

TEST REPORT

Applicant Name : Vuzix Corporation
Address : FCC: 25 Hendrix Rd, West Henrietta, New York, United States
14586
ISED: 25 Hendrix Road West Henrietta NY 14586 United
States Of America (Excluding The States Of Alaska)
Report Number : SZNS220630-29398E-RFA
FCC ID: 2AA9D-492
IC: 11503A-492

Test Standard (s)

FCC PART 15.247; RSS-GEN ISSUE 5, FEBRUARY 2021 AMENDMENT 2; RSS-247, ISSUE 2,
FEBRUARY 2017

Sample Description

Product Type: Shield
Model No.: 492
Multiple Model(s) No.: N/A
Trade Mark: Vuzix
Date Received: 2022/06/30
Report Date: 2022/09/16

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

Prepared and Checked By:

Approved By:



Nick Fang
EMC Engineer



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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GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

HVIN	492
FVIN	492
Frequency Range	Bluetooth: 2402~2480MHz
Transmit Peak Power	11.98dBm
Modulation Technique	Bluetooth: GFSK, $\pi/4$ -DQPSK, 8DPSK
Antenna Specification*	1.5dBi (provided by the applicant)
Voltage Range	DC 3.8V from battery or DC 5.0V from USB Port
Sample serial number	SZNS220630-29398E-RF-S1 (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 Commissions rules and RSS-247, Issue 2, February 2017, RSS-GEN Issue 5, Feb. 2021 Amendment 2 of the Innovation, Science and Economic Development Canada 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 and RSS-247, Issue 2, February 2017, RSS-GEN Issue 5, Feb. 2021 Amendment 2 of the Innovation, Science and Economic Development Canada rules.

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.

Each test item follows test standards and with no deviation.

Measurement Uncertainty

Parameter		Uncertainty
Occupied Channel Bandwidth		5%
RF Frequency		0.082×10^{-7}
RF output power, conducted		0.73dB
Unwanted Emission, conducted		1.6dB
AC Power Lines Conducted Emissions		2.72dB
Emissions, Radiated	9kHz - 30MHz	2.66dB
	30MHz - 1GHz	4.28dB
	1GHz - 18GHz	4.98dB
	18GHz - 26.5GHz	5.06dB
	26.5GHz- 40GHz	4.72dB
Temperature		1℃
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 1/F., Building A, Changyuan New Material Port, Science & Industry Park, Nanshan District, Shenzhen, Guangdong, P.R. 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 4297.01

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 5077A.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

The system was configured for testing in an engineering mode.

EUT Exercise Software

“QRCT4 ”* exercise software was use to test and the power level is 9*. The software and power level was provided by the applicant.

Special Accessories

No special accessory.

Equipment Modifications

No modification was made to the EUT tested.

Support Equipment List and Details

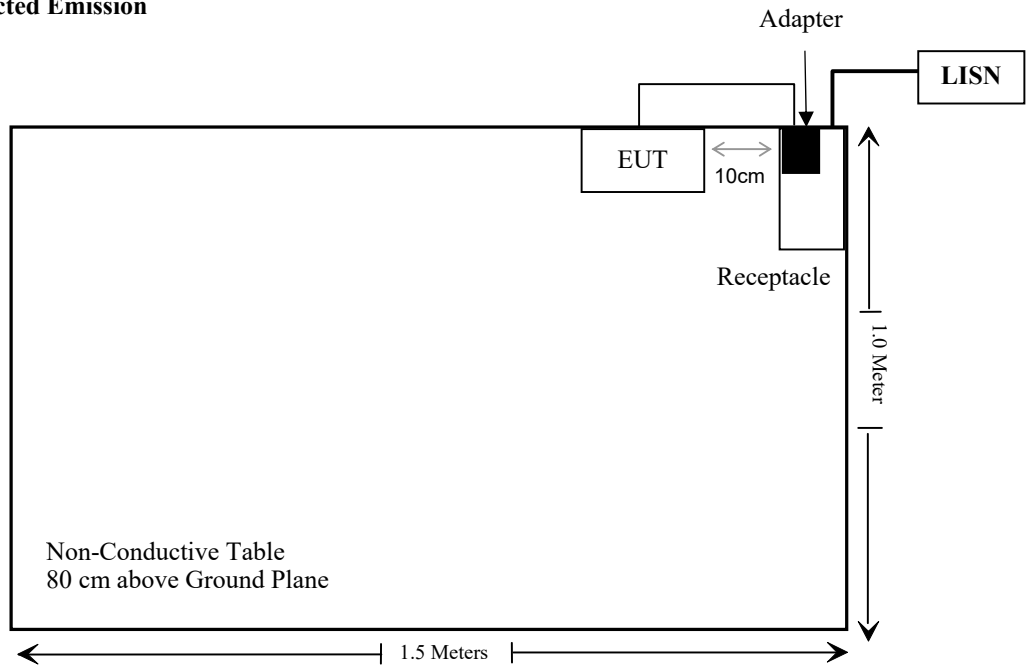
Manufacturer	Description	Model	Serial Number
Epik	Adapter	E250	Unknown

External I/O Cable

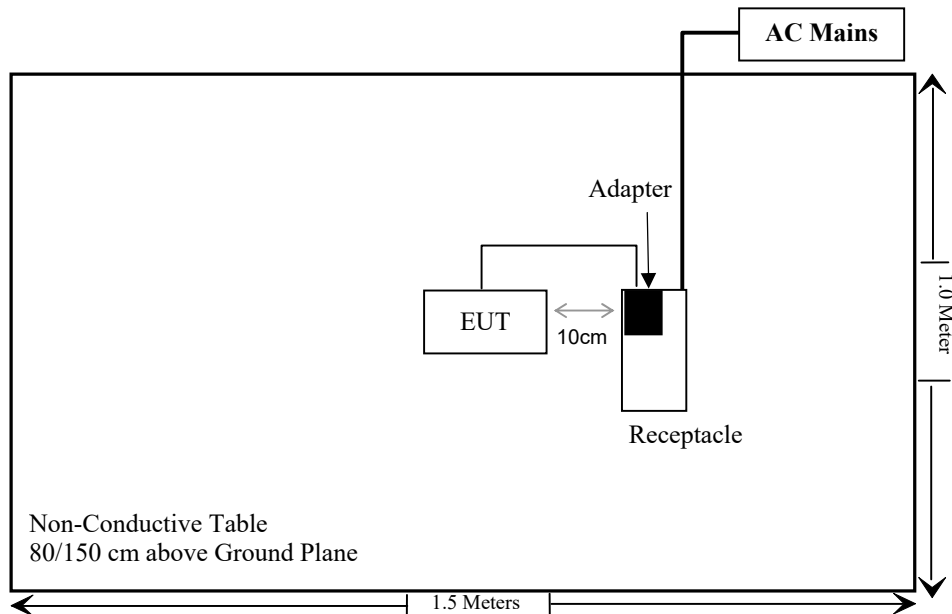
Cable Description	Length (m)	From Port	To
Un-shield Detachable USB Cable	1.0	Adapter	EUT

Block Diagram of Test Setup

For Conducted Emission



For Radiated Emissions:



SUMMARY OF TEST RESULTS

Rules	Description of Test	Result
§1.1307 & §2.1093	RF Exposure	Compliant
RSS-102	RF EXPOSURE	Compliant
FCC §15.203 RSS-Gen §6.8	Antenna Requirement	Compliant
FCC §15.207(a) RSS-Gen §8.8	AC Line Conducted Emissions	Compliant
FCC §15.205, §15.209, §15.247(d) RSS-247 § 5.5, RSS-GEN § 8.10	Radiated Emissions	Compliant
FCC §15.247(a)(1) RSS-247 § 5.1(a), RSS-GEN § 6.7	20 dB Emission Bandwidth & 99% Occupied Bandwidth	Compliant
FCC §15.247(a)(1) RSS-247 § 5.1 (b)	Channel Separation Test	Compliant
FCC §15.247(a)(1)(iii) RSS-247 § 5.1 (d)	Time of Occupancy (Dwell Time)	Compliant
FCC §15.247(a)(1)(iii) RSS-247 § 5.1 (d)	Quantity of hopping channel Test	Compliant
FCC §15.247(b)(1) RSS-247 § 5.1(b) & § 5.4(b)	Peak Output Power Measurement	Compliant
FCC §15.247(d) RSS-247 § 5.5	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	2021/12/13	2022/12/12
Rohde & Schwarz	L.I.S.N.	ENV216	101314	2021/12/13	2022/12/12
Anritsu Corp	50 Coaxial Switch	MP59B	6100237248	2021/12/13	2022/12/12
Unknown	RF Coaxial Cable	No.17	N0350	2021/12/14	2022/12/13
Unknown	RF Coaxial Cable	No.18	N0850	2021/12/14	2022/12/13
Conducted Emission Test Software: e3 19821b (V9)					
Radiated Emissions Test					
Rohde& Schwarz	Test Receiver	ESR	102725	2021/12/13	2022/12/12
Rohde&Schwarz	Spectrum Analyzer	FSV40	101949	2021/12/13	2022/12/12
SONOMA INSTRUMENT	Amplifier	310 N	186131	2021/11/09	2022/11/08
A.H. Systems, inc.	Preamplifier	PAM-0118P	135	2021/11/09	2022/11/08
Quinstar	Amplifier	QLW-18405536-J0	15964001002	2021/11/11	2022/11/10
Schwarzbeck	Bilog Antenna	VULB9163	9163-323	2021/07/06	2024/07/05
Schwarzbeck	Horn Antenna	BBHA9120D	9120D-1067	2020/01/05	2023/01/04
Schwarzbeck	HORN ANTENNA	BBHA9170	9170-359	2020/01/05	2023/01/04
Radiated Emission Test Software: e3 19821b (V9)					
Unknown	RF Coaxial Cable	No.10	N050	2021/12/14	2022/12/13
Unknown	RF Coaxial Cable	No.11	N1000	2021/12/14	2022/12/13
Unknown	RF Coaxial Cable	No.12	N040	2021/12/14	2022/12/13
Unknown	RF Coaxial Cable	No.13	N300	2021/12/14	2022/12/13
Unknown	RF Coaxial Cable	No.14	N800	2021/12/14	2022/12/13
Unknown	RF Coaxial Cable	No.15	N600	2021/12/14	2022/12/13
Unknown	RF Coaxial Cable	No.16	N650	2021/12/14	2022/12/13
Wainwright	High Pass Filter	WHKX3.6/18 G-10SS	5	2021/12/14	2022/12/13

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
RF Conducted Test					
Rohde & Schwarz	Spectrum Analyzer	FSV-40	101495	2021/12/13	2022/12/12
SPECTRUM ANALYZER	Rohde & Schwarz	FSU26	200982	2022/07/05	2023/07/04
WEINSCHTEL	3dB Attenuator	Unknown	F-03-EM121	2021/11/28	2022/11/27

* **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).

§1.1307 & §2.1093 – RF EXPOSURE

Applicable Standard

FCC§1.1307 and §2.1093.

Measurement Result

Please refer to SAR test report: SZNS220630-29398E-SA

RSS-102– RF EXPOSURE

Applicable Standard

According to RSS-102, systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guideline.

Result: Compliance.

Please refer to SAR test report: SZNS220630-29398E-SA

FCC §15.203 & RSS-GEN §6.8 – 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.

According to FCC § 15.203, the applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report (and in the notice to be included in the user manual, provided below).

When measurements at the antenna port are used to determine the RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer.

The test report shall state the RF power, output power setting and spurious emission measurements with each antenna type that is used with the transmitter being tested.

For licence-exempt equipment with detachable antennas, the user manual shall also contain the following notice in a conspicuous location:

This radio transmitter [enter the device's ISED certification number] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device. Immediately following the above notice, the manufacturer shall provide a list of all antenna types which can be used with the transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna type.

Antenna Connector Construction

The EUT has one internal antenna arrangement which was permanently attached and the maximum antenna gain is 1.5dBi, fulfill the requirement of this section. Please refer to the EUT photos.

Antenna Type	Antenna Gain	Impedance	Frequency Range
Integral	1.5dBi	50 Ω	2.4~2.5GHz

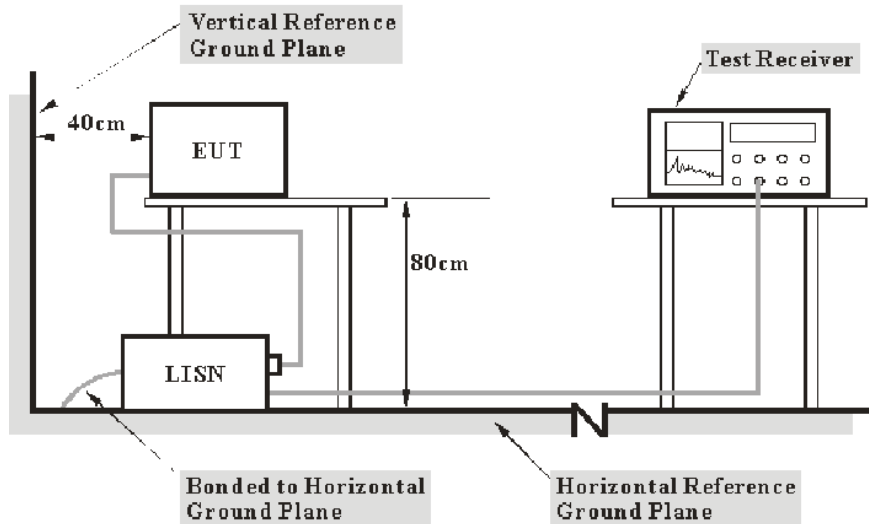
Result: Compliance

FCC §15.207 (a) & RSS-GEN § 8.8 – AC LINE CONDUCTED EMISSIONS

Applicable Standard

FCC §15.207(a), RSS-GEN § 8.8

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 & RSS-Gen.

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

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.

Transd Factor & Margin Calculation

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

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

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:

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

Test Data

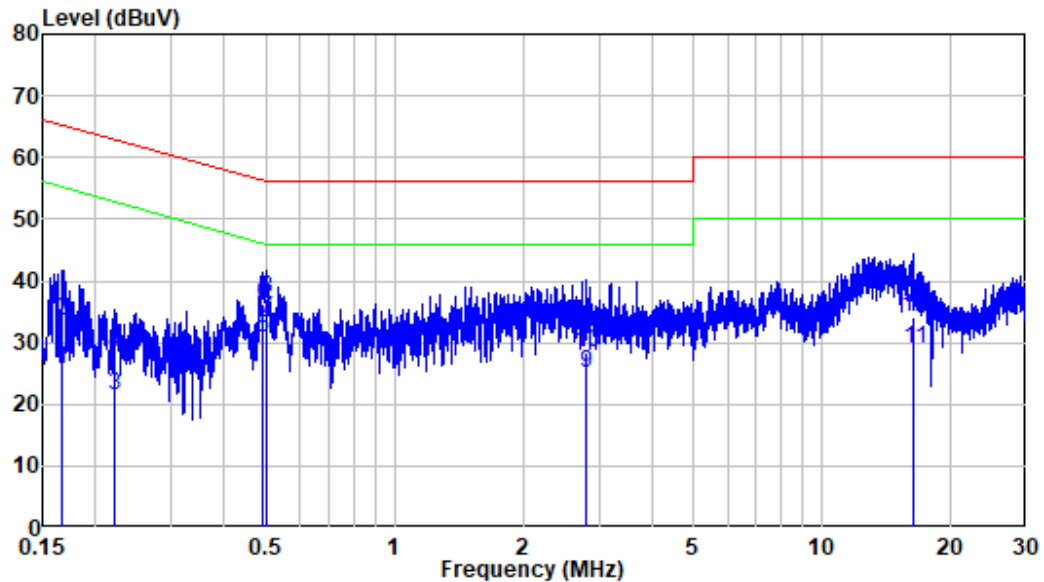
Environmental Conditions

Temperature:	24 °C
Relative Humidity:	49 %
ATM Pressure:	101.0 kPa

The testing was performed by Jason on 2022-08-11.

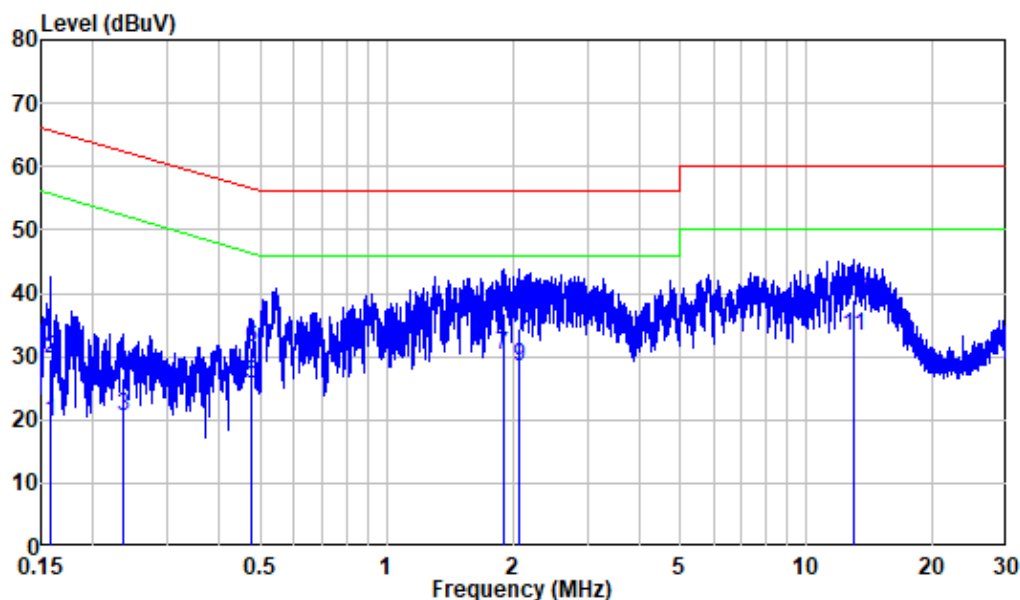
EUT operation mode: Transmitting (worst case is 8DPSK, low channel)

AC 120V/60 Hz, Line



Site : Shielding Room
 Condition: Line
 Mode : BT
 Model : 492
 Power : AC 120V 60Hz

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.167	9.80	15.91	25.71	55.09	-29.38	Average
2	0.167	9.80	23.78	33.58	65.09	-31.51	QP
3	0.221	9.80	11.56	21.36	52.79	-31.43	Average
4	0.221	9.80	18.56	28.36	62.79	-34.43	QP
5	0.490	9.80	21.04	30.84	46.18	-15.34	Average
6	0.490	9.80	26.42	36.22	56.18	-19.96	QP
7	0.501	9.80	24.06	33.86	46.00	-12.14	Average
8	0.501	9.80	27.26	37.06	56.00	-18.94	QP
9	2.803	9.83	15.19	25.02	46.00	-20.98	Average
10	2.803	9.83	18.48	28.31	56.00	-27.69	QP
11	16.355	9.96	19.14	29.10	50.00	-20.90	Average
12	16.355	9.96	24.06	34.02	60.00	-25.98	QP

AC 120V/60 Hz, Neutral

Site : Shielding Room
 Condition: Neutral
 Mode : BT
 Model : 492
 Power : AC 120V 60Hz

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.159	9.80	9.91	19.71	55.53	-35.82	Average
2	0.159	9.80	19.81	29.61	65.53	-35.92	QP
3	0.235	9.80	10.65	20.45	52.26	-31.81	Average
4	0.235	9.80	16.70	26.50	62.26	-35.76	QP
5	0.476	9.80	15.75	25.55	46.41	-20.86	Average
6	0.476	9.80	21.62	31.42	56.41	-24.99	QP
7	1.890	9.82	20.26	30.08	46.00	-15.92	Average
8	1.890	9.82	27.03	36.85	56.00	-19.15	QP
9	2.070	9.82	18.47	28.29	46.00	-17.71	Average
10	2.070	9.82	24.65	34.47	56.00	-21.53	QP
11	12.946	10.03	23.23	33.26	50.00	-16.74	Average
12	12.946	10.03	28.80	38.83	60.00	-21.17	QP

