial Cable	No.10	N050	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.11	N1000	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.12	N040	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.13	N300	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.14	N800	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.15	N600	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.16	N650	2022/11/25	2023/11/24
Wainwright	High Pass Filter	WHKX3.6/18 G-10SS	5	2022/11/25	2023/11/24

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
RF Conducted Test					
Rohde&Schwarz	Spectrum Analyzer	FSU26	200120	2023/4/18	2024/4/17
WEINSCHTEL	10dB Attenuator	5324	AU 3842	2022/11/25	2023/11/24
Unknown	RF Cable	Unknown	1	Each time	Each time

* **Statement of Traceability:** Shenzhen Accurate Technology Co., Ltd. attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

FCC §15.247 (i) & §1.1307 (b) (3) & §2.1091- MPE-Based Exemption

Applicable Standard

According to subpart 15.247 (i) and subpart 2.1091 systems operating under the provisions of this section shall be operated in a manner that ensures the public is not exposed to RF energy level in excess of the communication guidelines.

According to KDB 447498 D04 Interim General RF Exposure Guidance

MPE-Based Exemption:

General frequency and separation-distance dependent MPE-based effective radiated power(ERP) thresholds are in Table B.1 [Table 1 of § 1.1307(b)(1)(i)(C)] to support an exemption from further evaluation from 300 kHz through 100 GHz.

Table 1 to § 1.1307(b)(3)(i)(C) - Single RF Sources Subject to Routine Environmental Evaluation

RF Source frequency (MHz)	Threshold ERP (watts)
0.3-1.34	$1,920 R^2$.
1.34-30	$3,450 R^2/f^2$.
30-300	$3.83 R^2$.
300-1,500	$0.0128 R^2 f$.
1,500-100,000	$19.2 R^2$.

R is the minimum separation distance in meters

f = frequency in MHz

Result

Mode	Frequency (MHz)	Tune up conducted power	Antenna Gain		ERP		Evaluation Distance (m)	ERP Limit (mW)
		(dBm)	(dBi)	(dBd)	(dBm)	(mW)		
Bluetooth	2402-2480	1.0	1.9	-0.25	0.75	1.189	0.2	768

Note: 1. The tune up conducted power and antenna gain was declared by the applicant.

2. 0dBd=2.15dBi

To maintain compliance with the FCC's RF exposure guidelines, place the equipment at least 20cm from nearby persons.

Result: Compliant.

FCC §15.203 – ANTENNA REQUIREMENT

Applicable Standard

According to FCC § 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

Antenna Connector Construction

The EUT has one internal antenna, which was permanently attached, and the maximum antenna gain is 1.9dBi, fulfill the requirement of this section. Please refer to the EUT photos.

Result: Compliant.

FCC §15.207 (a) – AC LINE CONDUCTED EMISSIONS

Applicable Standard

FCC §15.207(a)

EUT Setup



Note: 1. Support units were connected to second LISN.
2. Both of LISNs (AMN) 80 cm from EUT and at the least 80 cm from other units and other metal planes support units.

The measurement procedure of EUT setup is according with ANSI C63.10-2013. The related limit was specified in FCC Part 15.207.

The spacing between the peripherals was 10 cm.

EMI Test Receiver Setup

The EMI test receiver was set to investigate the spectrum from 150 kHz to 30 MHz.

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

Frequency Range	IF B/W
150 kHz – 30 MHz	9 kHz

Test Procedure

During the conducted emission test, the adapter was connected to the outlet of the LISN.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All final data was recorded in the Quasi-peak and average detection mode.

Factor & Over limit Calculation

The factor is calculated by adding LISN VDF (Voltage Division Factor), Cable Loss and Transient Limiter Attenuation. The basic equation is as follows:

$$\text{Factor} = \text{LISN VDF} + \text{Cable Loss}$$

The “**Over Limit**” column of the following data tables indicates the degree of compliance with the applicable limit. For example, a over limit of -7 dB means the emission is 7 dB below the limit. The equation for over limit calculation is as follows:

$$\begin{aligned}\text{Over Limit} &= \text{level} - \text{Limit} \\ \text{Level} &= \text{reading level} + \text{Factor}\end{aligned}$$

Test Data

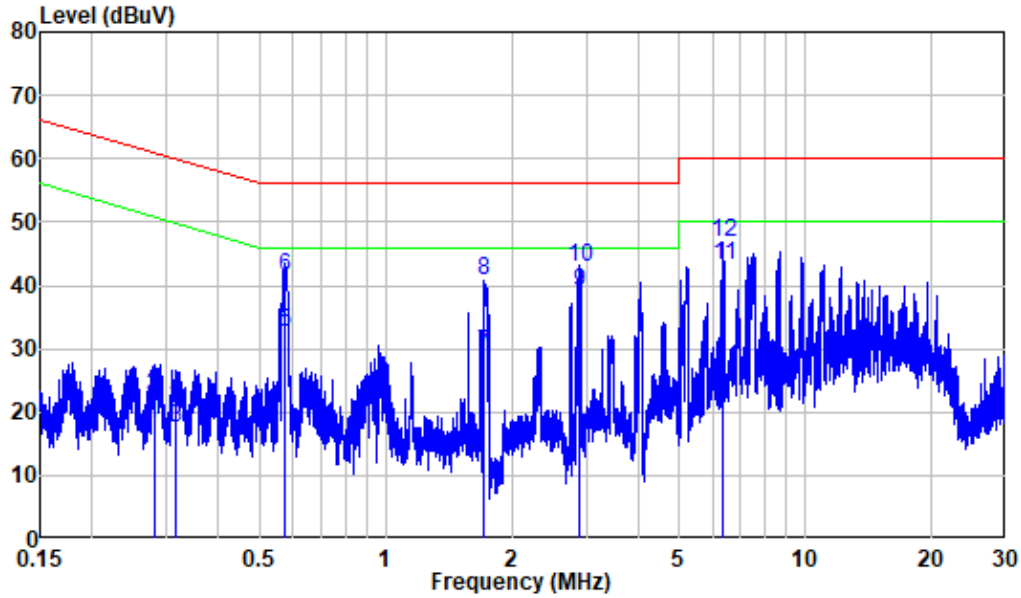
Environmental Conditions

Temperature:	25 °C
Relative Humidity:	50 %
ATM Pressure:	100.19 kPa

The testing was performed by Jeef Huang on 2023-07-19.

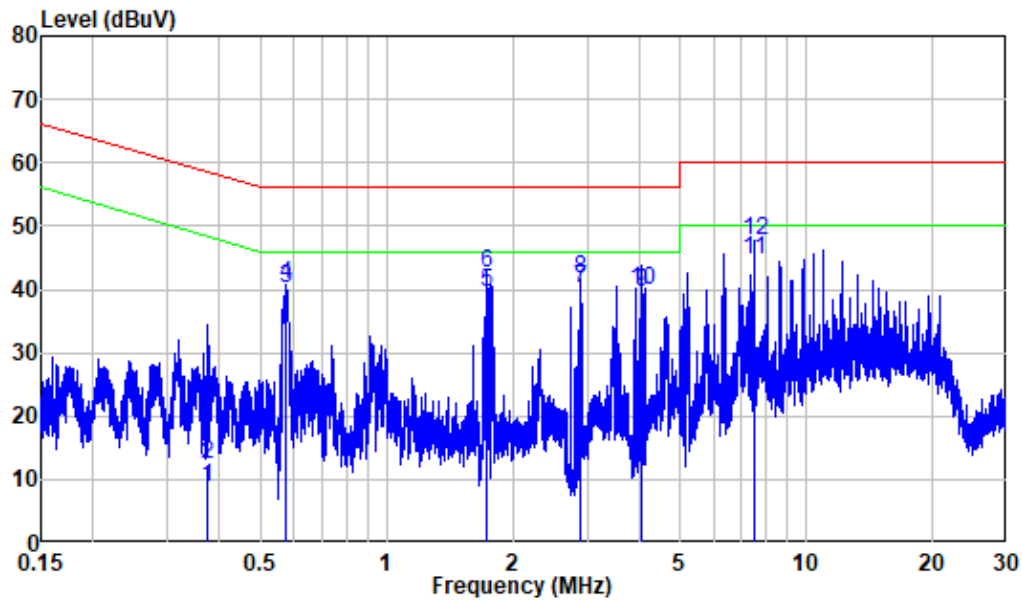
EUT operation mode: Transmitting (the worst case is 8DPSK Mode, Middle channel)

AC 120V/60 Hz, Line



Site : Shielding Room
 Condition: Line
 Job No. : RA230717-41157E-RF
 Mode : Charging+BT Transmitting
 Power : AC 120V 60Hz

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.280	10.38	7.75	18.13	50.81	-32.68	Average
2	0.280	10.38	12.33	22.71	60.81	-38.10	QP
3	0.317	10.42	6.95	17.37	49.77	-32.40	Average
4	0.317	10.42	11.66	22.08	59.77	-37.69	QP
5	0.577	10.61	21.88	32.49	46.00	-13.51	Average
6	0.577	10.61	30.74	41.35	56.00	-14.65	QP
7	1.718	10.41	18.87	29.28	46.00	-16.72	Average
8	1.718	10.41	30.26	40.67	56.00	-15.33	QP
9	2.883	10.48	28.56	39.04	46.00	-6.96	Average
10	2.883	10.48	32.46	42.94	56.00	-13.06	QP
11	6.365	10.60	32.45	43.05	50.00	-6.95	Average
12	6.365	10.60	36.14	46.74	60.00	-13.26	QP

AC 120V/60 Hz, Neutral

Site : Shielding Room
 Condition: Neutral
 Job No. : RA230717-41157E-RF
 Mode : Charging+BT Transmitting
 Power : AC 120V 60Hz

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.373	10.40	-1.71	8.69	48.44	-39.75	Average
2	0.373	10.40	2.06	12.46	58.44	-45.98	QP
3	0.576	10.47	29.62	40.09	46.00	-5.91	Average
4	0.576	10.47	30.24	40.71	56.00	-15.29	QP
5	1.736	10.47	29.13	39.60	46.00	-6.40	Average
6	1.736	10.47	32.00	42.47	56.00	-13.53	QP
7	2.896	10.53	29.62	40.15	46.00	-5.85	Average
8	2.896	10.53	31.25	41.78	56.00	-14.22	QP
9	4.043	10.54	29.08	39.62	46.00	-6.38	Average
10	4.043	10.54	29.30	39.84	56.00	-16.16	QP
11	7.506	10.56	34.23	44.79	50.00	-5.21	Average
12	7.506	10.56	37.10	47.66	60.00	-12.34	QP

FCC §15.205, §15.209 & §15.247(d) – RADIATED EMISSIONS

Applicable Standard

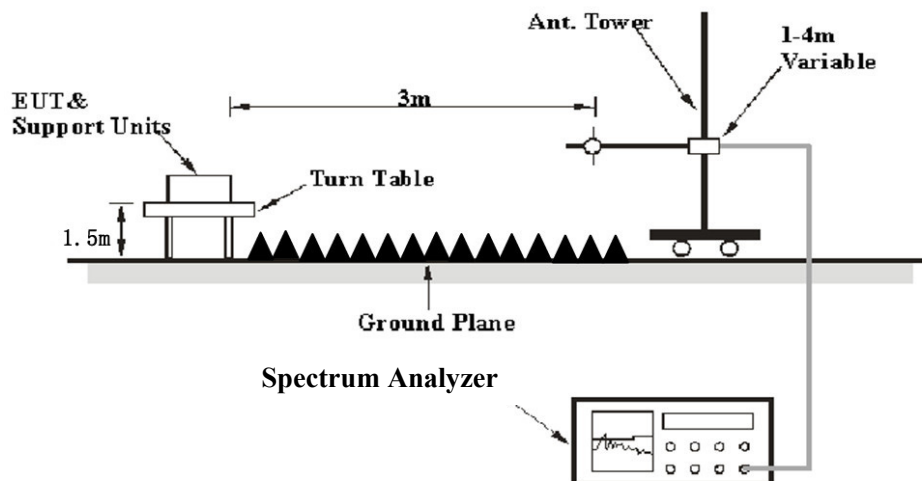
FCC §15.205; §15.209; §15.247(d)

EUT Setup

Below 1 GHz:



Above 1GHz:



The radiated emission tests were performed in the 3 meters, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC 15.209 and FCC 15.247 limits.

EMI Test Receiver & Spectrum Analyzer Setup

The EMI test receiver & Spectrum Analyzer Setup were set with the following configurations:

Frequency Range	RBW	Video B/W	IF B/W	Measurement
30 MHz – 1000 MHz	100 kHz	300 kHz	120 kHz	QP
Above 1 GHz	1 MHz	3 MHz	/	PK

For average measurement:

Use the duty cycle factor correction factor method per 15.35(c).

Duty cycle=On time/100milliseconds, On time= $N1*L1+N2*L2+...Nn-1*Ln-1+Nn*Ln$,

Where N1 is number of type 1 pulses, L1 is length of type 1 pulse, etc.

Average Emission Level=Peak Emission Level+20*log(Duty cycle)

Test Procedure

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

All final data was recorded in Quasi-peak detection mode for frequency range of 30 MHz -1 GHz and peak and Average detection modes for frequencies above 1 GHz.

Factor & Over limit/Margin Calculation

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

$$\text{Factor} = \text{Antenna Factor} + \text{Cable Loss} - \text{Amplifier Gain}$$

The “**Over Limit/Margin**” column of the following data tables indicates the degree of compliance with the applicable limit. For example, an Over Limit/Margin of -7dB means the emission is 7dB below the limit. The equation for calculation is as follows:

$$\begin{aligned}\text{Over Limit} &= \text{Level} - \text{Limit} \\ \text{Level} &= \text{Read Level} + \text{Factor}\end{aligned}$$

Test Data

Environmental Conditions

Temperature:	23~25.6 °C
Relative Humidity:	51~53 %
ATM Pressure:	100.19 ~101 kPa

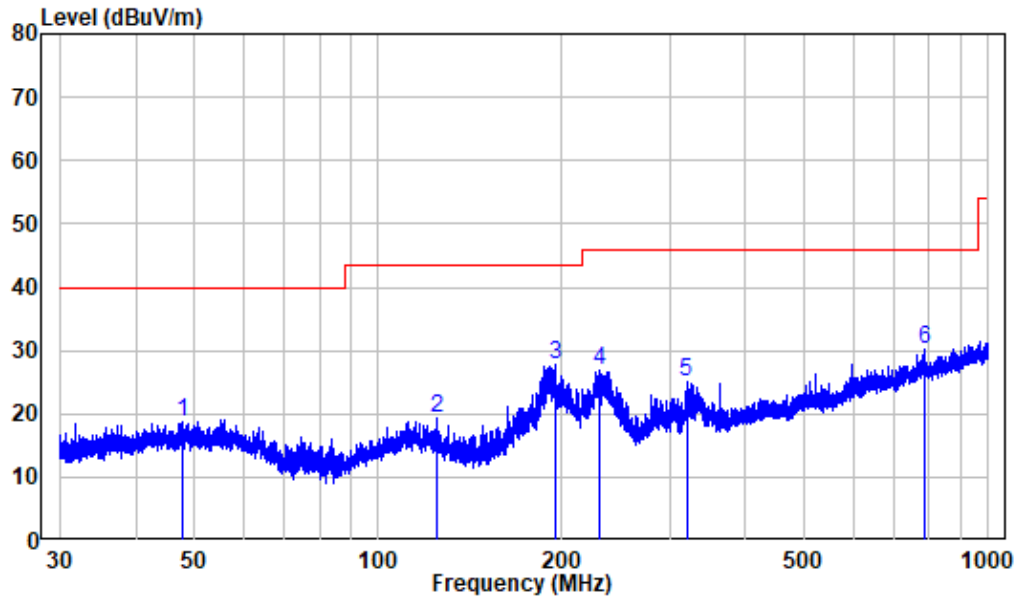
The testing was performed by Jason Liu on 2023-07-19 for below 1GHz and Leve Li on 2023-07-21 for above 1GHz.

EUT operation mode: Transmitting (Pre-scan in the X, Y and Z axes of orientation, the worst case X-axes of orientation were recorded)

30MHz-1GHz: (worst case is 8DPSK Mode, low channel)

Note: When the test result of peak was less than the limit of QP more than 6dB, just peak value were recorded.

