TESTING LABORATORY
CERTIFICATE#4323.01

FCC PART 15.247
TEST REPORT

For

Shanghai Ratta Smart Technology Co., Ltd.

Room 301, Building No.1, 168 Jixin Road, Minhang, Shanghai 201104 China

FCC ID: 2AQZ9-A5X

Report Type:	**Product Type:**
Original Report	SuperNote

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GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Applicant	Shanghai Ratta Smart Technology Co., Ltd.
Tested Model	A5 X
Product Type	SuperNote
Power Supply	DC 5V from Adapter and DC 3.8V from battery
Maximum Output Power	GFSK:3.26dBm π/4-DQPSK:4.62dBm 8DPSK:4.89dBm
RF Function	Classic BT
Operating Band/Frequency	2402-2480MHz
Channel Number	79
Channel Separation	1 MHz
Modulation Type	GFSK, π/4-DQPSK, 8DPSK
Antenna Type	FPC antenna
*Maximum Antenna Gain	2.66 dBi

Note: The maximum antenna gain is provided by the applicant.

**All measurement and test data in this report was gathered from production sample serial number: RSHA210121001-1. (Assigned by the BACL. The EUT supplied by the applicant was received on 2021-01-21)*

Objective

This test report is prepared on behalf of *Shanghai Ratta Smart Technology Co., Ltd.* in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commission's 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.

Related Submittal(s)/Grant(s)

FCC Part 15.247 DTS Submittal with FCC ID: 2AQZ9-A5X
FCC Part 15.407 NII Submittal with FCC ID: 2AQZ9-A5X

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 558074 D01 15.247 Meas Guidance v05r02.

All emissions measurement was performed and Bay Area Compliance Laboratories Corp. (Kunshan). The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

Measurement Uncertainty

Item		Uncertainty
AC Power Lines Conducted Emissions		3.19dB
RF conducted test with spectrum		0.9dB
RF Output Power with Power meter		0.5dB
Radiated emission	30MHz~1GHz	6.11dB
	1GHz~6GHz	4.45dB
	6GHz~18GHz	5.23dB
	18GHz~40GHz	5.65dB
Occupied Bandwidth		0.5kHz
Temperature		1.0℃
Humidity		6%

Test Facility

The test site used by Bay Area Compliance Laboratories Corp. (Kunshan) to collect test data is located on the No.248 Chenghu Road, Kunshan, Jiangsu province, China.

Bay Area Compliance Laboratories Corp. (Kunshan) Lab is accredited to ISO/IEC 17025 by A2LA (Lab code: 4323.01) and the FCC designation No. CN1185 under the FCC KDB 974614 D01 and CAB identifier CN0004 under the ISED requirement. The facility also complies with the radiated and AC line conducted test site criteria set forth in ANSI C63.4-2014.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

Channel list for Bluetooth:

Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2402	40	2442
1	2403	…	…
…	…	…	…
…	…	78	2480
39	2441	/	/

EUT was tested with Channel 0, 39 and 78.

EUT Exercise Software

RF test software: QRCT

GFSK, π/4-DQPSK, 8DPSK Power level: Default

Special Accessories

No special accessory.

Equipment Modifications

No modification was made to the EUT tested.

Support Equipment List and Details

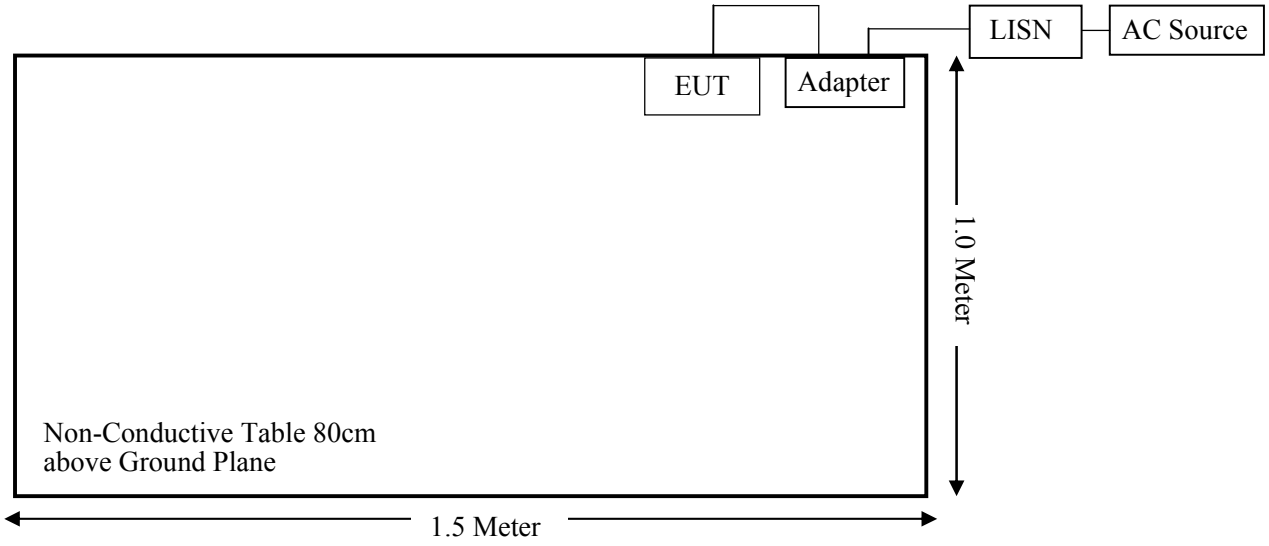
Manufacturer	Description	Model	Serial Number
TIANYIN	Adapter	TPA-67C050100VU01	/

External I/O Cable

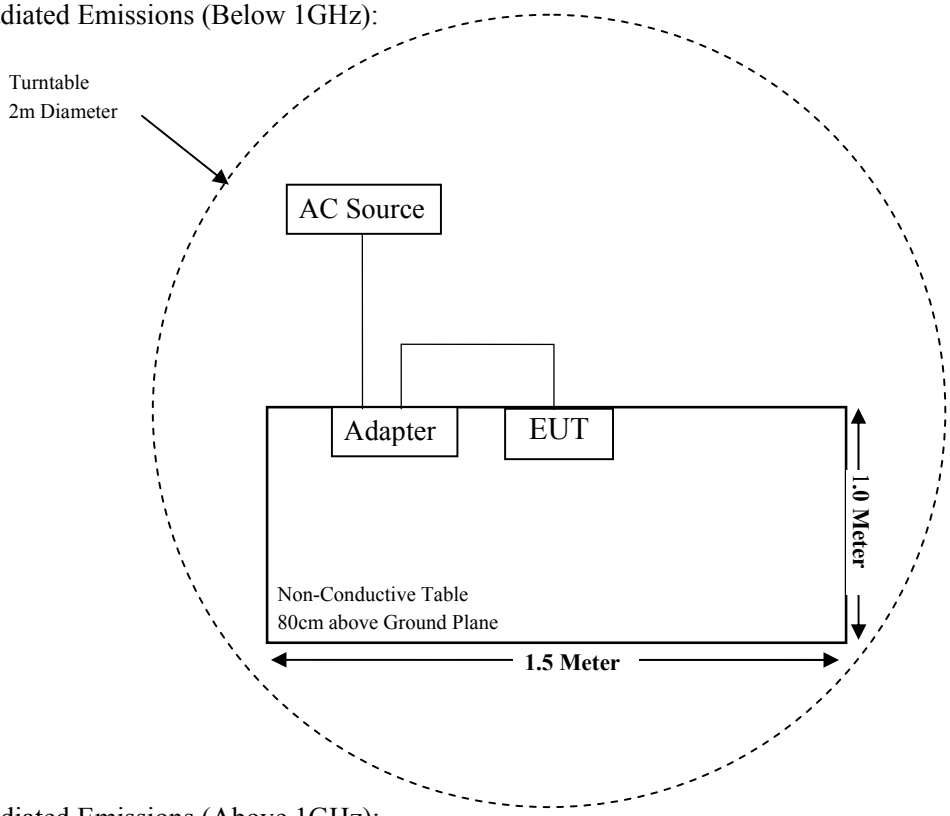
Cable Description	Length (m)	From Port	To Port
Power Cable 1	1.0	EUT	Adapter
Power Cable 2	1.0	Adapter	LISN/AC Source

Block Diagram of Test Setup

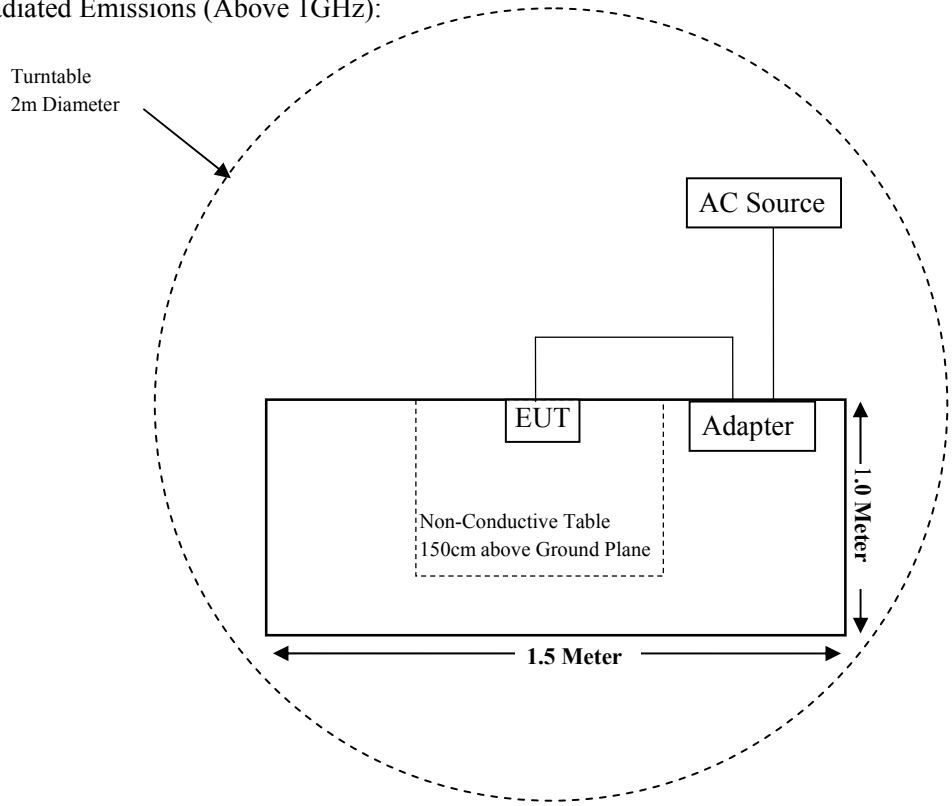
For Conducted Emissions:



For Radiated Emissions (Below 1GHz):



For Radiated Emissions (Above 1GHz):



SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
§15.247 (I), §1.1310 & §2.1093	RF Exposure	Compliant
§15.203	Antenna Requirement	Compliant
§15.207(a)	AC Line Conducted Emissions	Compliant
§15.205, §15.209 & §15.247(d)	Radiated Emissions & Restricted Bands Emissions	Compliant
§15.247(a)(1)	20 dB Emission 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
Radiated Emission Test（Chamber 1#）					
Rohde & Schwarz	EMI Test Receiver	ESCI	100195	2020-11-27	2021-11-26
Sunol Sciences	Broadband Antenna	JB3	A090314-2	2020-01-07	2023-01-06
Sonoma Instrument	Pre-amplifier	310N	171205	2020-08-14	2021-08-13
Rohde & Schwarz	Auto test Software	EMC32	100361	/	/
MICRO-COAX	Coaxial Cable	Cable-8	008	2020-08-15	2021-08-14
MICRO-COAX	Coaxial Cable	Cable-9	009	2020-08-15	2021-08-14
MICRO-COAX	Coaxial Cable	Cable-10	010	2020-08-15	2021-08-14
Radiated Emission Test（Chamber 2#）					
Rohde & Schwarz	EMI Test Receiver	ESU40	100207	2020-08-15	2021-08-14
ETS-LINDGREN	Horn Antenna	3115	9311-4159	2020-07-15	2023-07-14
ETS-LINDGREN	Horn Antenna	3116	2516	2020-01-07	2023-01-06
A.H.Systems,inc	Amplifier	PAM-0118P	512	2020-08-14	2021-08-13
EM Electronics Corporation	Amplifier	EM18G40G	060726	2020-08-05	2021-08-04
MICRO-TRONICS	Band Reject Filter	BRM50702	G024	2020-08-05	2021-08-04
Narda	Attenuator	10dB	010	2020-08-15	2021-08-14
Rohde & Schwarz	Auto test Software	EMC32	100361	/	/
MICRO-COAX	Coaxial Cable	Cable-11	011	2020-08-15	2021-08-14
MICRO-COAX	Coaxial Cable	Cable-12	012	2020-08-15	2021-08-14
MICRO-COAX	Coaxial Cable	Cable-13	013	2020-08-15	2021-08-14
RF Conducted Test					
Rohde & Schwarz	EMI Test Receiver	ESIB26	100146	2020-11-27	2021-11-26
Rohde & Schwarz	Signal Analyzer	FSV40	101116	2020-07-28	2021-07-27
Narda	Attenuator	10dB	010	2020-08-15	2021-08-14
Shanghai Ratta Smart Technology Co.,Ltd.	RF Cable	Shanghai Ratta Smart Technology Co.,Ltd. C01	C01	Each Time	/
Conducted Emission Test					
Rohde & Schwarz	EMI Test Receiver	ESR	1316.3003K03 -101746-zn	2020-08-05	2021-08-04
Rohde & Schwarz	LISN	ENV216	101115	2020-11-27	2021-11-26
Audix	Test Software	e3	V9	/	/
Rohde & Schwarz	Pulse limiter	ESH3-Z2	357.8810.52	2020-08-10	2021-08-09
MICRO-COAX	Coaxial Cable	Cable-15	015	2020-08-15	2021-08-14

*** Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

FCC §1.1310 & §2.1093- RF EXPOSURE

Applicable Standard

According to FCC§1.1310,§2.1093.

Measurement Result

Compliance, please refer to SAR Report: RSHA210121001-20C.

FCC §15.203 - ANTENNA REQUIREMENT

Applicable Standard

According to § 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 user of a standard antenna jack or electrical connector is prohibited. The structure and application of the EUT were analyzed to determine Compliance with section §15.203 of the rules. §15.203 state that the subject device must meet the following criteria:

a. Antenna must be permanently attached to the unit.
b. Antenna must use a unique type of connector to attach to the EUT.

Unit must be professionally installed, and installer shall be responsible for verifying that the correct antenna is employed with the unit.
And according to FCC 47 CFR section 15.247 (b), if the transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Antenna Connector Construction

The EUT has an FPC antenna for Bluetooth, and the antenna gain is 2.66 dBi, which is permanently attached to the unit, fulfill the requirement of this section. Please refer to the EUT photos.