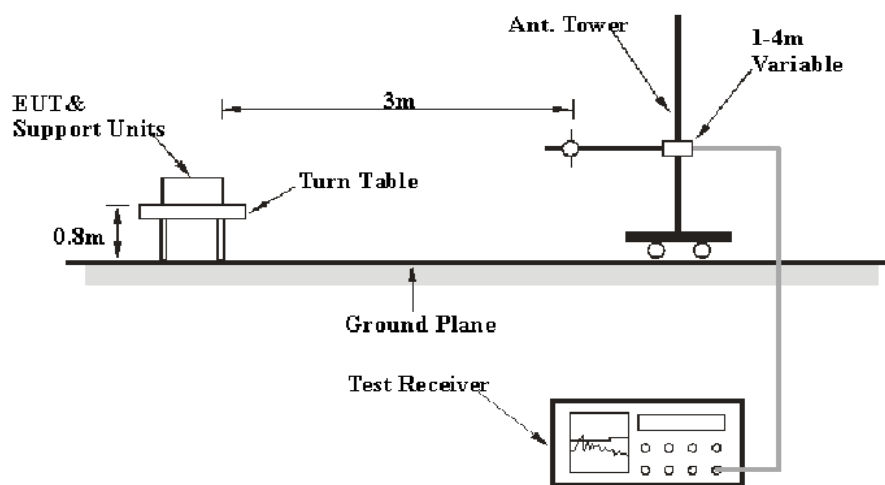
FCC §15.209, §15.205 & §15.247(d) & RSS-247§ 5.5 - SPURIOUS EMISSIONS

Applicable Standard

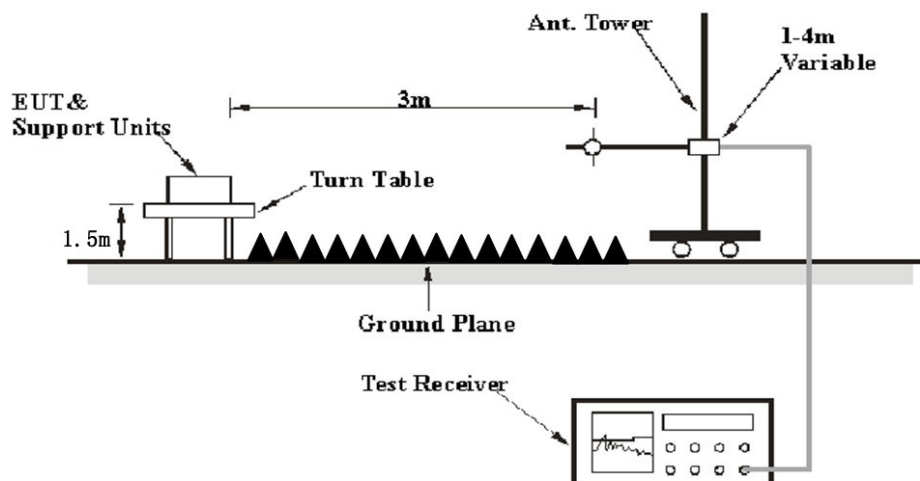
FCC §15.205; §15.209; §15.247(d); RSS-247§ 5.5; RSS-GEN § 8.10

EUT Setup

Below 1 GHz:



Above 1GHz:



The radiated emission performed in the 3 meters, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC 15.209, FCC 15.247, RSS-247, RSS-Gen 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= $N_1 \cdot L_1 + N_2 \cdot L_2 + \dots + N_{n-1} \cdot L_{n-1} + N_n \cdot L_n$,

where N_1 is number of type 1 pulses, L_1 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 & 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:

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

Test Data

Environmental Conditions

Temperature:	26.8~28°C
Relative Humidity:	52~68%
ATM Pressure:	101.0 kPa

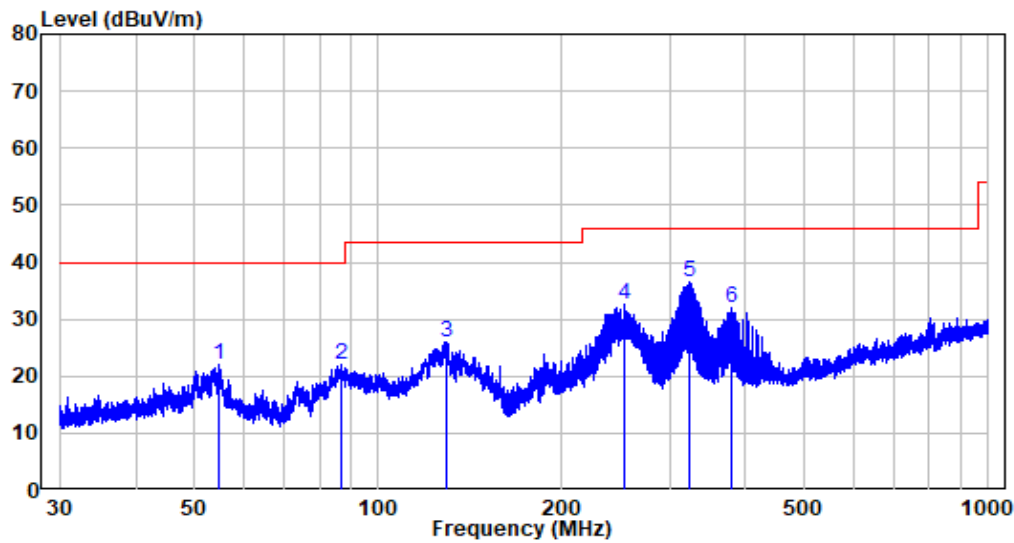
The testing was performed by RSE on 2022-08-11 for below 1GHz, Jeff Jiang on 2022-07-29~2022-08-20 for above 1GHz.

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

Below 1GHz: (worst case is 8DPSK, low channel)

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

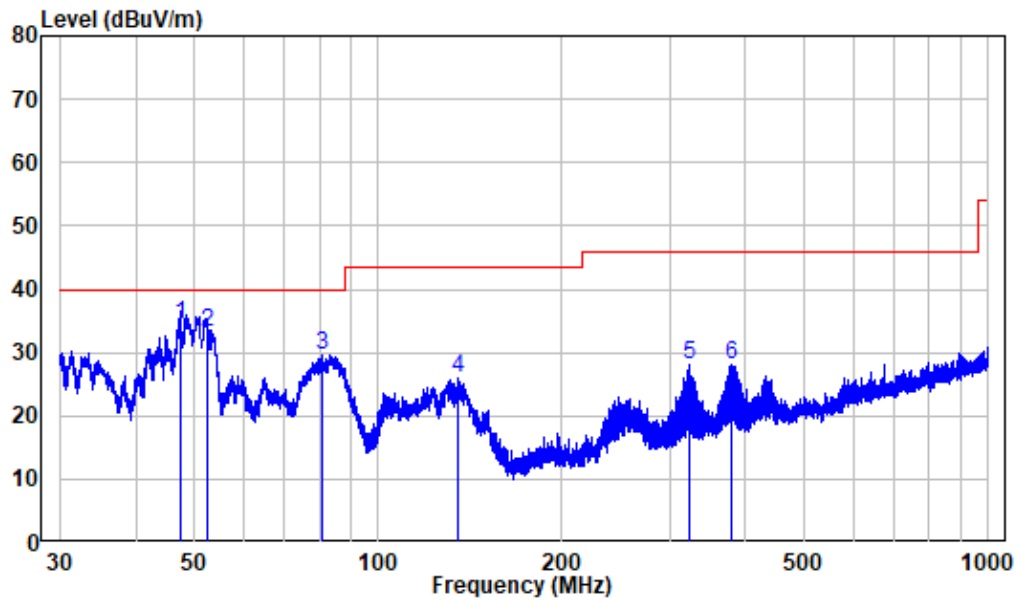
Horizontal



Site : chamber
Condition: 3m HORIZONTAL
Job No. : SZNS220630-29398E-RF
Test Mode: BT

	Freq Factor		Read Level	Level	Limit	Over	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	54.595	-10.31	32.24	21.93	40.00	-18.07	Peak
2	86.693	-14.98	37.00	22.02	40.00	-17.98	Peak
3	129.354	-14.84	40.92	26.08	43.50	-17.42	Peak
4	252.837	-10.66	43.20	32.54	46.00	-13.46	Peak
5	322.613	-8.36	44.91	36.55	46.00	-9.45	Peak
6	378.253	-7.18	39.26	32.08	46.00	-13.92	Peak

Vertical



Site : chamber
Condition: 3m VERTICAL
Job No. : SZNS220630-29398E-RF
Test Mode: BT

	Freq	Factor	Read Level	Level	Limit	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	47.429	-10.00	44.48	34.48	40.00	-5.52	QP
2	52.345	-10.04	43.25	33.21	40.00	-6.79	QP
3	80.609	-16.75	46.41	29.66	40.00	-10.34	Peak
4	134.795	-15.01	40.92	25.91	43.50	-17.59	Peak
5	322.613	-8.36	36.43	28.07	46.00	-17.93	Peak
6	378.253	-7.18	35.22	28.04	46.00	-17.96	Peak

Above 1GHz: (worst case for 8DPSK)

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB/m)	Corrected Amplitude (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/QP/AV		Height (m)	Polar (H/V)				
Low Channel(2402MHz)									
2310	68.24	PK	16	2.5	H	-7.24	61.00	74	-13.00
2310	68.72	PK	213	2	V	-7.24	61.48	74	-12.52
2390	69.78	PK	161	1.2	H	-7.22	62.56	74	-11.44
2390	69.45	PK	119	1.1	V	-7.22	62.23	74	-11.77
4804	54.15	PK	190	1.2	H	-3.51	50.64	74	-23.36
4804	54.66	PK	161	1.3	V	-3.51	51.15	74	-22.85
Middle Channel(2441MHz)									
4882	54.93	PK	136	1.6	H	-3.37	51.56	74	-22.44
4882	54.82	PK	14	2.1	V	-3.37	51.45	74	-22.55
High Channel(2480 MHz)									
2483.5	70.58	PK	82	1.8	H	-7.2	63.38	74	-10.62
2483.5	71.17	PK	25	1.5	V	-7.2	63.97	74	-10.03
2500	69.33	PK	294	1.2	H	-7.18	62.15	74	-11.85
2500	69.72	PK	213	1.7	V	-7.18	62.54	74	-11.46
4960	55.17	PK	26	1.7	H	-3.01	52.16	74	-21.84
4960	54.76	PK	296	1.5	V	-3.01	51.75	74	-22.25

Field Strength of Average						
Frequency (MHz)	Peak Measurement @3m (dBμV/m)	Polar (H/V)	Duty Cycle Correction Factor (dB)	Corrected Amplitude (dBμV/m)	FCC Part 15.247/RSS-247	
					Limit (dBμV/m)	Margin (dB)
Low Channel(2402MHz)						
2310	61.00	H	-24.72	36.28	54	-17.72
2310	61.48	V	-24.72	36.76	54	-17.24
2390	62.56	H	-24.72	37.84	54	-16.16
2390	62.23	V	-24.72	37.51	54	-16.49
4804	50.64	H	-24.72	25.92	54	-28.08
4804	51.15	V	-24.72	26.43	54	-27.57
Middle Channel(2441MHz)						
4882	51.56	H	-24.72	26.84	54	-27.16
4882	51.45	V	-24.72	26.73	54	-27.27
High Channel(2480MHz)						
2483.5	63.38	H	-24.72	38.66	54	-15.34
2483.5	63.97	V	-24.72	39.25	54	-14.75
2500	62.15	H	-24.72	37.43	54	-16.57
2500	62.54	V	-24.72	37.82	54	-16.18
4960	52.16	H	-24.72	27.44	54	-26.56
4960	51.75	V	-24.72	27.03	54	-26.97

Note:

Absolute Level = Corrected Factor + Reading

Margin = Corrected. Amplitude - Limit

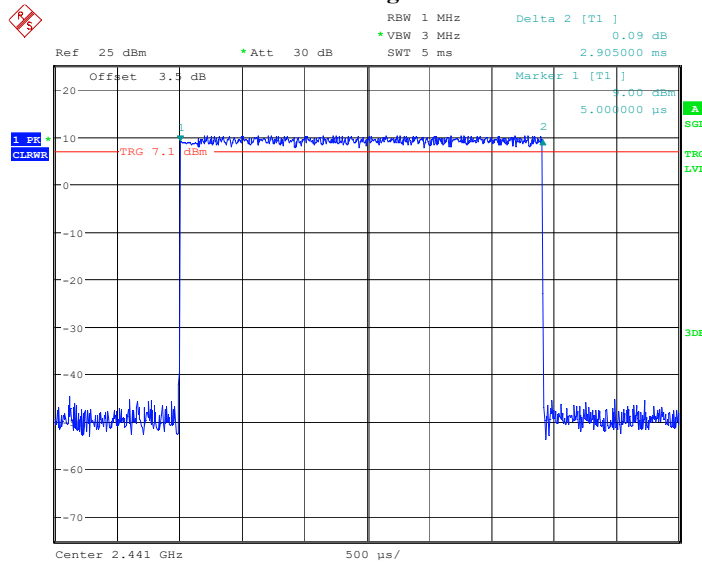
Average level= Peak level+ Duty Cycle Corrected Factor

The worst case duty cycle as below:

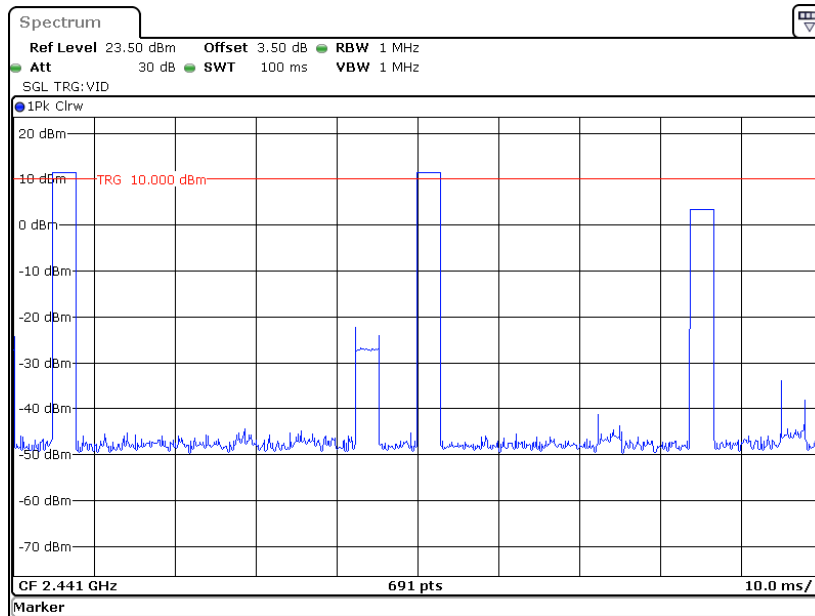
Duty cycle = Ton/100ms = 2.905*2/100=0.0581

Duty Cycle Corrected Factor = 20lg (Duty cycle) = 20lg0.0581 = -24.72

Duty Cycle:

Pulse length: 2.905ms

Date: 29.JUL.2022 21:45:00

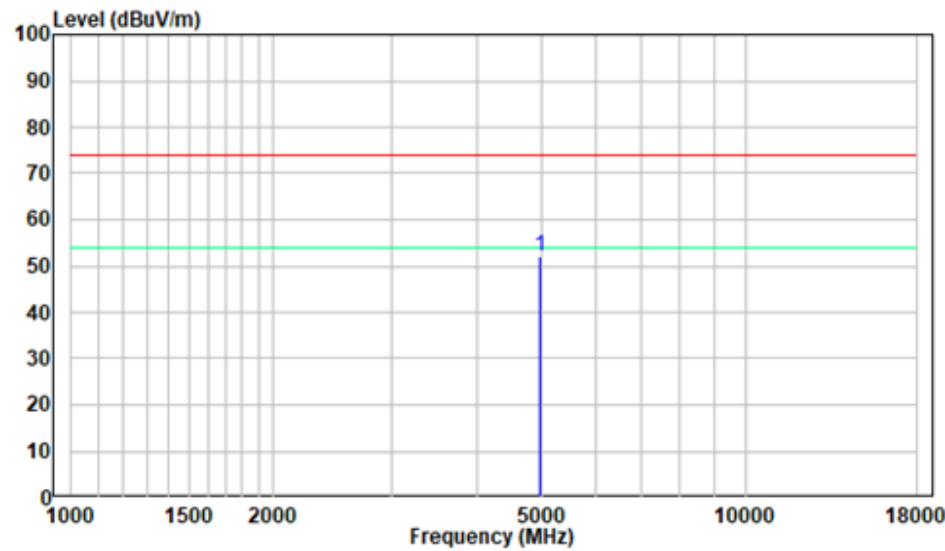
Maximum Pulse number in 100ms: 2

Date: 20.AUG.2022 15:34:00

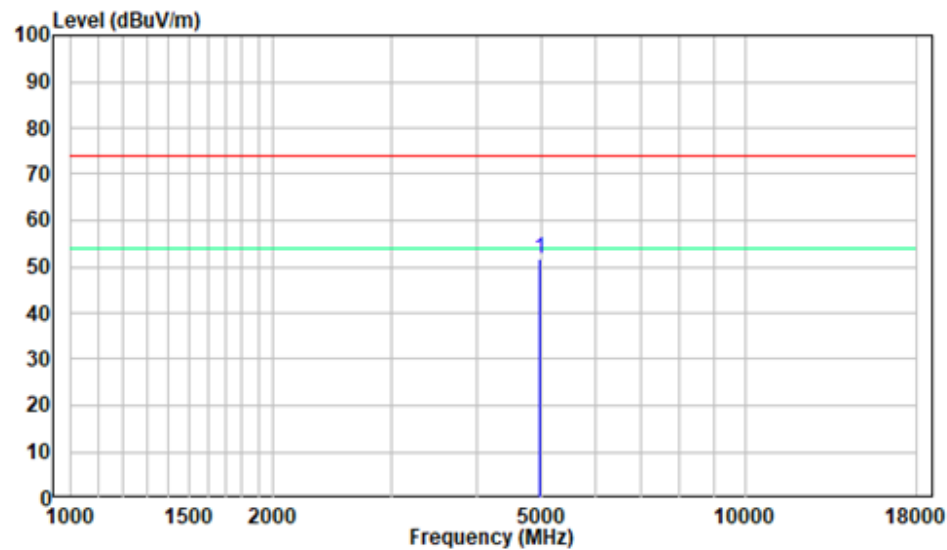
1 GHz - 18 GHz: (Pre-Scan plots)

High channel

Horizontal



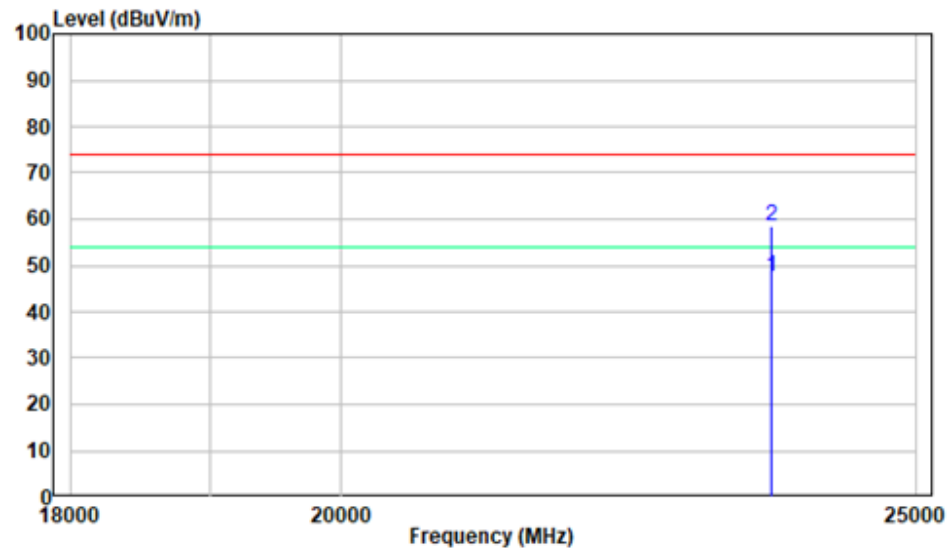
Vertical



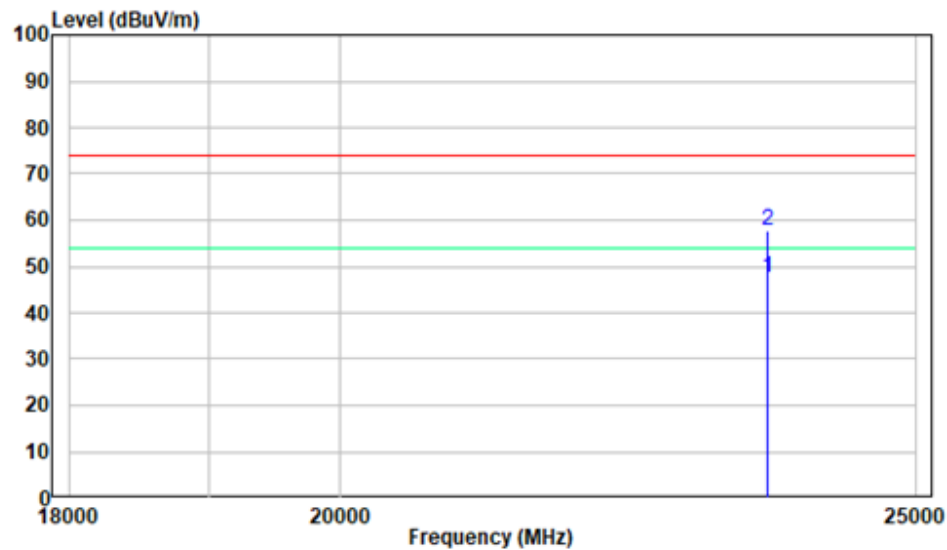
18-25GHz: (Pre-Scan plots)

High channel

Horizontal



Vertical



FCC §15.247(a) (1) & RSS-247 § 5.1 (b) -CHANNEL SEPARATION TEST**Applicable Standard**

According to FCC §15.247(a) (1):

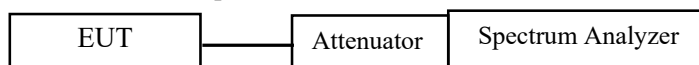
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that 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.