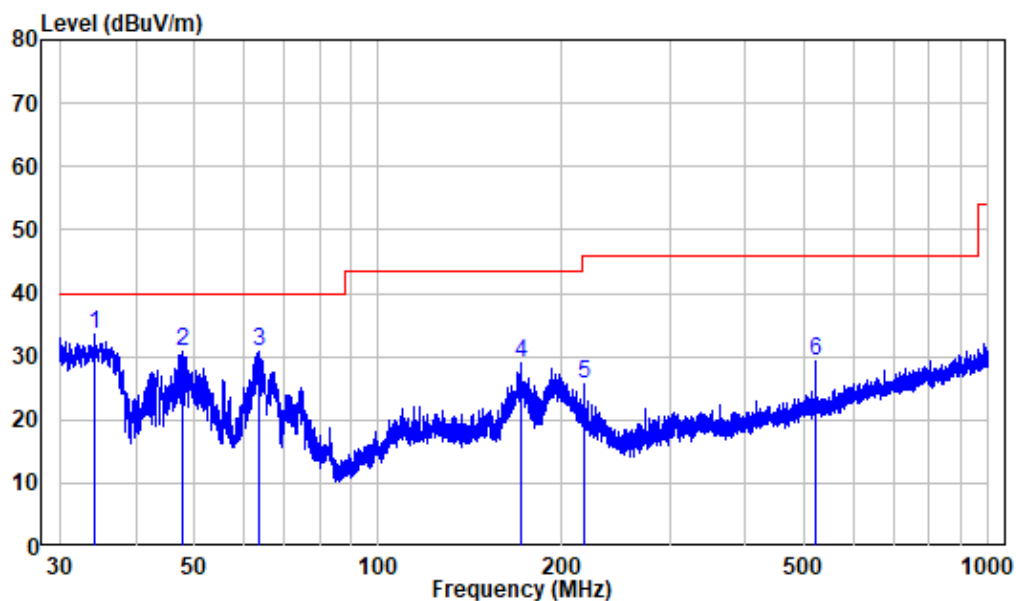
Horizontal:



Site : chamber
Condition: 3m HORIZONTAL
Job No. : RA230717-41157E-RF
Test Mode: Charging+BT Transmitting

	Freq Factor		Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	47.805	-10.00	28.58	18.58	40.00	-21.42	Peak
2	124.514	-14.26	33.46	19.20	43.50	-24.30	Peak
3	194.795	-11.41	39.30	27.89	43.50	-15.61	Peak
4	230.199	-11.10	37.94	26.84	46.00	-19.16	Peak
5	320.077	-8.45	33.36	24.91	46.00	-21.09	Peak
6	787.161	-0.07	30.32	30.25	46.00	-15.75	Peak

Vertical



Site : chamber
 Condition: 3m VERTICAL
 Job No. : RA230717-41157E-RF
 Test Mode: Charging+BT Transmitting

	Freq	Factor	Read Level	Limit Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	34.306	-11.76	45.16	33.40	40.00	-6.60	Peak
2	47.742	-10.00	40.94	30.94	40.00	-9.06	Peak
3	63.703	-12.05	42.92	30.87	40.00	-9.13	Peak
4	170.793	-13.50	42.50	29.00	43.50	-14.50	Peak
5	217.831	-11.53	37.23	25.70	46.00	-20.30	Peak
6	519.976	-4.29	33.43	29.14	46.00	-16.86	Peak

Above 1GHz: (worst case is 8DPSK Mode, 3DH5)

Frequency (MHz)	Receiver		Turntable Angle Degree	Rx Antenna		Factor (dB/m)	Absolute Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/Ave		Height (m)	Polar (H/V)				
Low Channel(2402MHz)									
2315.04	65.25	PK	221	2.3	H	-10.38	54.87	74	-19.13
2347.68	65.37	PK	229	1.1	V	-10.73	54.64	74	-19.36
2390	65.04	PK	109	1.4	H	-10.62	54.42	74	-19.58
2390	64.81	PK	35	1.1	V	-10.62	54.19	74	-19.81
4804	75.44	PK	157	1.6	H	-5.57	69.87	74	-4.13
4804	74.38	PK	158	1.6	V	-5.57	68.81	74	-5.19
Middle Channel(2441MHz)									
4882	78.22	PK	342	2.5	H	-5.22	73.00	74	-1.00
4882	75.33	PK	180	2.5	V	-5.22	70.11	74	-3.89
High Channel(2480 MHz)									
2483.5	66.20	PK	68	2.1	H	-10.46	55.74	74	-18.26
2483.5	65.97	PK	154	2.4	V	-10.46	55.51	74	-18.49
2497.52	66.97	PK	226	2.2	H	-10.34	56.63	74	-17.37
2492.27	66.87	PK	331	1.3	V	-10.39	56.48	74	-17.52
4960	75.42	PK	90	2	H	-4.90	70.52	74	-3.48
4960	74.23	PK	177	2	V	-4.90	69.33	74	-4.67

Field Strength of Average							
Frequency (MHz)	Peak Measurement @3m (dBμV/m)	Polar (H/V)	Duty Cycle Correction Factor (dB)	Absolute Level (dBμV/m)	FCC Part 15.247		
					Limit (dBμV/m)	Margin (dB)	Comment
Low Channel(2402MHz)							
2315.04	54.87	H	-24.77	30.10	54	-23.90	Bandedge
2347.68	54.64	V	-24.77	29.87	54	-24.13	Bandedge
2390	54.42	H	-24.77	29.65	54	-24.35	Bandedge
2390	54.19	V	-24.77	29.42	54	-24.58	Bandedge
4804	69.87	H	-24.77	45.10	54	-8.90	Harmonic
4804	68.81	V	-24.77	44.04	54	-9.96	Harmonic
Middle Channel(2441MHz)							
4882	73.00	H	-24.77	48.23	54	-5.77	Harmonic
4882	70.11	V	-24.77	45.34	54	-8.66	Harmonic
High Channel(2480MHz)							
2483.5	55.74	H	-24.77	30.97	54	-23.03	Bandedge
2483.5	55.51	V	-24.77	30.74	54	-23.26	Bandedge
2497.52	56.63	H	-24.77	31.86	54	-22.14	Bandedge
2492.27	56.48	V	-24.77	31.71	54	-22.29	Bandedge
4960	70.52	H	-24.77	45.75	54	-8.25	Harmonic
4960	69.33	V	-24.77	44.56	54	-9.44	Harmonic

Note:

Absolute Level = Corrected Factor + Reading

Margin = Absolute Level - Limit

Average level= Peak level+ Duty Cycle Corrected Factor

The other emissions which were 20dB below limit or in noise floor level was not recorded.

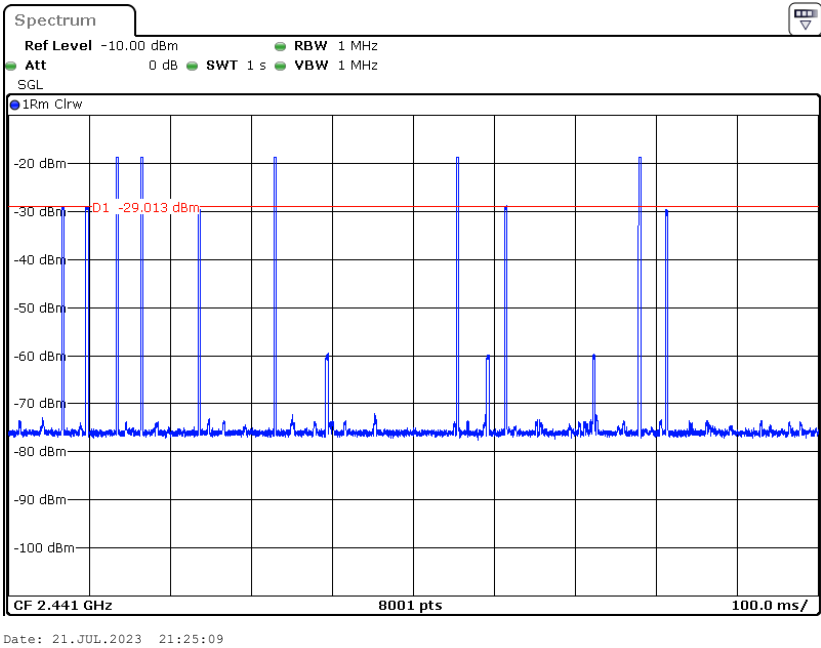
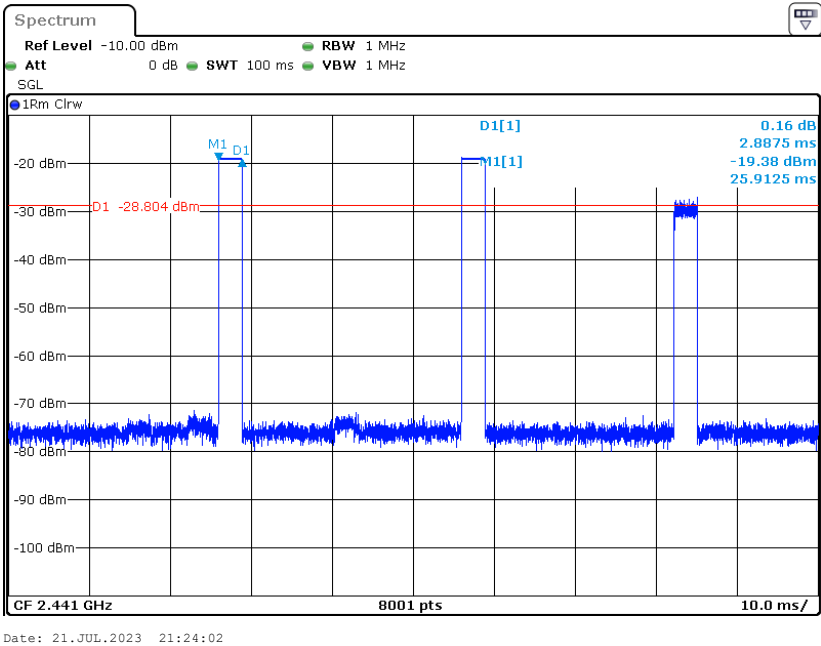
Worst case duty cycle:

Refer the plots, the maximum hops in 100ms period was 2(second high signal was from other channels)

Duty cycle = Ton/100ms = 2.8875*2/100=0.05775

Duty Cycle Corrected Factor = 20lg (Duty cycle) = 20lg0.05775 = -24.77

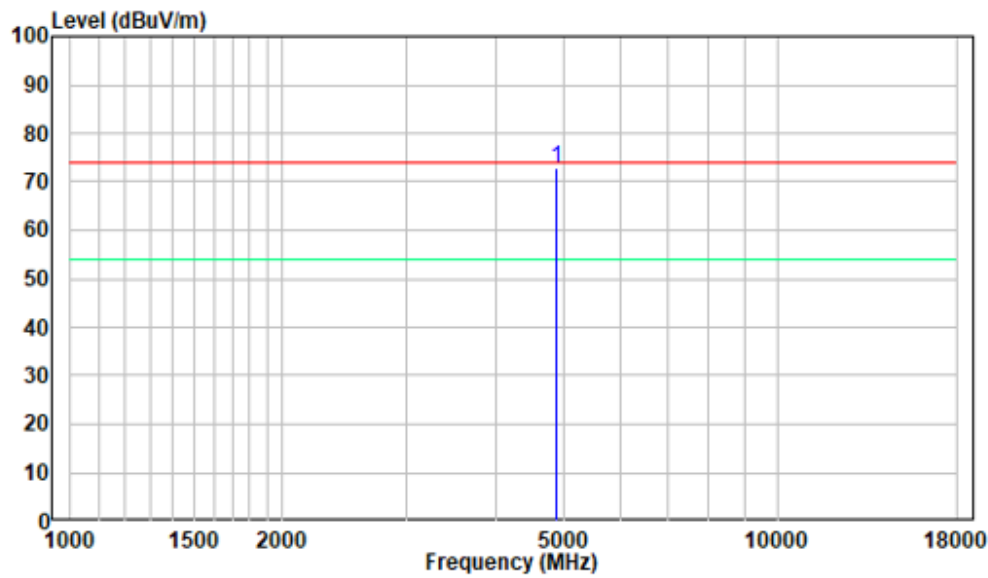
Duty cycle



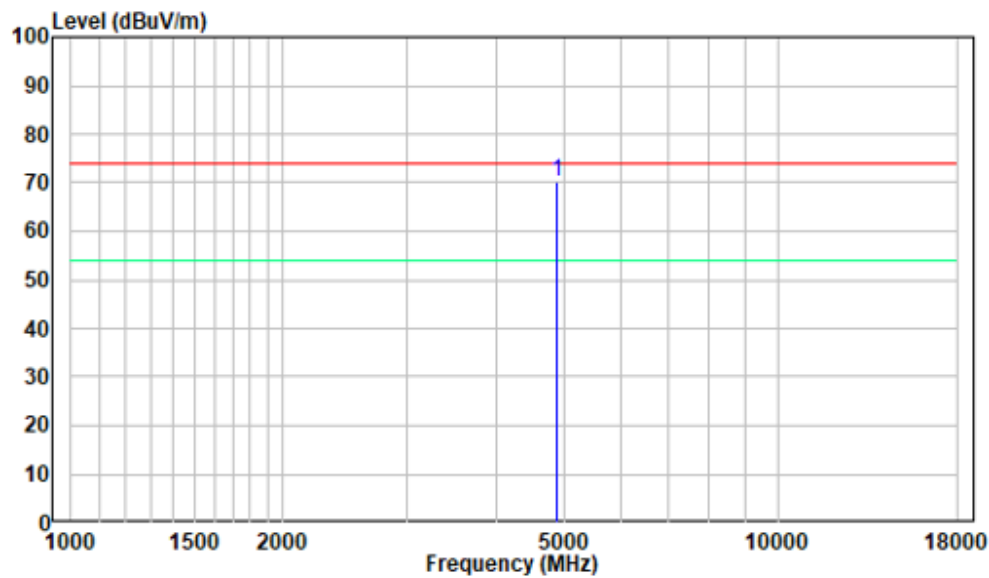
1-18GHz

Pre-scan for Low Channel

Horizontal:



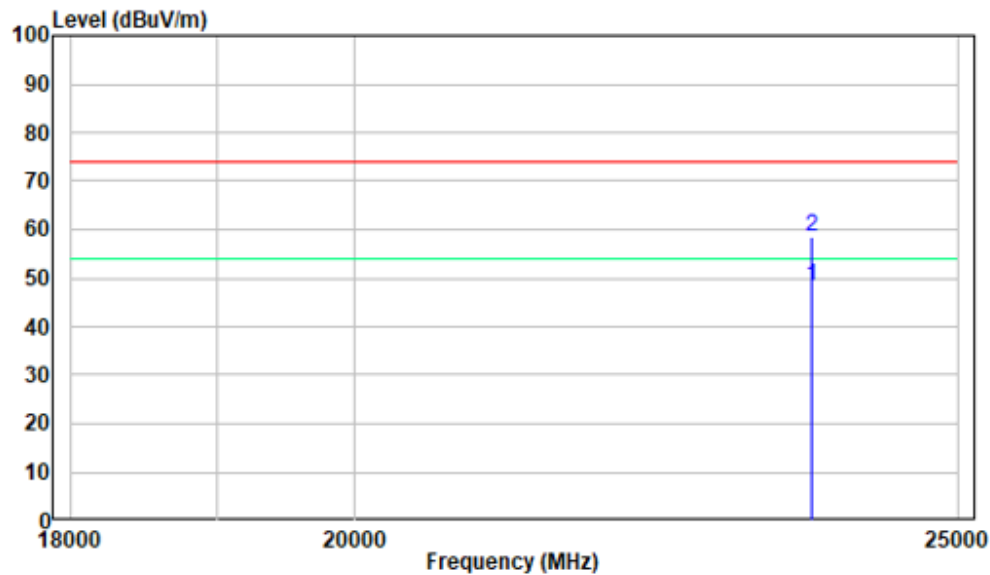
Vertical:



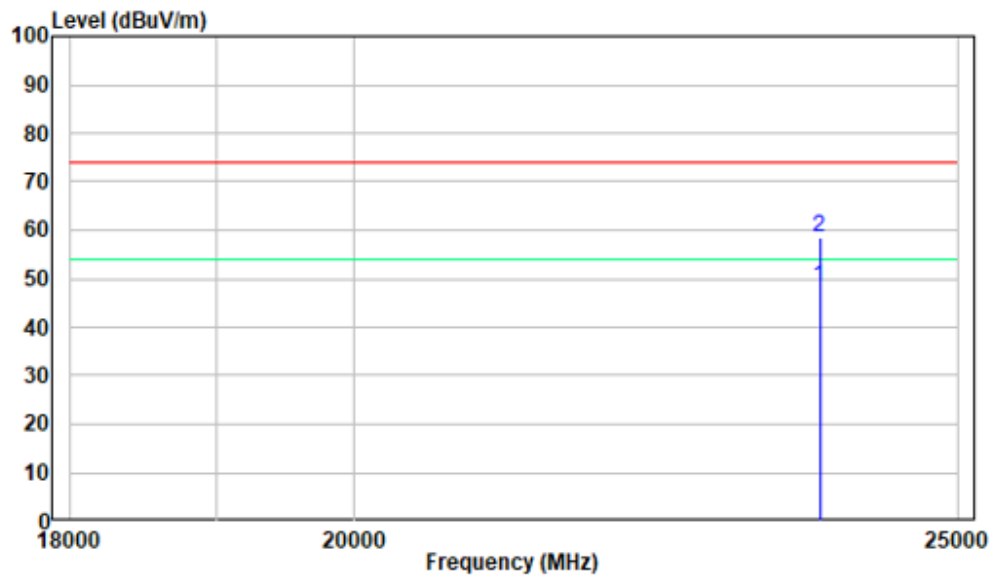
18-25GHz

Pre-scan for Low Channel

Horizontal:



Vertical:



FCC §15.247(a) (1)-CHANNEL SEPARATION TEST

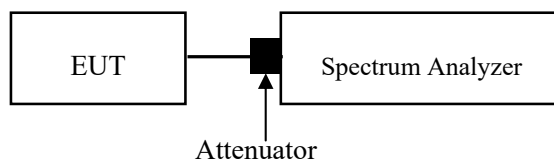
Applicable Standard

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 operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 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. 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.

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.2

1. Set the EUT in transmitting mode, maxhold the channel.
2. Set the adjacent channel of the EUT and maxhold another trace.
3. Measure the channel separation.



Test Data

Environmental Conditions

Temperature:	26~27 °C
Relative Humidity:	45~50 %
ATM Pressure:	101.0 kPa

The testing was performed by Jacob Huang on 2023-07-24.

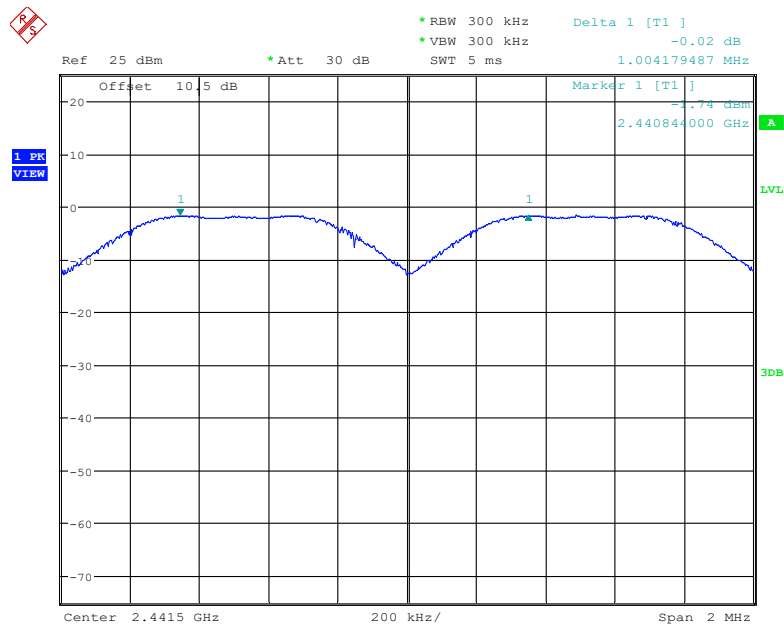
EUT operation mode: Transmitting

Please refer to following table and plots.