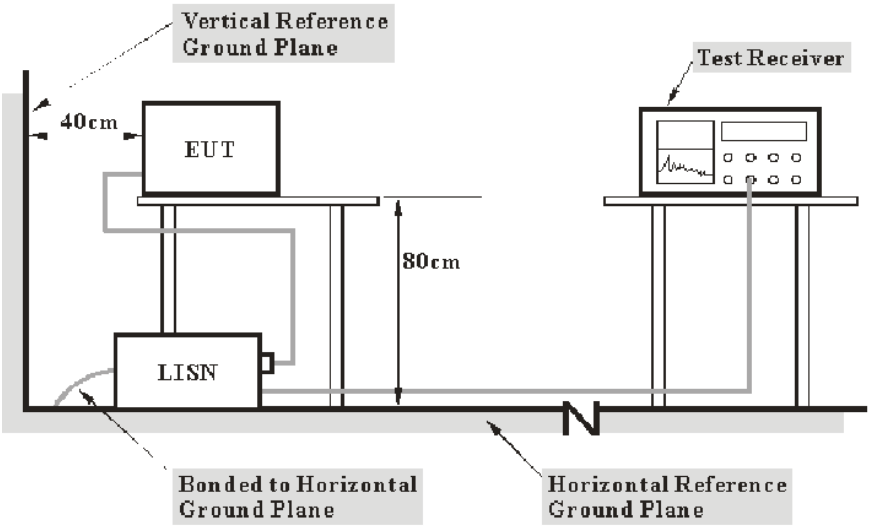
Result: Compliant.

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.

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:

Factor (dB) = LISN VDF (dB) + Cable Loss (dB) + Transient Limiter Attenuation (dB)

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

Over Limit (dB) = Read level (dBμV) + Factor (dB) - Limit (dBμV)

Test Results Summary

According to the recorded data in following table, the EUT complied with the FCC Part 15.207.

Test Data

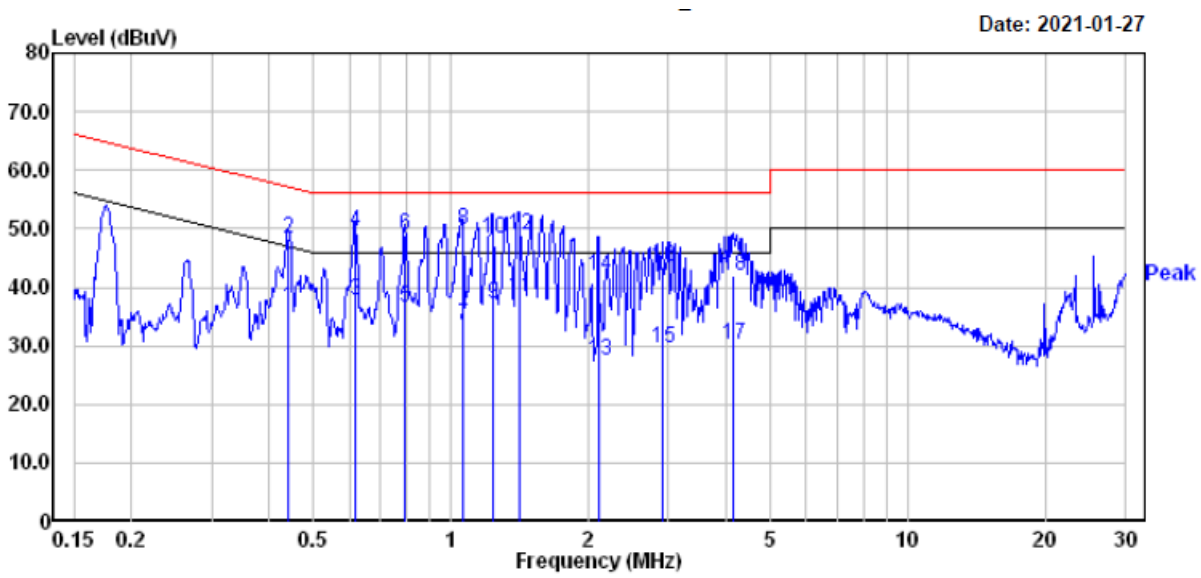
Environmental Conditions

Temperature:	25.2 ℃
Relative Humidity:	50 %
ATM Pressure:	101.5 kPa

The testing was performed by Chao Gao on 2021-01-27.

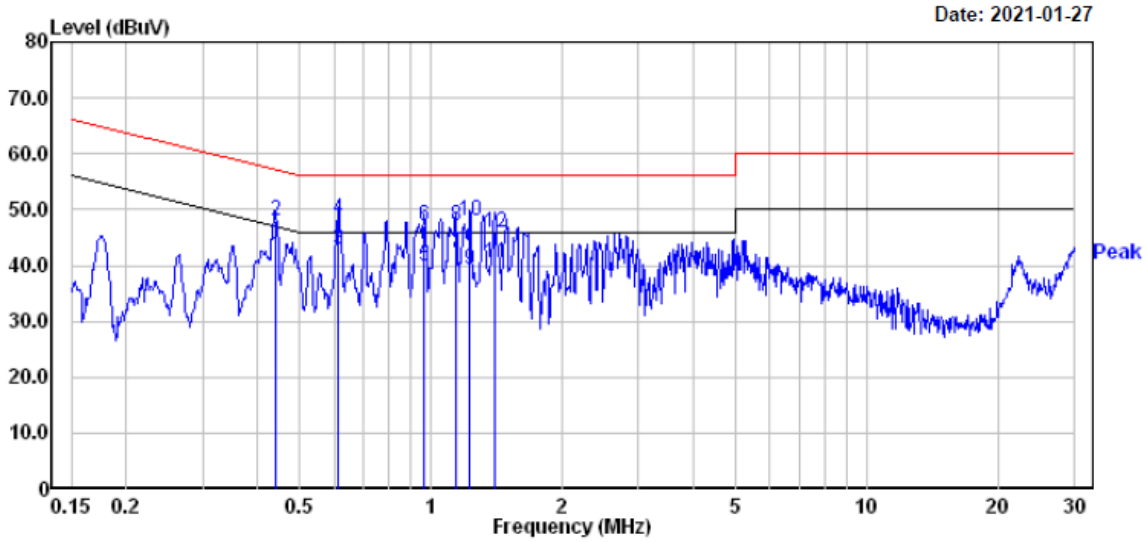
EUT operation mode: Transmitting in low channel of EDR(8DPSK) mode (worst case)

AC 120V/60 Hz, Line



	Freq	Read Level	Factor	Level	Limit Line	Over Limit	Remark
	MHz	dBuV	dB	dBuV	dBuV	dB	
1	0.440	16.80	19.75	36.55	47.07	-10.52	Average
2	0.440	28.70	19.75	48.45	57.07	-8.62	QP
3	0.617	18.10	19.75	37.85	46.00	-8.15	Average
4	0.617	29.70	19.75	49.45	56.00	-6.55	QP
5	0.792	16.91	19.70	36.61	46.00	-9.39	Average
6	0.792	29.11	19.70	48.81	56.00	-7.19	QP
7	1.060	13.70	19.82	33.52	46.00	-12.48	Average
8	1.060	30.00	19.82	49.82	56.00	-6.18	QP
9	1.236	17.41	19.81	37.22	46.00	-8.78	Average
10	1.236	28.41	19.81	48.22	56.00	-7.78	QP
11	1.411	18.41	19.83	38.24	46.00	-7.76	Average
12	1.411	29.01	19.83	48.84	56.00	-7.16	QP
13	2.110	7.80	19.74	27.54	46.00	-18.46	Average
14	2.110	22.10	19.74	41.84	56.00	-14.16	QP
15	2.915	10.10	19.46	29.56	46.00	-16.44	Average
16	2.915	23.90	19.46	43.36	56.00	-12.64	QP
17	4.158	10.80	19.47	30.27	46.00	-15.73	Average
18	4.158	22.60	19.47	42.07	56.00	-13.93	QP

AC 120V/60 Hz, Neutral



	Freq	Read Level	Factor	Level	Limit Line	Over Limit	Remark
	MHz	dBuV	dB	dBuV	dBuV	dB	
1	0.440	22.00	19.75	41.75	47.07	-5.32	Average
2	0.440	28.40	19.75	48.15	57.07	-8.92	QP
3	0.614	23.00	19.75	42.75	46.00	-3.25	Average
4	0.614	28.60	19.75	48.35	56.00	-7.65	QP
5	0.968	20.10	19.79	39.89	46.00	-6.11	Average
6	0.968	27.30	19.79	47.09	56.00	-8.91	QP
7	1.141	22.40	19.81	42.21	46.00	-3.79	Average
8	1.141	27.30	19.81	47.11	56.00	-8.89	QP
9	1.229	19.41	19.81	39.22	46.00	-6.78	Average
10	1.229	28.11	19.81	47.92	56.00	-8.08	QP
11	1.403	20.61	19.83	40.44	46.00	-5.56	Average
12	1.403	26.01	19.83	45.84	56.00	-10.16	QP

Note:
1) Factor (dB) = LISN VDF (dB) + Cable Loss (dB) + Transient Limiter Attenuation (dB)
2) Over Limit (dB) = Read level (dBµV) + Factor (dB) - Limit (dBµV)

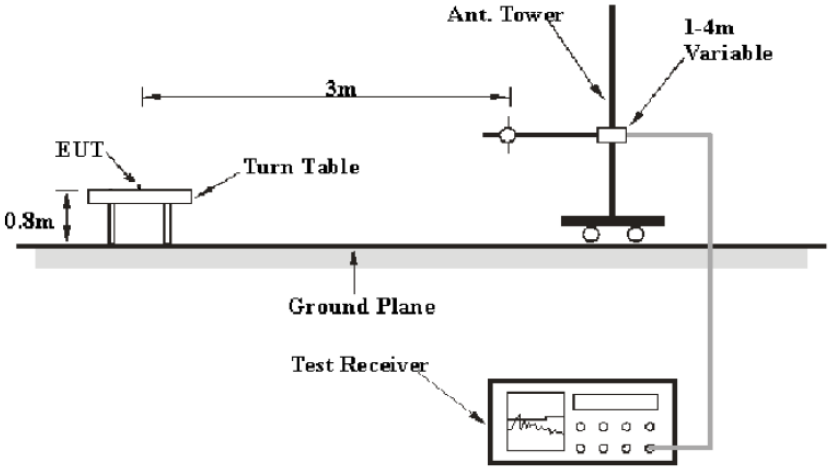
FCC §15.205, §15.209 & §15.247(d) – RADIATED EMISSIONS

Applicable Standard

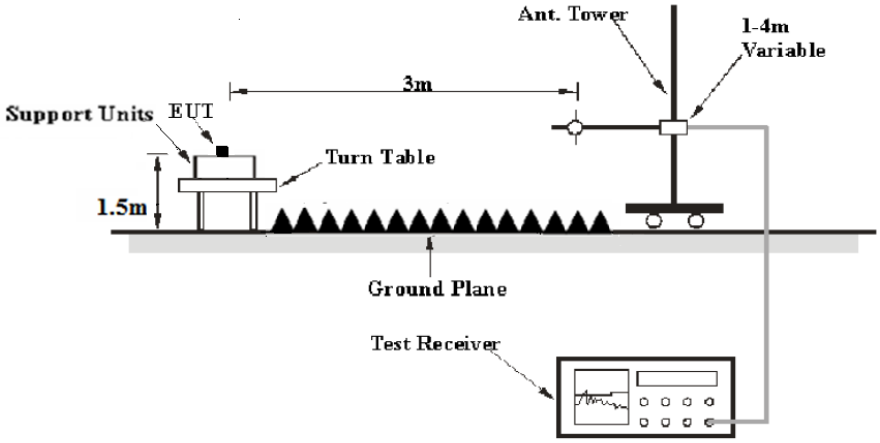
FCC §15.205; §15.209; §15.247(d)

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 Setup

The system was investigated from 30 MHz to 25 GHz.

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

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

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.

Corrected Amplitude & Margin Calculation

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

Corrected Amplitude (dBμV /m) = Meter Reading (dBμV) + Antenna Factor (dB/m) + Cable Loss (dB) - Amplifier Gain (dB)

The "**Margin**" column of the following data tables indicates the degree of Compliance with the applicable limit. For example, a margin of 7dB means the emission is 7dB below the limit. The equation for margin calculation is as follows:

Margin (dB) = Limit (dBμV/m) – Corrected Amplitude (dBμV /m)

Test Results Summary

According to the recorded data in following table, the EUT complied with the FCC Title 47, Part 15, Subpart C, section 15.205, 15.209 and 15.247.

Test Data

Environmental Conditions

Temperature:	23.1~24.5 ℃
Relative Humidity:	50~52 %
ATM Pressure:	101.1~101.5 kPa

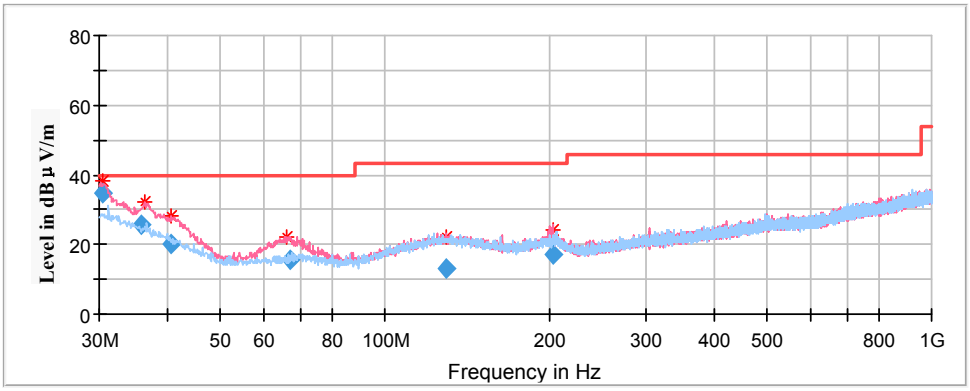
The testing was performed by Chao Gao from 2021-01-29 to 2021-06-05.