According to RSS-247 § 5.1 (b):

Frequency hopping systems (FHSs) 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, FHSs operating in the band 2400-2483.5 MHz 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 that the systems operate with an output power no greater than 0.125 W. 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

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

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

Temperature:	27.1 °C
Relative Humidity:	58 %
ATM Pressure:	101.0 kPa

The testing was performed by Roger Ling on 2022-07-29.

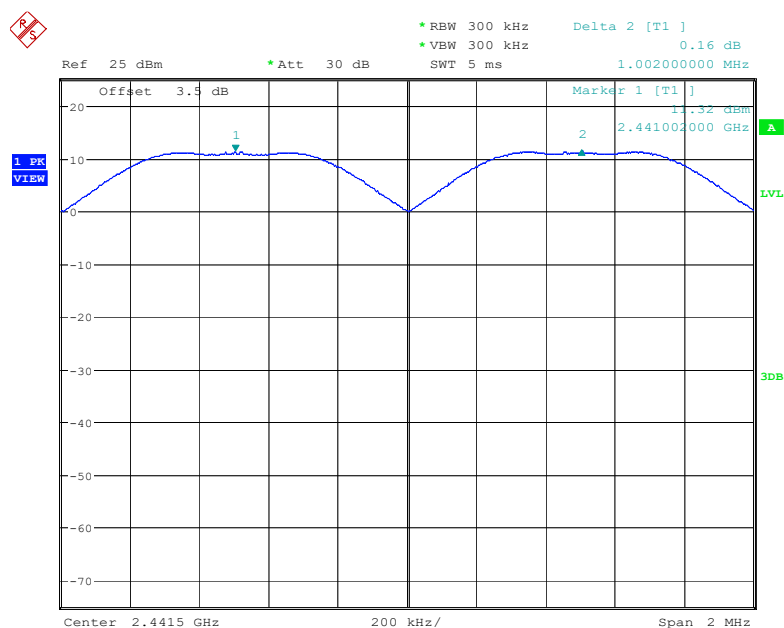
EUT operation mode: Transmitting

Test Result: Pass

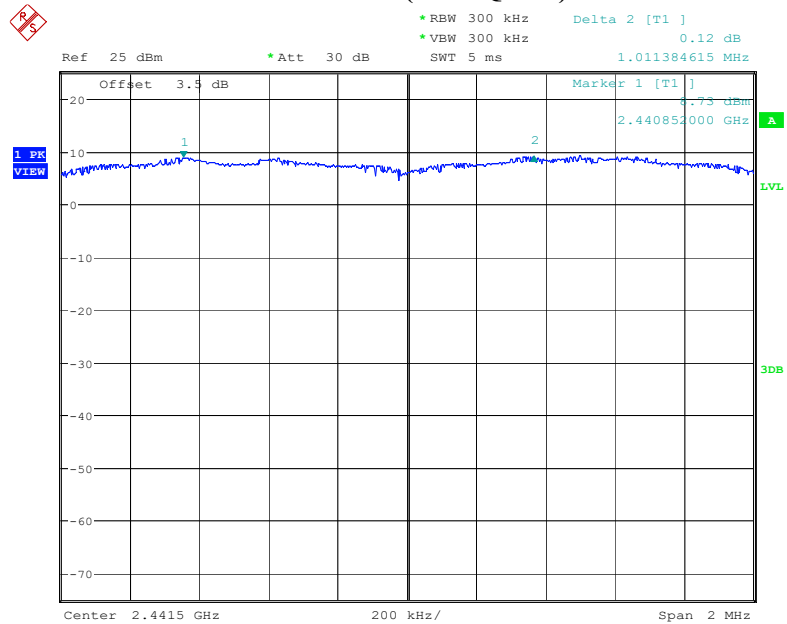
Please refer to following table and plots.

Test Mode	Channel Separation (MHz)	20 dBc BW (MHz)	Two-thirds of the 20 dB bandwidth (MHz)	Channel Separation Limit	Result
BDR(GFSK)					
Hopping	1.002	0.951	0.634	> two-thirds of the 20 dB bandwidth	Compliance
EDR($\pi/4$-DQPSK)					
Hopping	1.011	1.299	0.866	> two-thirds of the 20 dB bandwidth	Compliance
EDR(8DPSK)					
Hopping	0.948	1.305	0.870	> two-thirds of the 20 dB bandwidth	Compliance

BDR (GFSK)

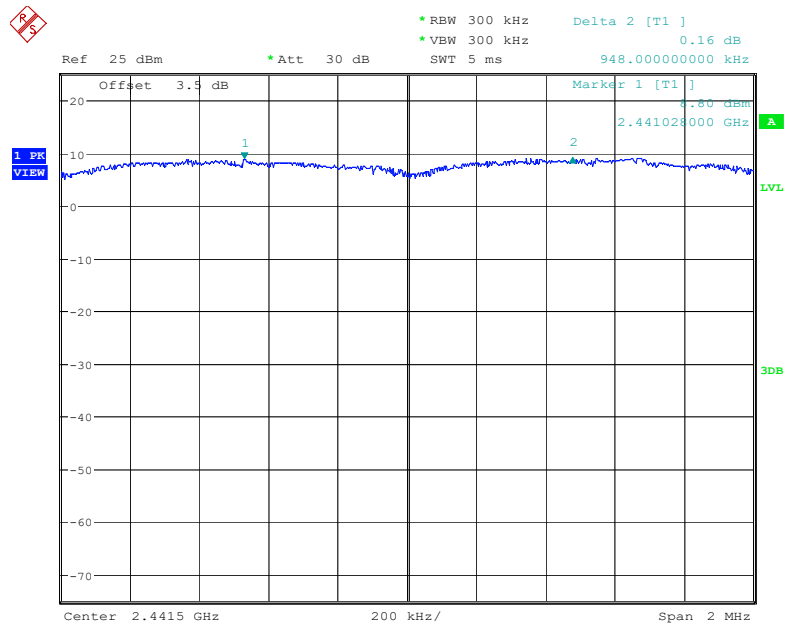


Date: 29.JUL.2022 21:03:45

EDR ($\pi/4$ -DQPSK)

Date: 29.JUL.2022 21:55:34

EDR (8DPSK)



Date: 29.JUL.2022 21:58:06

FCC §15.247(a) (1) & RSS-247 § 5.1 (a), RSS-GEN § 6.7 – 20 dB EMISSION BANDWIDTH & 99% OCCUPIED BANDWIDTH

Applicable Standard

According to FCC §15.247(a) (1):

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.

According to RSS-247 § 5.1 (a), RSS-GEN § 6.7:

The occupied bandwidth or the “99% emission bandwidth” is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

In some cases, the “20 dB bandwidth” is required, which is defined as the frequency range between two points, one at the lowest frequency below and one at the highest frequency above the carrier frequency, at which the maximum power level of the transmitted emission is attenuated 20 dB below the maximum in-band power level of the modulated signal, where the two points are on the outskirts of the in-band emission.

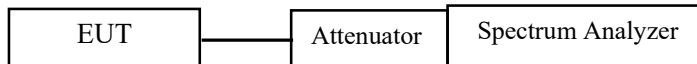
Test Procedure

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:	27.1 °C
Relative Humidity:	58 %
ATM Pressure:	101.0 kPa

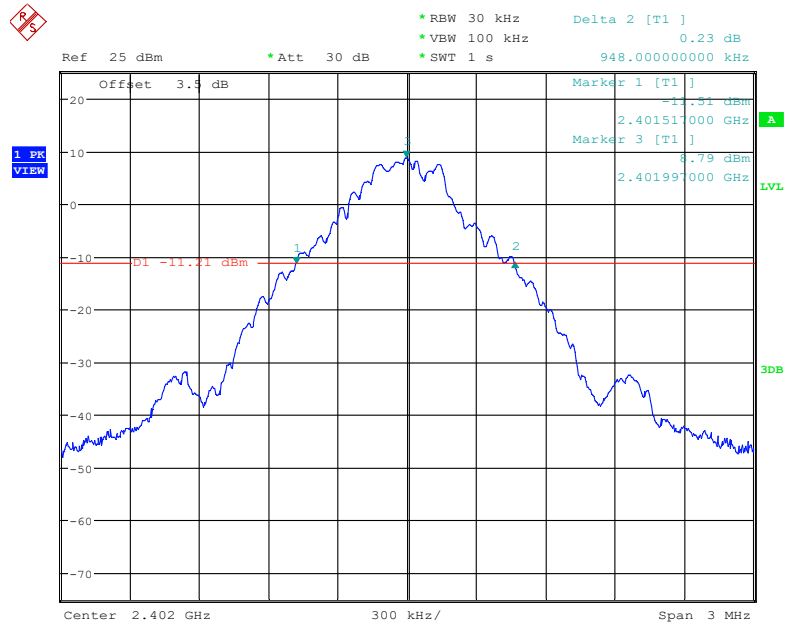
The testing was performed by Roger Ling on 2022-08-29.

EUT operation mode: Transmitting

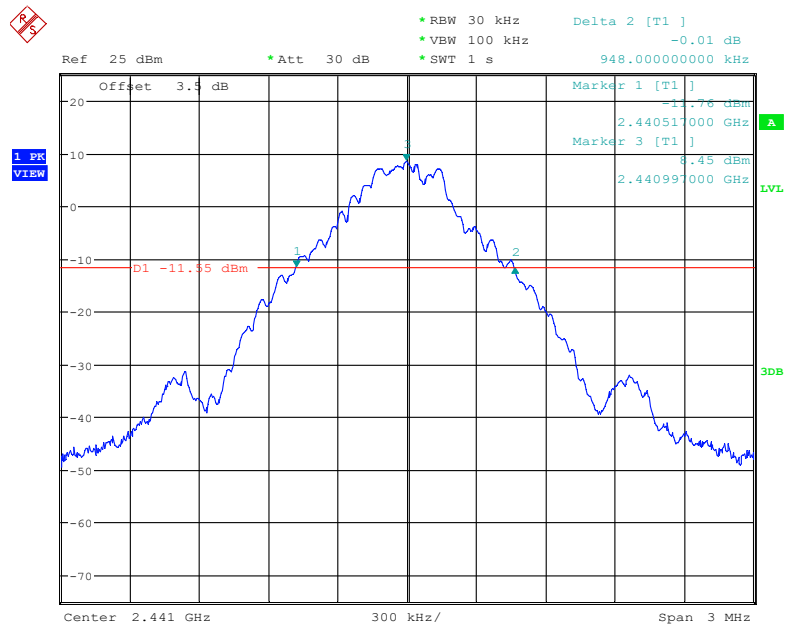
Test Result: Pass

Please refer to following table and plots.

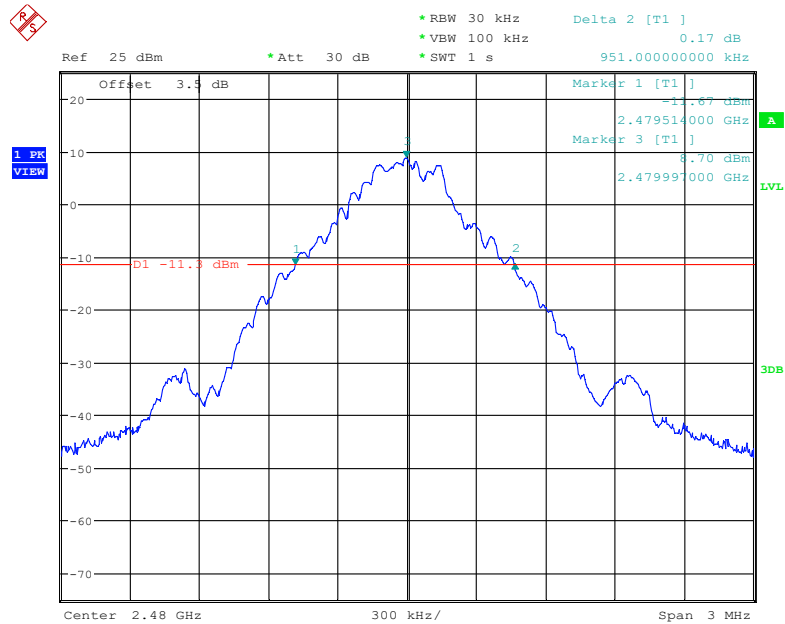
Mode	Channel	Frequency (MHz)	99% Emission Bandwidth (MHz)	20 dB Emission Bandwidth (MHz)
BDR (GFSK)	Low	2402	0.852	0.948
	Middle	2441	0.852	0.948
	High	2480	0.852	0.951
EDR ($\pi/4$-DQPSK)	Low	2402	1.182	1.299
	Middle	2441	1.176	1.293
	High	2480	1.182	1.299
EDR (8DPSK)	Low	2402	1.185	1.305
	Middle	2441	1.179	1.302
	High	2480	1.188	1.305