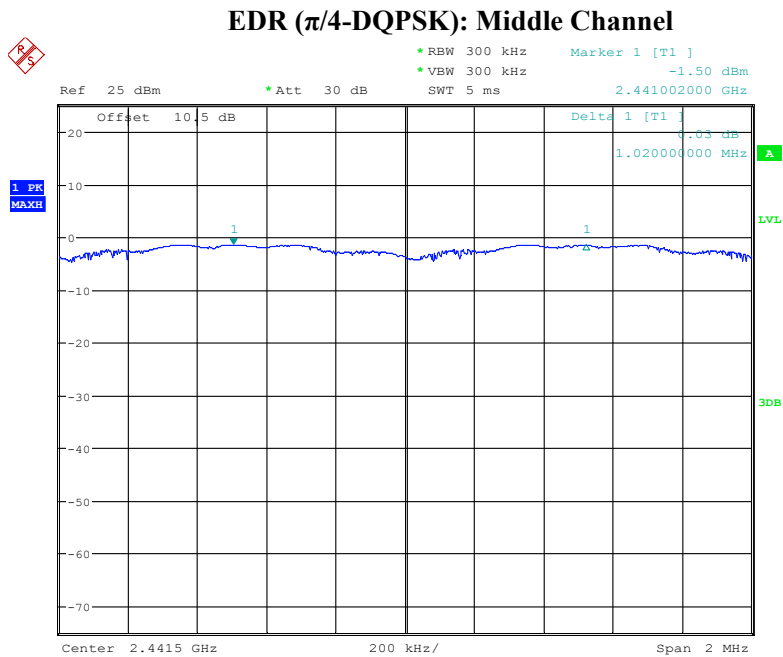
Test Mode	Channel Separation (MHz)	20 dBc BW (MHz)	Two-thirds of the 20 dB bandwidth (MHz)	Channel Separation Limit	Result
BDR(GFSK)					
Hopping	1.004	0.942	0.628	> two-thirds of the 20 dB bandwidth	Compliance
EDR($\pi/4$-DQPSK)					
Hopping	1.020	1.314	0.876	> two-thirds of the 20 dB bandwidth	Compliance
EDR(8DPSK)					
Hopping	1.004	1.305	0.87	> two-thirds of the 20 dB bandwidth	Compliance

Note: The limit > two-thirds of the 20 dB bandwidth

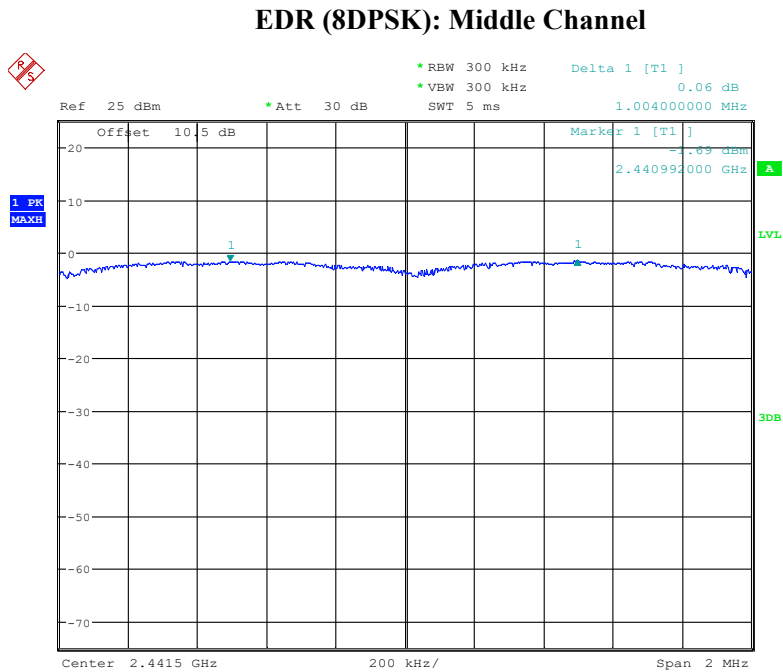
BDR (GFSK): Middle Channel



Date: 24.JUL.2023 16:30:42



Date: 24.JUL.2023 15:11:49



Date: 24.JUL.2023 16:38:34

FCC §15.247(a) (1) – 20 dB EMISSION BANDWIDTH & 99% OCCUPIED BANDWIDTH

Applicable Standard

Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 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.

Test Procedure

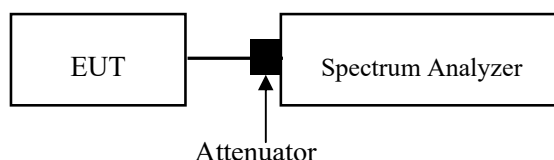
Test Method: ANSI C63.10-2013 Clause 7.8.7 & Clause 6.9.2

The following conditions shall be observed for measuring the occupied bandwidth and 20 dB bandwidth:

- The transmitter shall be operated at its maximum carrier power measured under normal test conditions.
- The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.
- The detector of the spectrum analyzer shall be set to “Sample”. However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or “Max Hold”) may be necessary to determine the occupied / 20 dB bandwidth if the device is not transmitting continuously.
- The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / 20 dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.

For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).



Test Data**Environmental Conditions**

Temperature:	26~27 °C
Relative Humidity:	45~50 %
ATM Pressure:	101.0 kPa

The testing was performed by Jacob Huang on 2023-07-24.

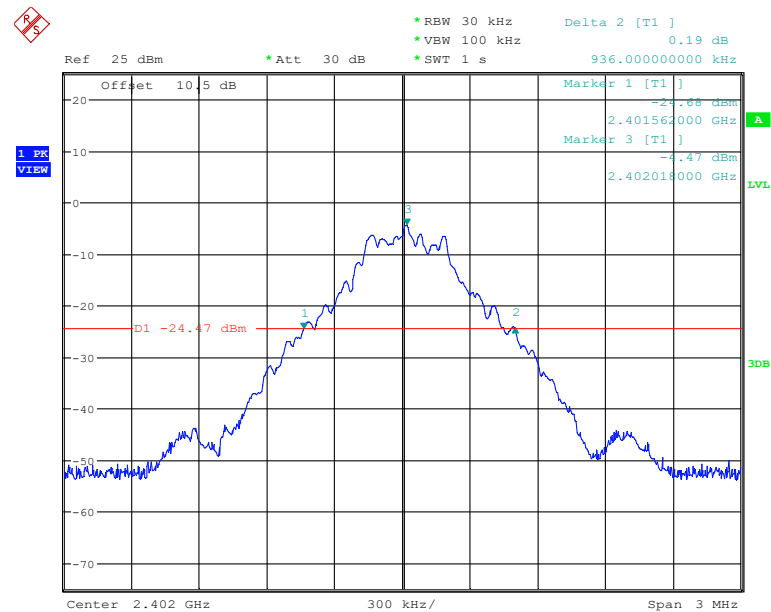
EUT operation mode: Transmitting

Test Result: Compliant.

Mode	Channel	Frequency (MHz)	99% Emission Bandwidth (MHz)	20 dB Emission Bandwidth (MHz)
BDR (GFSK)	Low	2402	0.846	0.936
	Middle	2441	0.852	0.942
	High	2480	0.852	0.936
EDR ($\pi/4$-DQPSK)	Low	2402	1.224	1.314
	Middle	2441	1.242	1.311
	High	2480	1.209	1.314
EDR (8DPSK)	Low	2402	1.233	1.296
	Middle	2441	1.248	1.299
	High	2480	1.227	1.305

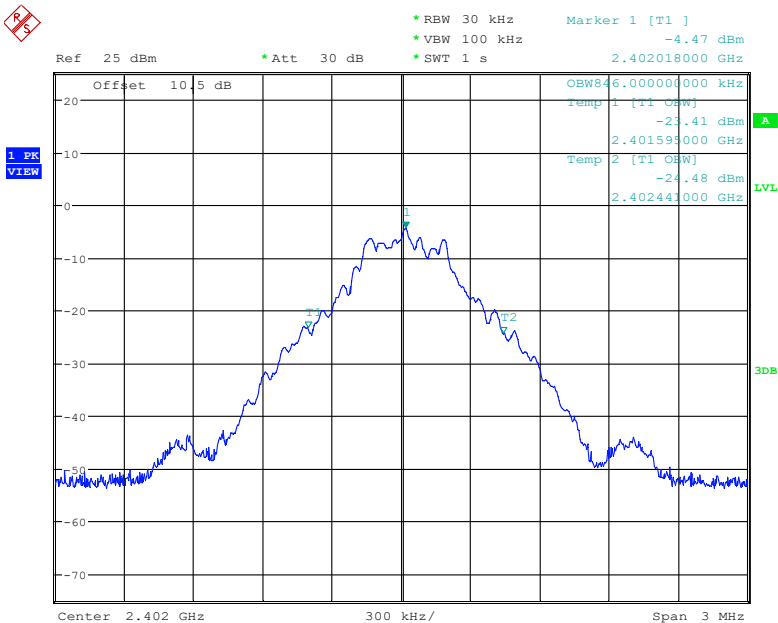
BDR (GFSK):

20dB Emission Bandwidth, Low Channel



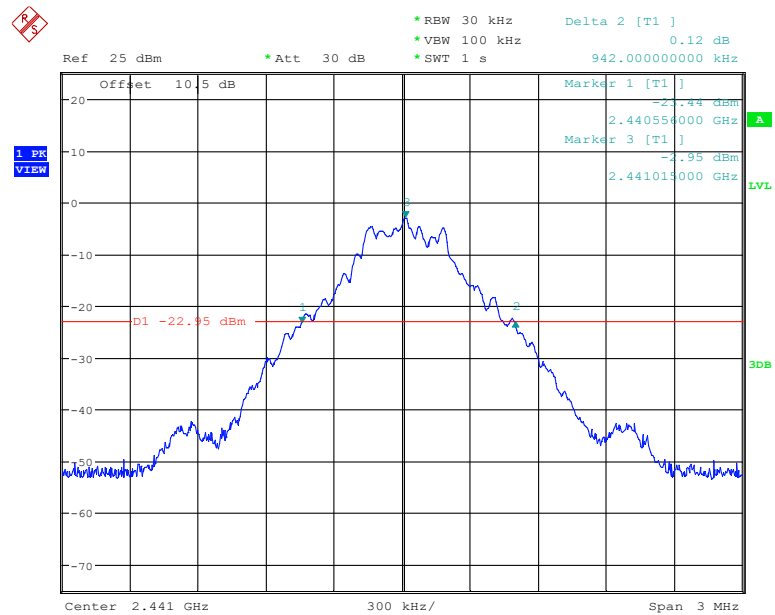
Date: 24.JUL.2023 14:27:32

99% Occupied Bandwidth, Low Channel



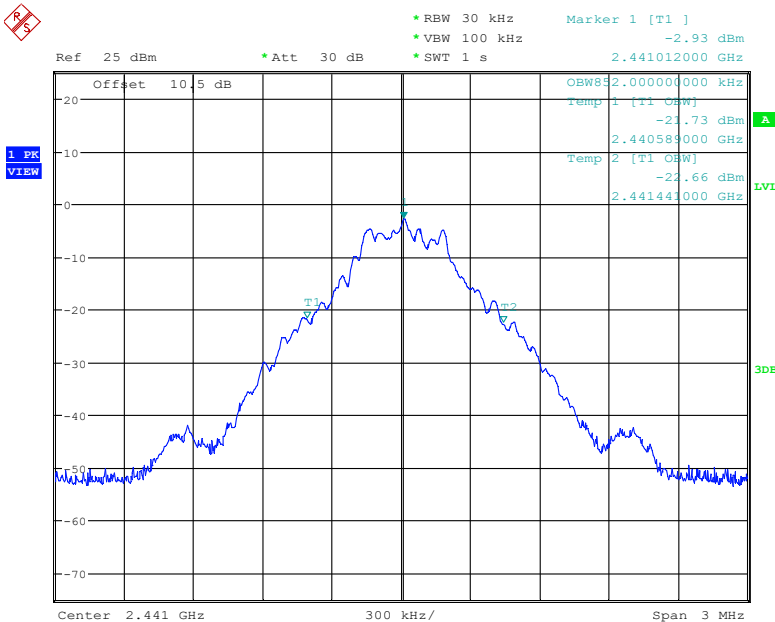
Date: 24.JUL.2023 14:26:56

20dB Emission Bandwidth, Middle Channel



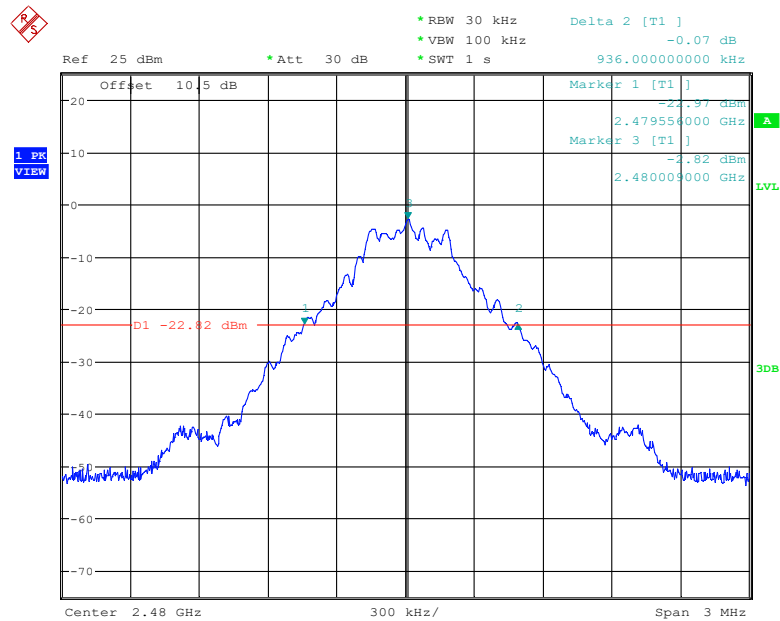
Date: 24.JUL.2023 14:35:21

99% Occupied Bandwidth, Middle Channel



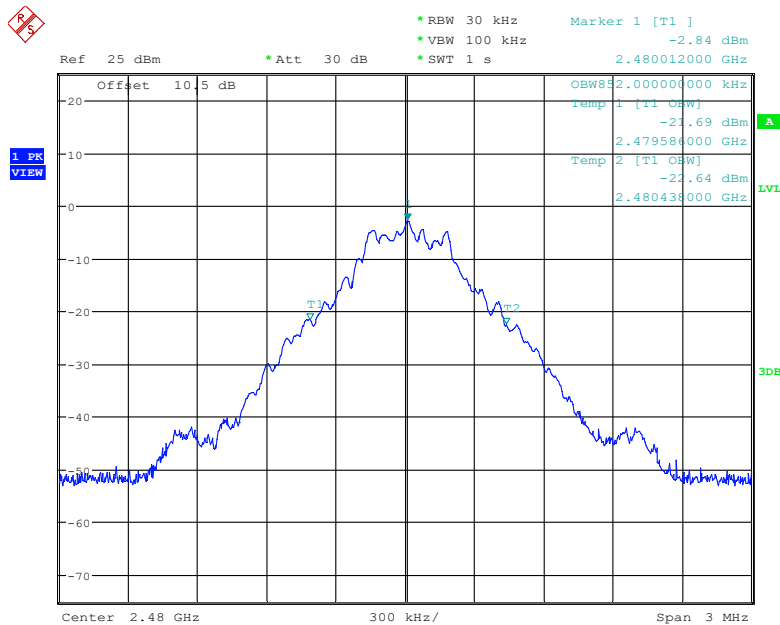
Date: 24.JUL.2023 14:34:46

20dB Emission Bandwidth, High Channel



Date: 24.JUL.2023 14:42:38

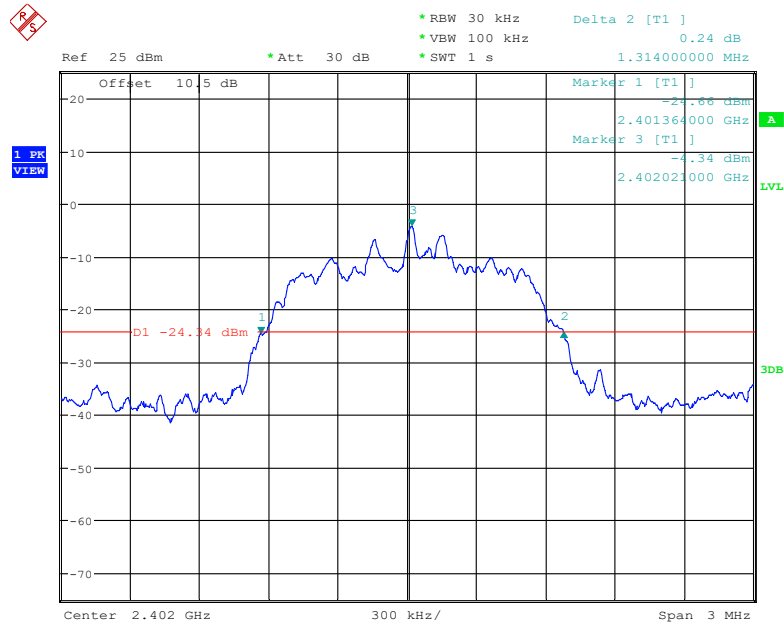
99% Occupied Bandwidth, High Channel



Date: 24.JUL.2023 14:42:02

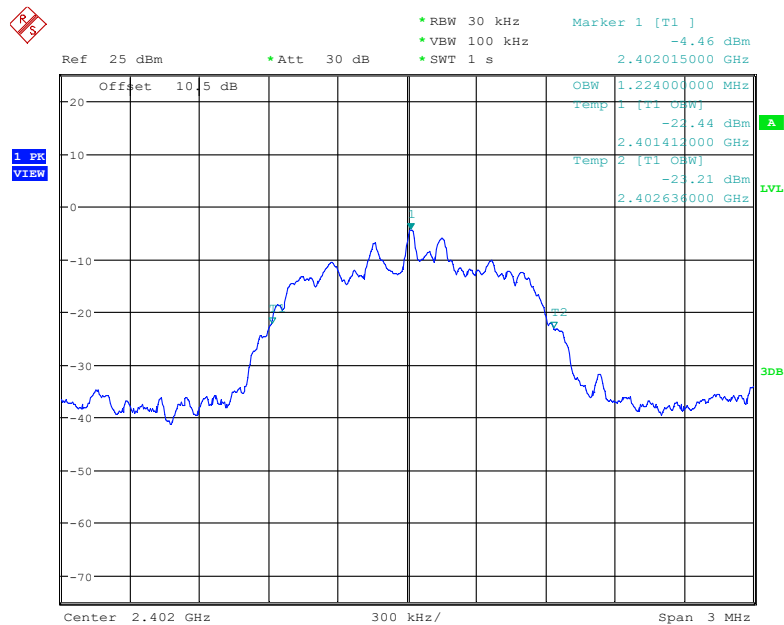
EDR ($\pi/4$ -DQPSK):