EUT operation mode: Transmitting

Spurious Emission Test:

30MHz-1GHz:

Pre-Scan with GFSK, π/4-DQPSK, 8DPSK modes of operation in the X,Y and Z axes of orientation, the worst case ***low channel of EDR(8DPSK) Mode in Z-axis of orientation*** *was recorded*



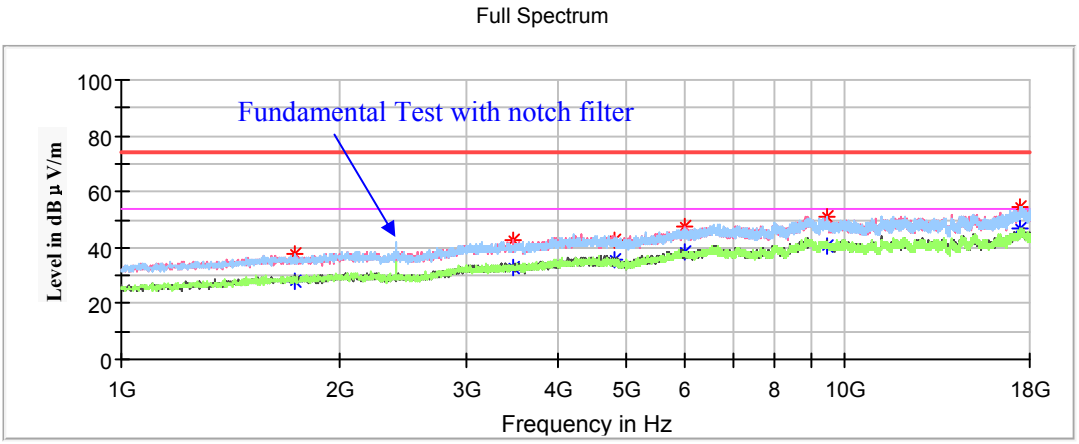
Frequency (MHz)	Corrected Amplitude	Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBµV/m)	Margin (dB)
	Quasi-peak (dBµV/m)	Height (cm)	Polar (H/V)				
30.418671	34.53	100.0	V	18.0	-4.1	40.00	5.47
35.909000	25.68	100.0	V	84.0	-7.8	40.00	14.32
40.732650	20.14	100.0	V	210.0	-11.0	40.00	19.86
66.982850	15.67	100.0	V	0.0	-16.4	40.00	24.33
129.120300	13.27	100.0	V	198.0	-10.6	43.50	30.23
202.288650	17.33	100.0	V	42.0	-11.0	43.50	26.17

1GHz-18GHz:

Pre-Scan with GFSK, π/4-DQPSK, 8DPSK modes of operation in the X,Y and Z axes of orientation, the worst case ***EDR(8DPSK) Mode in Z-axis of orientation*** *was recorded*

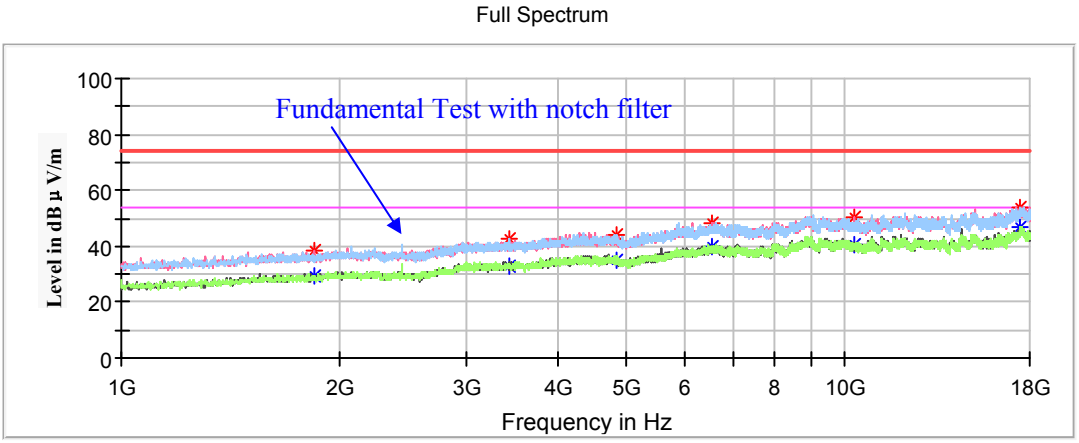
Note:
1. This test was performed with the 2.4-2.5 GHz notch filter.
2. Corrected Factor (dB/m) = Antenna factor (RX) (dB/m) + Cable Loss (dB) – Amplifier Factor (dB)
   Corrected Amplitude (dBμV/m) = Corrected Factor (dB/m) + Reading (dBμV)
   Margin (dB) = Limit (dBμV/m) – Corrected Amplitude (dBμV/m)

Low Channel: 2402MHz



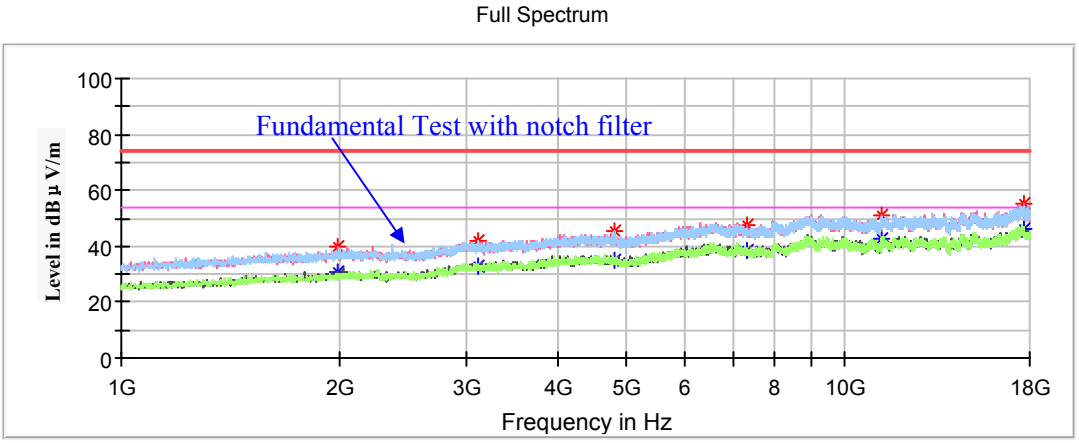
Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	MaxPeak (dBμV/m)	Average (dBμV/m)	Height (cm)	Polar (H/V)				
1741.200000	---	28.01	150.0	H	192.0	-5.7	54.00	25.99
1741.200000	37.61	---	150.0	H	192.0	-5.7	74.00	36.39
3478.600000	42.40	---	150.0	V	231.0	-1.7	74.00	31.60
3478.600000	---	32.71	150.0	V	231.0	-1.7	54.00	21.29
4804.000000	42.76	---	200.0	V	204.0	0.6	74.00	31.24
4804.000000	---	35.49	200.0	V	204.0	0.6	54.00	18.51
5986.100000	---	38.28	200.0	V	230.0	4.1	54.00	15.72
5986.100000	47.42	---	200.0	V	230.0	4.1	74.00	26.58
9430.300000	50.87	---	200.0	H	224.0	9.2	74.00	23.13
9430.300000	---	40.78	200.0	H	224.0	9.2	54.00	13.22
17496.800000	---	47.02	150.0	H	4.0	14.4	54.00	6.98
17496.800000	54.34	---	150.0	H	4.0	14.4	74.00	19.66

Middle Channel: 2441MHz



Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBµV/m)	Margin (dB)
	MaxPeak (dBµV/m)	Average (dBµV/m)	Height (cm)	Polar (H/V)				
1843.200000	---	29.68	150.0	V	345.0	-5.4	54.00	24.32
1843.200000	38.70	---	150.0	V	345.0	-5.4	74.00	35.30
3427.600000	---	32.60	150.0	H	311.0	-1.8	54.00	21.40
3427.600000	42.31	---	150.0	H	311.0	-1.8	74.00	31.69
4882.000000	---	34.92	200.0	H	185.0	0.5	54.00	19.08
4882.000000	43.77	---	200.0	H	185.0	0.5	74.00	30.23
6540.300000	---	39.83	150.0	V	77.0	5.4	54.00	14.17
6540.300000	48.30	---	150.0	V	77.0	5.4	74.00	25.70
10302.400000	---	40.39	150.0	V	219.0	8.5	54.00	13.61
10302.400000	50.23	---	150.0	V	219.0	8.5	74.00	23.77
17450.900000	53.65	---	200.0	H	198.0	14.3	74.00	20.35
17452.600000	---	46.81	200.0	H	68.0	14.3	54.00	7.19

High Channel: 2480MHz

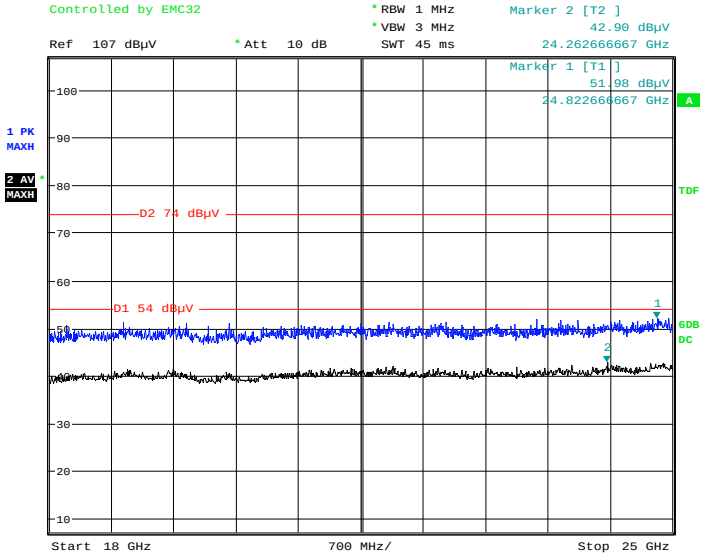


Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBµV/m)	Margin (dB)
	MaxPeak (dBµV/m)	Average (dBµV/m)	Height (cm)	Polar (H/V)				
1996.200000	---	30.48	150.0	V	0.0	-4.9	54.00	23.52
1996.200000	40.11	---	150.0	V	0.0	-4.9	74.00	33.89
3108.000000	41.85	---	150.0	V	49.0	-2.0	74.00	32.15
3108.000000	---	33.12	150.0	V	49.0	-2.0	54.00	20.88
4808.000000	---	35.19	150.0	H	71.0	0.6	54.00	18.81
4808.000000	45.36	---	150.0	H	71.0	0.6	74.00	28.64
7329.100000	47.73	---	150.0	V	159.0	5.1	74.00	26.27
7329.100000	---	38.72	150.0	V	159.0	5.1	54.00	15.28
11206.800000	---	42.45	150.0	V	337.0	10.1	54.00	11.55
11206.800000	51.28	---	150.0	V	337.0	10.1	74.00	22.72
17643.000000	---	45.81	150.0	V	0.0	14.1	54.00	8.19
17643.000000	55.42	---	150.0	V	0.0	14.1	74.00	18.58

18GHz-25GHz:

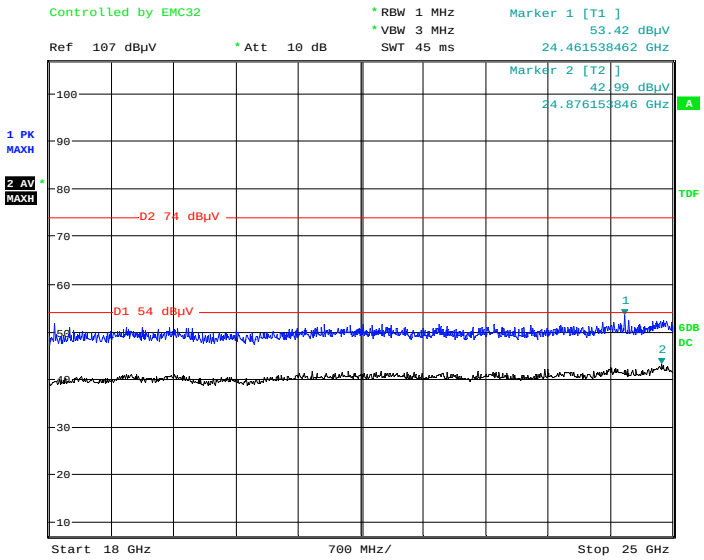
Pre-Scan with GFSK, π/4-DQPSK, 8DPSK modes of operation in the X,Y and Z axes of orientation,, the worst case ***low channel of EDR(8DPSK) Mode in Z-axis of orientation*** *was recorded*

Horizontal



Date: 9.MAR.2021 21:21:54

Vertical



Date: 9.MAR.2021 21:14:30

Restricted Bands Emissions:

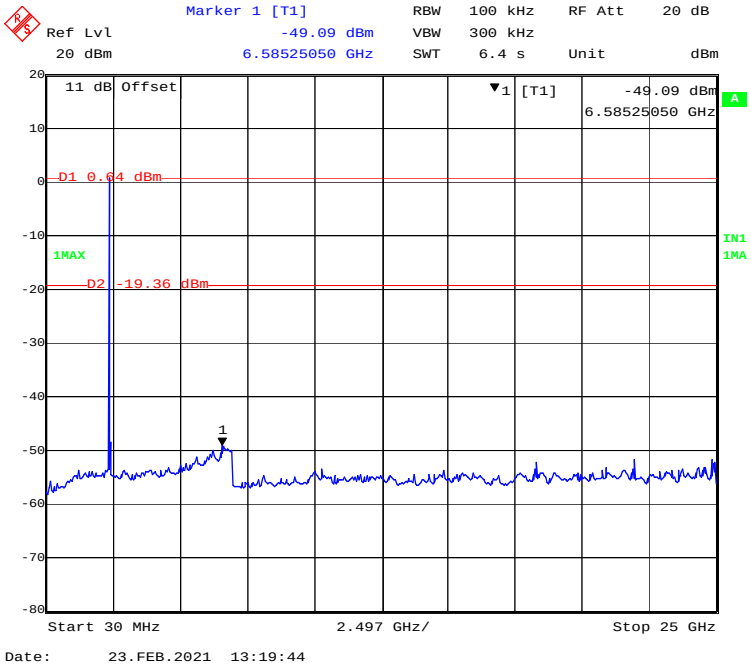
Pre-Scan with GFSK, π/4-DQPSK, 8DPSK modes of operation in the X,Y and Z axes of orientation, the worst case ***EDR(8DPSK) Mode in Z-axis of orientation*** *was recorded*

Note:
1. Corrected Factor (dB/m) = Antenna factor (RX) (dB/m) + Cable Loss (dB) – Amplifier Factor (dB)
   Corrected Amplitude (dBμV/m) = Corrected Factor (dB/m) + Reading (dBμV)
   Margin (dB) = Limit (dBμV/m) – Corrected Amplitude (dBμV/m)

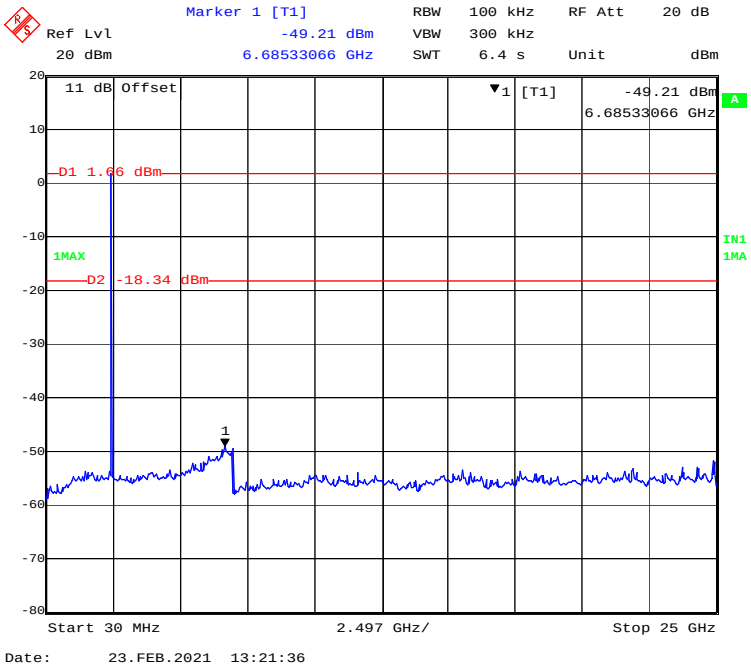
Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	MaxPeak (dBμV/m)	Average (dBμV/m)	Height (cm)	Polar (H/V)				
Low Channel: 2402MHz								
2390.000000	49.65	---	200.0	V	291.0	3.8	74.00	24.35
2390.000000	---	46.29	200.0	V	291.0	3.8	54.00	7.71
High Channel: 2480MHz								
2483.500000	---	47.15	150.0	V	326.0	4.2	54.00	6.85
2483.500000	50.98	---	150.0	V	326.0	4.2	74.00	23.02