*20 dB Emission Bandwidth***BDR (GFSK): Low Channel**

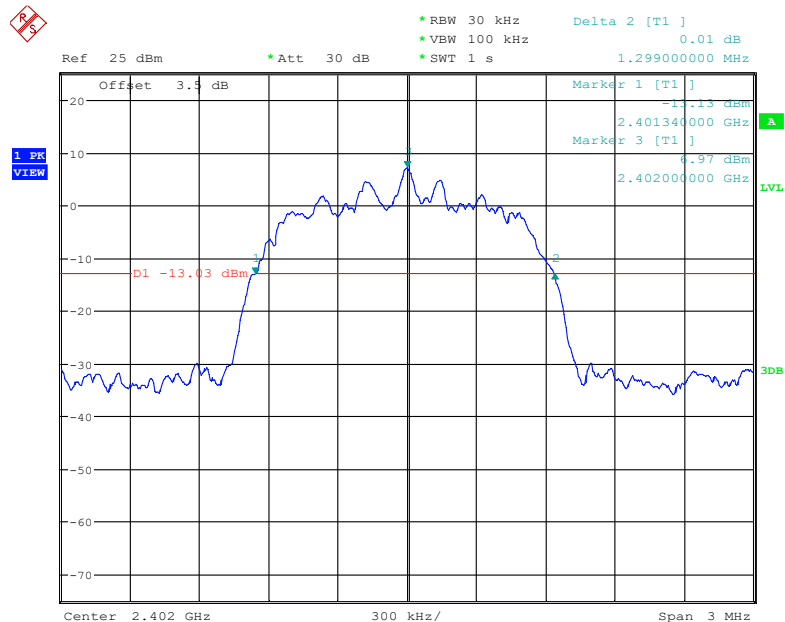
Date: 29.AUG.2022 19:24:59

BDR (GFSK): Middle Channel

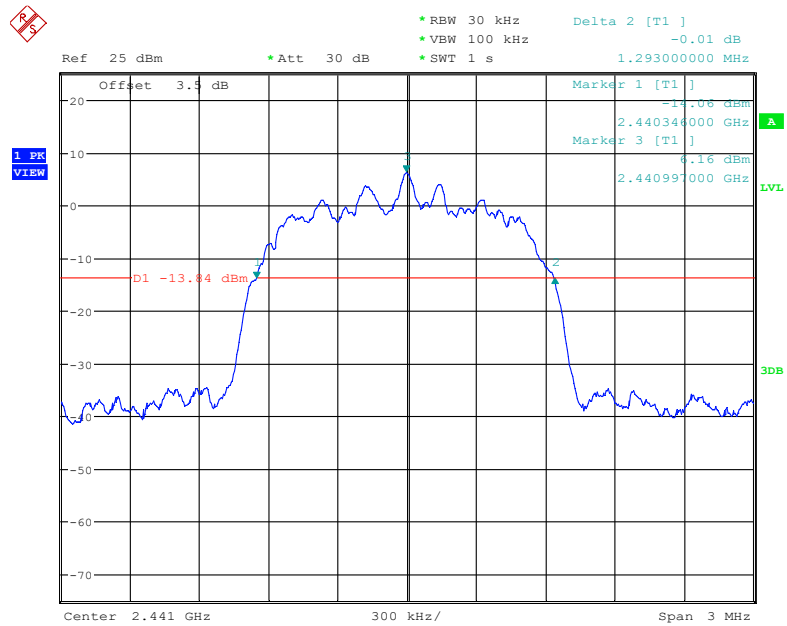
Date: 29.AUG.2022 19:31:35

BDR (GFSK): High Channel

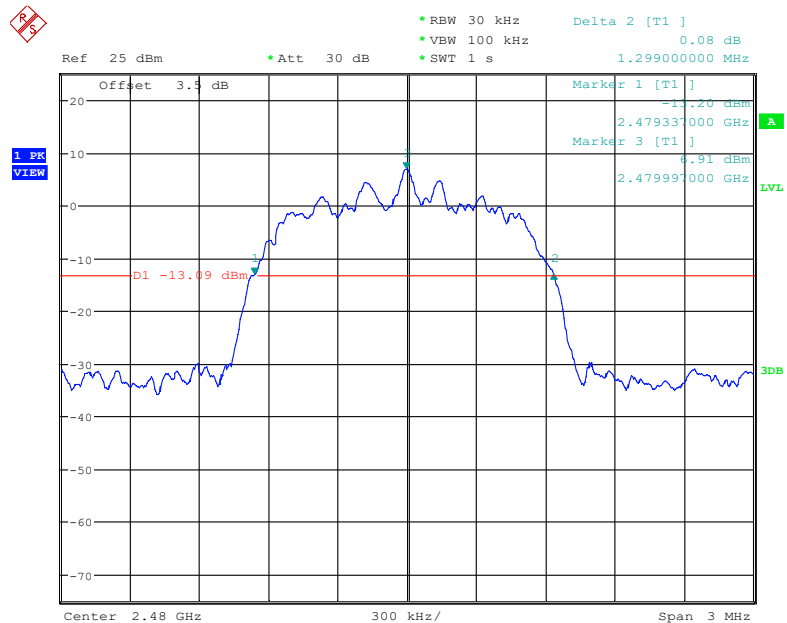
Date: 29.AUG.2022 19:36:17

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

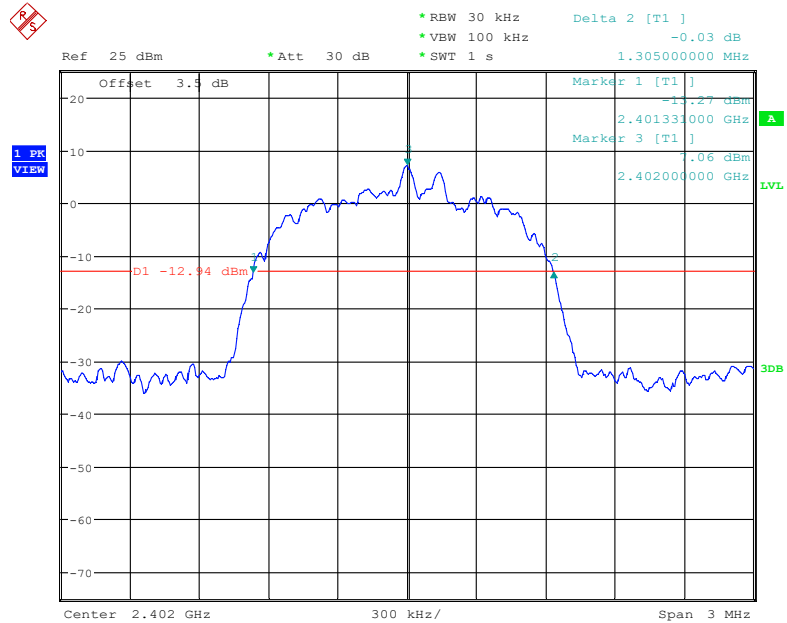
Date: 29.AUG.2022 19:26:39

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

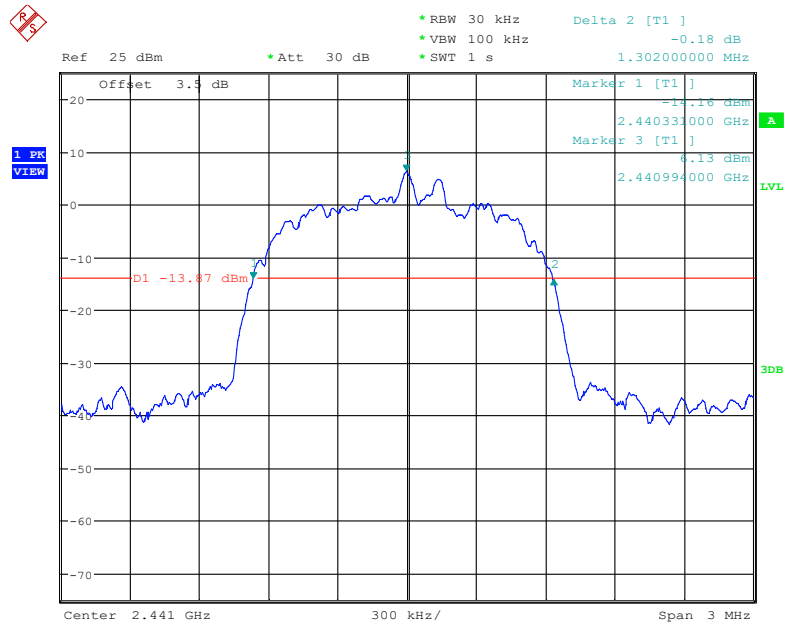
Date: 29.AUG.2022 19:33:03

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

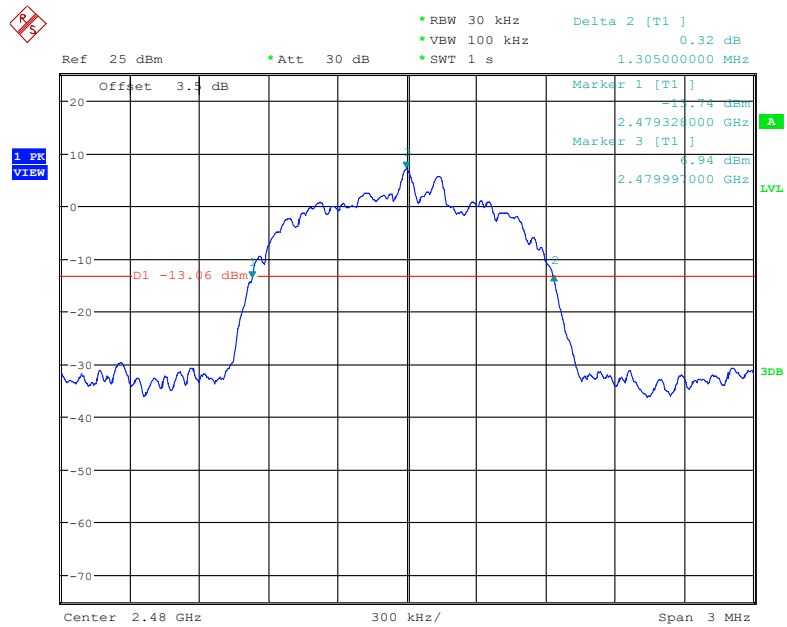
Date: 29.AUG.2022 19:37:46

EDR (8DPSK): Low Channel

Date: 29.AUG.2022 19:28:20

EDR (8DPSK): Middle Channel

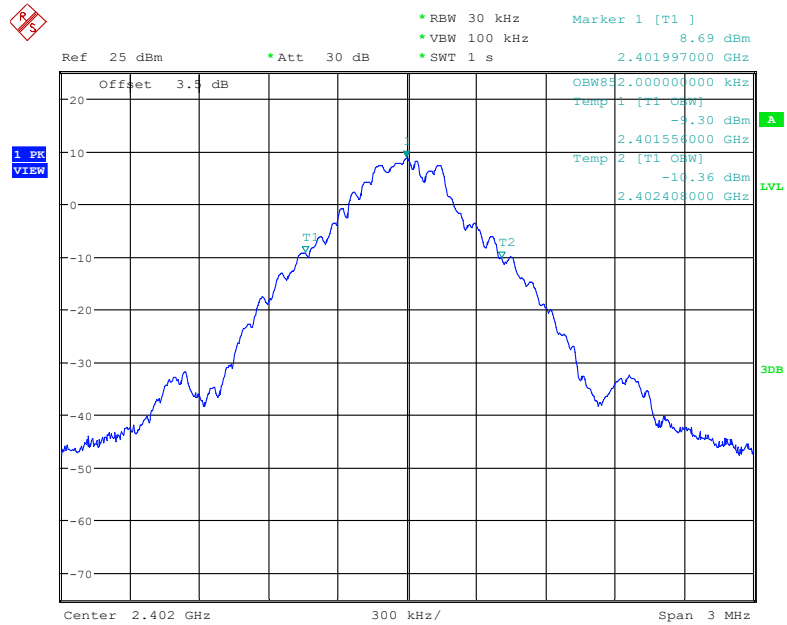
Date: 29.AUG.2022 19:34:32

EDR (8DPSK): High Channel

Date: 29.AUG.2022 19:39:16

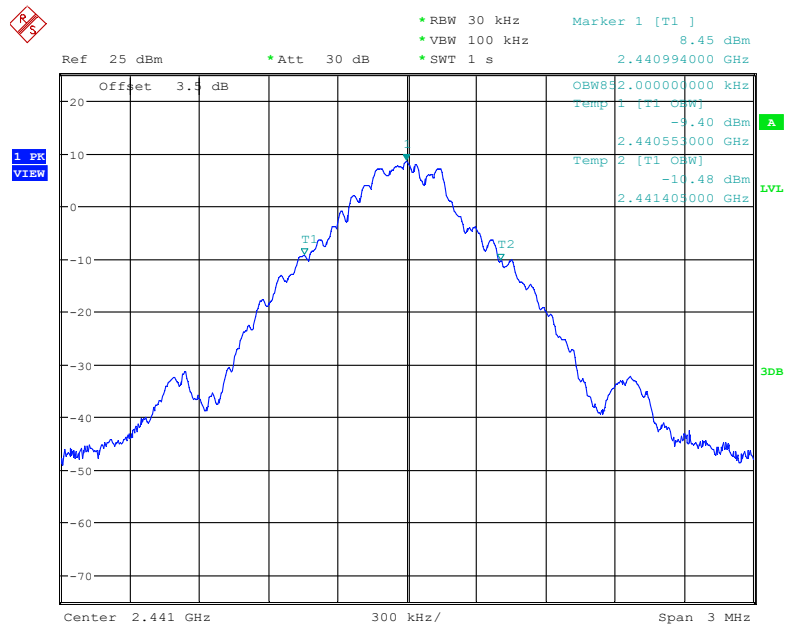
99% Emission Bandwidth

BDR (GFSK): Low Channel

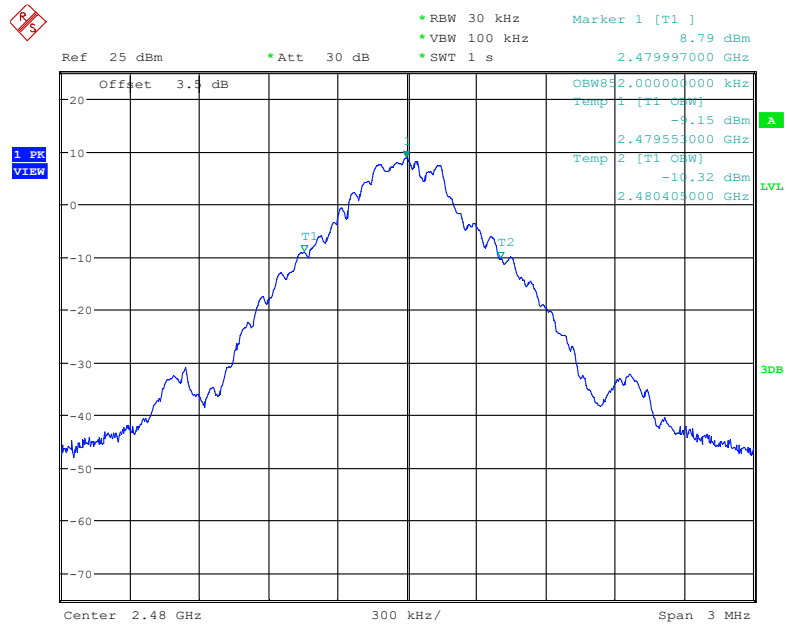


Date: 29.AUG.2022 19:24:21

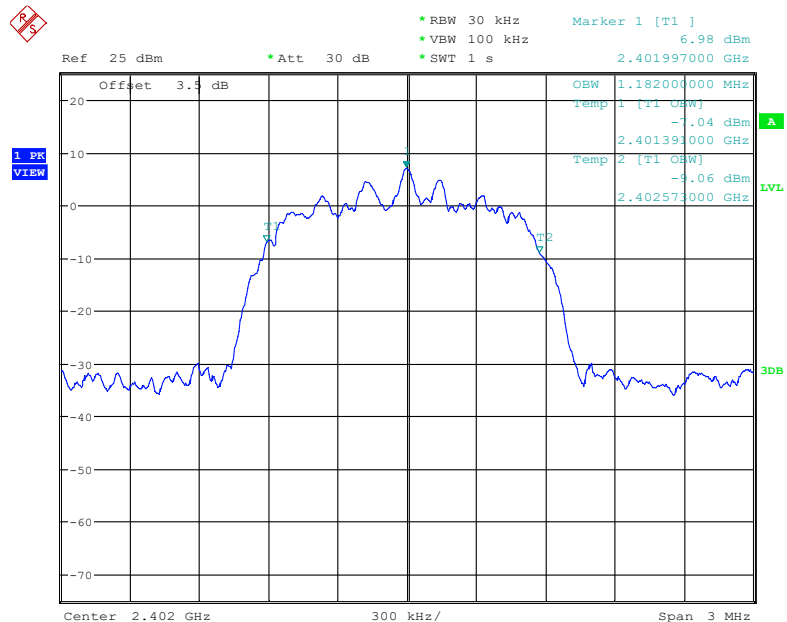
BDR (GFSK): Middle Channel



Date: 29.AUG.2022 19:30:57

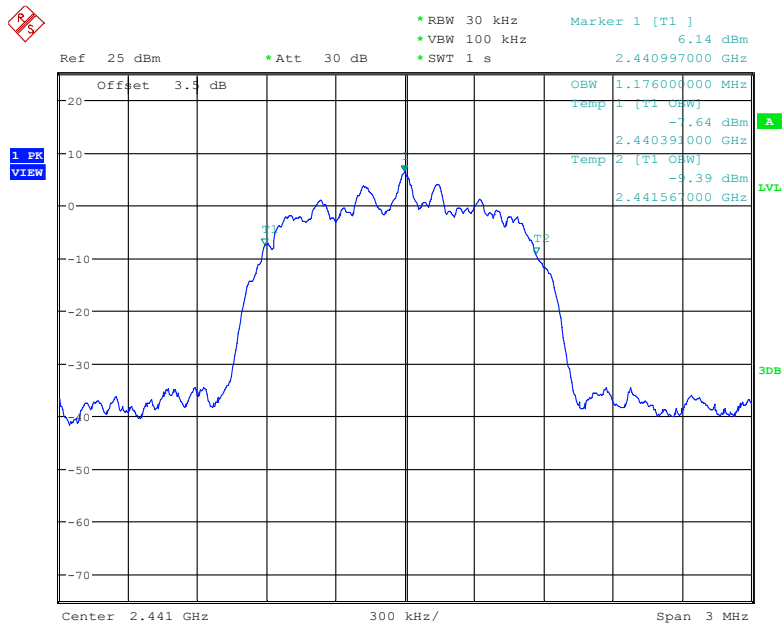
BDR (GFSK): High Channel

Date: 29.AUG.2022 19:35:39

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

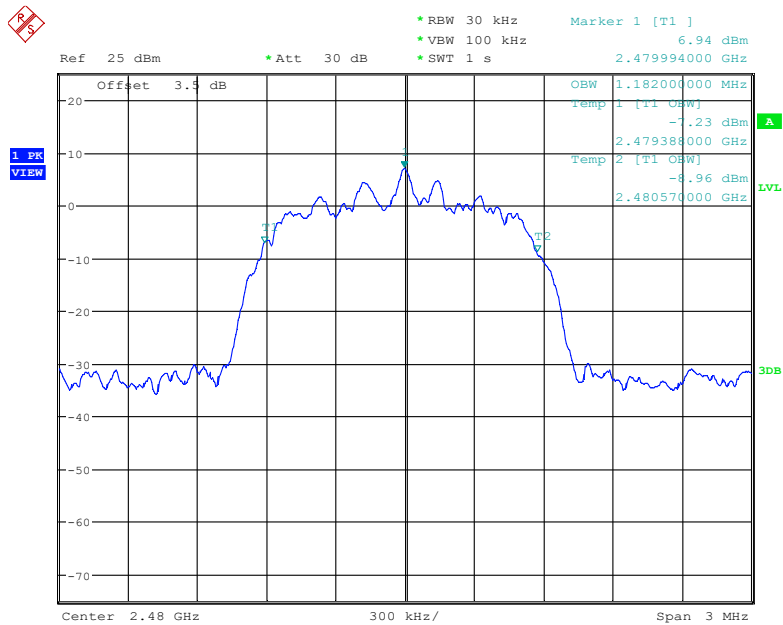
Date: 29.AUG.2022 19:26:01

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

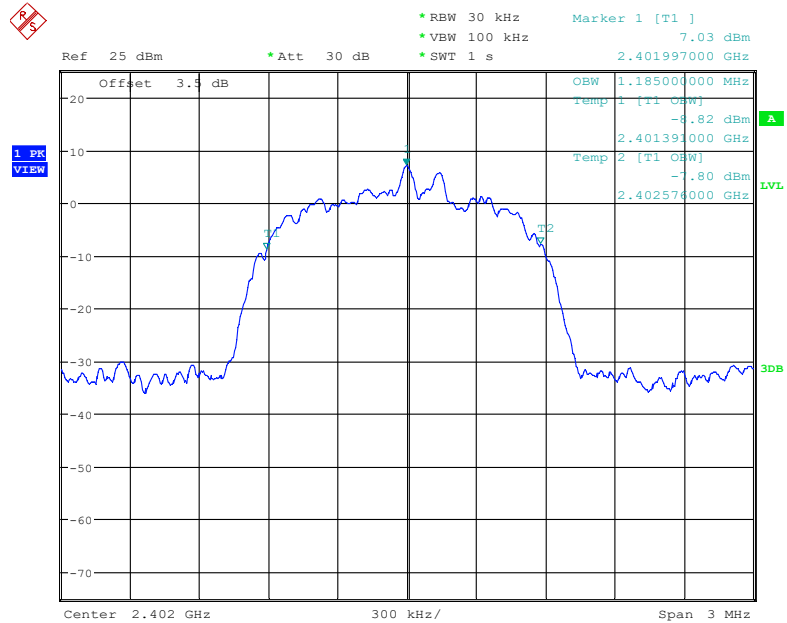


Date: 29.AUG.2022 19:32:25

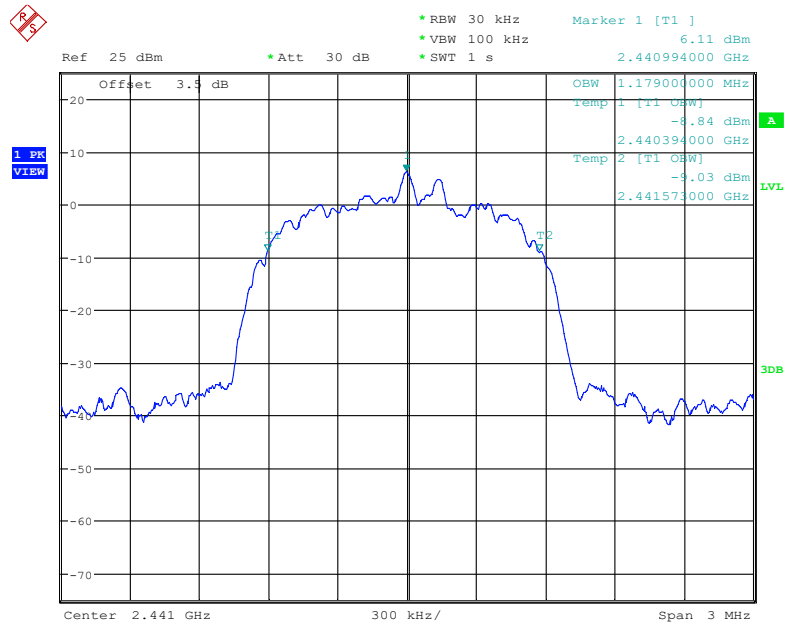
EDR ($\pi/4$ -DQPSK): High Channel



Date: 29.AUG.2022 19:37:08

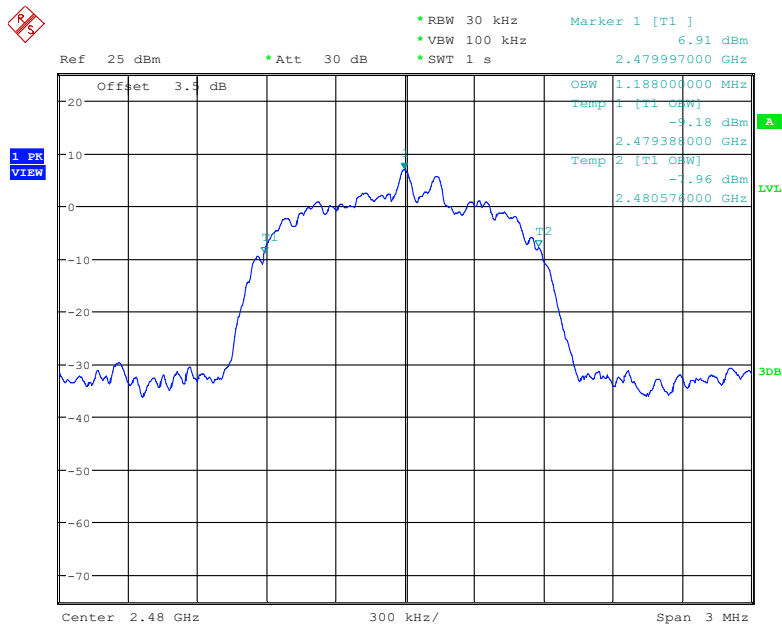
EDR (8DPSK): Low Channel

Date: 29.AUG.2022 19:27:42

EDR (8DPSK): Middle Channel

Date: 29.AUG.2022 19:33:54

EDR (8DPSK): High Channel



Date: 29.AUG.2022 19:38:38

FCC §15.247(a) (1) (iii) & RSS-247 § 5.1 (d) - QUANTITY OF HOPPING CHANNEL TEST

Applicable Standard

According to FCC §15.247(a) (1) (iii):

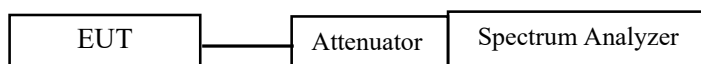
Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress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

According to RSS-247 § 5.1 (d):

Frequency hopping systems (FHSS) operating in the band 2400-2483.5 MHz shall use at least 15 hopping 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. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

Test Procedure

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:	27.1 °C
Relative Humidity:	58 %
ATM Pressure:	101.0 kPa

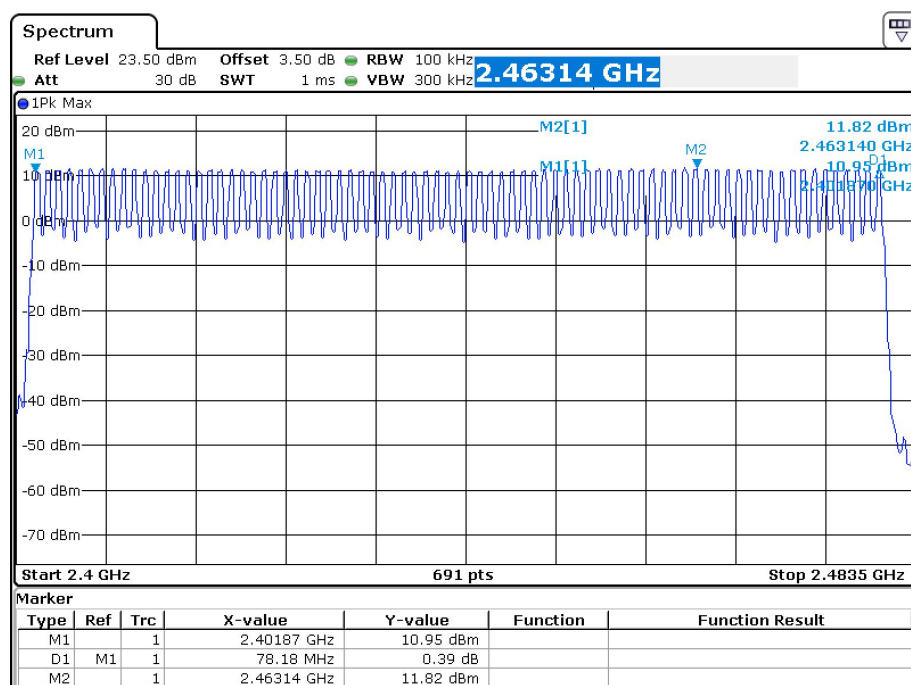
The testing was performed by Roger Ling on 2022-09-11.