20dB Emission Bandwidth, Low Channel



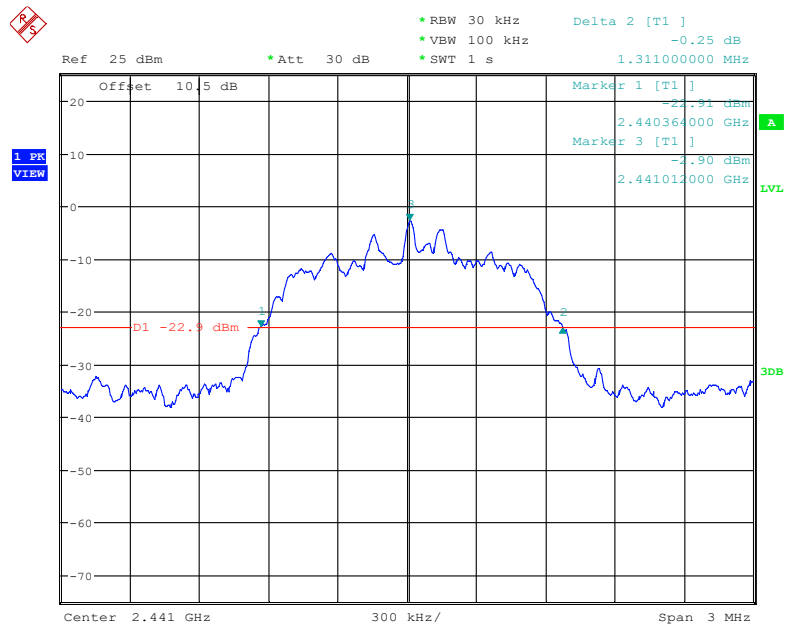
Date: 24.JUL.2023 14:29:59

99% Occupied Bandwidth, Low Channel



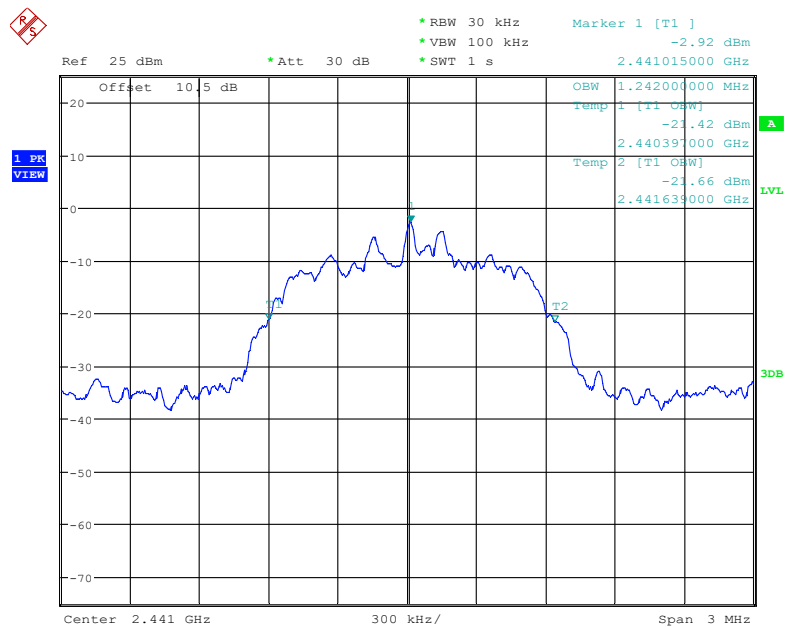
Date: 24.JUL.2023 14:29:24

20dB Emission Bandwidth, Middle Channel



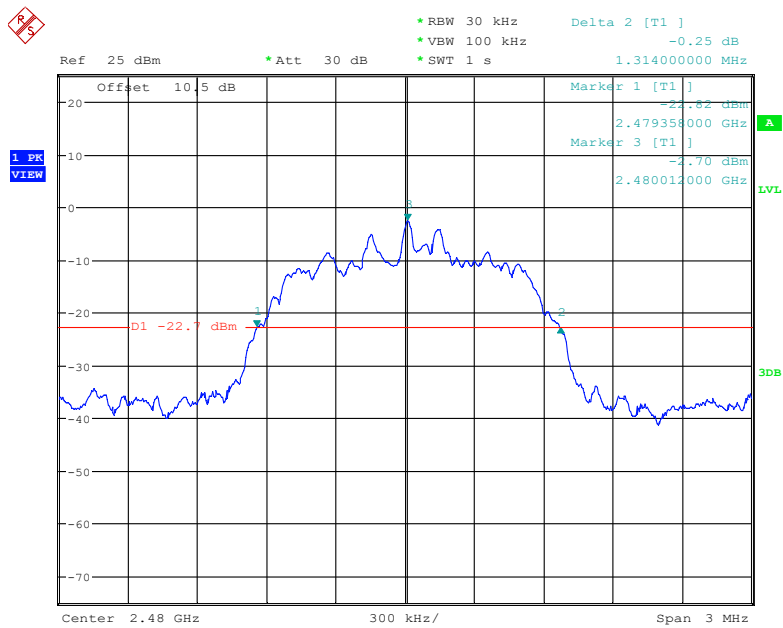
Date: 24.JUL.2023 14:37:36

99% Occupied Bandwidth, Middle Channel



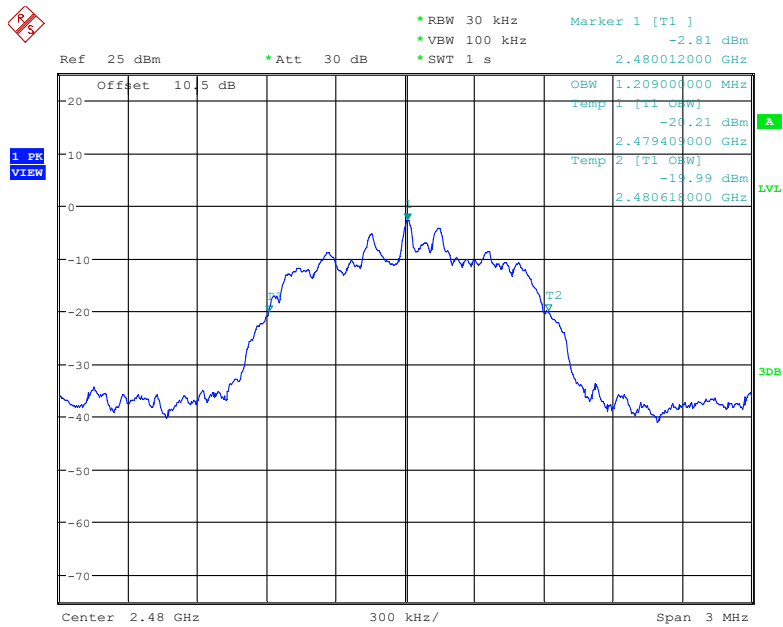
Date: 24.JUL.2023 14:37:00

20dB Emission Bandwidth, High Channel



Date: 24.JUL.2023 14:45:04

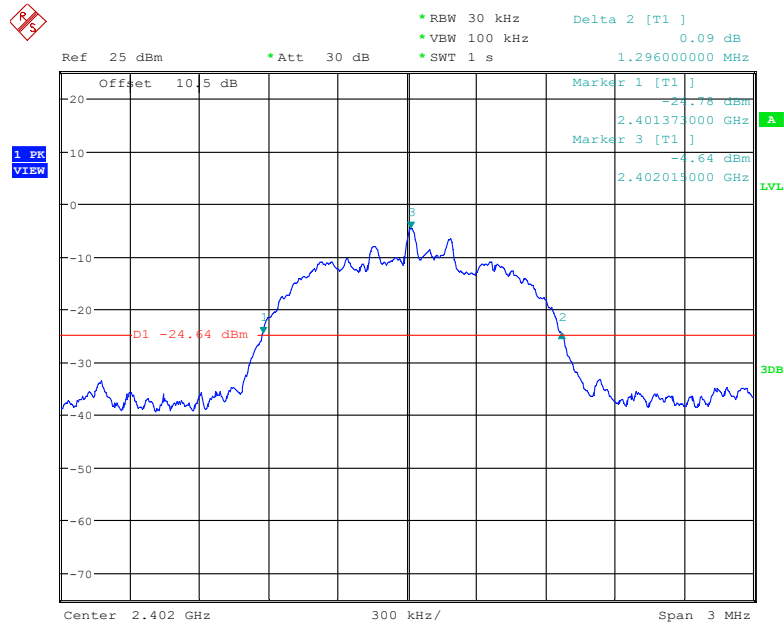
99% Occupied Bandwidth, High Channel



Date: 24.JUL.2023 14:44:28

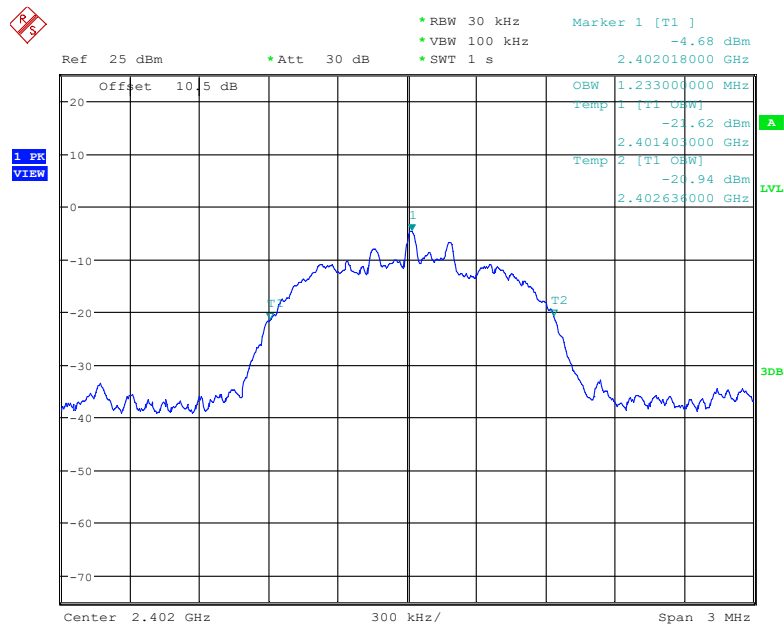
EDR (8DPSK):

20dB Emission Bandwidth, Low Channel



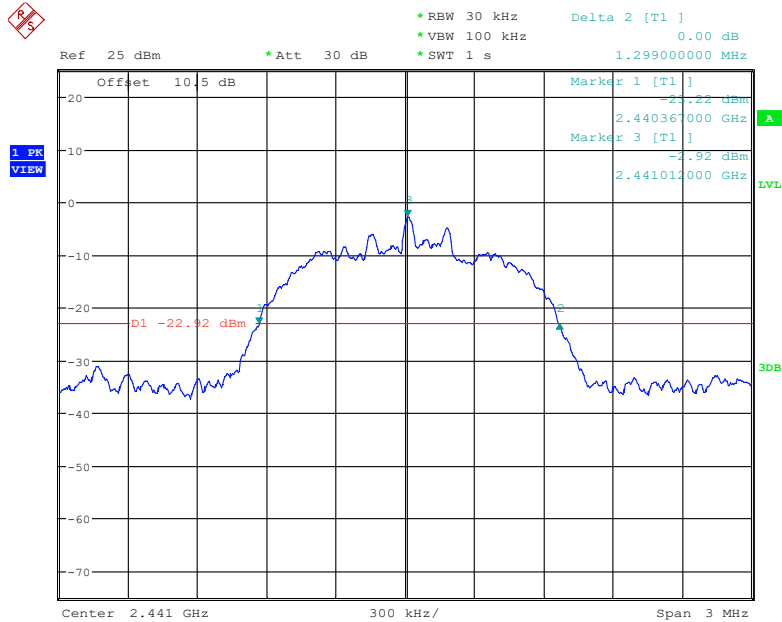
Date: 24.JUL.2023 14:32:35

99% Occupied Bandwidth, Low Channel



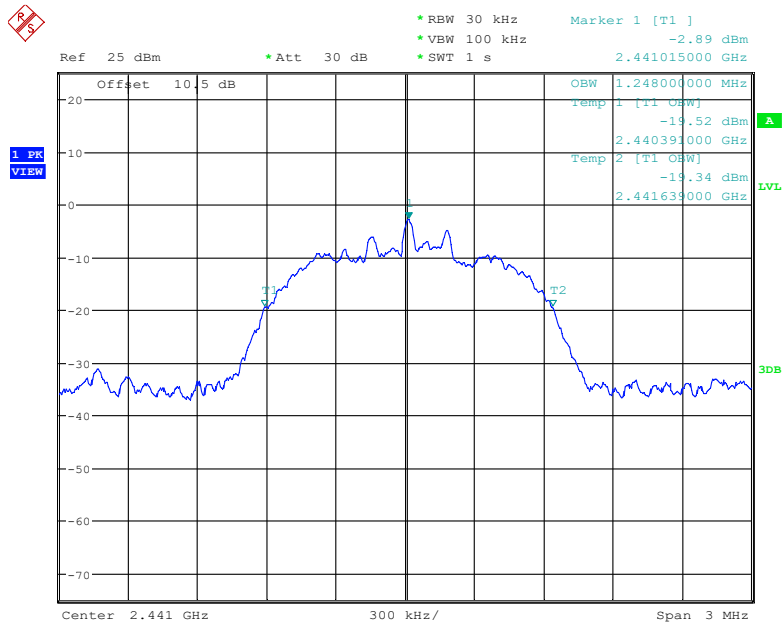
Date: 24.JUL.2023 14:31:59

20dB Emission Bandwidth, middle Channel



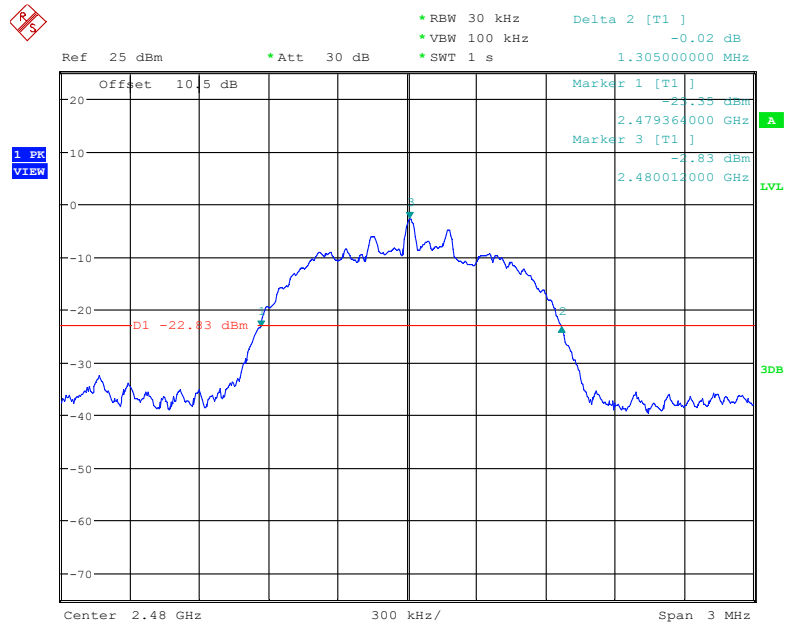
Date: 24.JUL.2023 14:39:48

99% Occupied Bandwidth, Middle Channel



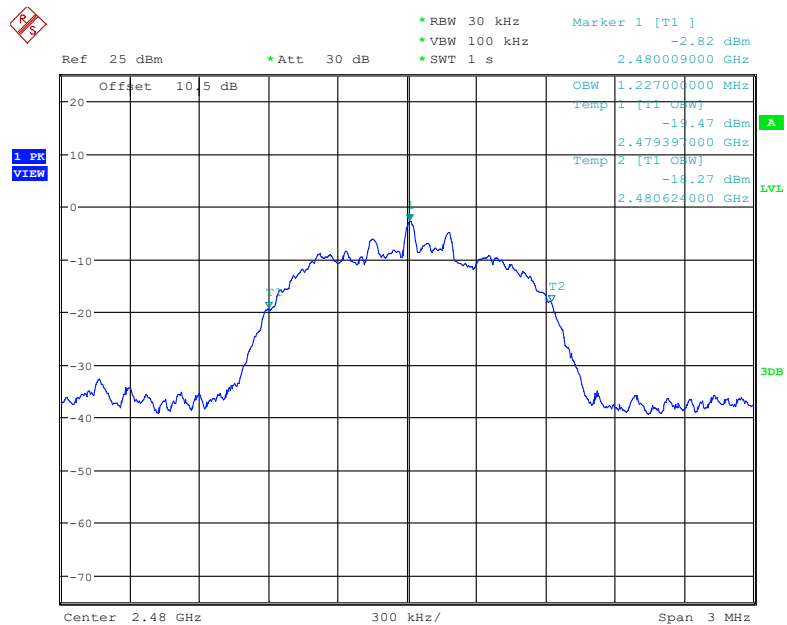
Date: 24.JUL.2023 14:39:01

20dB Emission Bandwidth, High Channel



Date: 24.JUL.2023 14:47:37

99% Occupied Bandwidth, High Channel



Date: 24.JUL.2023 14:47:01

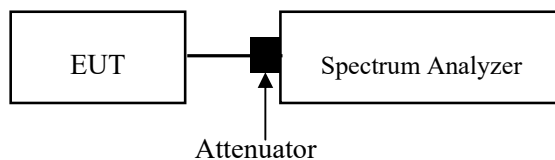
FCC §15.247(a) (1) (iii)-QUANTITY OF HOPPING CHANNEL TEST**Applicable Standard**

Frequency hopping systems in the 2400–2483.5 MHz 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. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.3

1. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.
2. Set the EUT in hopping mode from first channel to last.
3. By using the max-hold function record the quantity of the channel.

**Test Data****Environmental Conditions**

Temperature:	26~27 °C
Relative Humidity:	45~50 %
ATM Pressure:	101.0 kPa

The testing was performed by Jacob Huang on 2023-07-24.