Conducted Spurious Emissions at Antenna Port

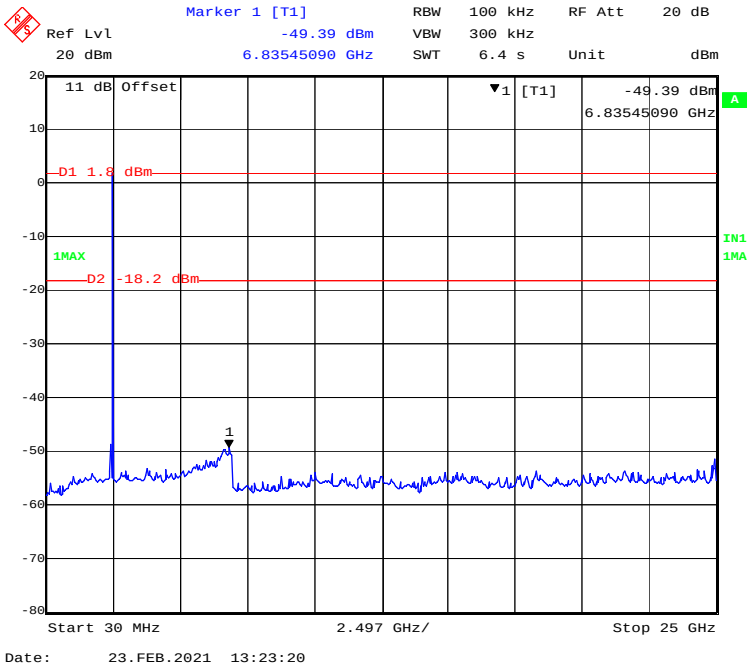
BDR (GFSK): Low Channel



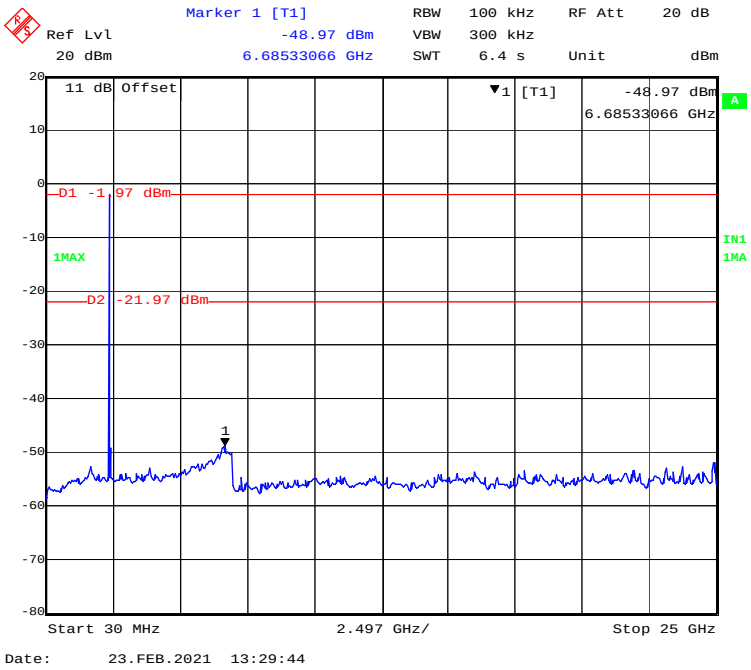
BDR (GFSK): Middle Channel



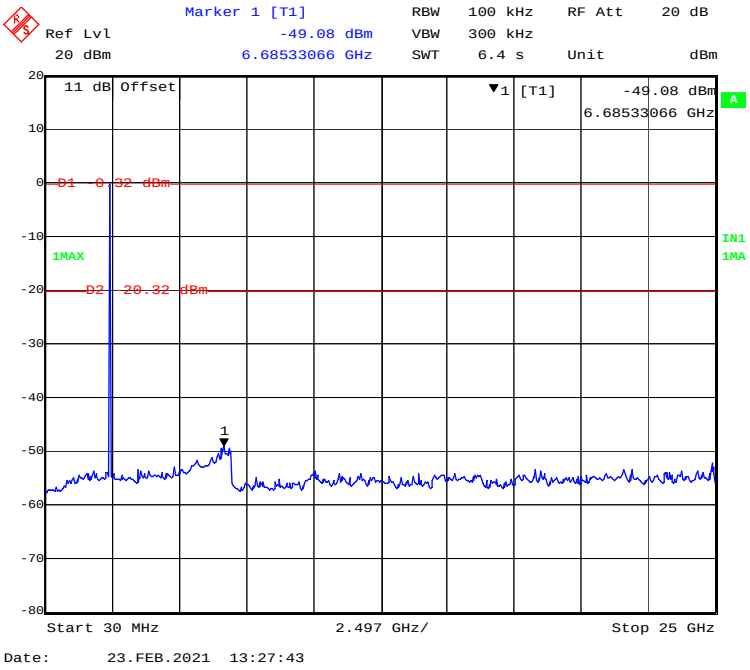
BDR (GFSK): High Channel



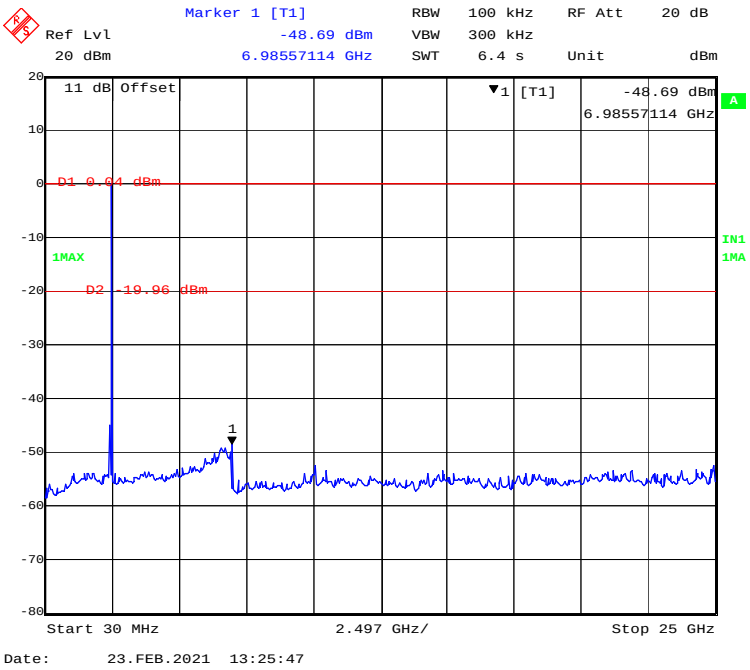
EDR (π/4-DQPSK): Low Channel



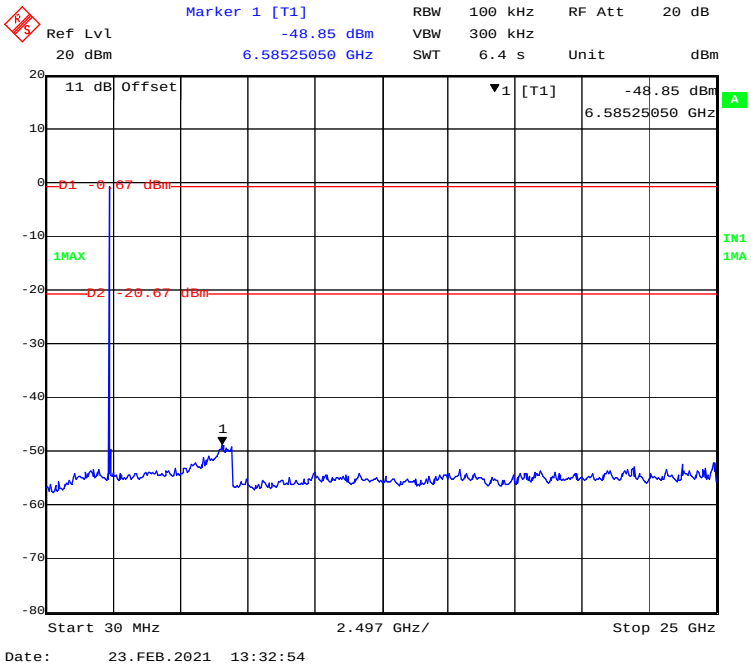
EDR (π/4-DQPSK): Middle Channel



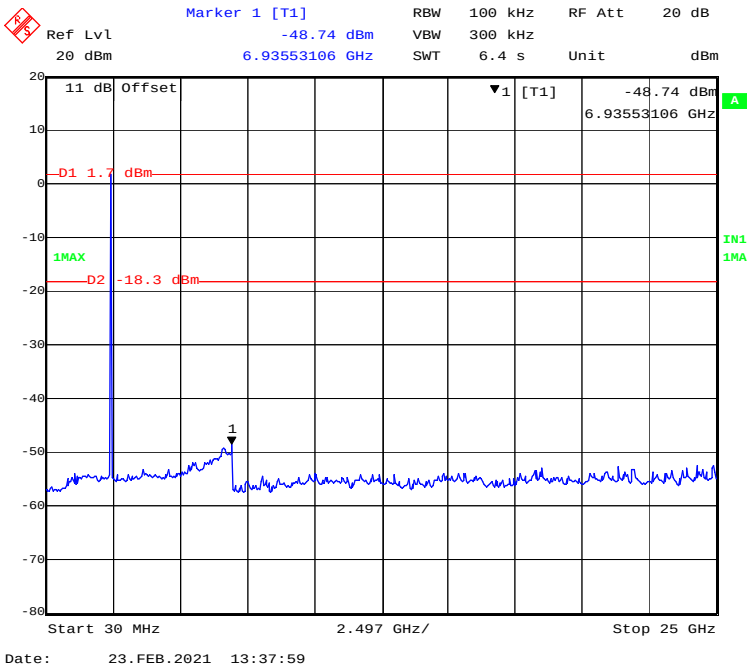
EDR (π/4-DQPSK): High Channel



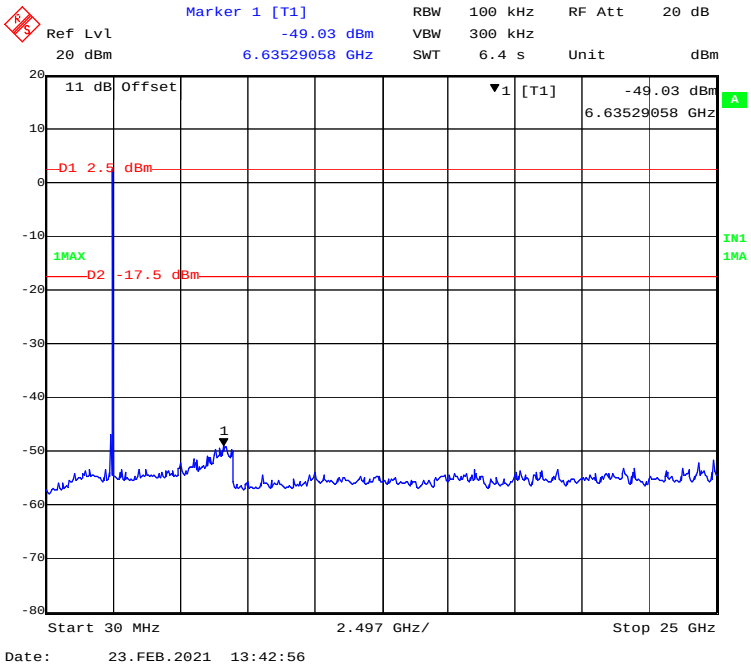
EDR (8DPSK): Low Channel



EDR (8DPSK): Middle Channel



EDR (8DPSK): High Channel



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

Applicable Standard

Frequency hopping systems shall have hoping 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.

Test Procedure

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

a. Span: Wide enough to capture the peaks of two adjacent channels.
b. RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
c. Video (or average) bandwidth (VBW) ≥ RBW.
d. Sweep: Auto.
e. Detector function: Peak.
f. Trace: Max hold.
g. Allow the trace to stabilize.

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

Test Data

Environmental Conditions

Temperature:	22.4 ℃
Relative Humidity:	50 %
ATM Pressure:	101.1 kPa

The testing was performed by Chao Gao on 2021-03-03.

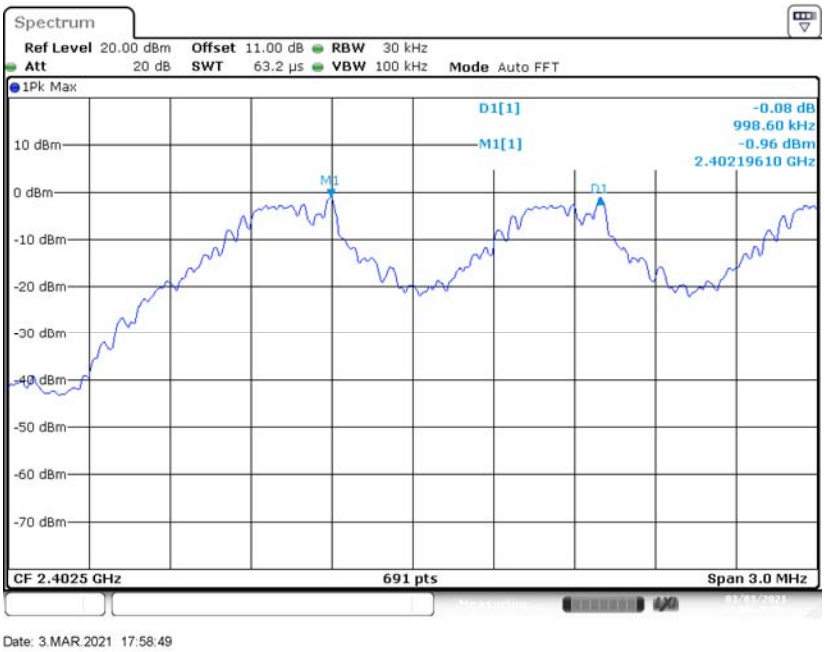
EUT operation mode: Transmitting

Test Result: Compliant.