EUT operation mode: Transmitting

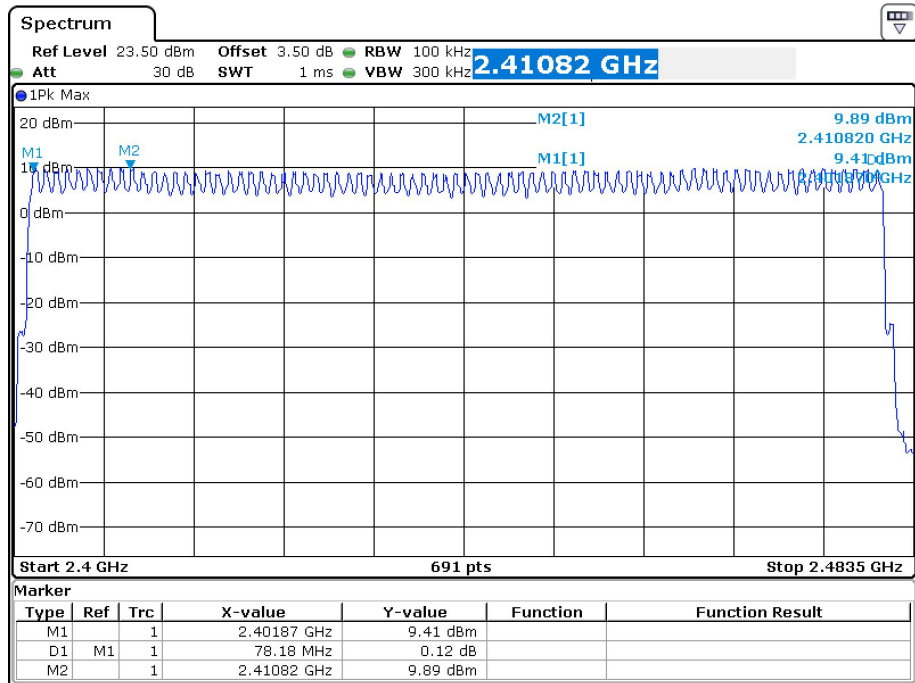
Test Result: Pass

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

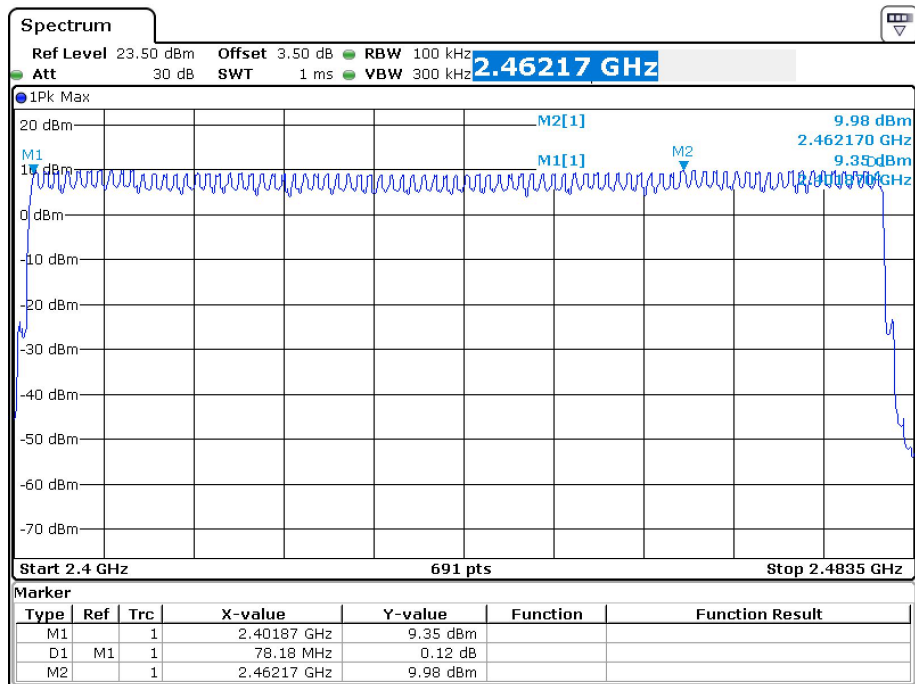
BDR (GFSK): Number of Hopping Channels

Date: 11.SEP.2022 11:53:52

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

Date: 11.SEP.2022 11:52:30

EDR (8DPSK): Number of Hopping Channels



Date: 11.SEP.2022 11:49:54

FCC §15.247(a) (1) (iii) & RSS-247 § 5.1 (d) - TIME OF OCCUPANCY (DWELL TIME)

Applicable Standard

According to FCC §15.247(a) (1) (iii):

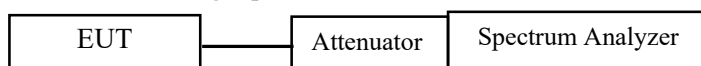
Frequency hopping systems in the 2400-2483.5 MHz shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions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

According to RSS-247 § 5.1 (d):

Frequency hopping systems (FHSs) operating in the band 2400-2483.5 MHz shall use at least 15 hopping 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. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

Test Procedure

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



Test Data

Environmental Conditions

Temperature:	27.1 °C
Relative Humidity:	58 %
ATM Pressure:	101.0 kPa

The testing was performed by Roger Ling on 2022-07-29~2022-08-01.

EUT operation mode: Transmitting

Test Result: Pass

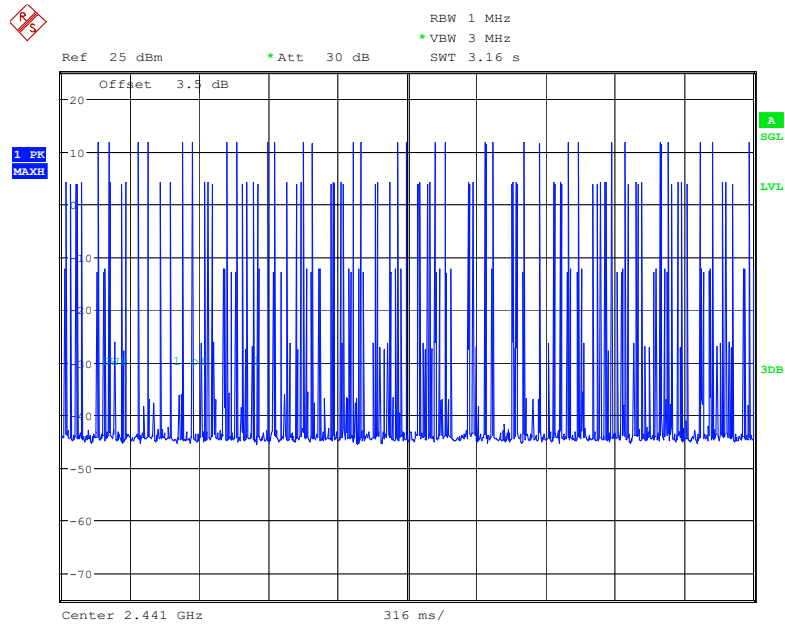
Please refer to following table and plots

Test Mode	Channel	Pulse Time [ms]	Total Hops [Num]	Result[s]	Limit[s]	Verdict
DH1	Hop	0.383	310	0.119	≤ 0.4	PASS
DH3	Hop	1.638	190	0.311	≤ 0.4	PASS
DH5	Hop	2.905	130	0.378	≤ 0.4	PASS
2DH1	Hop	0.389	320	0.124	≤ 0.4	PASS
2DH3	Hop	1.644	180	0.296	≤ 0.4	PASS
2DH5	Hop	2.890	110	0.318	≤ 0.4	PASS
3DH1	Hop	0.388	310	0.120	≤ 0.4	PASS
3DH3	Hop	1.641	150	0.246	≤ 0.4	PASS
3DH5	Hop	2.905	90	0.261	≤ 0.4	PASS

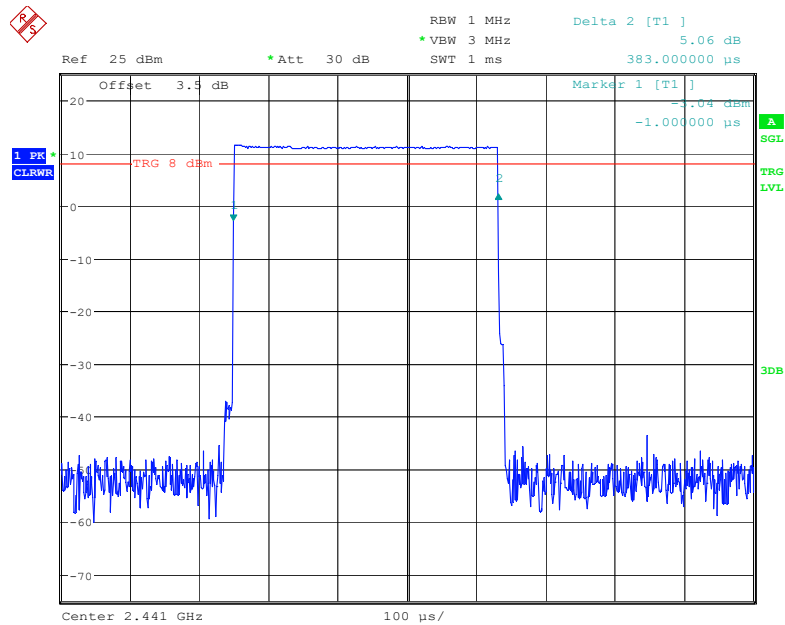
Note 1: A period time= $0.4 \times 79 = 31.6$ (S), Result= Pulse Time *Total hops