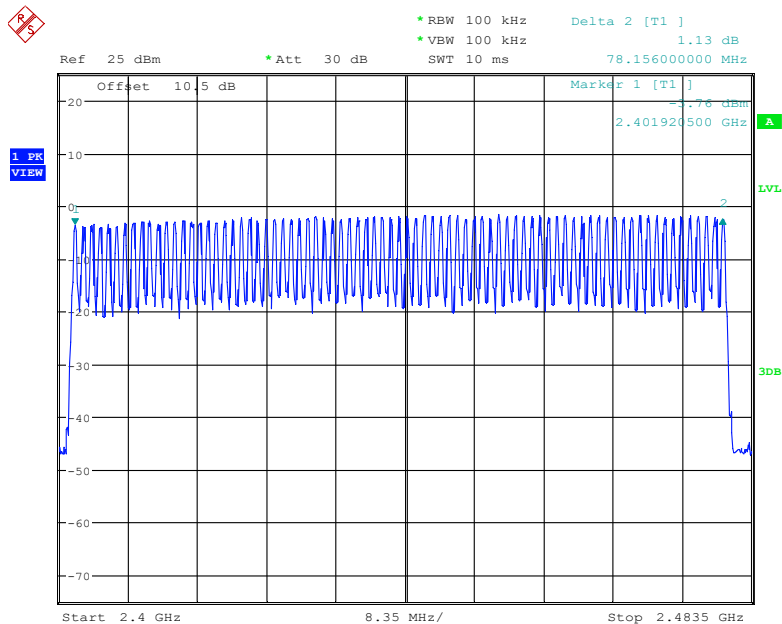
EUT operation mode: Transmitting

Test Result: Pass

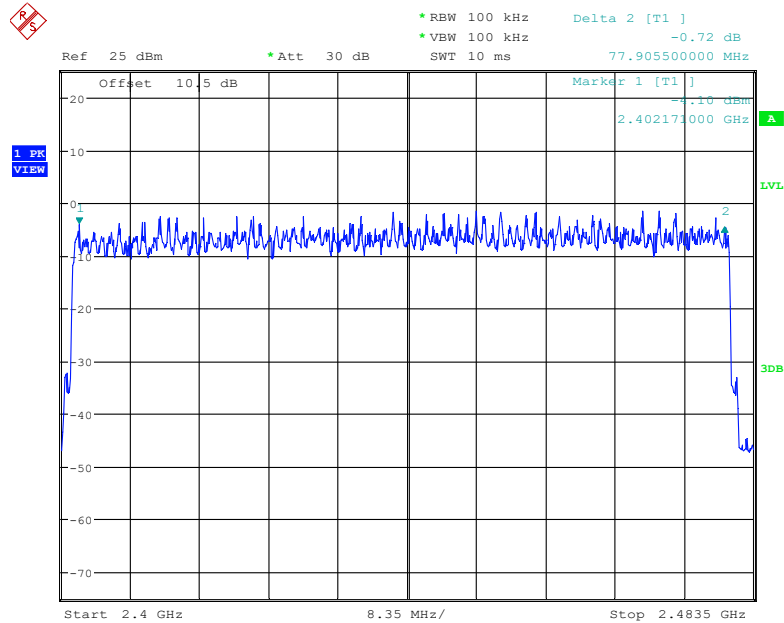
Please refer to following table and plots.

Mode	Frequency Range (MHz)	Number of Hopping Channel (CH)	Limit (CH)
BDR (GFSK)	2400-2483.5	79	≥15
EDR (π/4-DQPSK)	2400-2483.5	79	≥15
EDR (8DPSK)	2400-2483.5	79	≥15

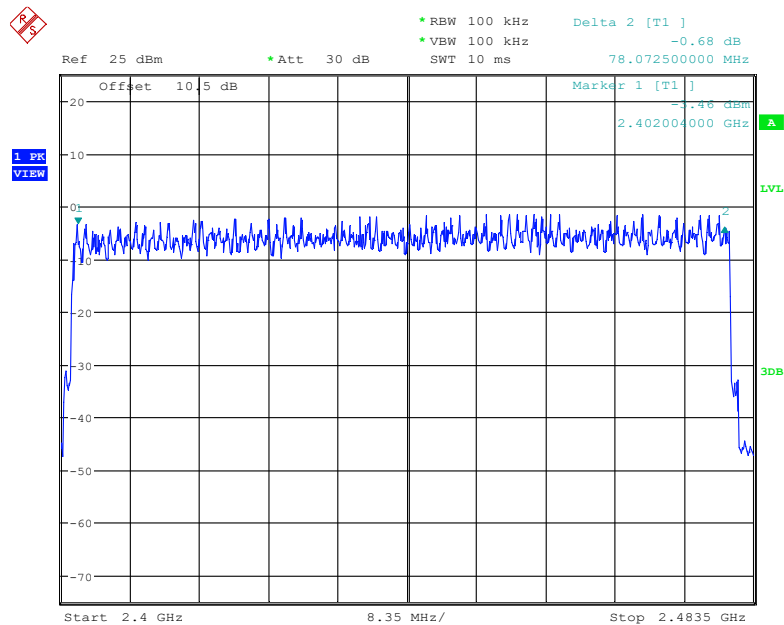
BDR (GFSK): Number of Hopping Channels



Date: 24.JUL.2023 14:56:33

EDR ($\pi/4$ -DQPSK): Number of Hopping Channels

Date: 24.JUL.2023 15:05:40

EDR (8DPSK): Number of Hopping Channels

Date: 24.JUL.2023 15:18:46

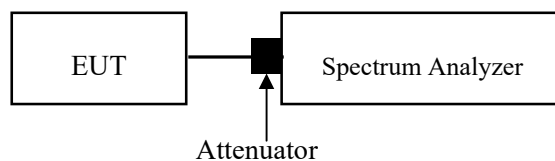
FCC §15.247(a) (1) (iii) - TIME OF OCCUPANCY (DWELL TIME)**Applicable Standard**

Frequency hopping systems in the 2400-2483.5 MHz 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. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.4

1. The EUT was worked in channel hopping.
2. Set the RBW to: 1MHz.
3. Set the VBW $\geq 3 \times$ RBW.
4. Set the span to 0Hz.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Recorded the time of single pulses

**Test Data****Environmental Conditions**

Temperature:	26~27 °C
Relative Humidity:	45~50 %
ATM Pressure:	101.0 kPa

The testing was performed by Jacob Huang on 2023-07-24.

EUT operation mode: Transmitting

Test Result: Pass

Please refer to following table and plots

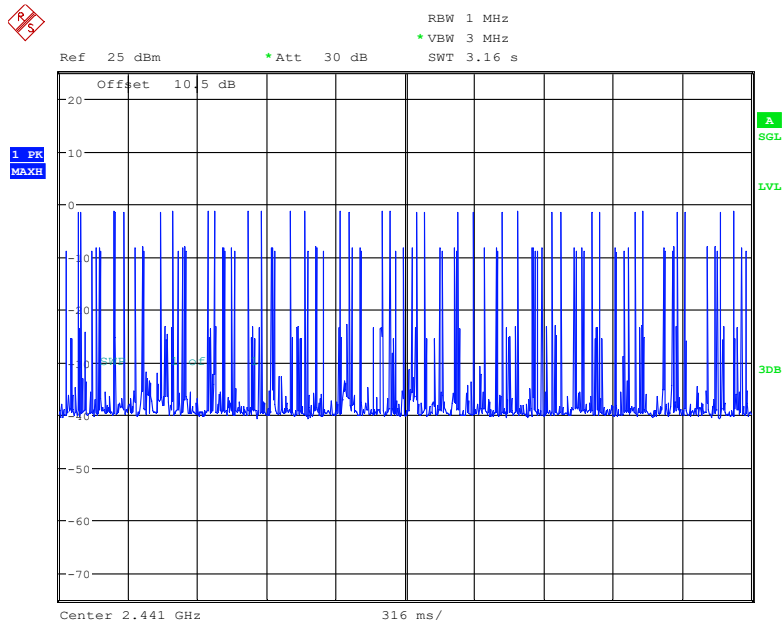
Test Mode	Channel	Pulse Time [ms]	Total Hops [Num]	Result[s]	Limit[s]	Verdict
DH1	Hop	0.409	310	0.127	≤0.4	PASS
DH3	Hop	1.668	160	0.267	≤0.4	PASS
DH5	Hop	2.930	110	0.322	≤0.4	PASS
2DH1	Hop	0.419	310	0.130	≤0.4	PASS
2DH3	Hop	1.674	160	0.268	≤0.4	PASS
2DH5	Hop	2.935	100	0.294	≤0.4	PASS
3DH1	Hop	0.420	320	0.134	≤0.4	PASS
3DH3	Hop	1.671	120	0.201	≤0.4	PASS
3DH5	Hop	2.940	90	0.265	≤0.4	PASS

Note 1: A period time=0.4*79=31.6(S), Result= Pulse Time *Total hops

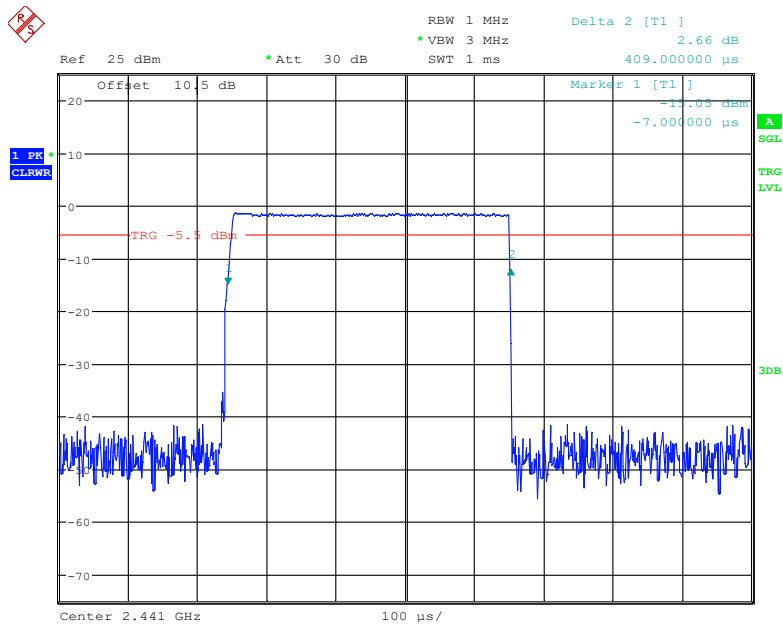
Note 2: Total hops=Hopping Number in 3.16s*10

Note 3: Hopping Number in 3.16s=Total of highest signals in 3.16s (Second high signals were other channel)