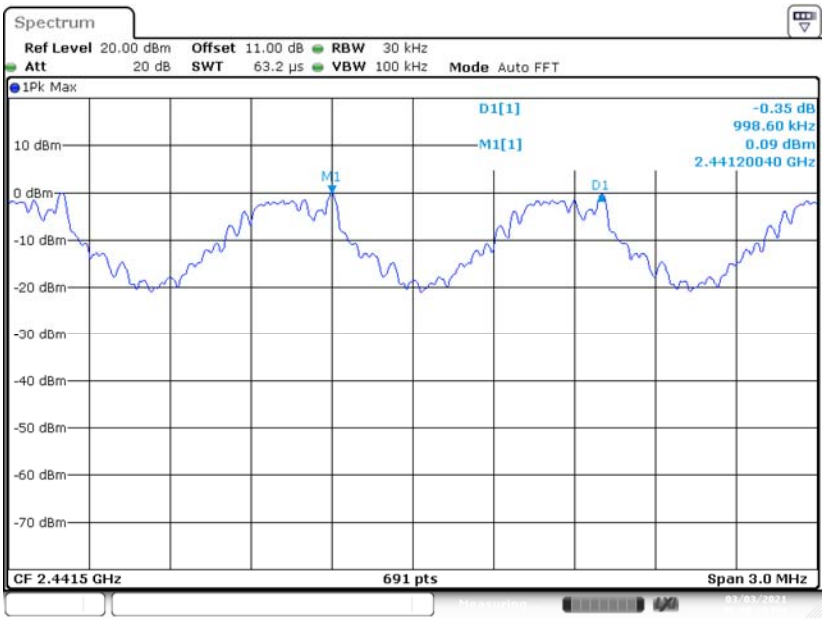
Mode	Channel	Frequency (MHz)	Channel Separation (MHz)	Limit (MHz)	Result
BDR (GFSK)	Low	2402	0.999	0.992	Pass
	Adjacent	2403			
	Middle	2441	0.999	0.980	Pass
	Adjacent	2442			
	High	2480	0.999	0.986	Pass
	Adjacent	2479			
EDR (π/4-DQPSK)	Low	2402	1.003	0.918	Pass
	Adjacent	2403			
	Middle	2441	1.003	0.918	Pass
	Adjacent	2442			
	High	2480	1.003	0.918	Pass
	Adjacent	2479			
EDR (8DPSK)	Low	2402	0.999	0.882	Pass
	Adjacent	2403			
	Middle	2441	0.999	0.886	Pass
	Adjacent	2442			
	High	2480	0.999	0.890	Pass
	Adjacent	2479			

Note: For BDR mode, Limit = 20 dB bandwidth; For EDR mode, Limit = 20 dB bandwidth*2/3

BDR (GFSK): Low Channel

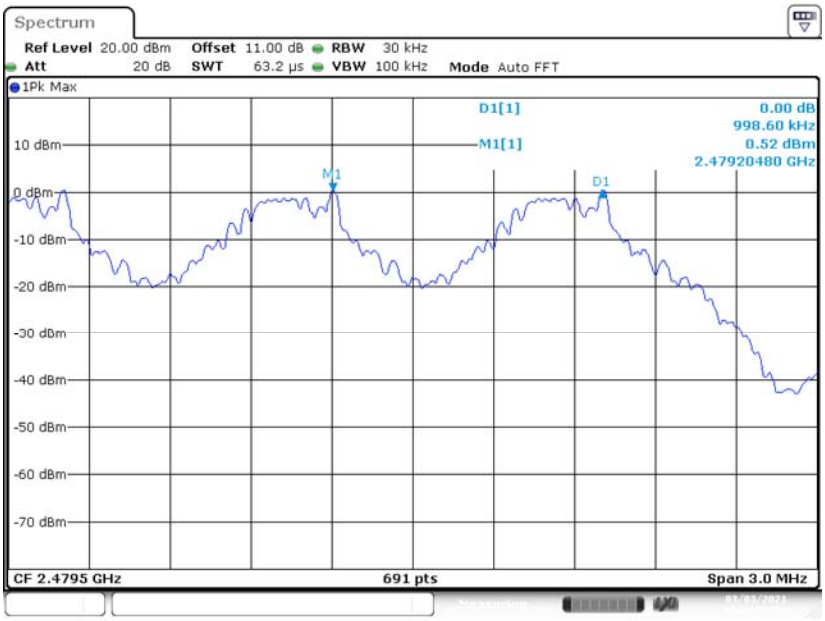


BDR (GFSK): Middle Channel



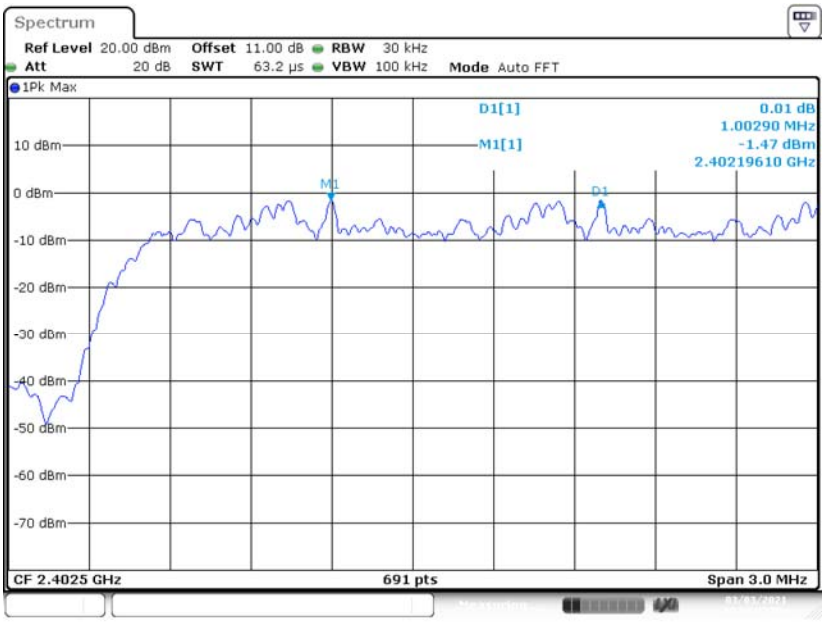
Date: 3.MAR.2021 18:00:28

BDR (GFSK): High Channel



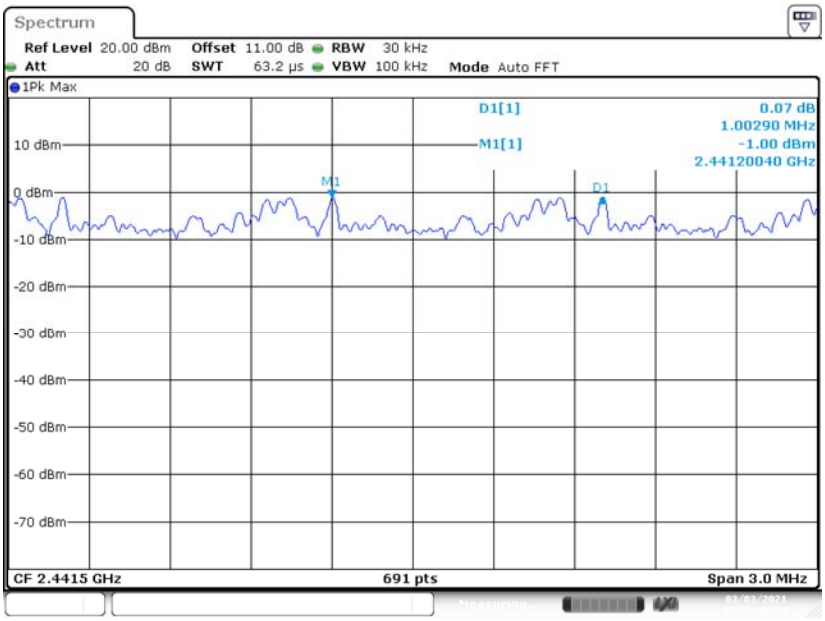
Date: 3.MAR.2021 18:01:53

EDR (π/4-DQPSK): Low Channel



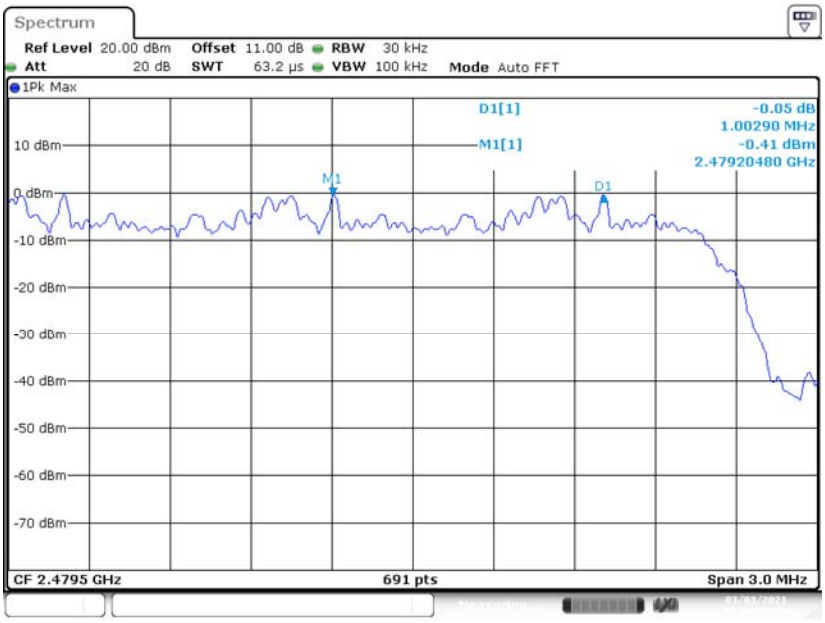
Date: 3.MAR.2021 17:53:32

EDR (π/4-DQPSK): Middle Channel



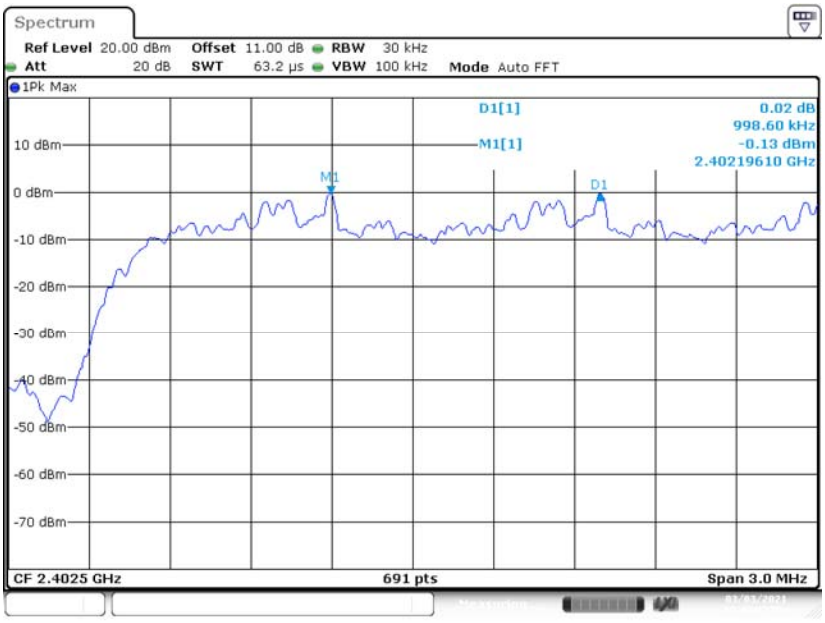
Date: 3.MAR.2021 17:52:06

EDR (π/4-DQPSK): High Channel



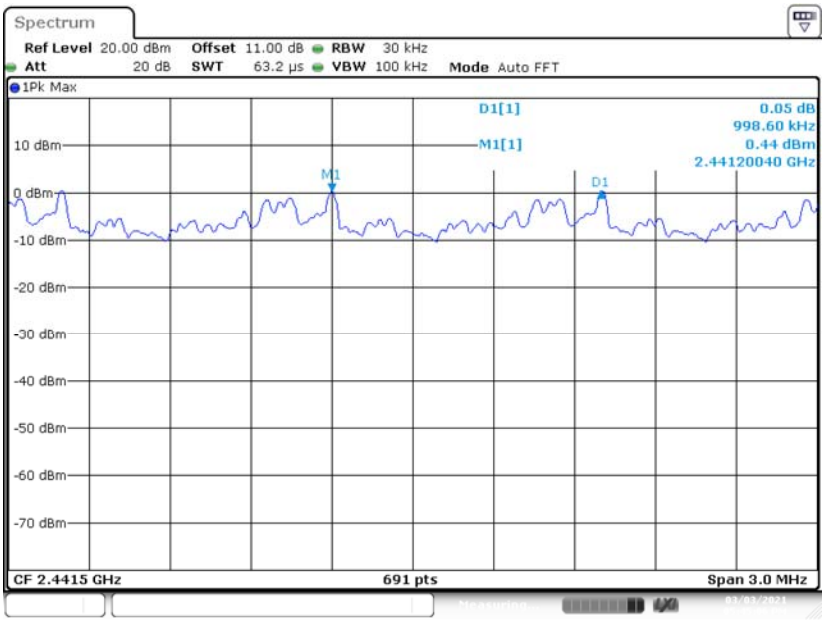
Date: 3.MAR.2021 17:49:51

EDR (8DPSK): Low Channel



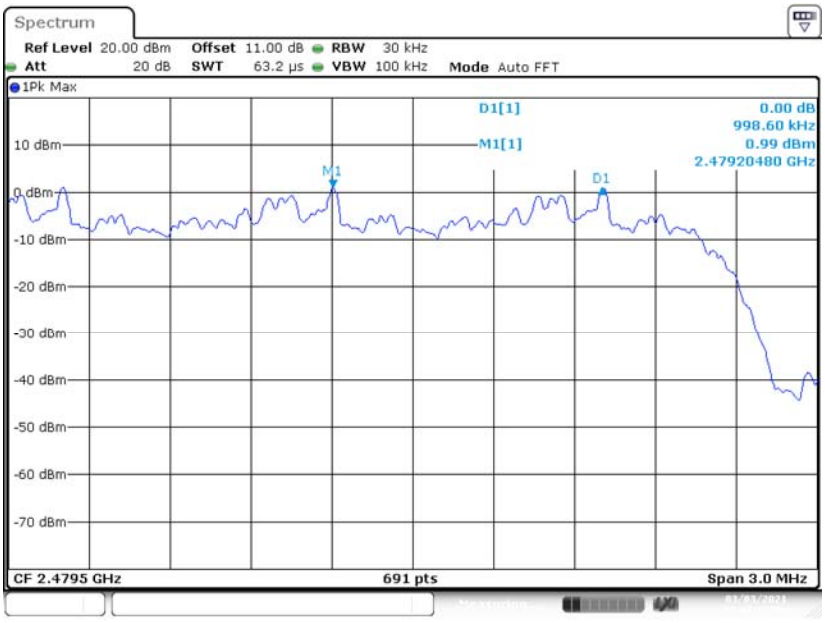
Date: 3.MAR.2021 17:43:02

EDR (8DPSK): Middle Channel



Date: 3.MAR.2021 17:45:07

EDR (8DPSK): High Channel



Date: 3.MAR.2021 17:47:17

FCC §15.247(a) (1) – 20 dB EMISSION 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

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
3. Measure the frequency difference of two frequencies that were attenuated 20 dB from the reference level. Record the frequency difference as the emission bandwidth.
4. Repeat above procedures until all frequencies measured were complete.

Test Data

Environmental Conditions

Temperature:	24.2 ℃
Relative Humidity:	50 %
ATM Pressure:	101.3 kPa

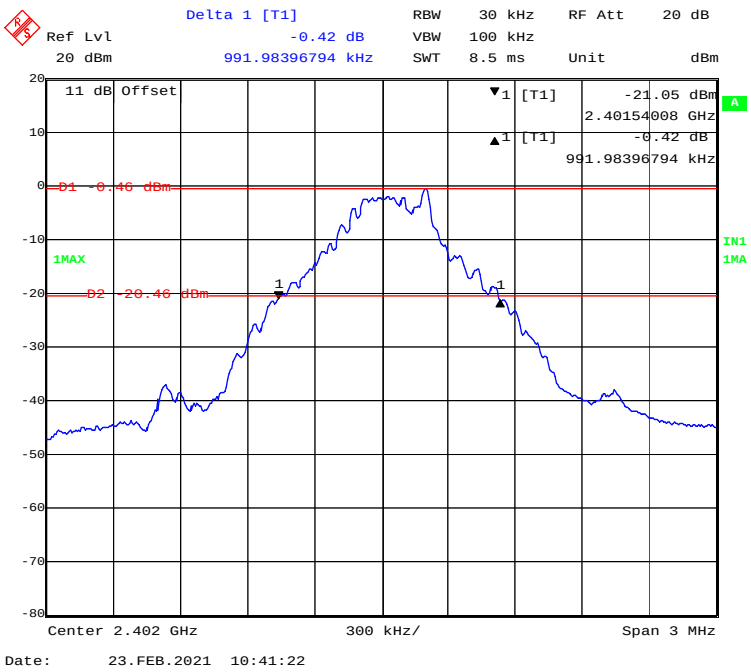
The testing was performed by Chao Gao on 2021-02-23.