Note 2: Total hops=Hopping Number in $3.16s \times 10$

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

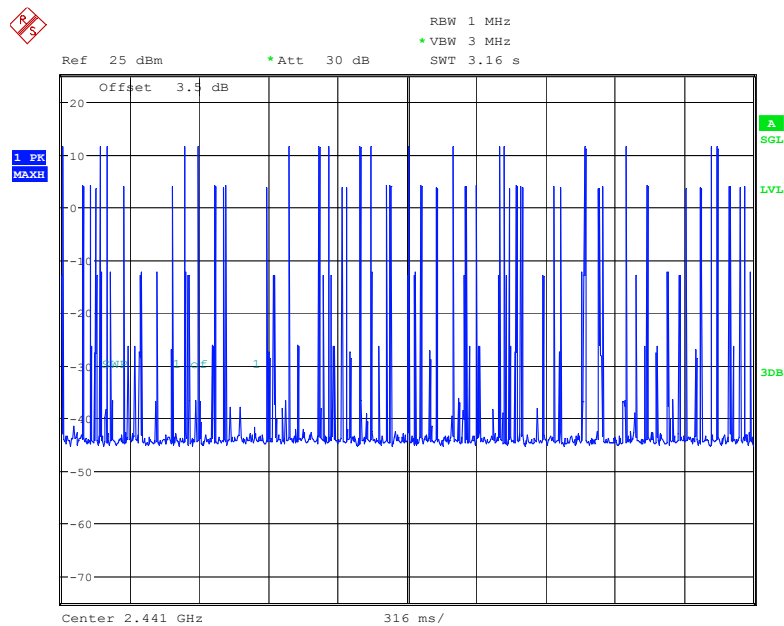
**BDR (GFSK):
DH1**

Date: 29.JUL.2022 20:59:03

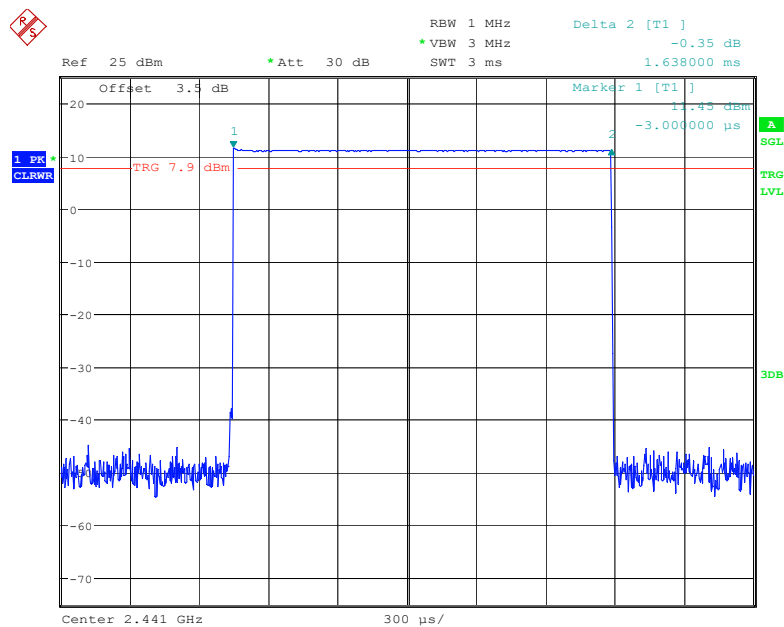


Date: 29.JUL.2022 20:59:18

DH3

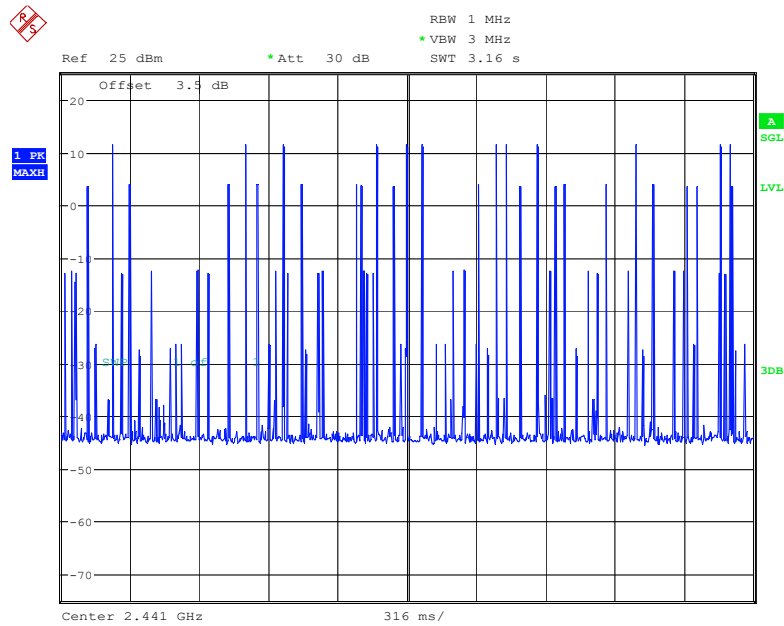


Date: 29.JUL.2022 21:00:43

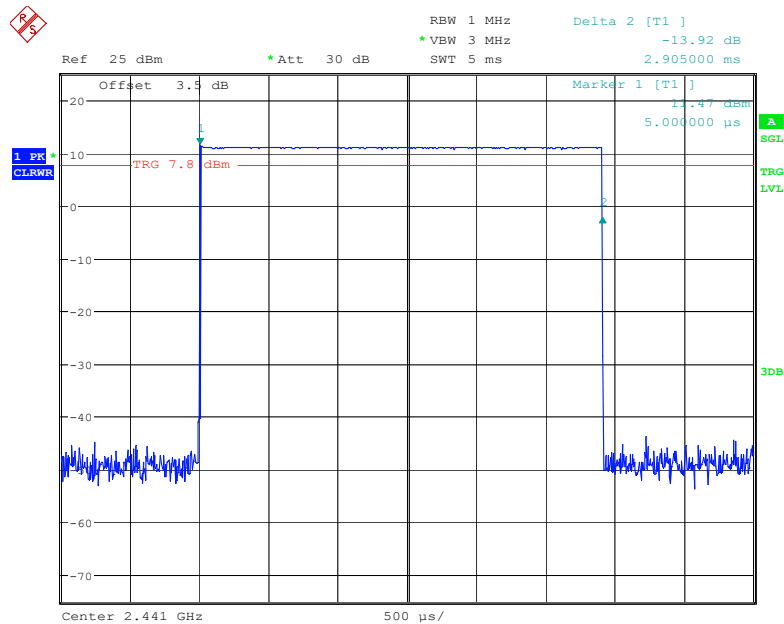


Date: 29.JUL.2022 21:00:57

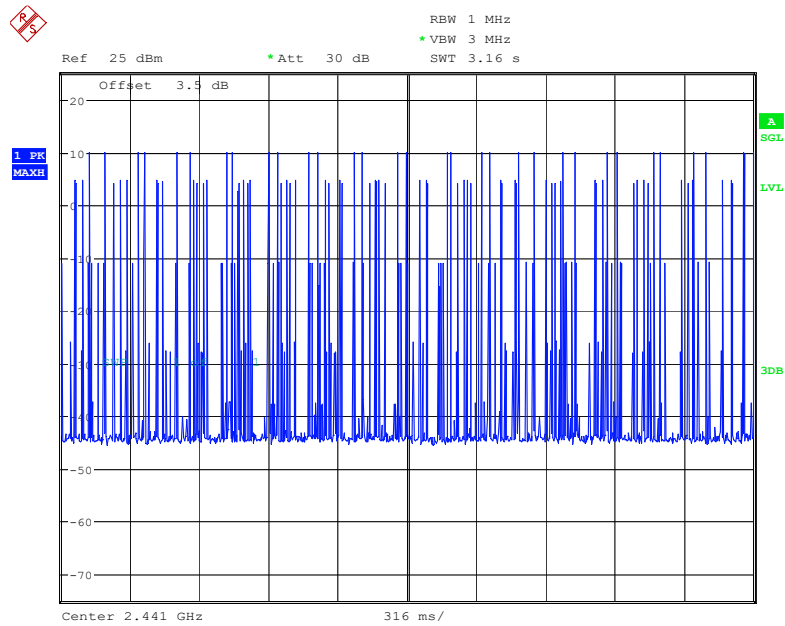
DH5



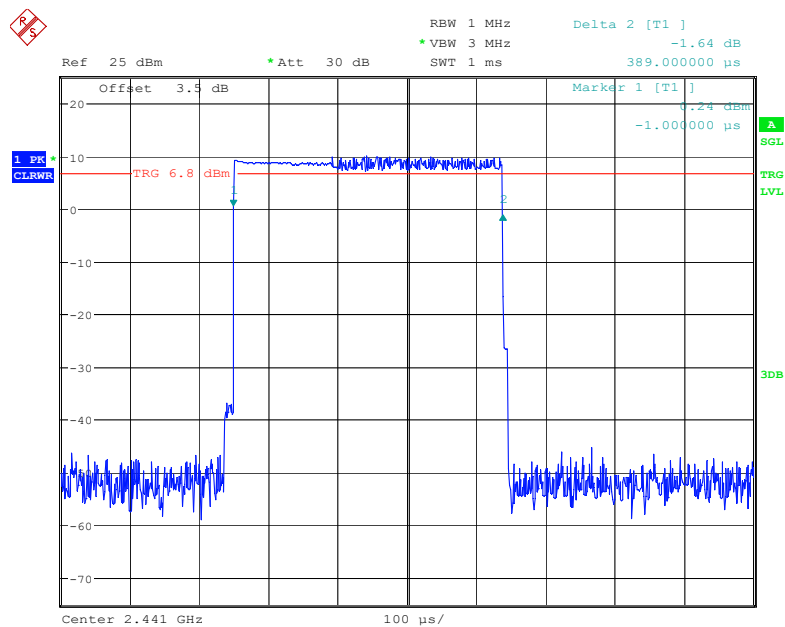
Date: 29.JUL.2022 21:03:58



Date: 29.JUL.2022 21:04:14

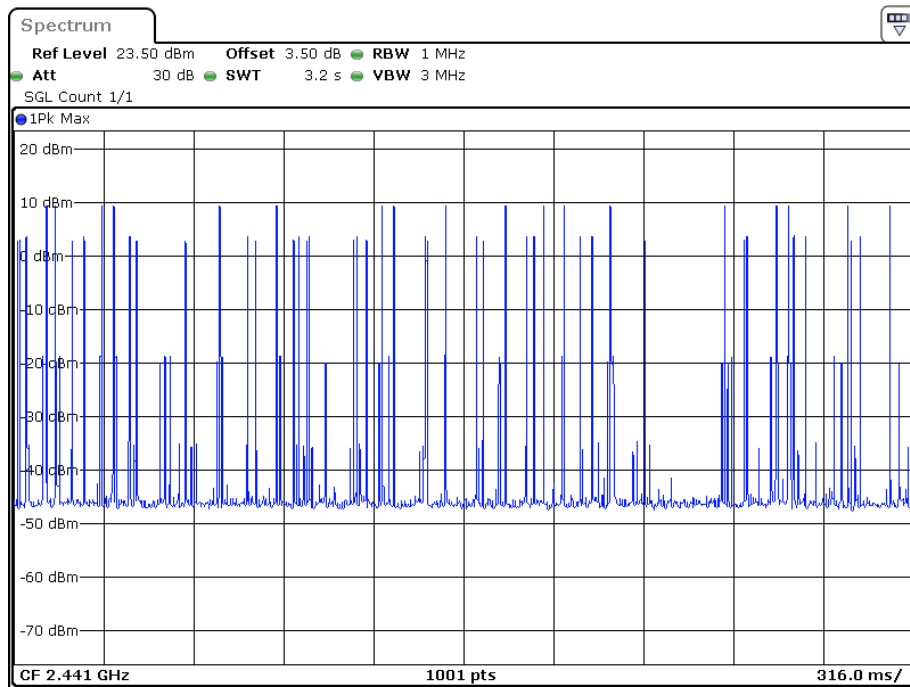
**EDR($\pi/4$ -DQPSK):
2DH1**

Date: 29.JUL.2022 21:31:35

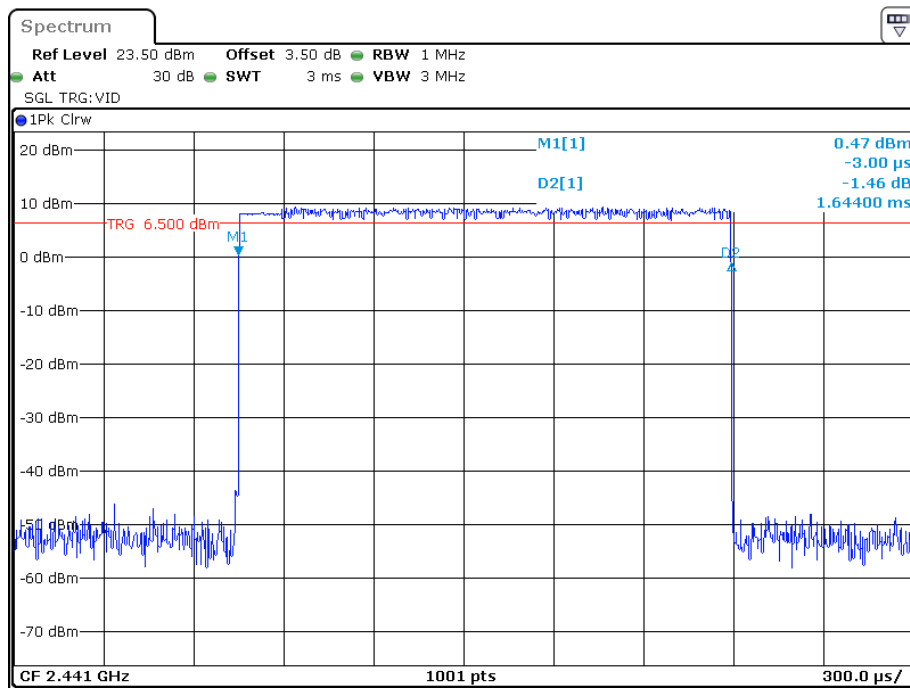


Date: 29.JUL.2022 21:31:50

2DH3

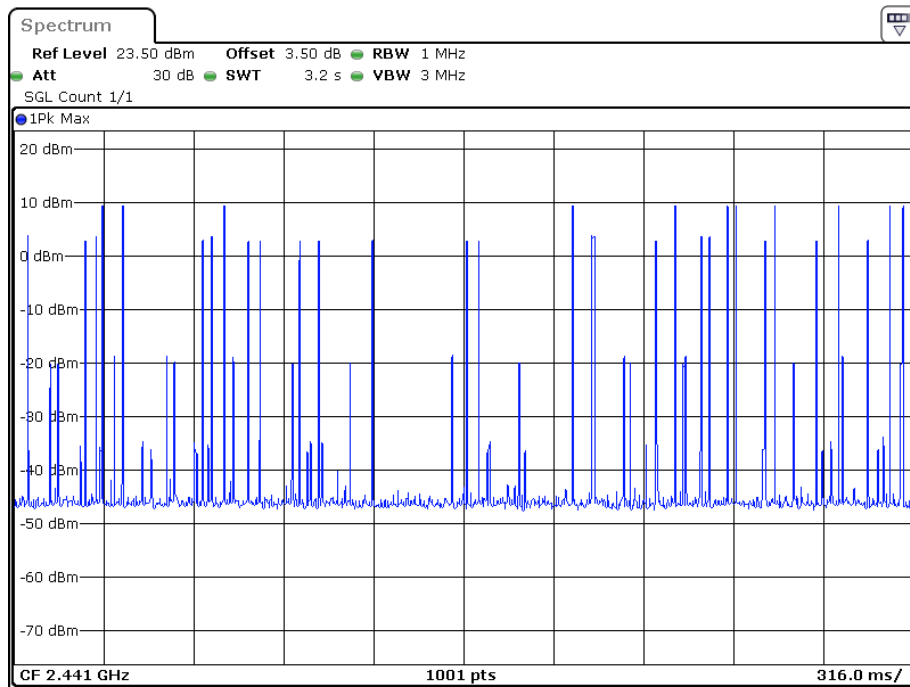


Date: 1.AUG.2022 14:53:38

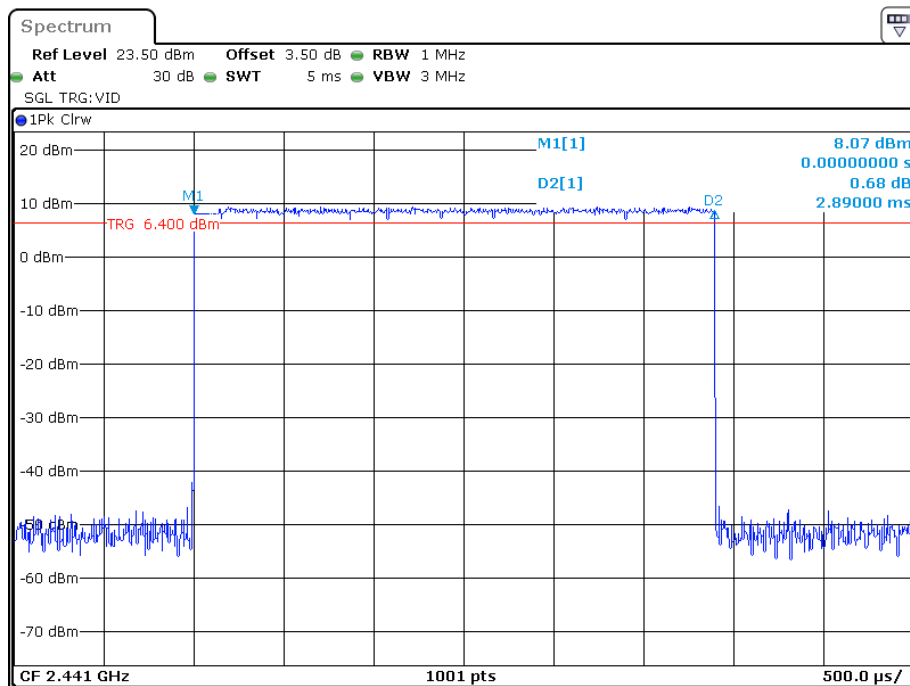


Date: 1.AUG.2022 14:53:55

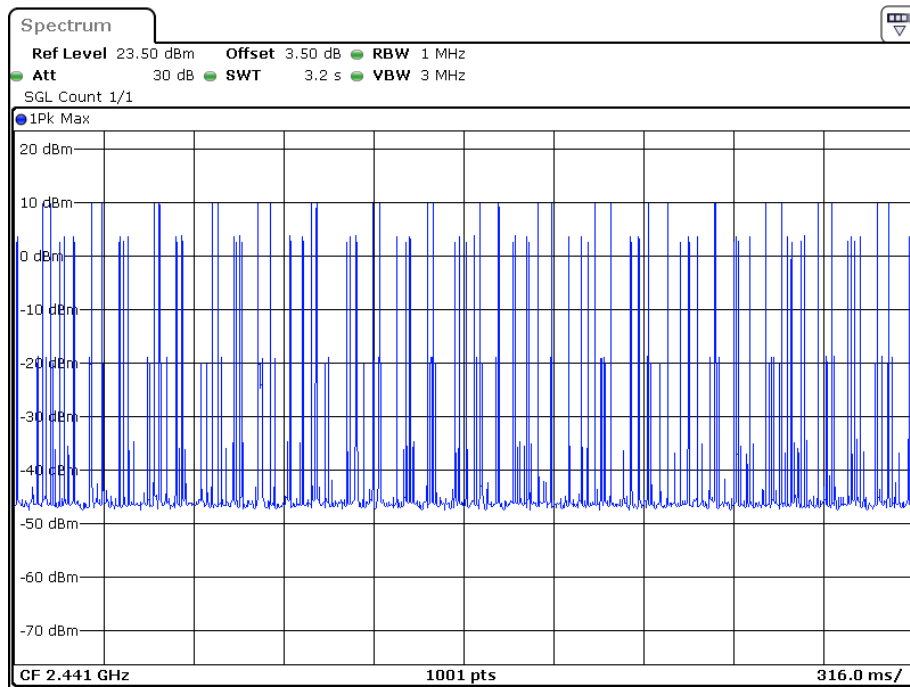
2DH5



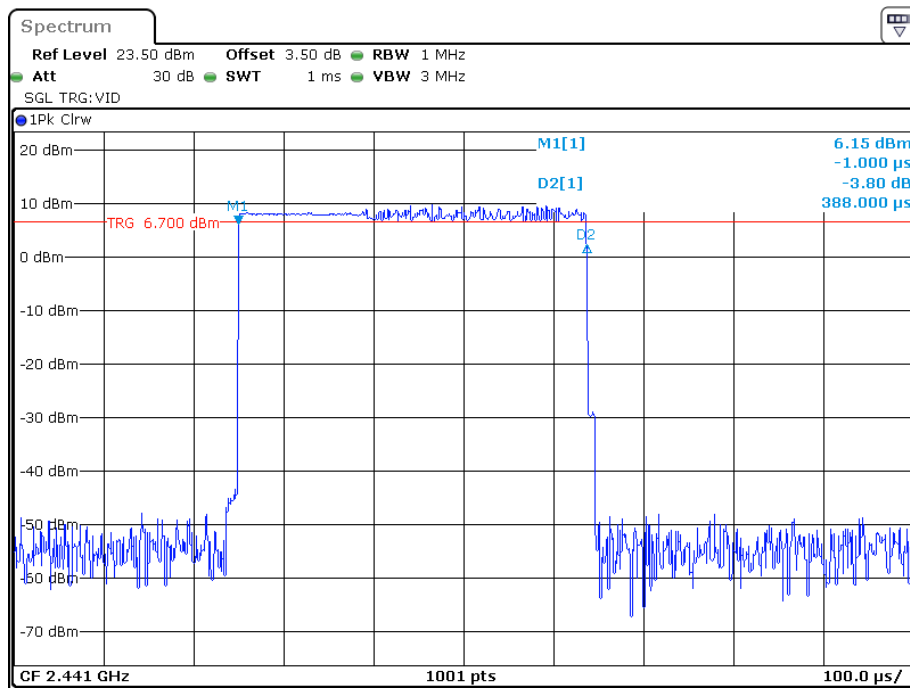
Date: 1.AUG.2022 15:03:46



Date: 1.AUG.2022 15:04:03

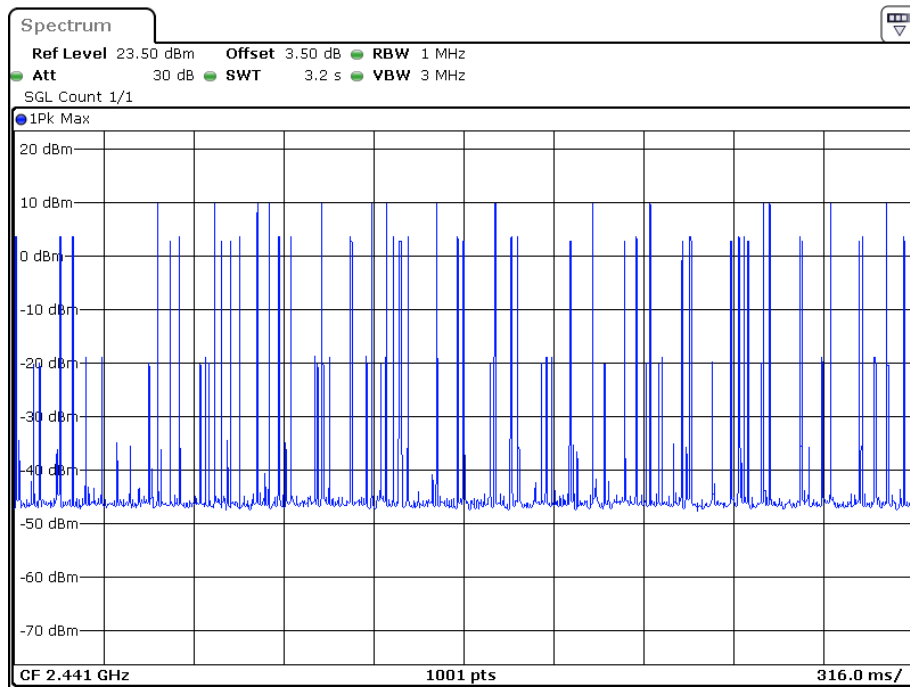
**EDR (8DPSK):
3DH1**

Date: 1.AUG.2022 14:54:41

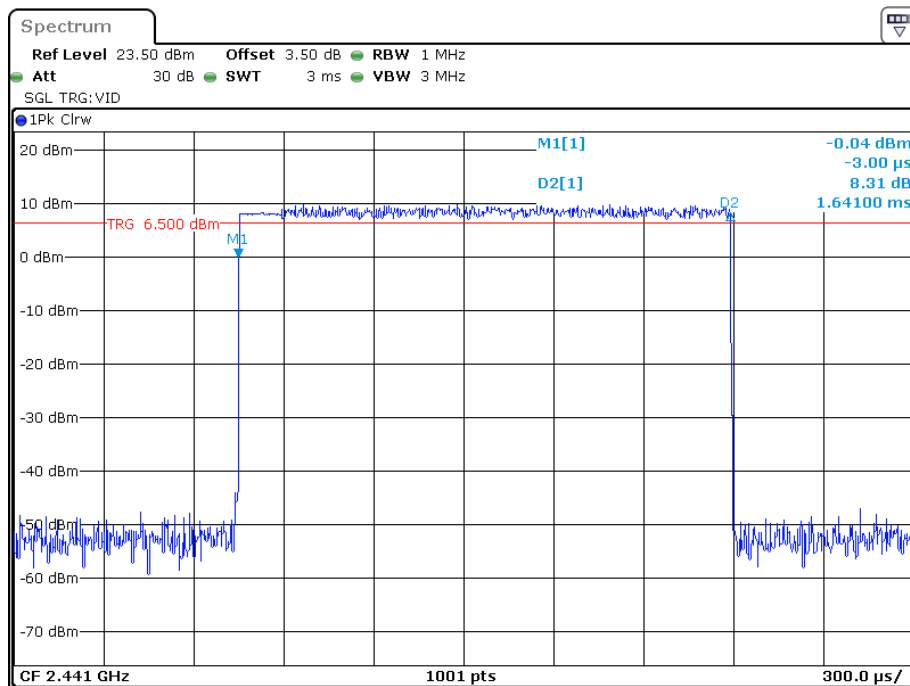


Date: 1.AUG.2022 14:54:58

3DH3

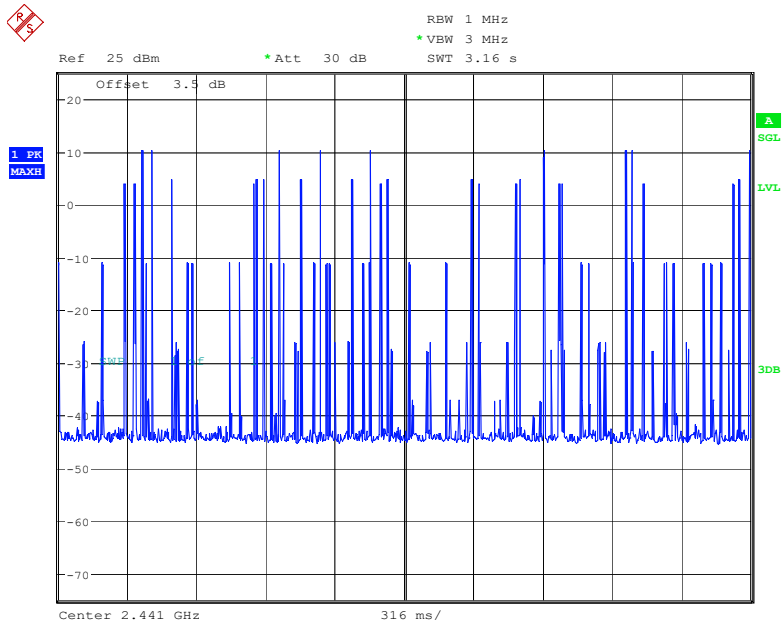


Date: 1.AUG.2022 14:55:46

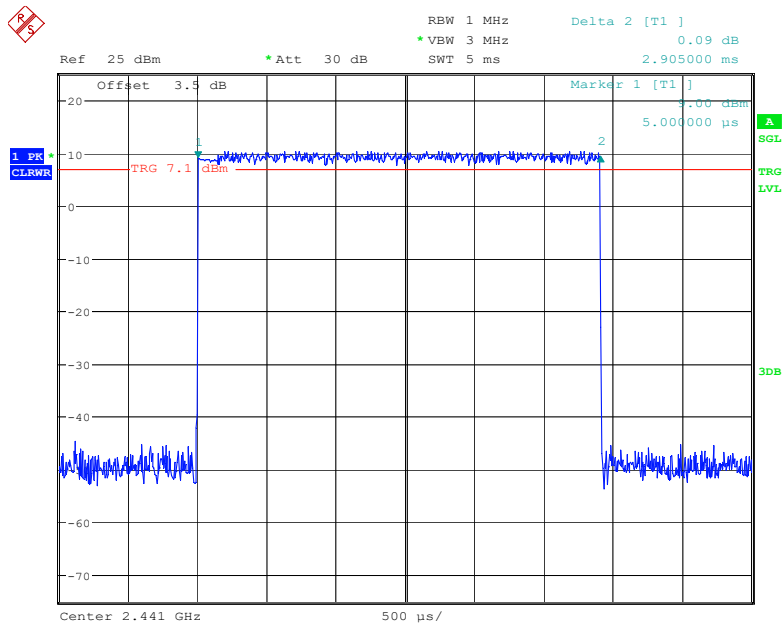


Date: 1.AUG.2022 14:56:03

3DH5



Date: 29.JUL.2022 21:44:44



Date: 29.JUL.2022 21:45:00

FCC §15.247(b) (1) & RSS-247§ 5.1(b) &§ 5.4(b) - PEAK OUTPUT POWER MEASUREMENT

Applicable Standard

According to FCC §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.

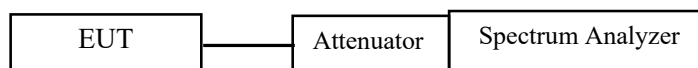
According to RSS-247§ 5.1(b) &§ 5.4(b):

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

Frequency hopping systems (FHSs) 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, FHSs operating in the band 2400-2483.5 MHz 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 that the systems operate with an output power no greater than 0.125 W.

Test Procedure

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:	27.1 °C
Relative Humidity:	58 %
ATM Pressure:	101.0 kPa

The testing was performed by Roger Ling on 2022-09-11.