BDR (GFSK):
DH1

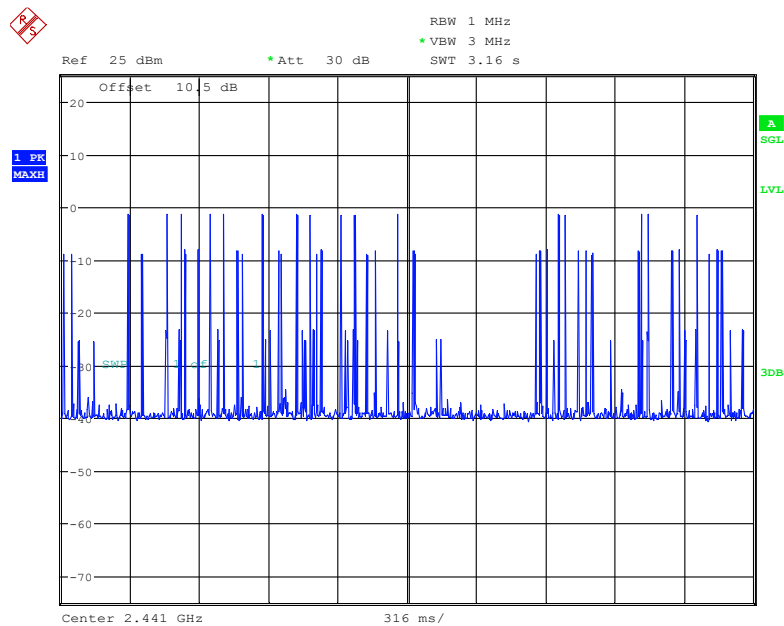


Date: 24.JUL.2023 14:52:16

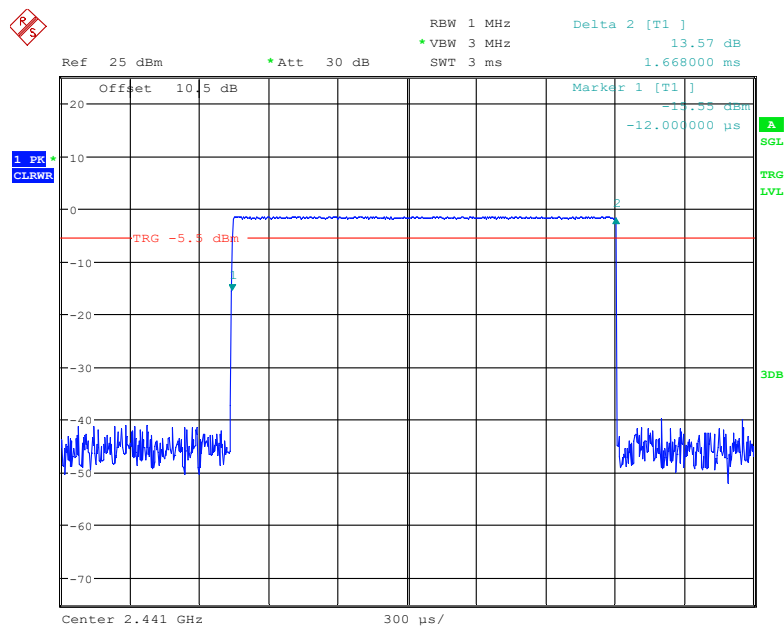


Date: 24.JUL.2023 14:52:34

DH3

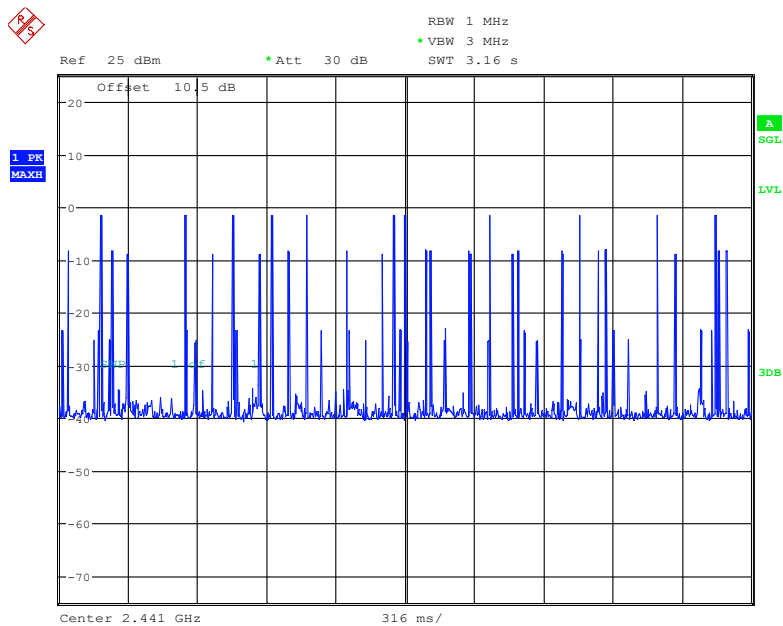


Date: 24.JUL.2023 14:53:54

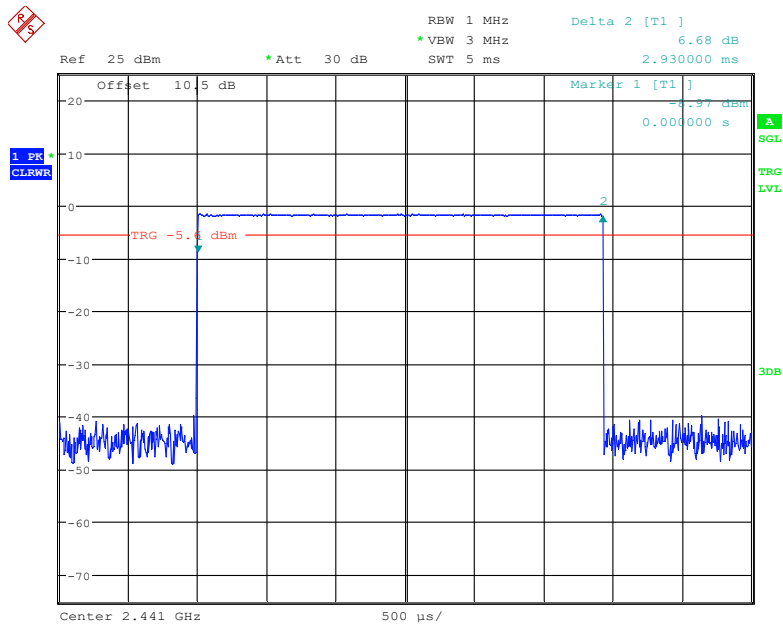


Date: 24.JUL.2023 14:54:12

DH5

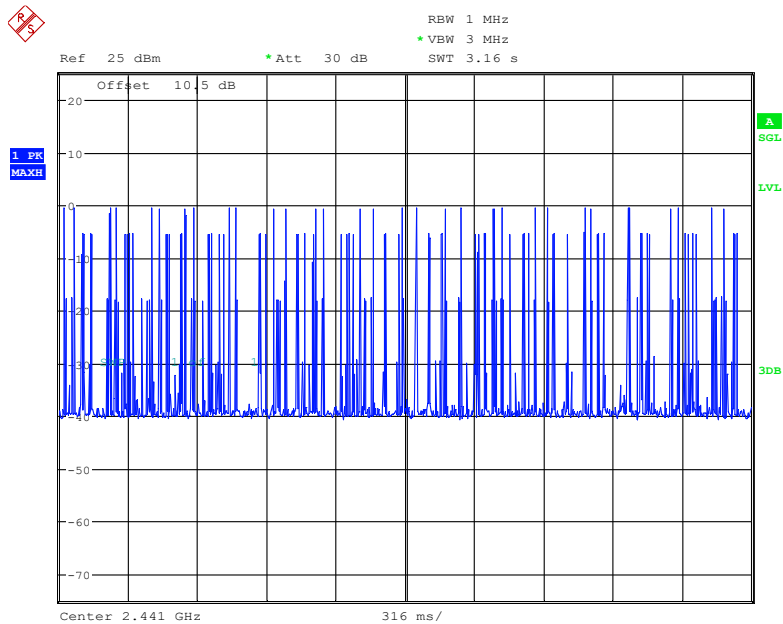


Date: 24.JUL.2023 16:53:40

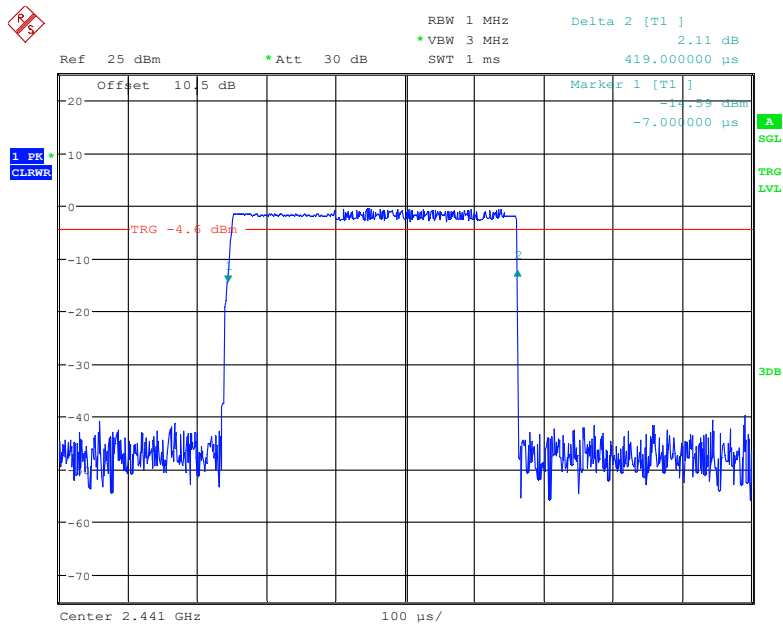


Date: 24.JUL.2023 14:57:40

EDR($\pi/4$ -DQPSK):
2DH1

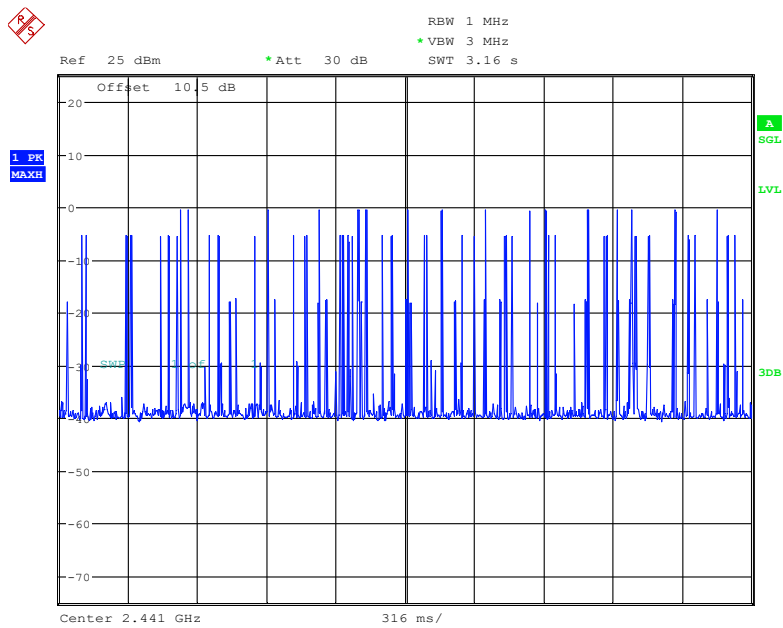


Date: 24.JUL.2023 15:01:16

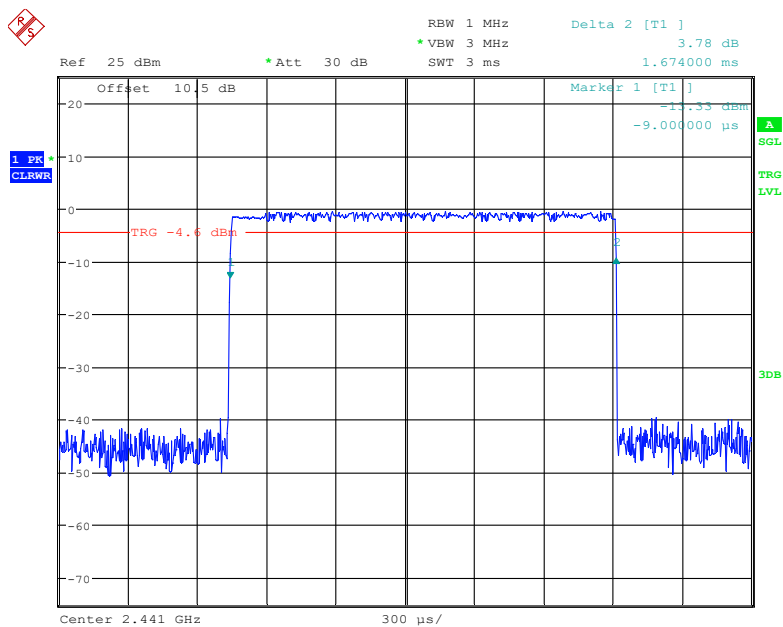


Date: 24.JUL.2023 15:01:37

2DH3

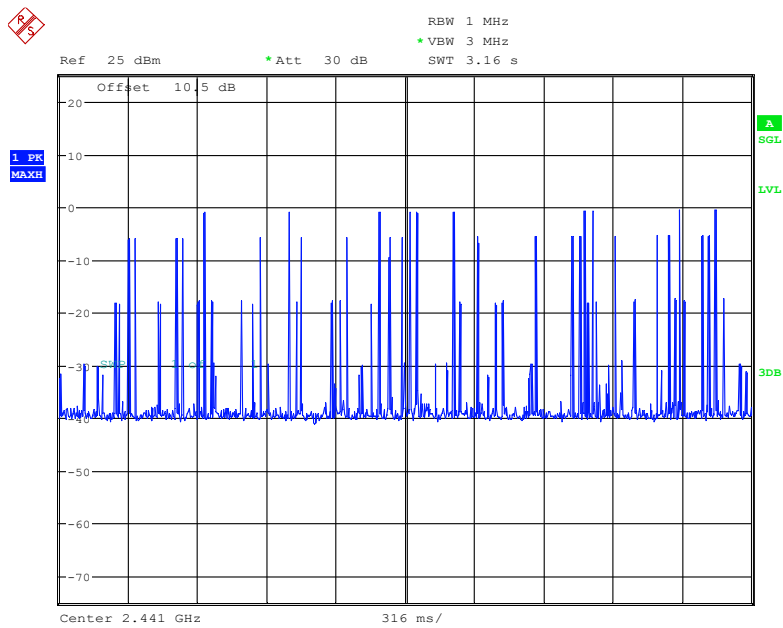


Date: 24.JUL.2023 15:02:34

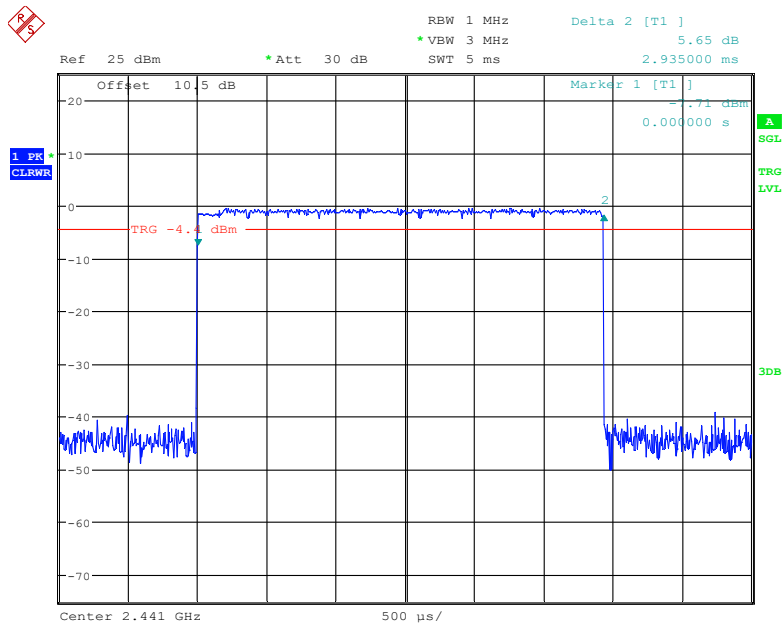


Date: 24.JUL.2023 15:02:52

2DH5

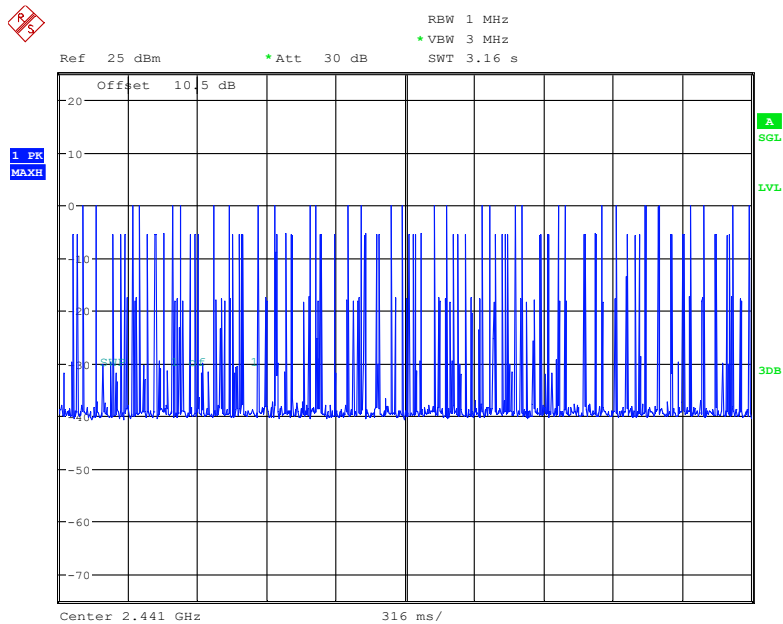


Date: 24.JUL.2023 15:12:33

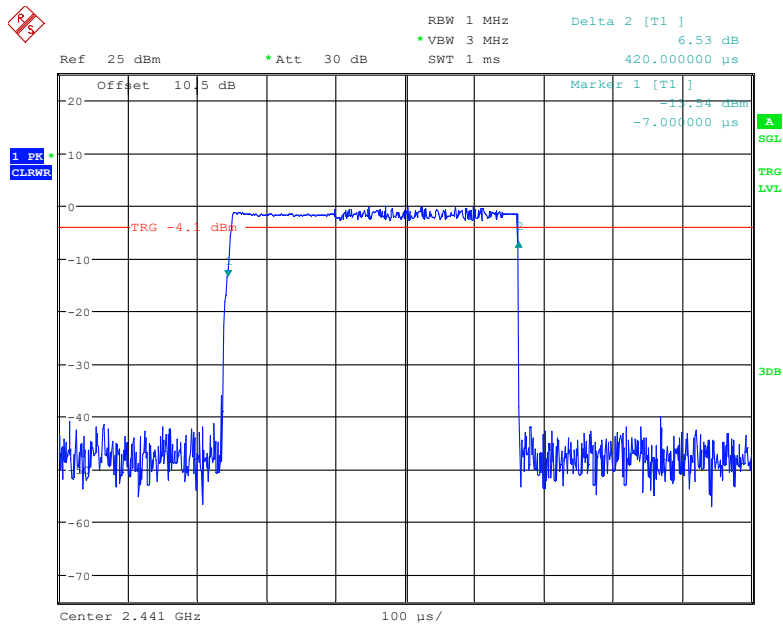


Date: 24.JUL.2023 15:12:54

EDR (8DPSK):
3DH1

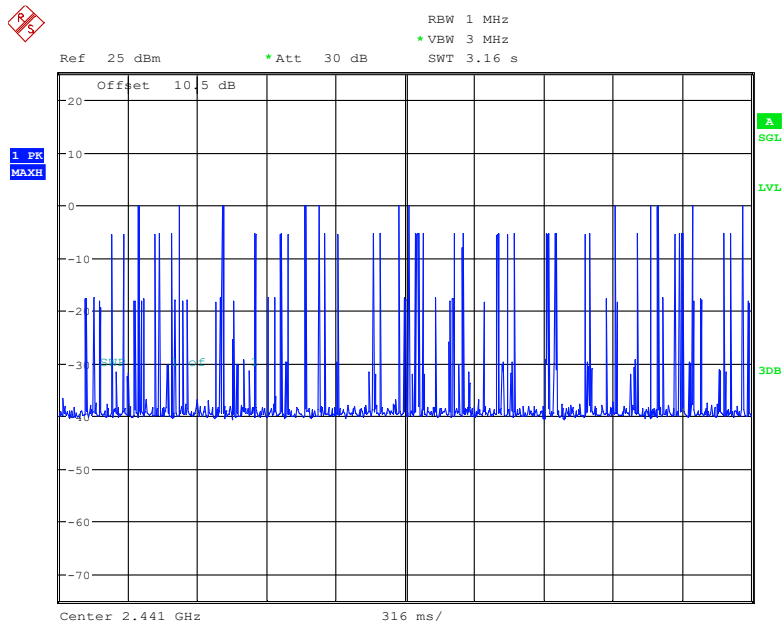


Date: 24.JUL.2023 15:15:32

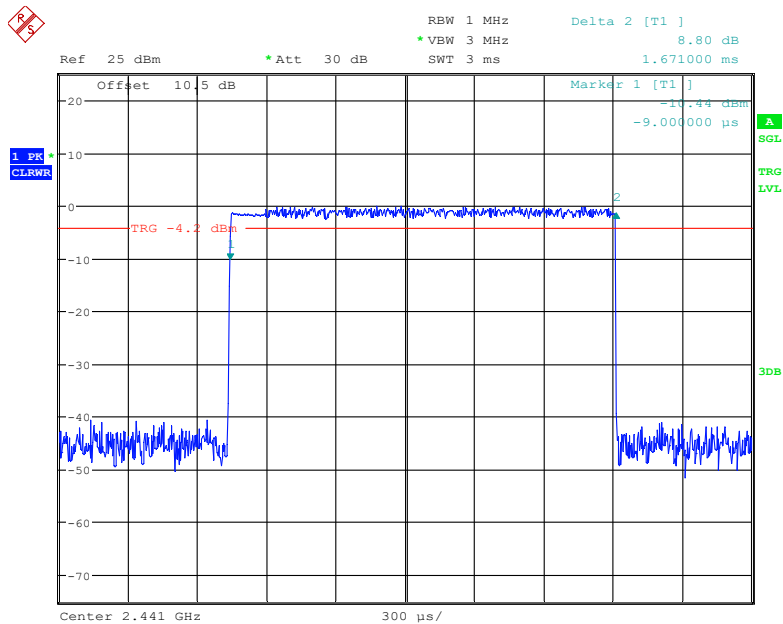


Date: 24.JUL.2023 15:15:51

3DH3

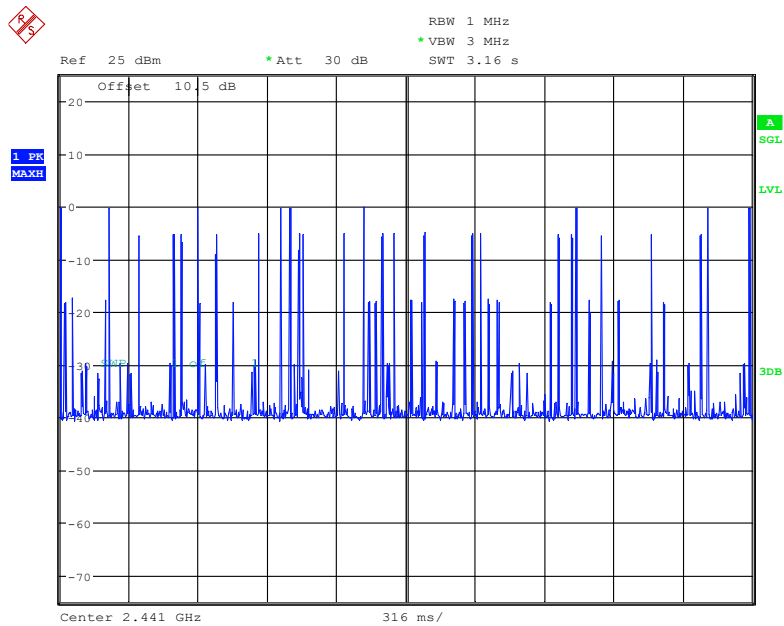


Date: 24.JUL.2023 15:16:18

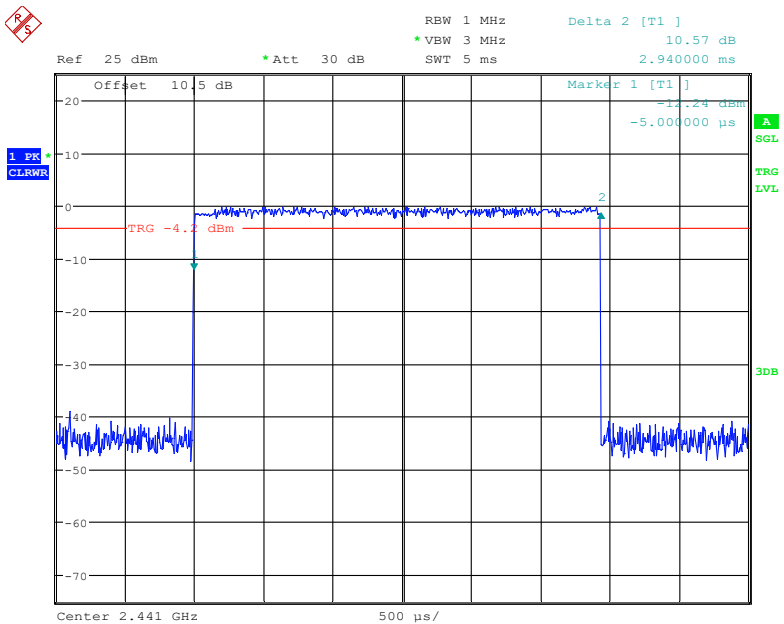


Date: 24.JUL.2023 15:16:39

3DH5



Date: 24.JUL.2023 15:19:44



Date: 24.JUL.2023 15:20:04

FCC §15.247(b) (1) - PEAK OUTPUT POWER MEASUREMENT

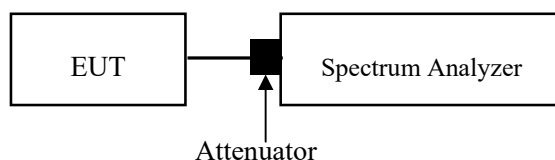
Applicable Standard

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

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.5

1. Place the EUT on a bench and set in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to one test equipment.
3. Add a correction factor to the display.