EUT operation mode: Transmitting

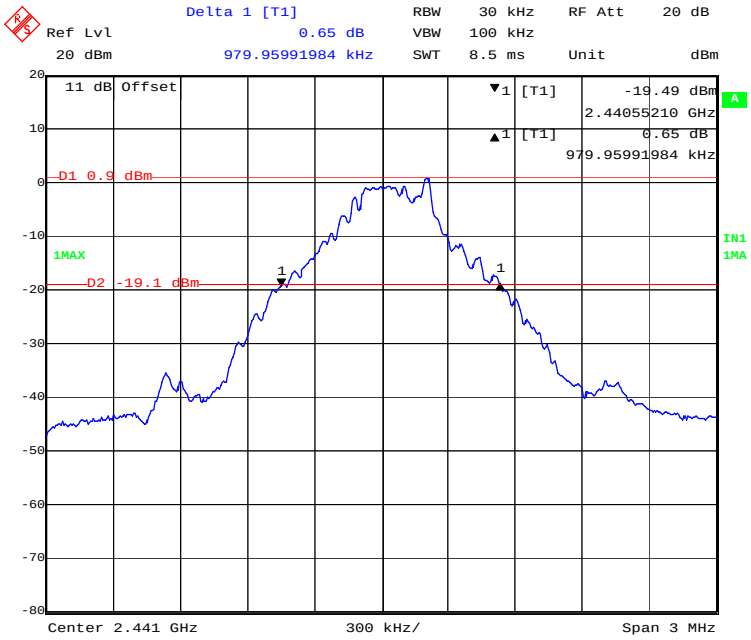
Test Result: Compliant.

Mode	Channel	Frequency (MHz)	20 dB Emission Bandwidth (MHz)
BDR (GFSK)	Low	2402	0.992
	Middle	2441	0.980
	High	2480	0.986
EDR (π/4-DQPSK)	Low	2402	1.377
	Middle	2441	1.377
	High	2480	1.377
EDR (8DPSK)	Low	2402	1.323
	Middle	2441	1.329
	High	2480	1.335

BDR (GFSK): Low Channel

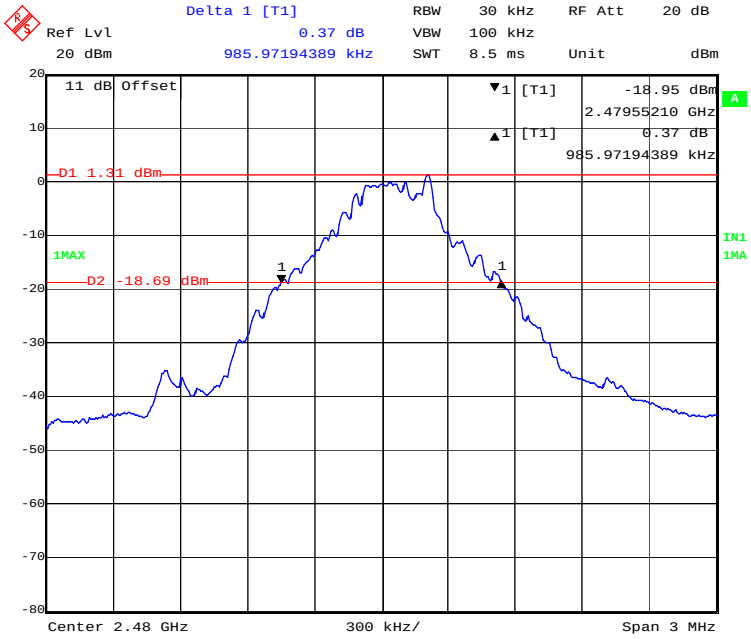


BDR (GFSK): Middle Channel



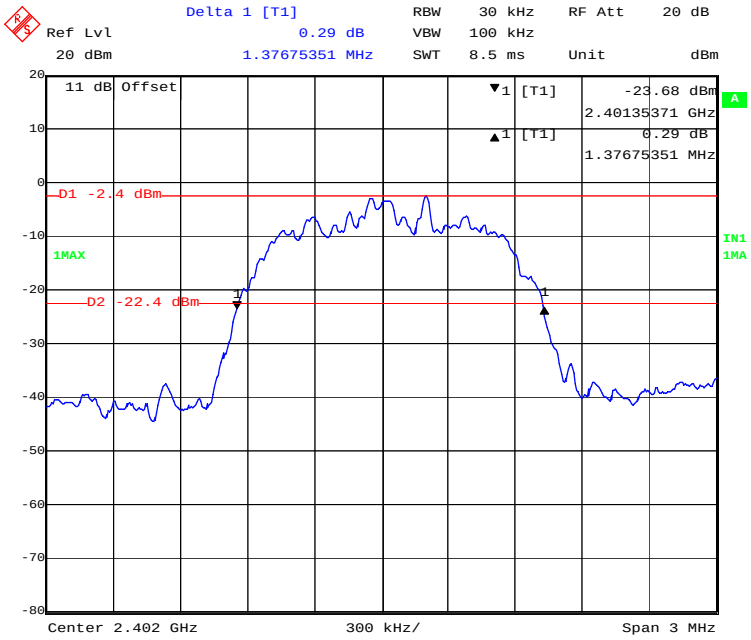
Date: 23.FEB.2021 10:04:56

BDR (GFSK): High Channel

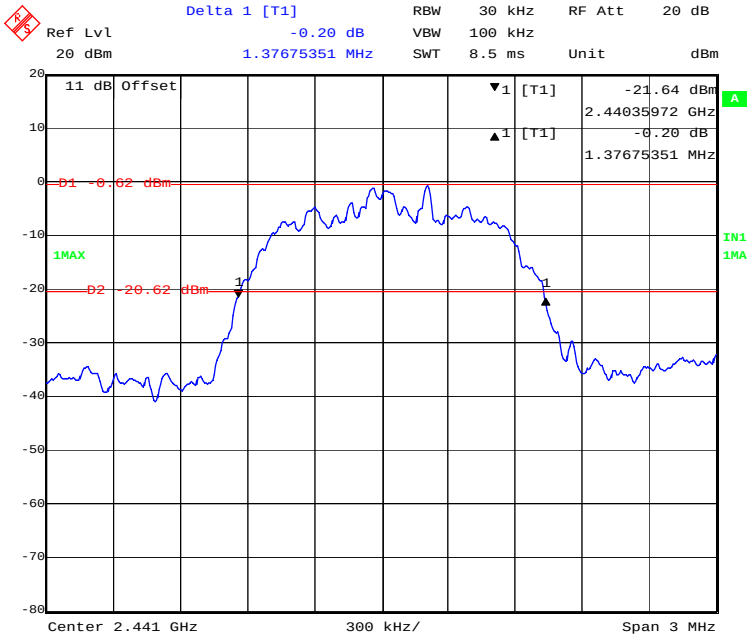


Date: 23.FEB.2021 10:02:35

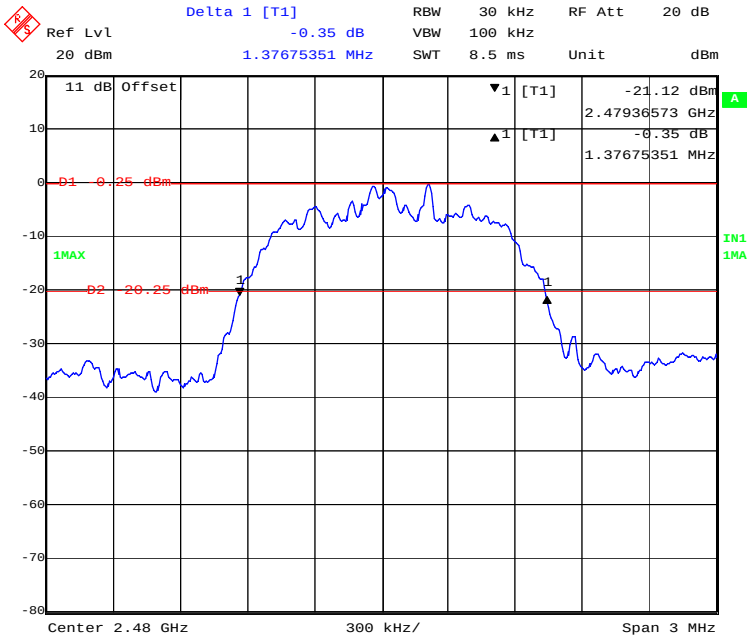
EDR (π/4-DQPSK): Low Channel



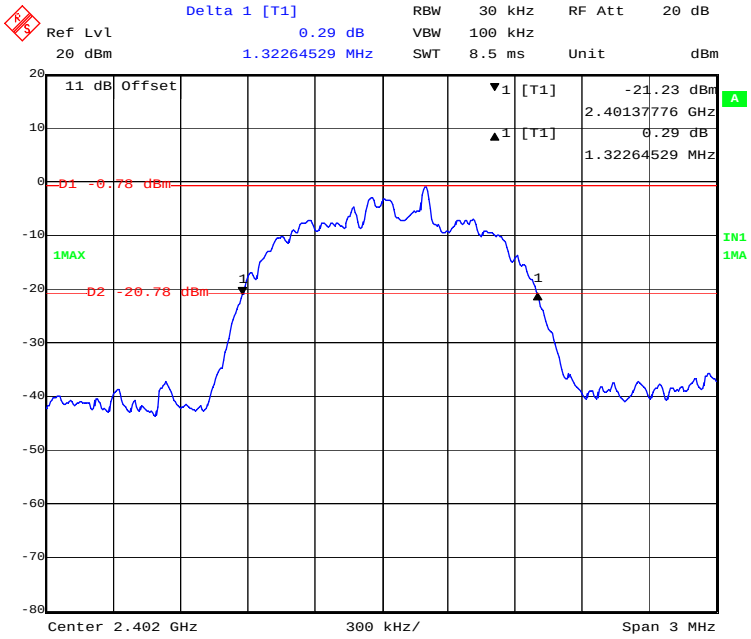
EDR(π/4-DQPSK): Middle Channel



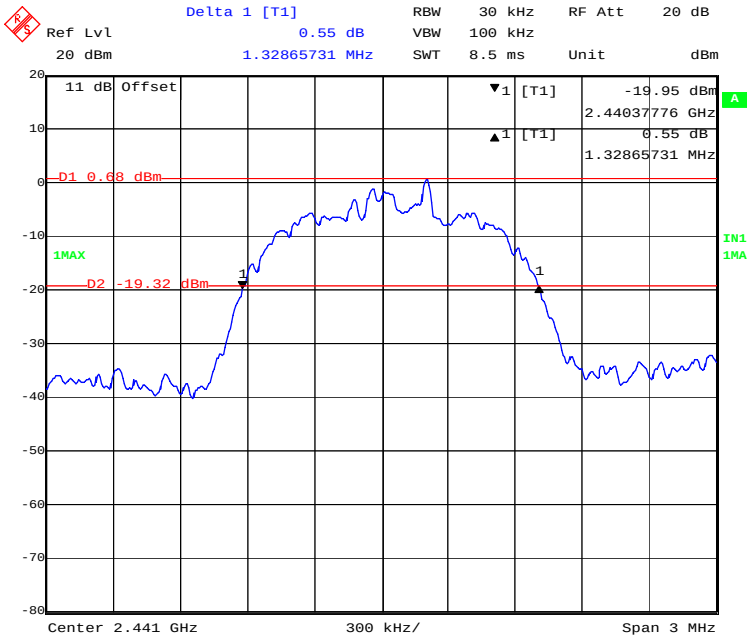
EDR (π/4-DQPSK): High Channel



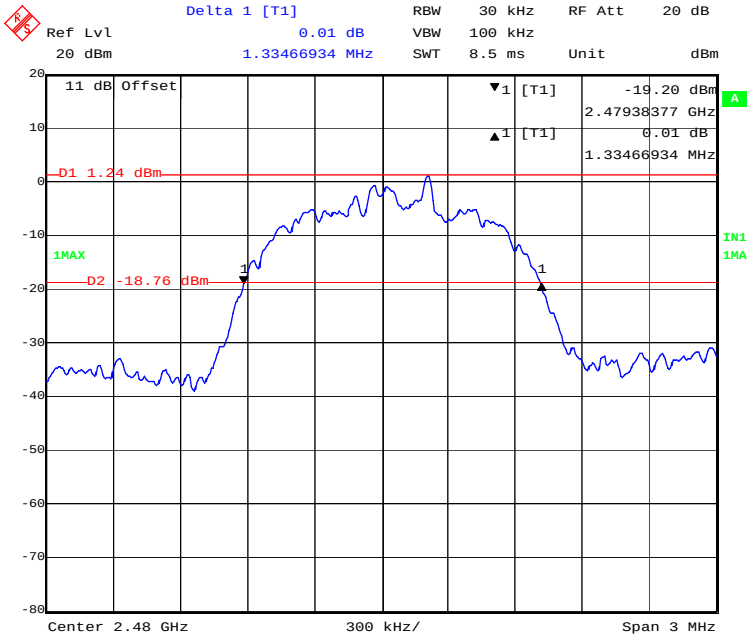
EDR (8DPSK): Low Channel



EDR (8DPSK): Middle Channel



EDR (8DPSK): High Channel



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

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

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

It might prove necessary to break the span up into subranges to show clearly all of the hopping frequencies.

Test Data

Environmental Conditions

Temperature:	24.2 ℃
Relative Humidity:	50 %
ATM Pressure:	101.5 kPa

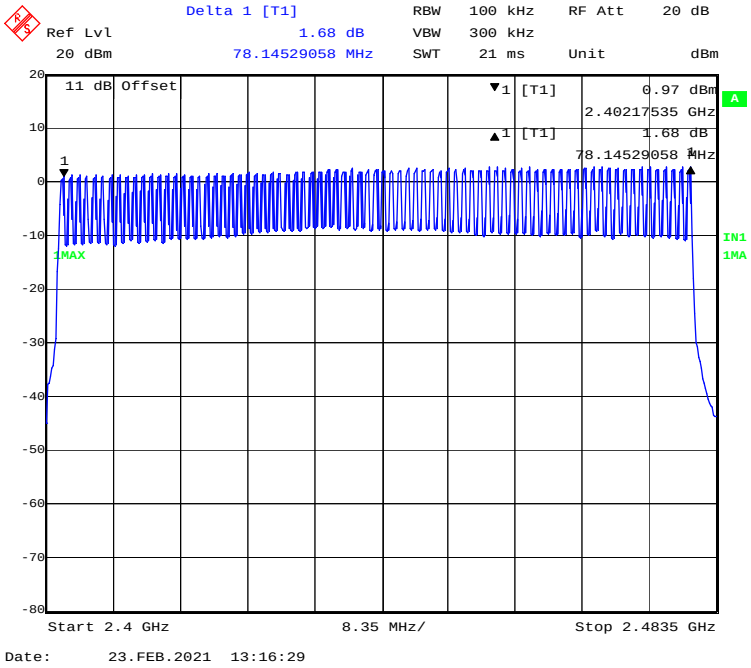
The testing was performed by Chao Gao on 2021-02-23.