EUT operation mode: Transmitting

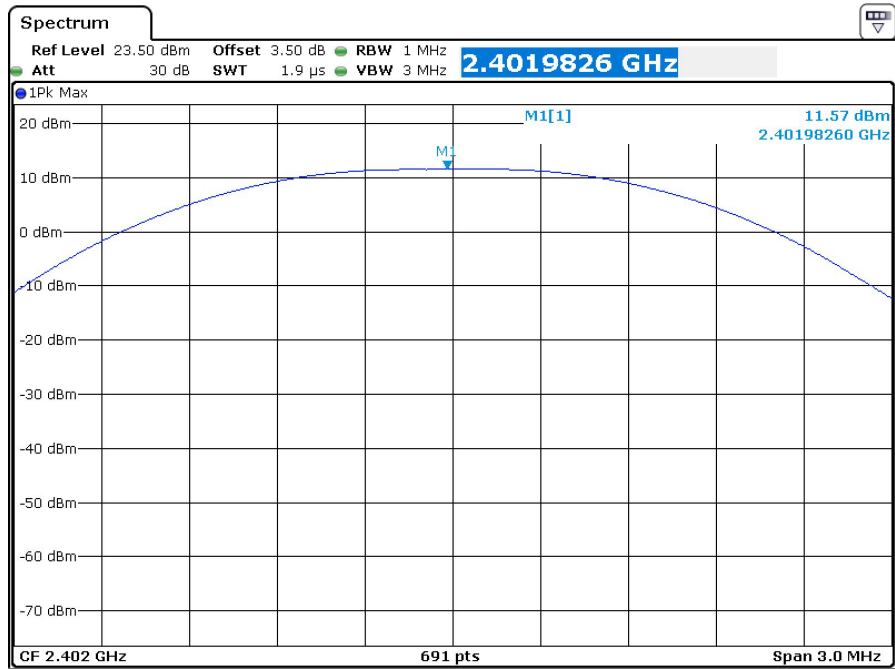
Test Result: Pass

Please refer to following table and plots.

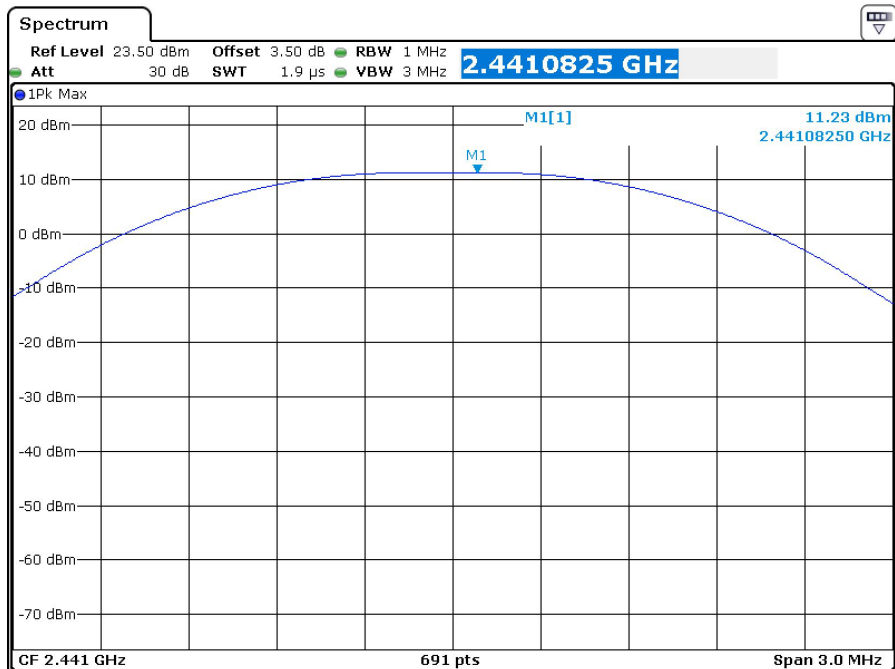
Mode	Channel	Frequency (MHz)	Peak Output Power	Limit (dBm)
			(dBm)	
BDR (GFSK)	Low	2402	11.57	21
	Middle	2441	11.23	21
	Max	2463	11.98	21
	High	2480	11.48	21
EDR ($\pi/4$-DQPSK)	Low	2402	11.06	21
	Max	2411	11.38	21
	Middle	2441	10.43	21
	High	2480	10.99	21
EDR (8DPSK)	Low	2402	11.17	21
	Middle	2441	10.65	21
	Max	2462	11.59	21
	High	2480	11.09	21

Note 1: The data above was tested in conducted mode.

Note 2: The maximum EIRP is 11.98 dBm+1.5dBi= 13.48dBm<36dBm, so it can meet the EIRP limit of ISCEDC.

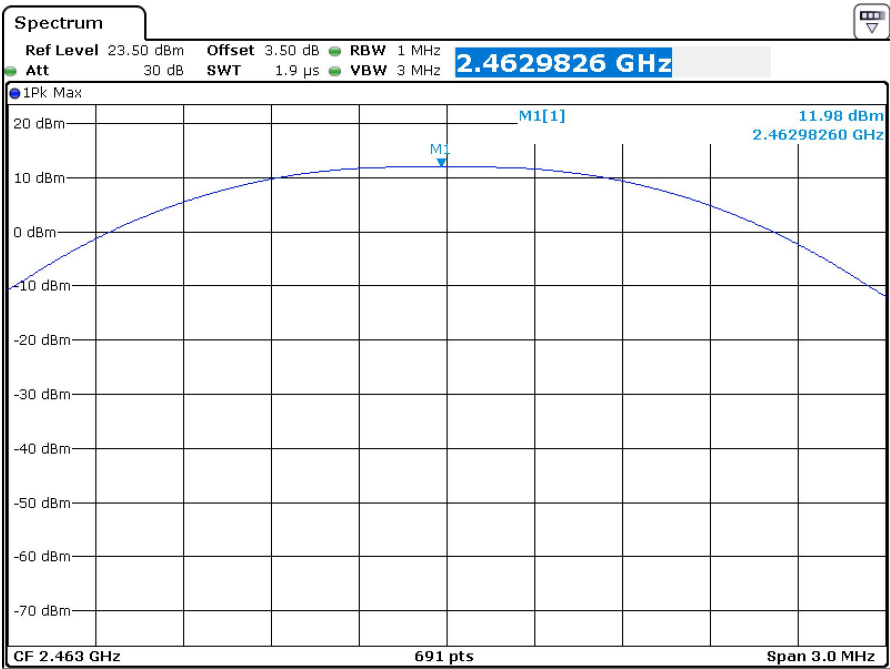
BDR (GFSK):**Low Channel**

Date: 11.SEP.2022 11:58:36

Middle Channel

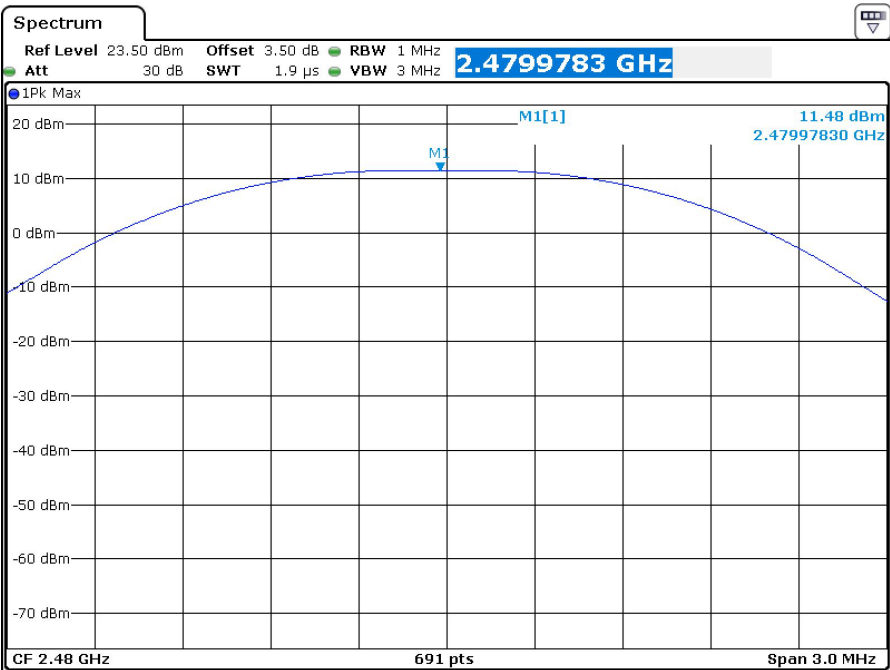
Date: 11.SEP.2022 11:59:02

2463MHz



Date: 11.SEP.2022 11:57:58

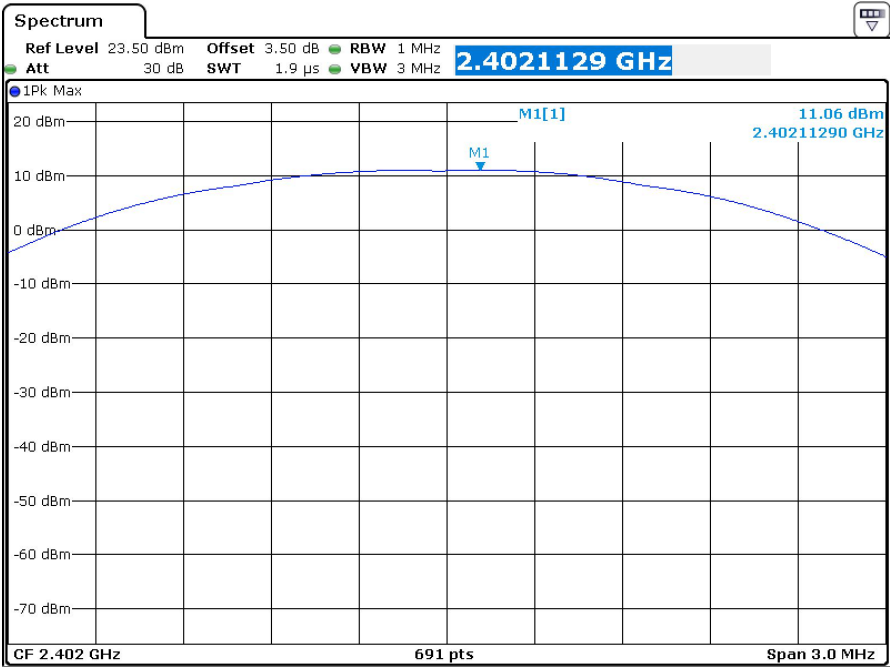
High Channel



Date: 11.SEP.2022 11:59:30

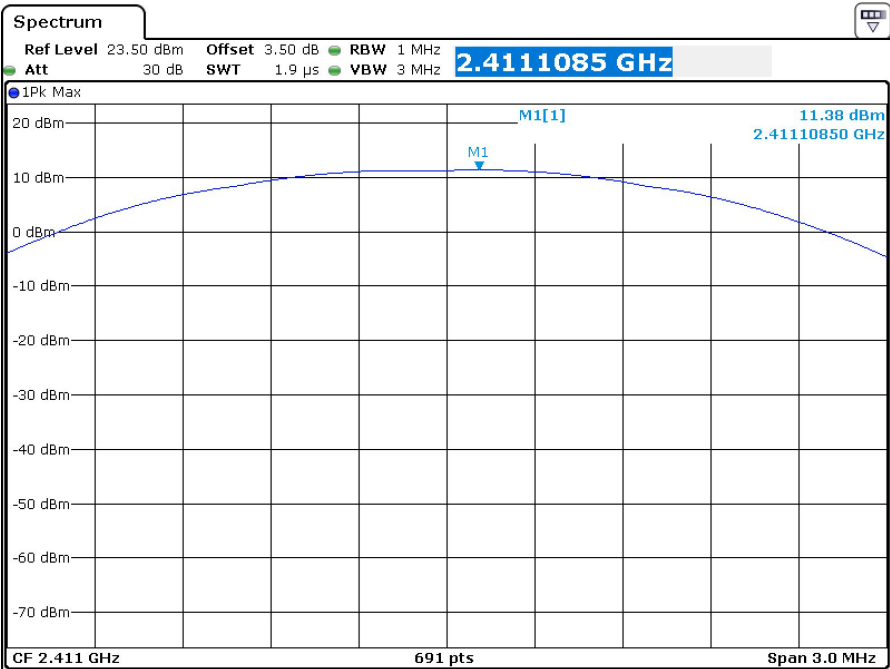
EDR ($\pi/4$ -DQPSK):