Test Data

Environmental Conditions

Temperature:	26~27 °C
Relative Humidity:	45~50 %
ATM Pressure:	101.0 kPa

The testing was performed by Jacob Huang on 2023-07-24.

EUT operation mode: Transmitting

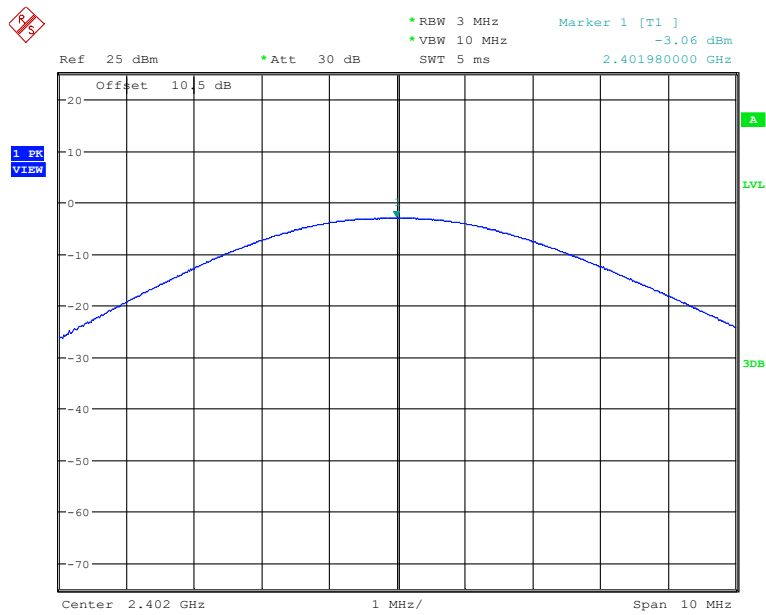
Test Result: Pass

Please refer to following table and plots.

Mode	Channel	Frequency (MHz)	Peak Output Power	Limit (dBm)
			(dBm)	
BDR (GFSK)	Low	2402	-3.06	20.97
	Middle	2441	-1.56	20.97
	High	2480	-1.49	20.97
EDR ($\pi/4$-DQPSK)	Low	2402	-1.17	20.97
	Middle	2441	-0.11	20.97
	High	2480	0.06	20.97
EDR (8DPSK)	Low	2402	-1.13	20.97
	Middle	2441	0.10	20.97
	High	2480	0.28	20.97

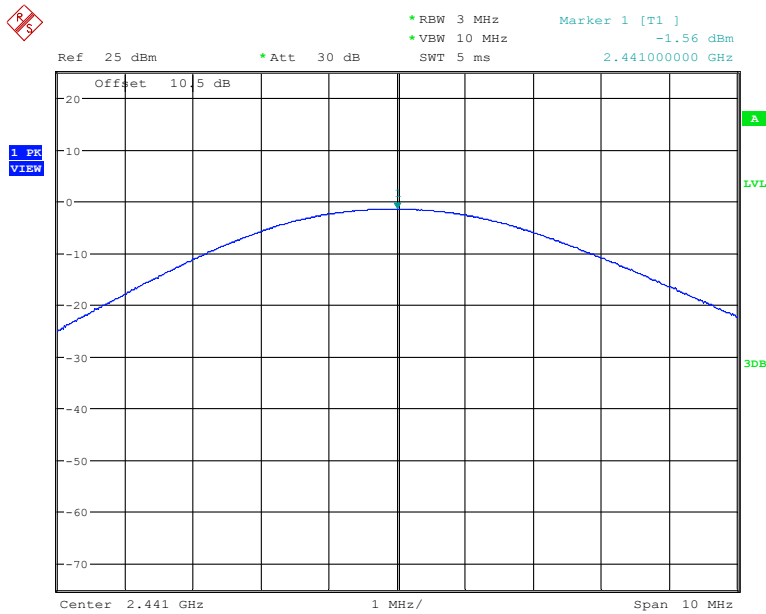
BDR (GFSK):

Low Channel



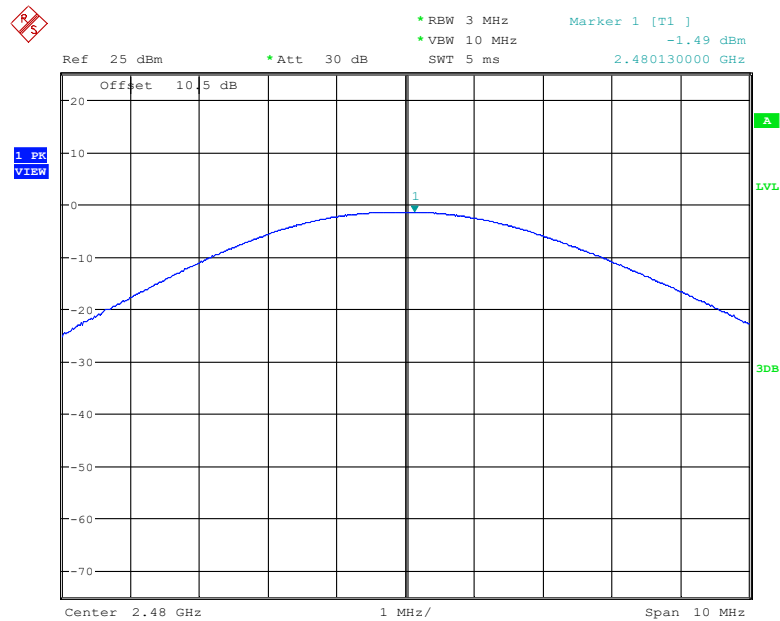
Date: 24.JUL.2023 14:26:20

Middle Channel



Date: 24.JUL.2023 14:34:10

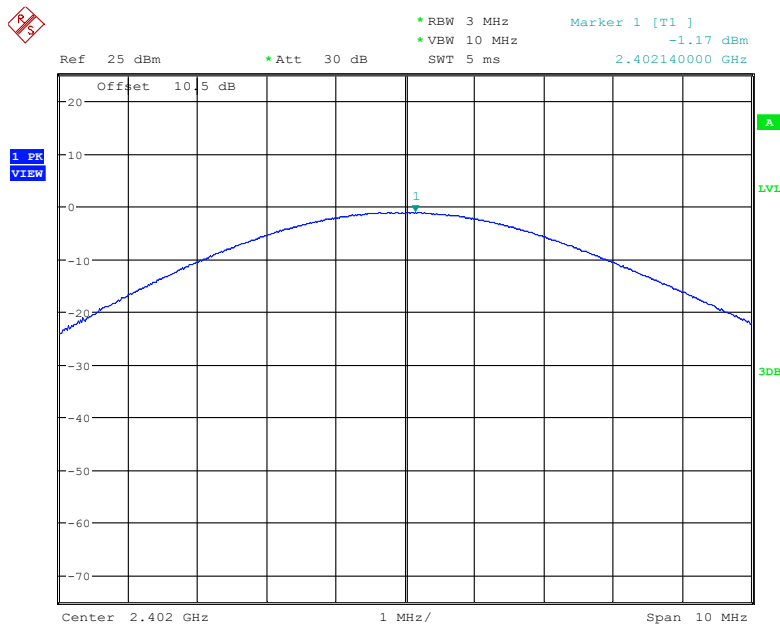
High Channel



Date: 24.JUL.2023 14:41:26

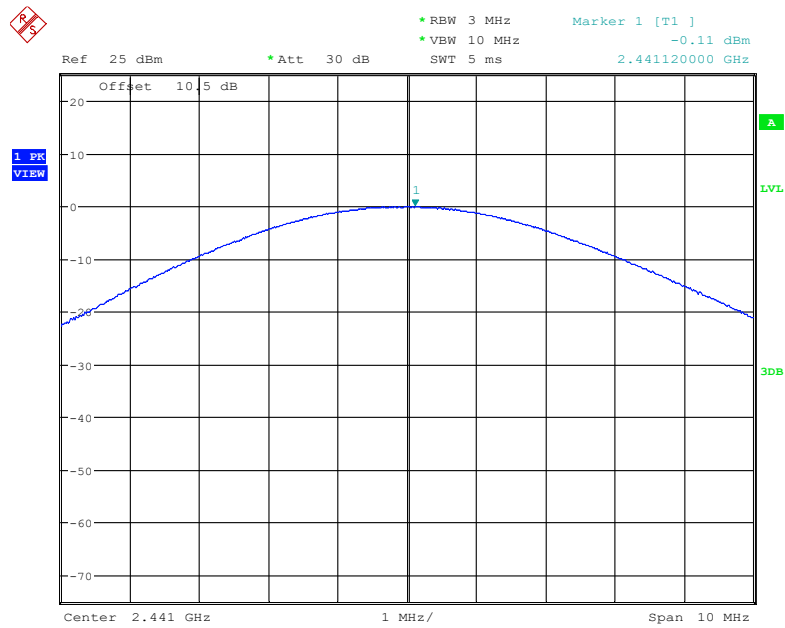
EDR ($\pi/4$ -DQPSK):

Low Channel



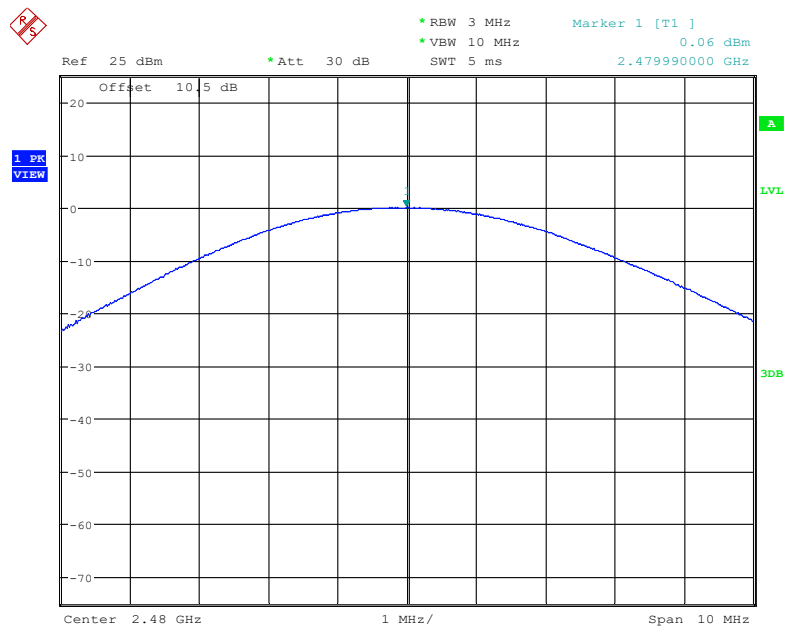
Date: 24.JUL.2023 14:28:48

Middle Channel



Date: 24.JUL.2023 14:36:13

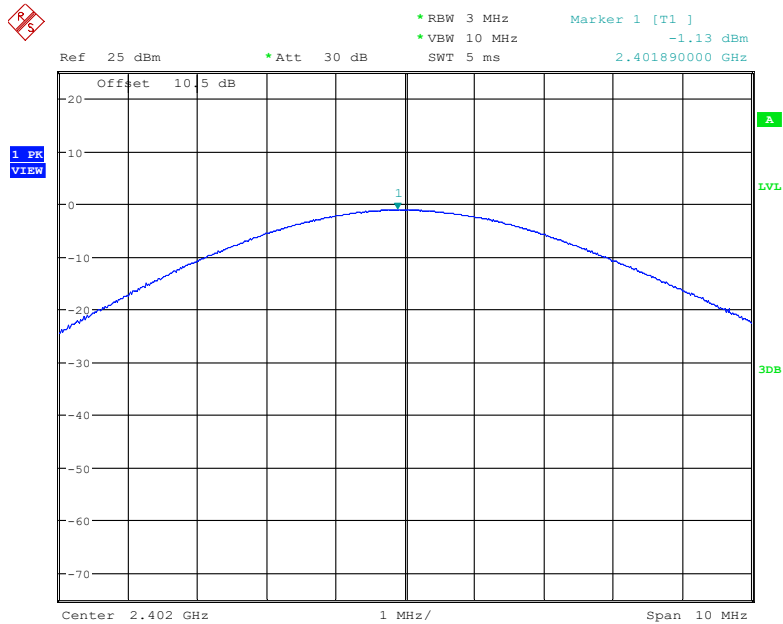
High Channel



Date: 24.JUL.2023 14:43:52

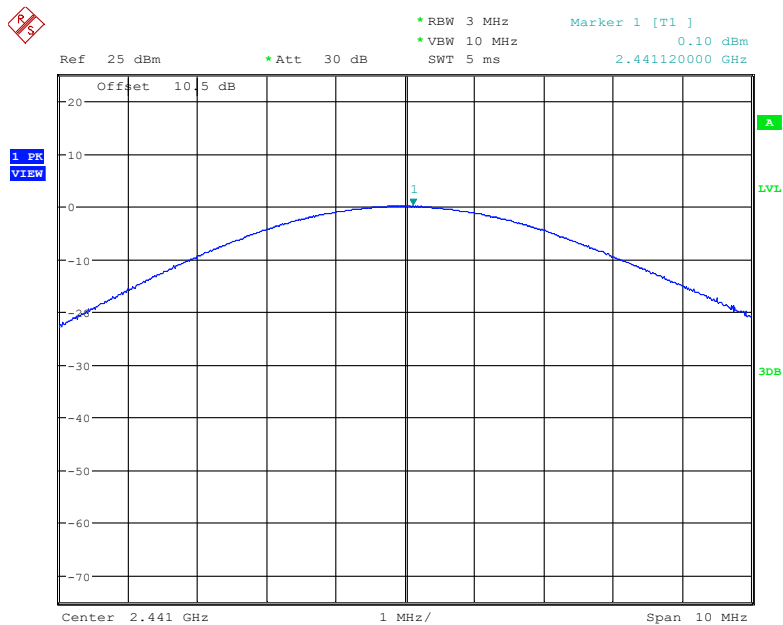
EDR (8DPSK):

Low Channel



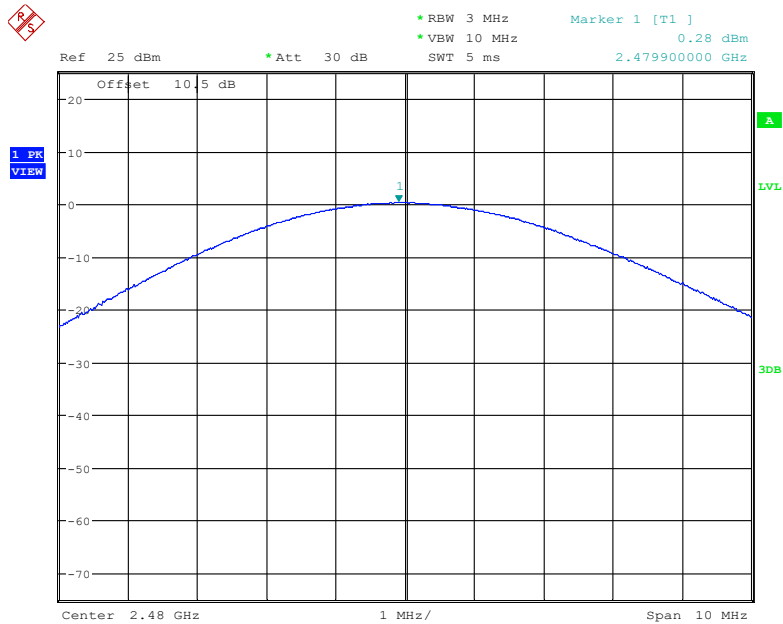
Date: 24.JUL.2023 14:31:23

Middle Channel



Date: 24.JUL.2023 14:38:25

High Channel



Date: 24.JUL.2023 14:46:25

FCC §15.247(d) - BAND EDGES TESTING

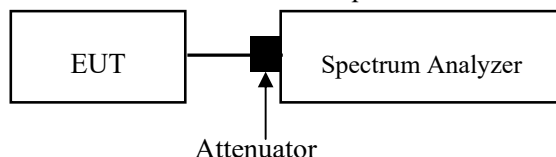
Applicable Standard

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, 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 30 dB instead of 20 dB. 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) (see §15.205(c)).

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.6 & Clause 6.10

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to a EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set RBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100 kHz bandwidth from band edge.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.



Test Data

Environmental Conditions

Temperature:	26~27 °C
Relative Humidity:	45~50 %
ATM Pressure:	101.0 kPa

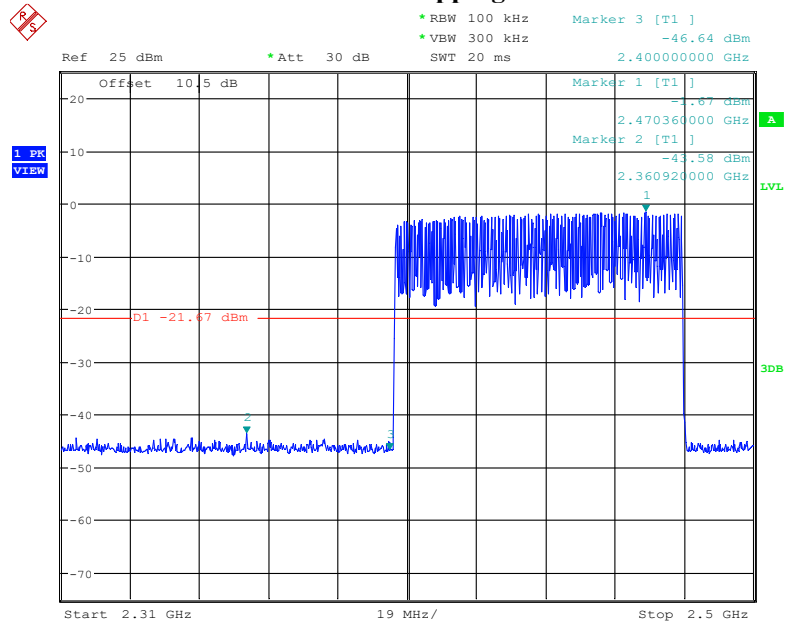
The testing was performed by Jacob Huang on 2023-07-24.