EUT operation mode: Hopping

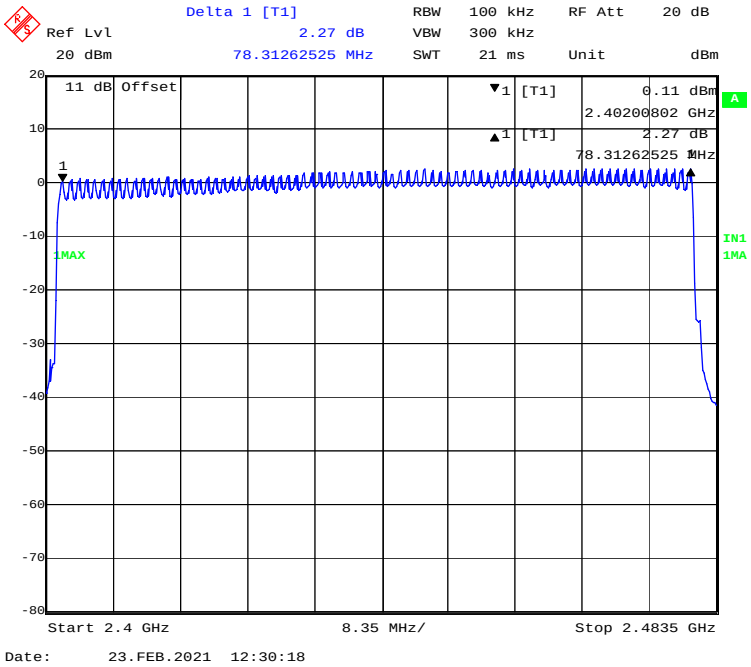
Test Result: Compliant.

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

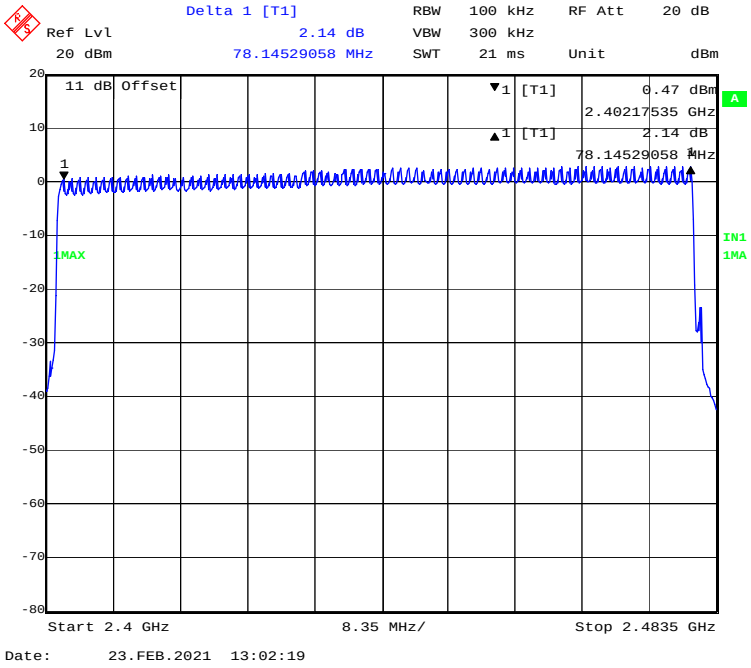
BDR (GFSK): Number of Hopping Channels



EDR (π/4-DQPSK): Number of Hopping Channels



EDR (8DPSK): Number of Hopping Channels



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

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

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

Test Data

Environmental Conditions

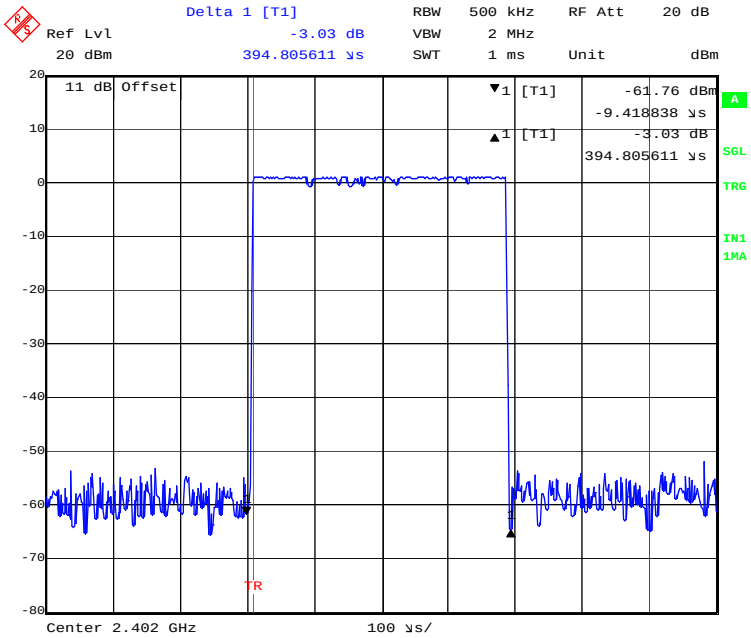
Temperature:	24.2 ℃
Relative Humidity:	50 %
ATM Pressure:	101.2 kPa

The testing was performed by Chao Gao on 2021-02-23.

EUT operation mode: Hopping

Mode		Channel	Pulse Width (ms)	Dwell Time (s)	Limit (s)	Result
BDR (GFSK)	DH1	Low	0.395	0.126	0.4	Pass
		Middle	0.391	0.125	0.4	Pass
		High	0.395	0.126	0.4	Pass
		Note: DH1:Dwell time = Pulse time*(1600/2/79)*31.6S				
	DH3	Low	1.668	0.267	0.4	Pass
		Middle	1.656	0.265	0.4	Pass
		High	1.674	0.268	0.4	Pass
		Note: DH3:Dwell time = Pulse time*(1600/4/79)*31.6S				
	DH5	Low	2.929	0.312	0.4	Pass
		Middle	2.910	0.310	0.4	Pass
		High	2.918	0.311	0.4	Pass
		Note: DH5:Dwell time = Pulse time*(1600/6/79)*31.6S				
EDR (π/4-DQPSK)	2DH1	Low	0.395	0.126	0.4	Pass
		Middle	0.395	0.126	0.4	Pass
		High	0.399	0.128	0.4	Pass
		Note: 2DH1:Dwell time = Pulse time*(1600/2/79)*31.6S				
	2DH3	Low	1.656	0.265	0.4	Pass
		Middle	1.662	0.266	0.4	Pass
		High	1.662	0.266	0.4	Pass
		Note: 2DH3:Dwell time = Pulse time*(1600/4/79)*31.6S				
	2DH5	Low	2.910	0.310	0.4	Pass
		Middle	2.926	0.312	0.4	Pass
		High	2.918	0.311	0.4	Pass
		Note: 2DH5:Dwell time = Pulse time*(1600/6/79)*31.6S				
EDR (8DPSK)	3DH1	Low	0.397	0.127	0.4	Pass
		Middle	0.395	0.126	0.4	Pass
		High	0.405	0.130	0.4	Pass
		Note:3 DH1:Dwell time = Pulse time*(1600/2/79)*31.6S				
	3DH3	Low	1.662	0.266	0.4	Pass
		Middle	1.662	0.266	0.4	Pass
		High	1.668	0.267	0.4	Pass
		Note: 3DH3:Dwell time = Pulse time*(1600/4/79)*31.6S				
	3DH5	Low	2.918	0.311	0.4	Pass
		Middle	2.926	0.312	0.4	Pass
		High	2.918	0.311	0.4	Pass
		Note: 3DH5:Dwell time = Pulse time*(1600/6/79)*31.6S				

BDR (GFSK): Pulse time, Low Channel, DH1



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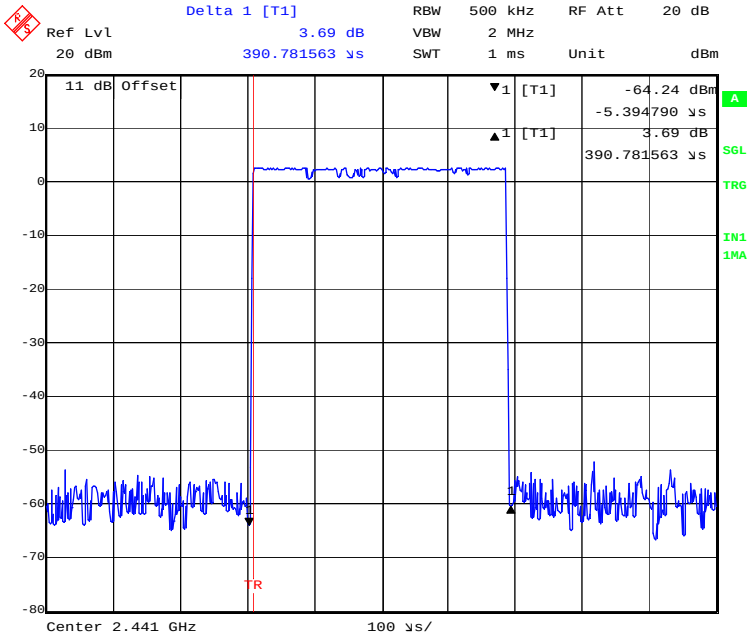
BDR (GFSK): Pulse time, Middle Channel, DH1



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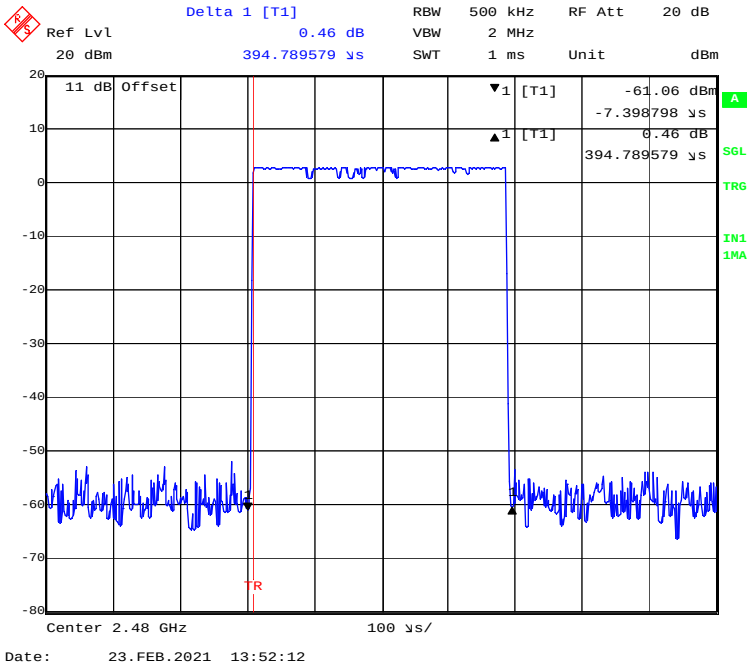
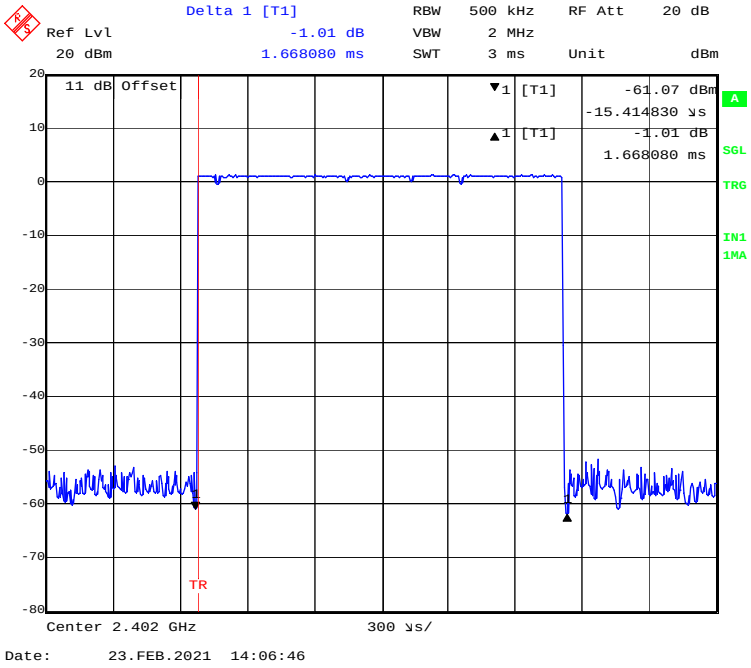
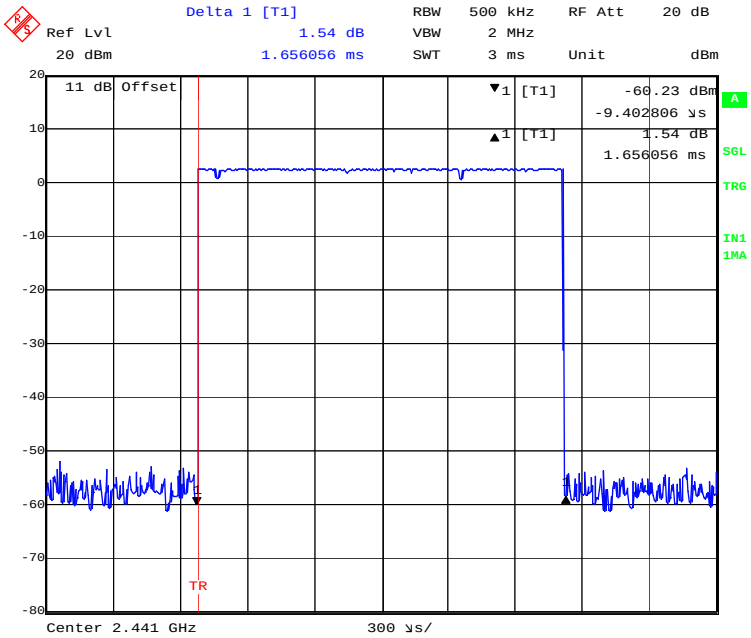
BDR (GFSK): Pulse time, High Channel, DH1



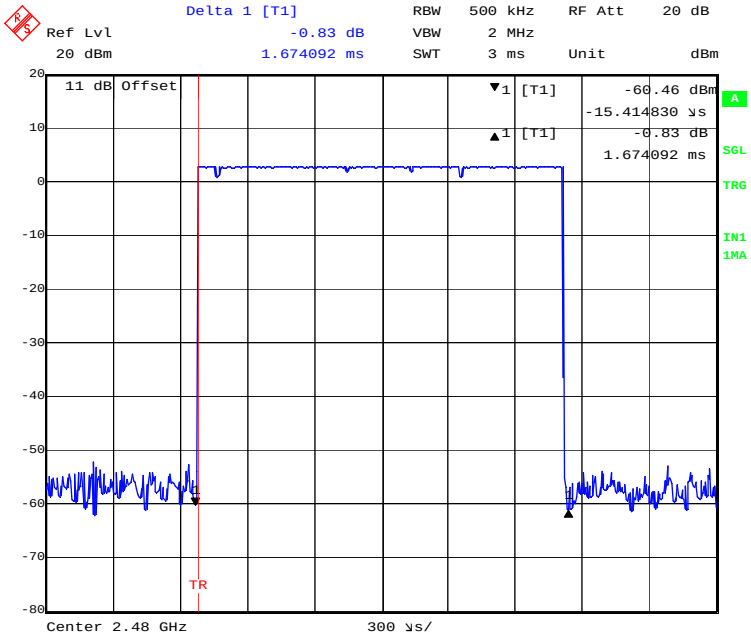
BDR (GFSK): Pulse time, Low Channel, DH3