Low Channel



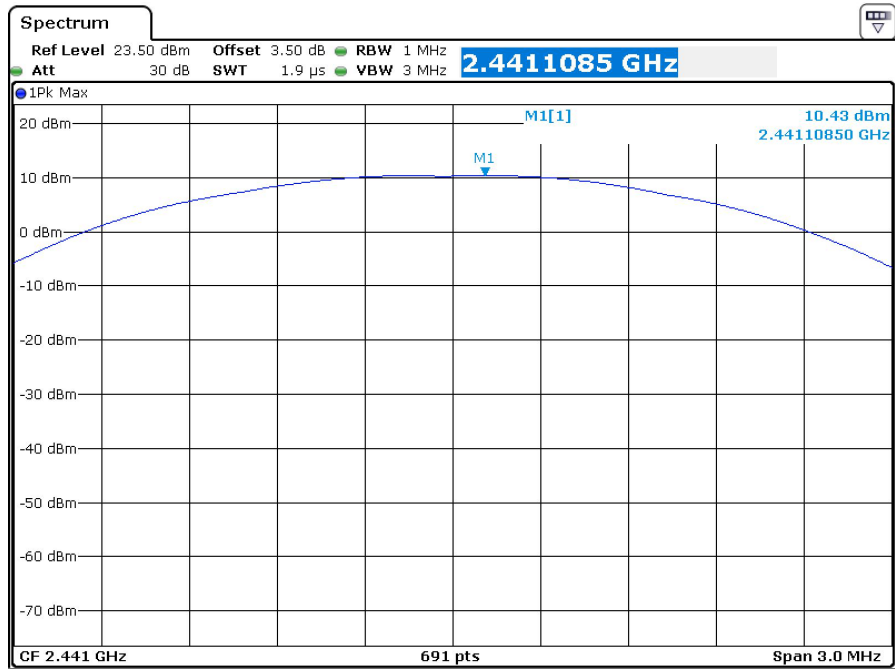
Date: 11.SEP.2022 13:11:54

2411MHz



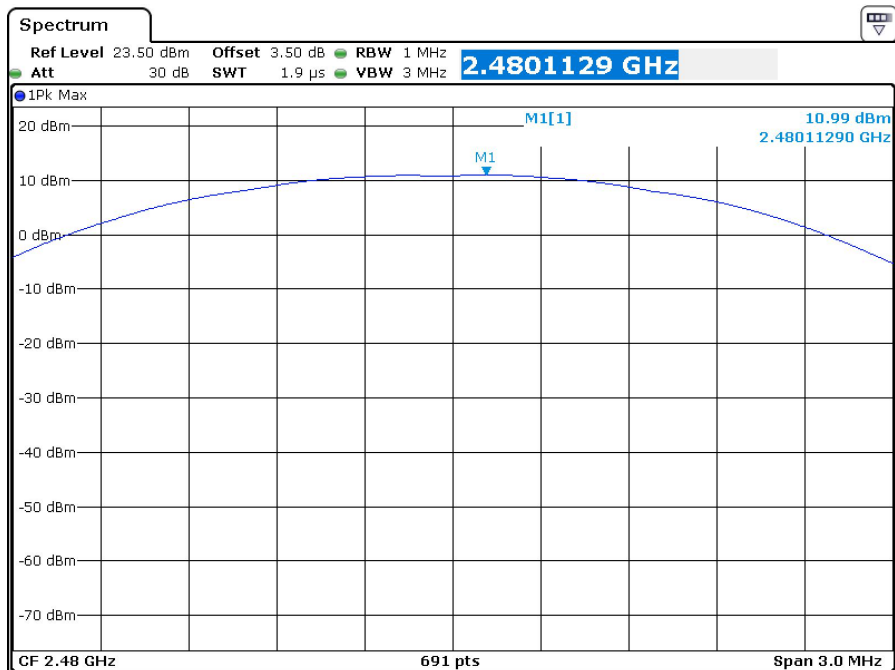
Date: 11.SEP.2022 13:11:02

Middle Channel

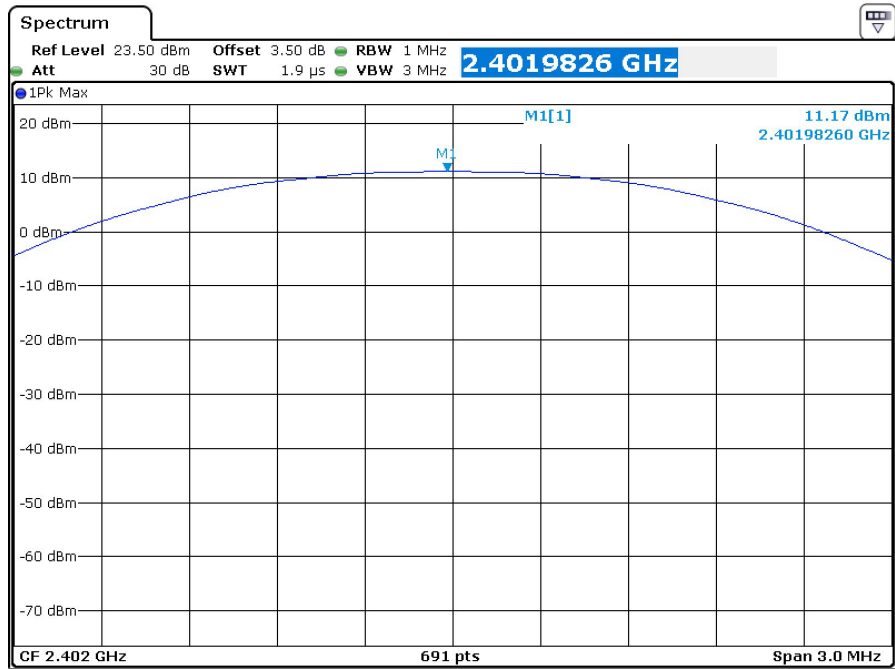


Date: 11.SEP.2022 13:12:32

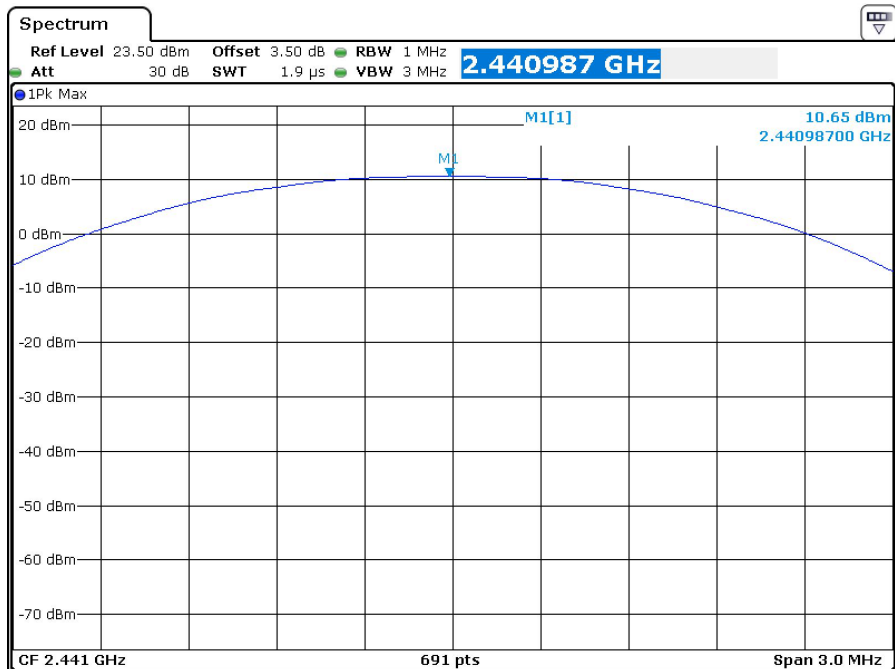
High Channel



Date: 11.SEP.2022 13:12:58

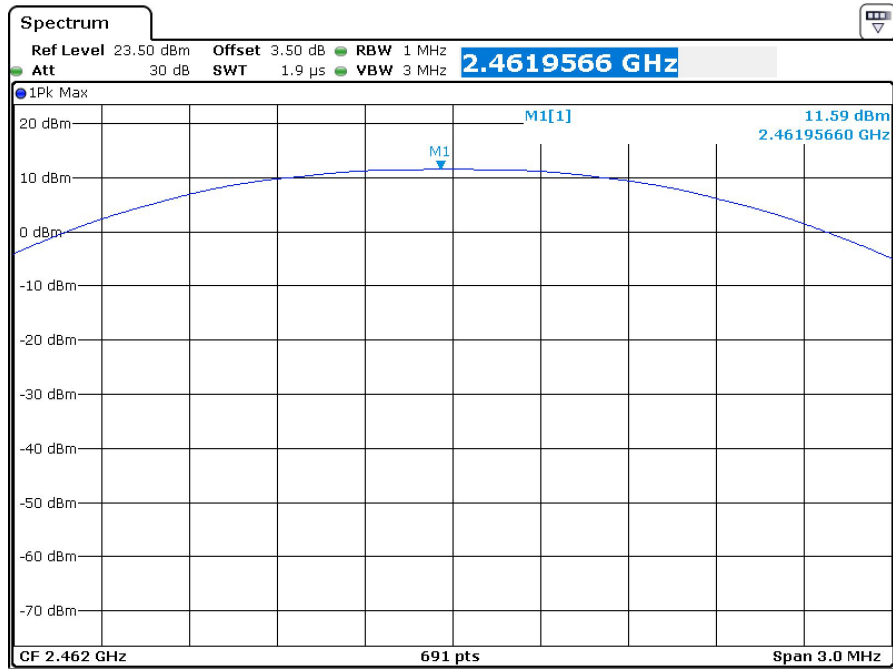
EDR (8DPSK):**Low Channel**

Date: 11.SEP.2022 13:14:30

Middle Channel

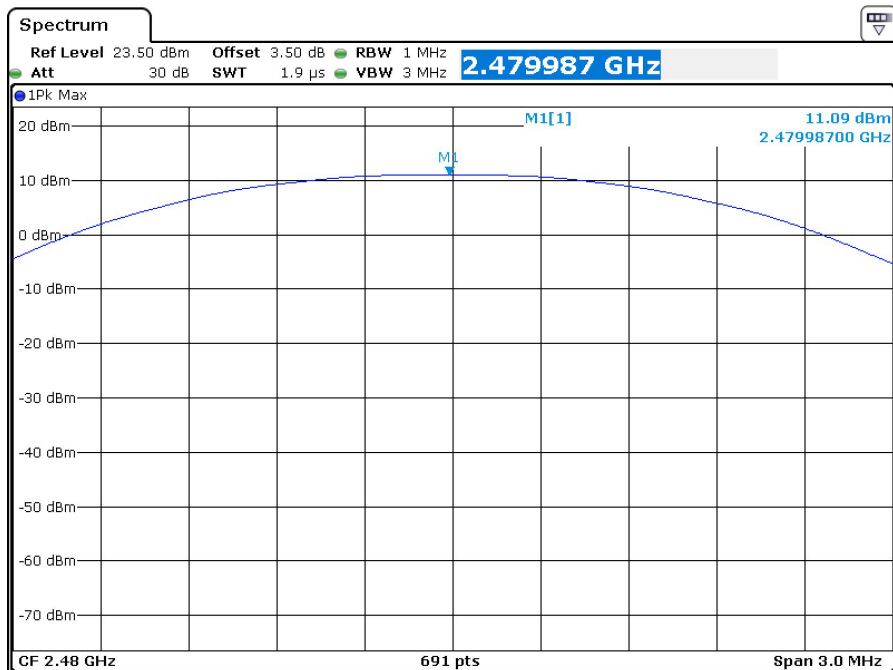
Date: 11.SEP.2022 13:15:03

2462MHz



Date: 11.SEP.2022 13:14:03

High Channel



Date: 11.SEP.2022 13:15:25

FCC §15.247(d) & RSS-247 § 5.5 - BAND EDGES TESTING

Applicable Standard

According to FCC §15.247(d).

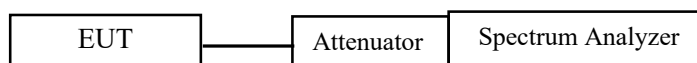
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the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

According to RSS-247 § 5.5.

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(e), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Test Procedure

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:	27.1 °C
Relative Humidity:	58 %
ATM Pressure:	101.0 kPa

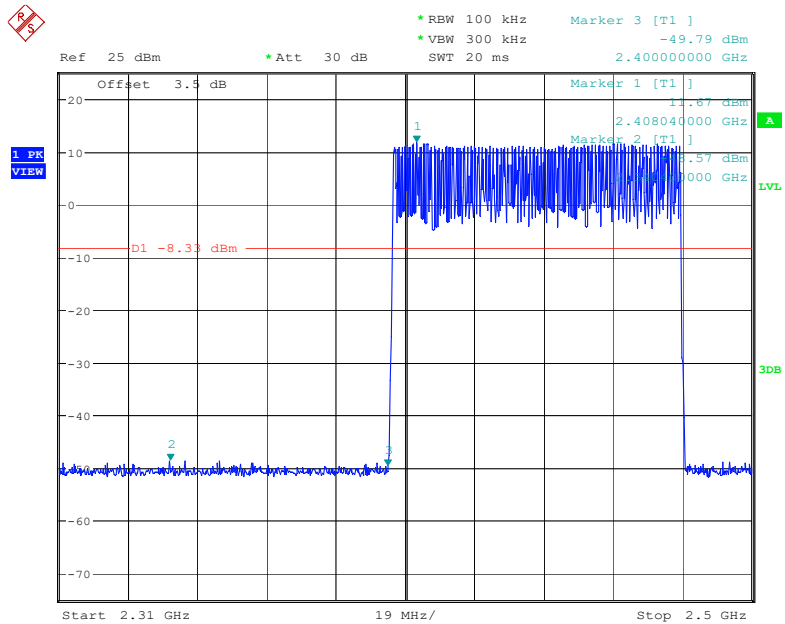
The testing was performed by Roger Ling on 2022-07-29~2022-09-15.

EUT operation mode: Transmitting

Test Result: Pass

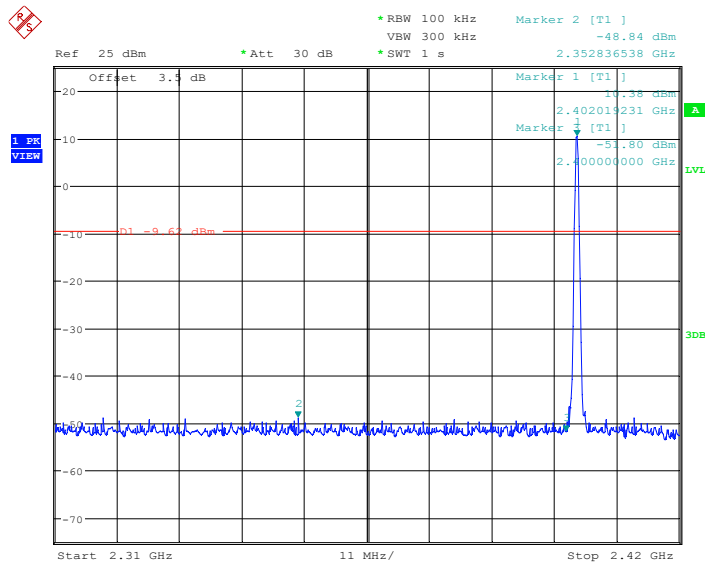
Please refer to following table and plots

BDR (GFSK): Band Edge-Left Side Hopping



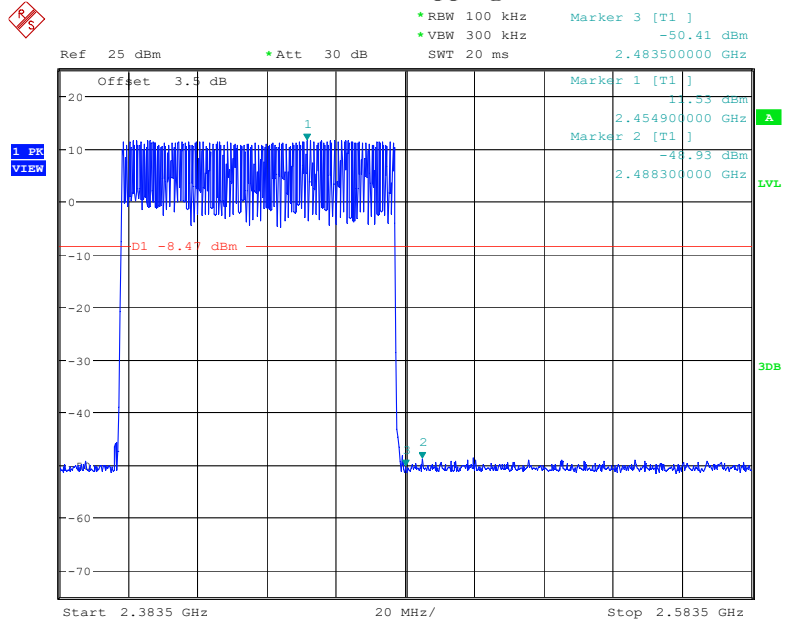
Date: 29.JUL.2022 21:06:03

Single



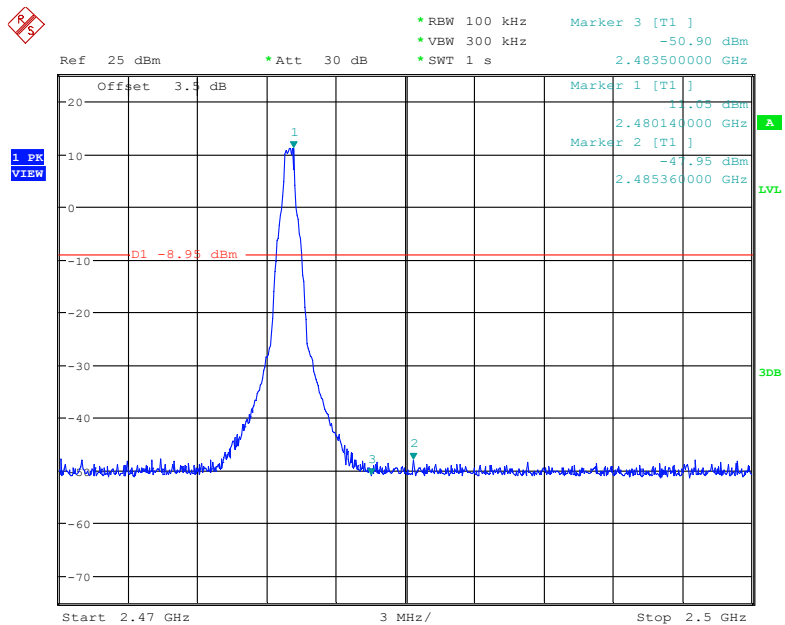
Date: 15.SEP.2022 17:31:12

BDR (GFSK): Band Edge-Right Side Hopping



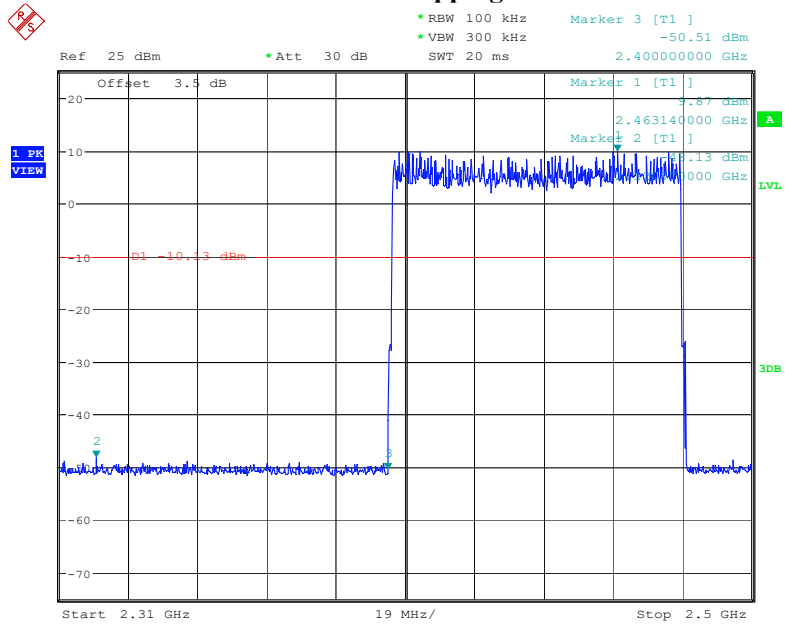
Date: 29.JUL.2022 21:07:52

Single



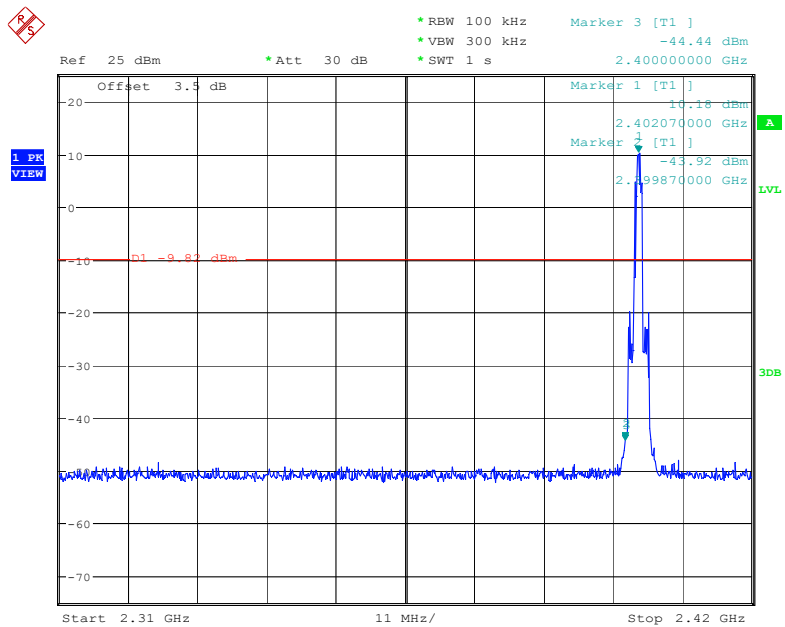
Date: 22.AUG.2022 17:44:59

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



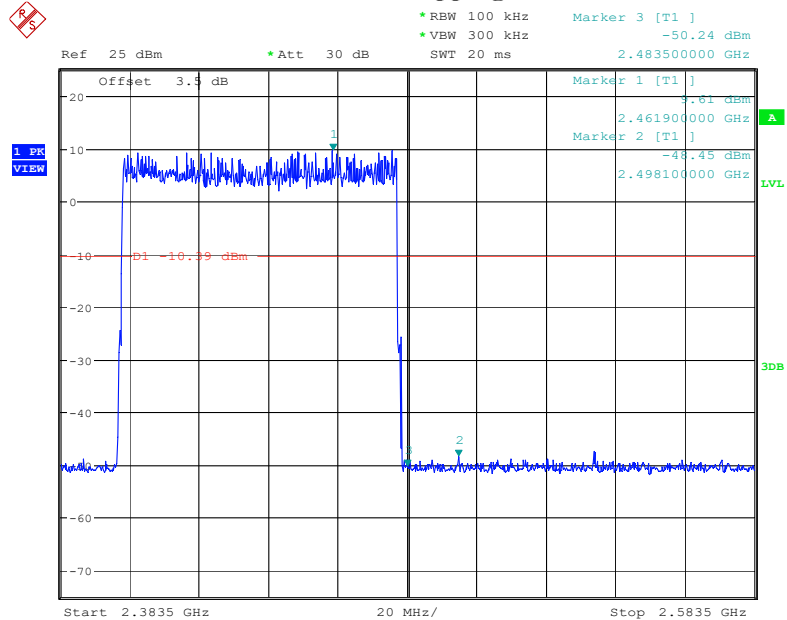
Date: 29.JUL.2022 21:38:34

Single



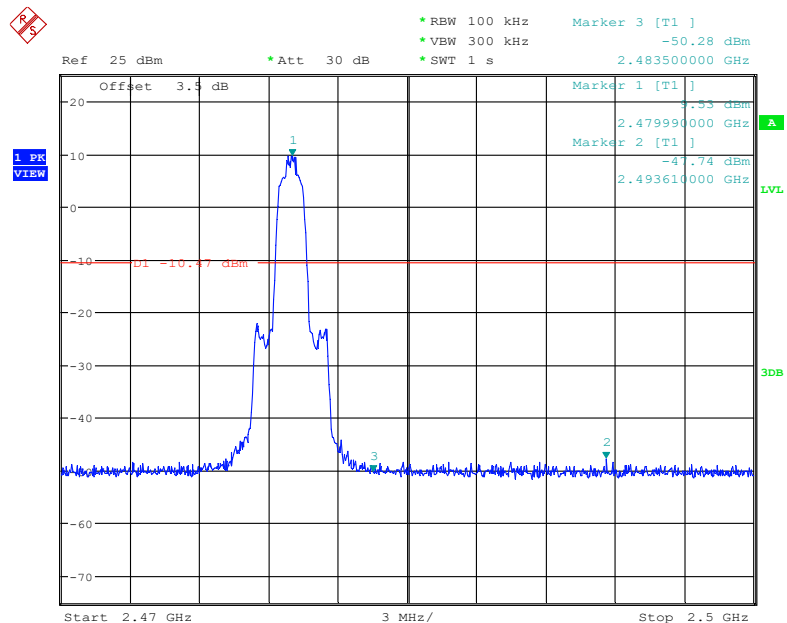
Date: 29.JUL.2022 00:47:59

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

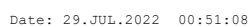


Date: 29.JUL.2022 21:40:22

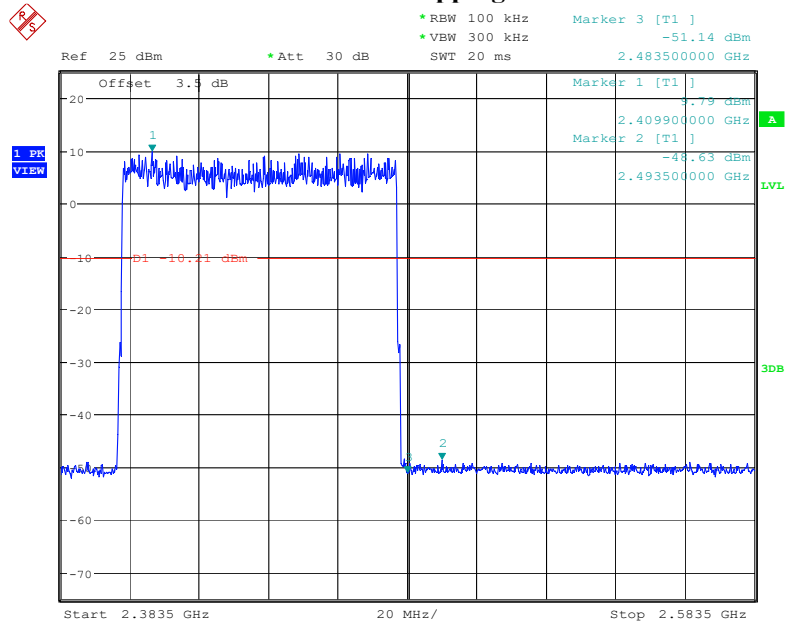
Single



Date: 22.AUG.2022 17:47:46

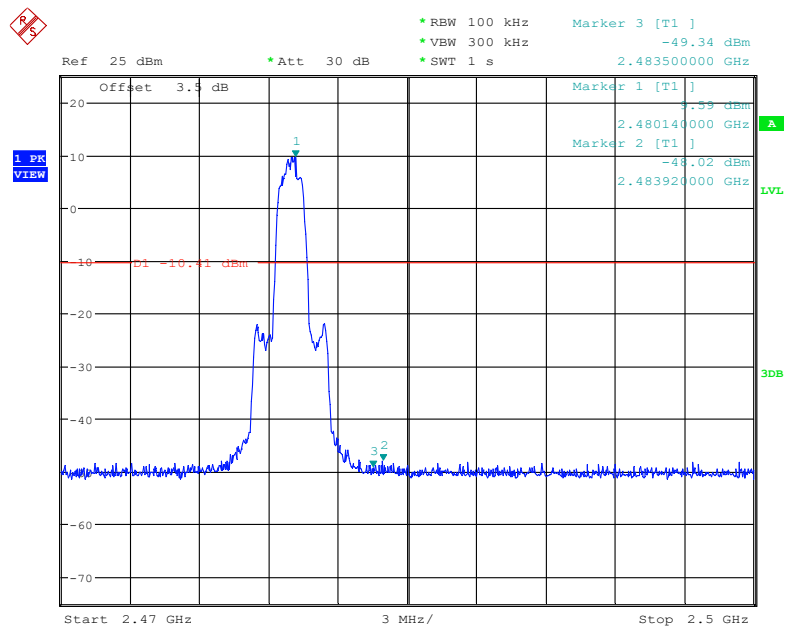


EDR (8DPSK): Band Edge-Right Side Hopping



Date: 29.JUL.2022 21:48:37

Single



Date: 22.AUG.2022 17:50:30

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