EUT operation mode: Transmitting

Test Result: Pass

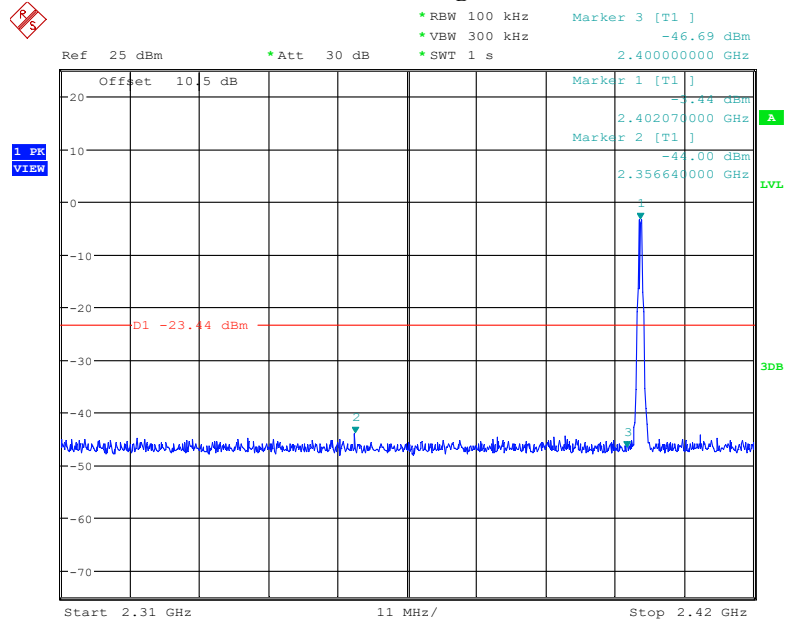
Please refer to following plots

BDR (GFSK): Band Edge-Left Side Hopping



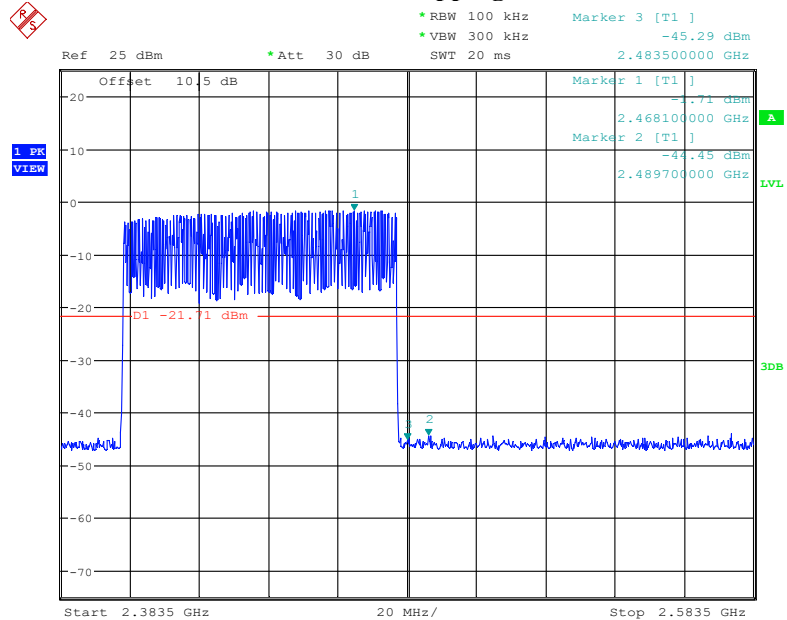
Date: 24.JUL.2023 14:58:53

Single



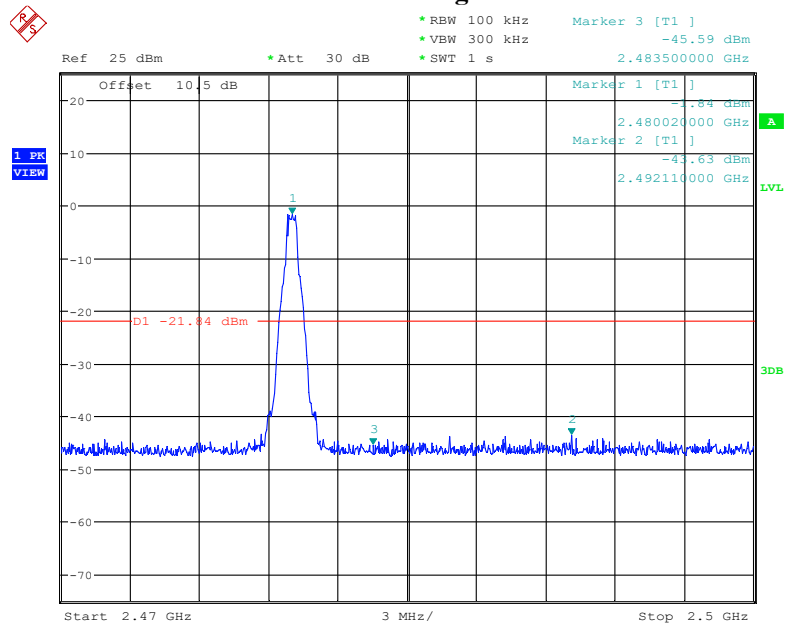
Date: 24.JUL.2023 14:27:56

BDR (GFSK): Band Edge-Right Side Hopping



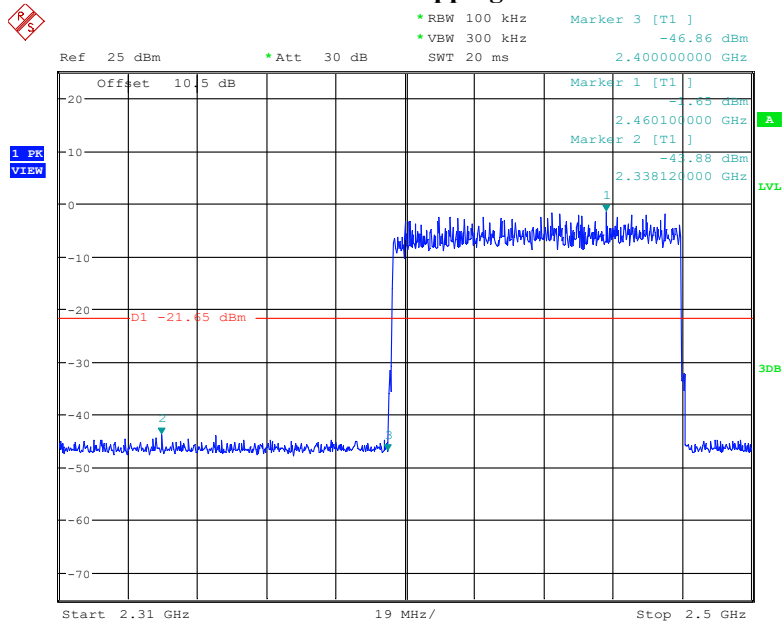
Date: 24.JUL.2023 15:00:16

Single



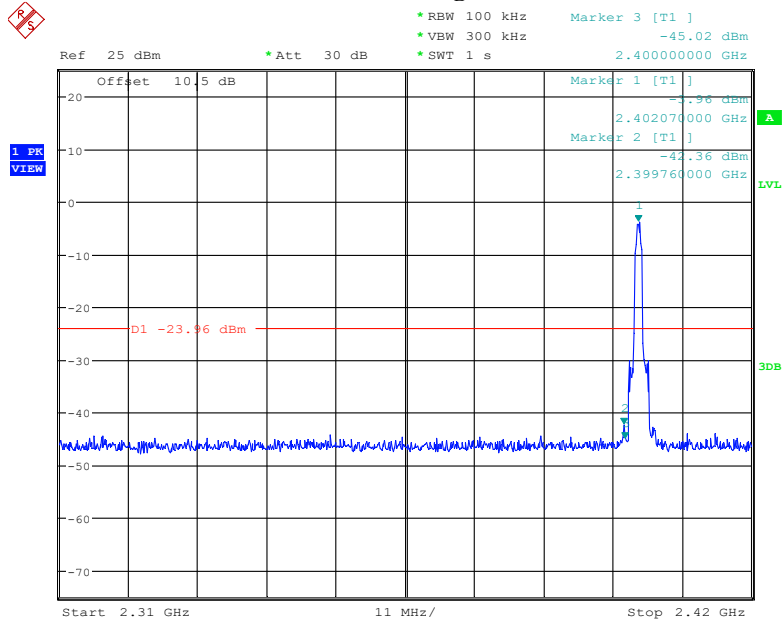
Date: 24.JUL.2023 14:43:01

EDR ($\pi/4$ -DQPSK): Band Edge-Left Side
Hopping



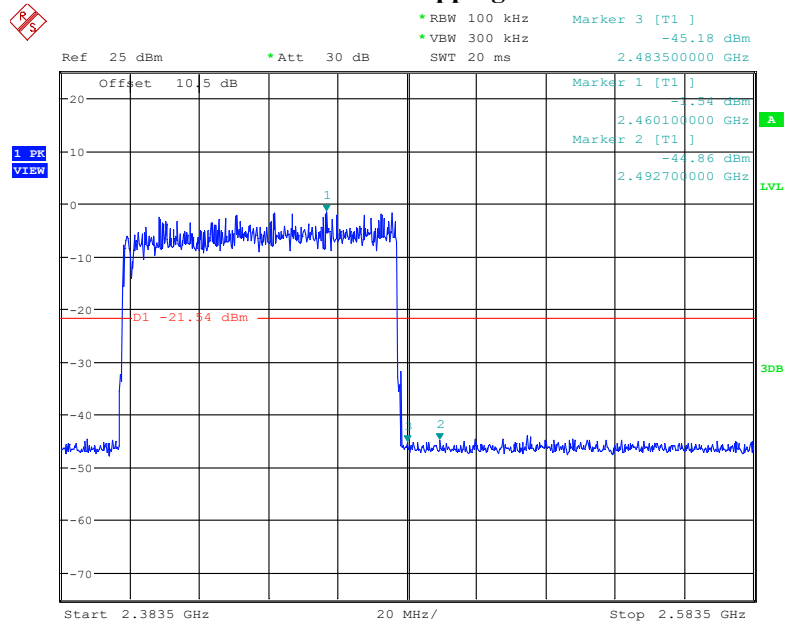
Date: 24.JUL.2023 15:13:55

Single



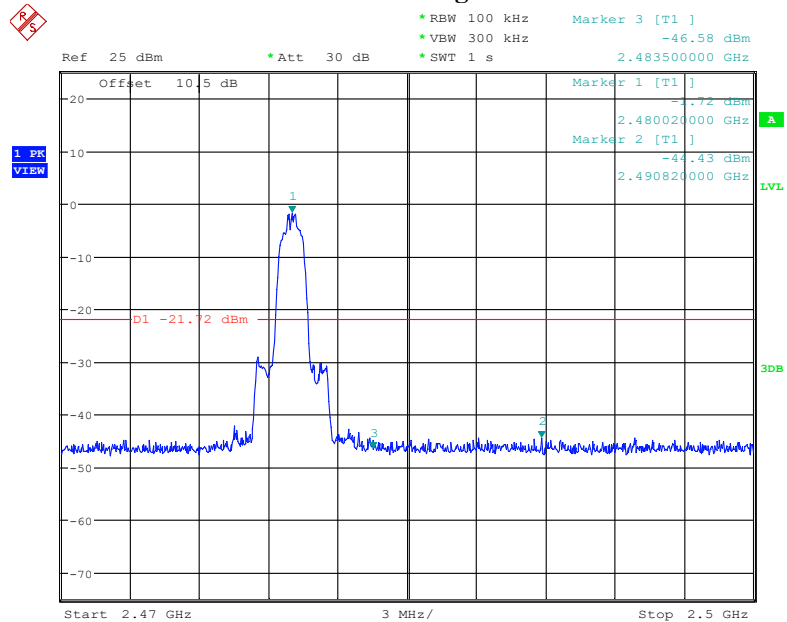
Date: 24.JUL.2023 14:30:36

EDR ($\pi/4$ -DQPSK): Band Edge-Right Side Hopping



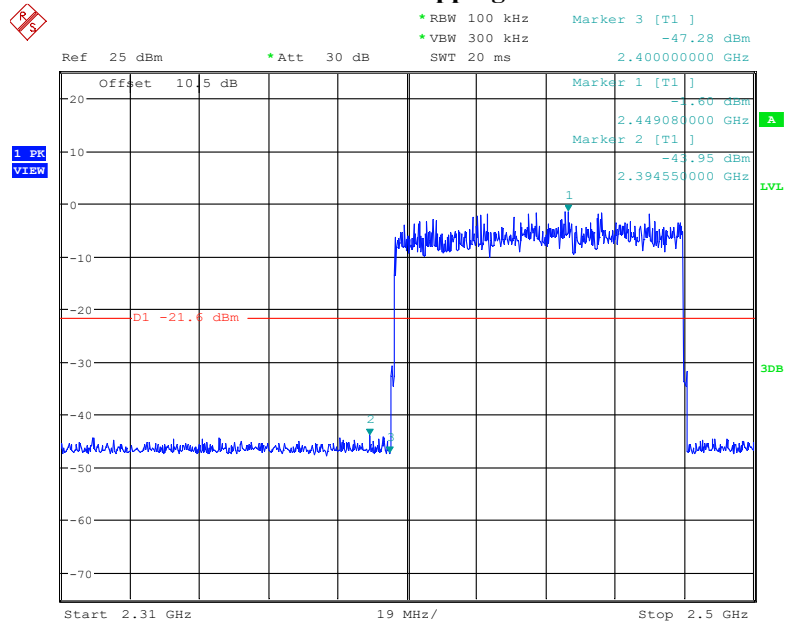
Date: 24.JUL.2023 15:14:58

Single



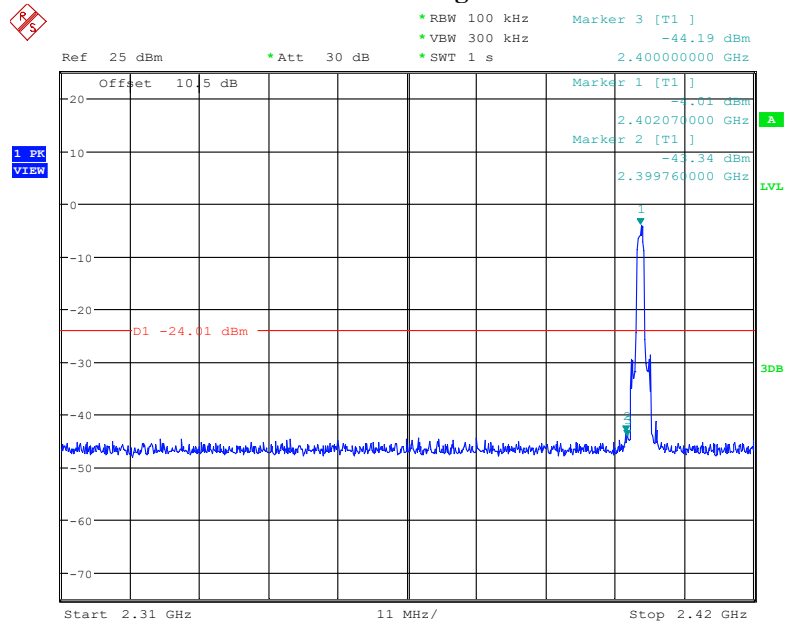
Date: 24.JUL.2023 14:45:27

EDR (8DPSK): Band Edge-Left Side Hopping

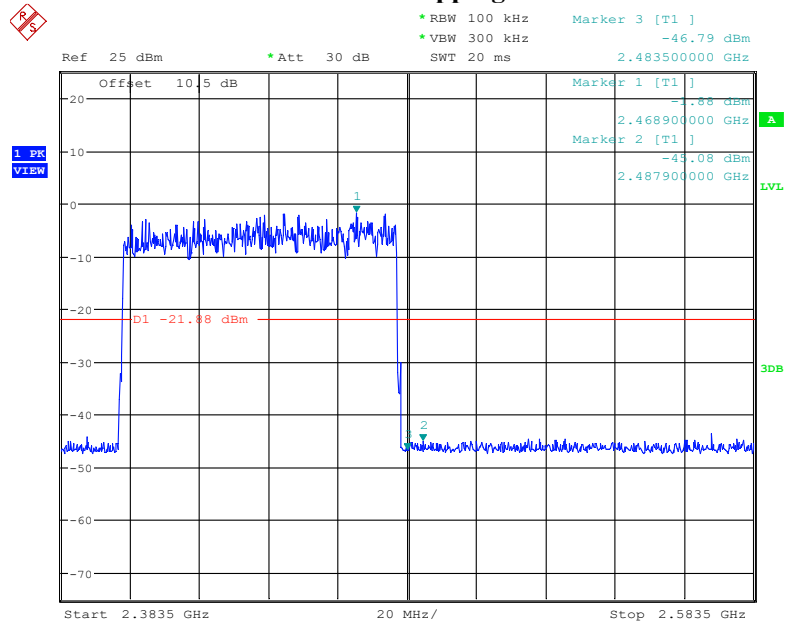


Date: 24.JUL.2023 15:21:07

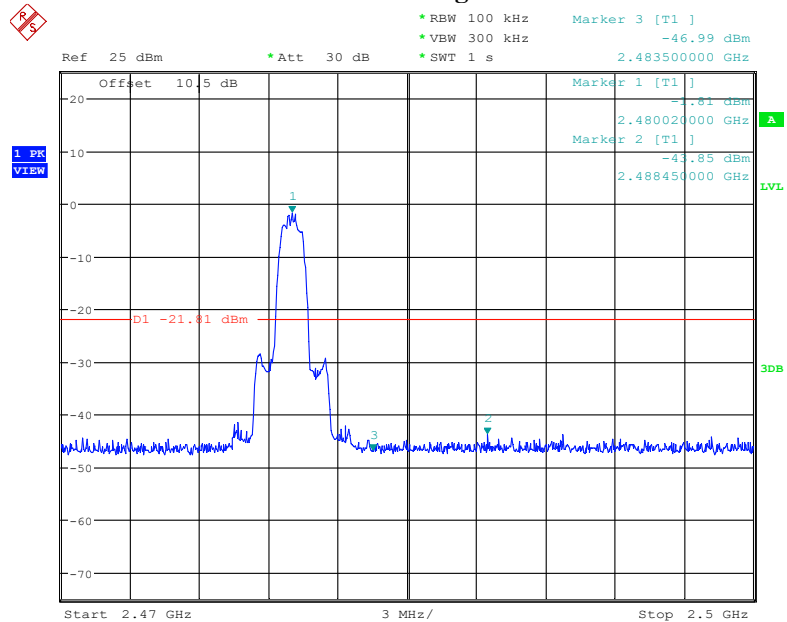
Single



Date: 24.JUL.2023 14:32:58

**EDR (8DPSK): Band Edge-Right Side
Hopping**

Date: 24.JUL.2023 15:22:09

Single

Date: 24.JUL.2023 14:48:00

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