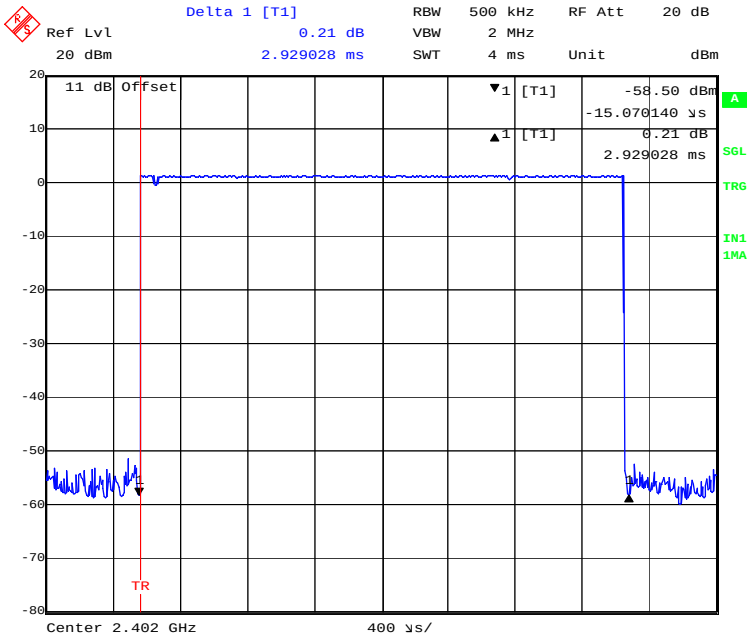
BDR (GFSK): Pulse time, Middle Channel, DH3



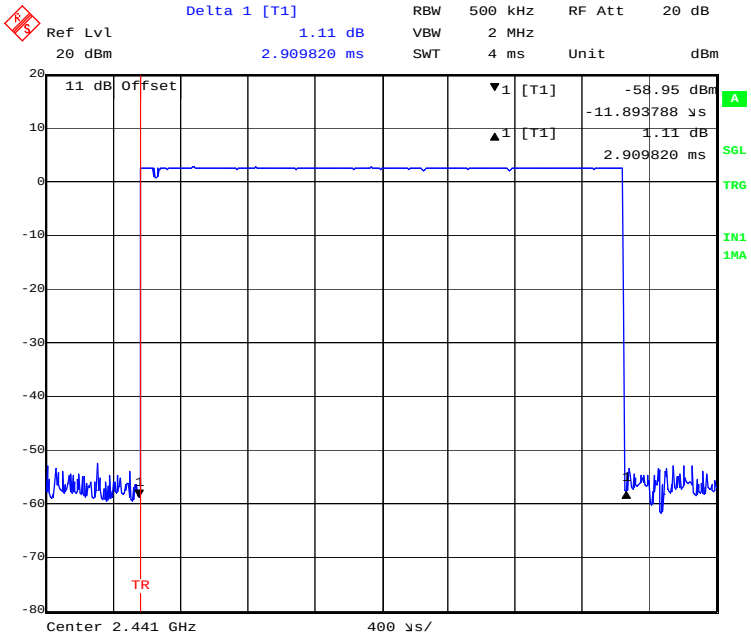
BDR (GFSK): Pulse time, High Channel, DH3



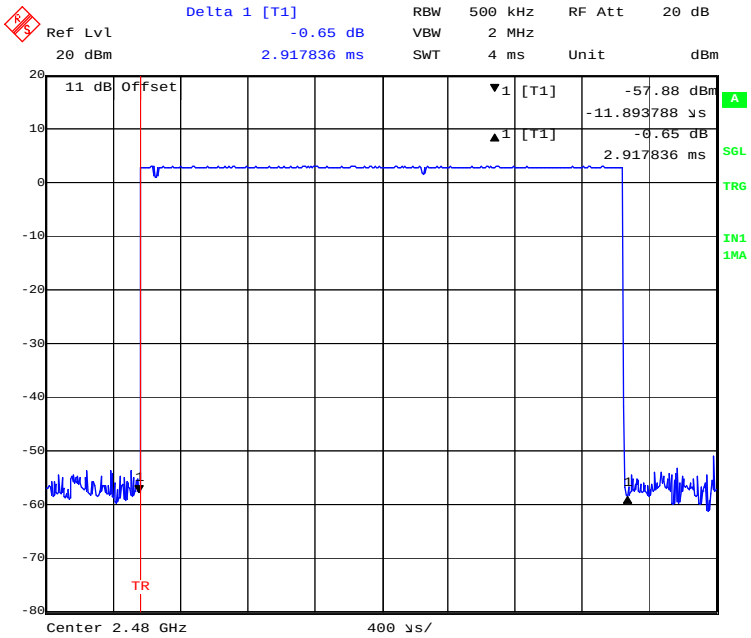
BDR (GFSK): Pulse time, Low Channel, DH5



BDR (GFSK): Pulse time, Middle Channel, DH5



BDR (GFSK): Pulse time, High Channel, DH5



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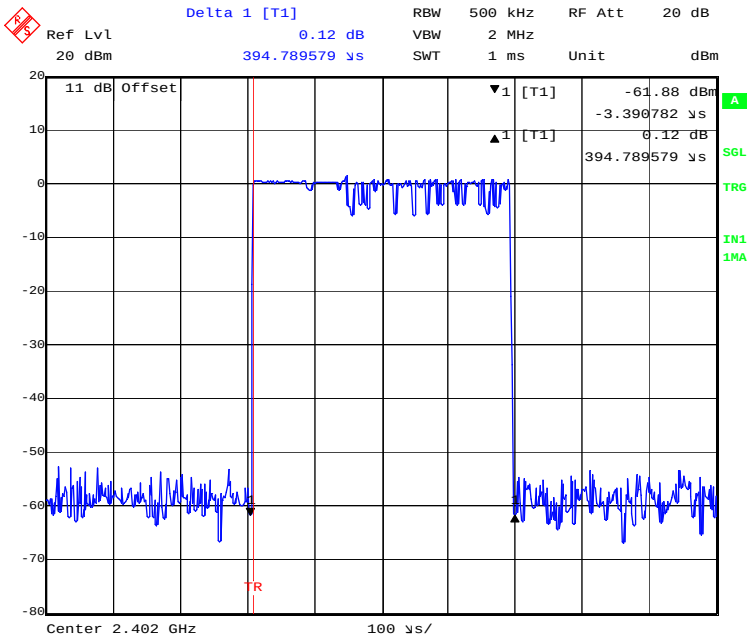
EDR (π/4-DQPSK): Pulse time, Low Channel, 2DH1



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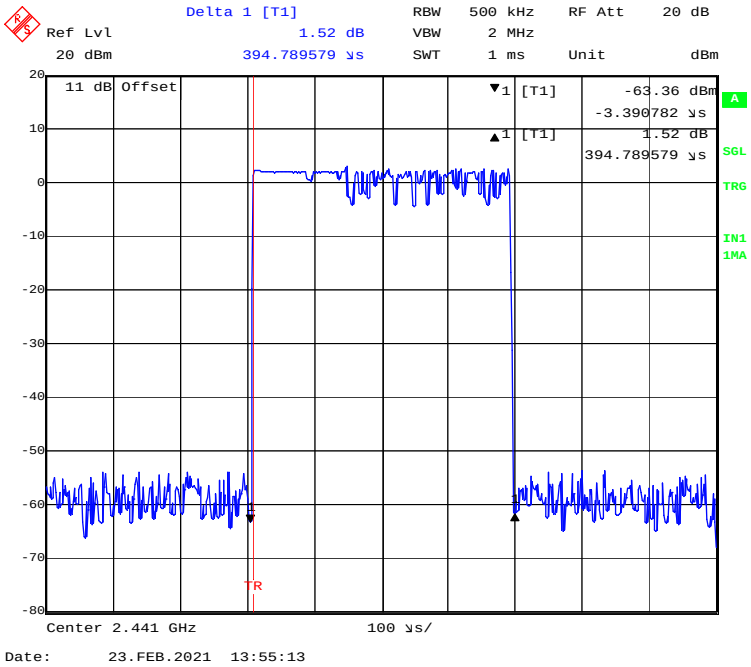
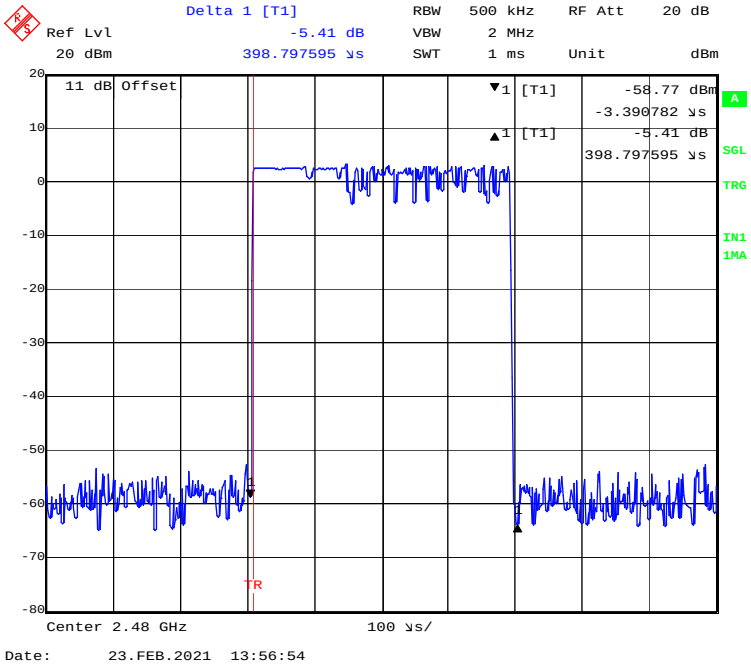
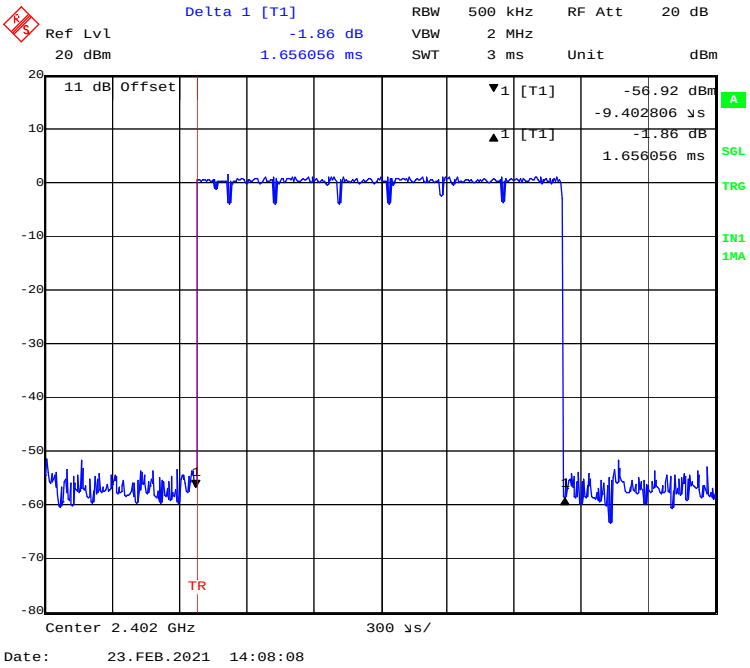
EDR (π/4-DQPSK):Pulse time, Middle Channel, 2DH1



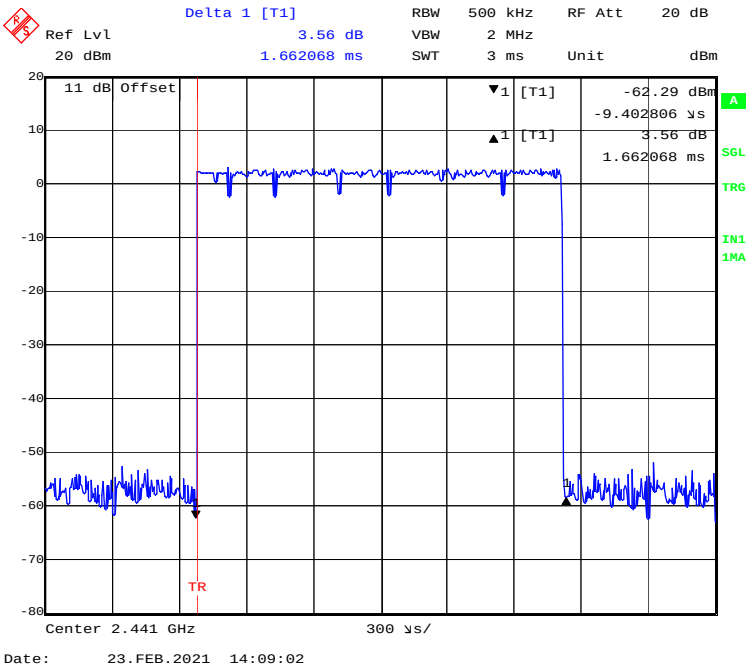
EDR (π/4-DQPSK):Pulse time, High Channel, 2DH1



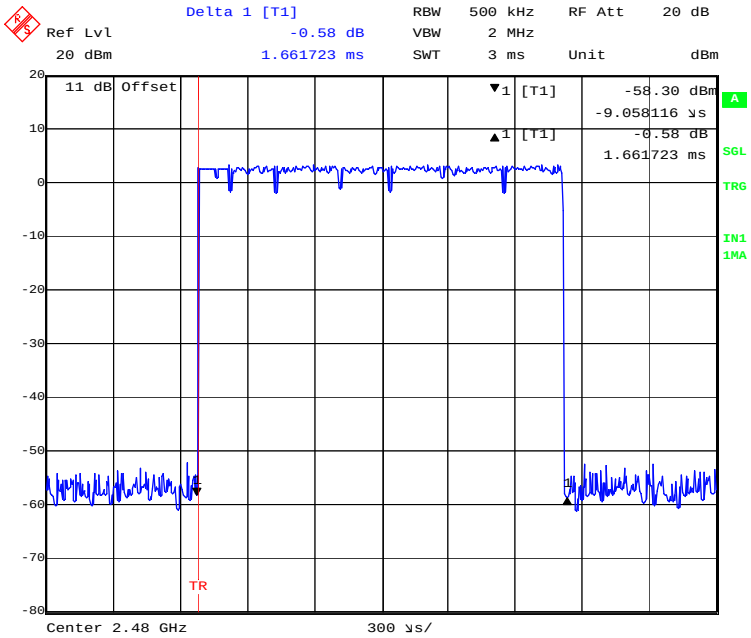
EDR (π/4-DQPSK):Pulse time, Low Channel, 2DH3



EDR (π/4-DQPSK):Pulse time, Middle Channel, 2DH3



EDR (π/4-DQPSK):Pulse time, High Channel, 2DH3



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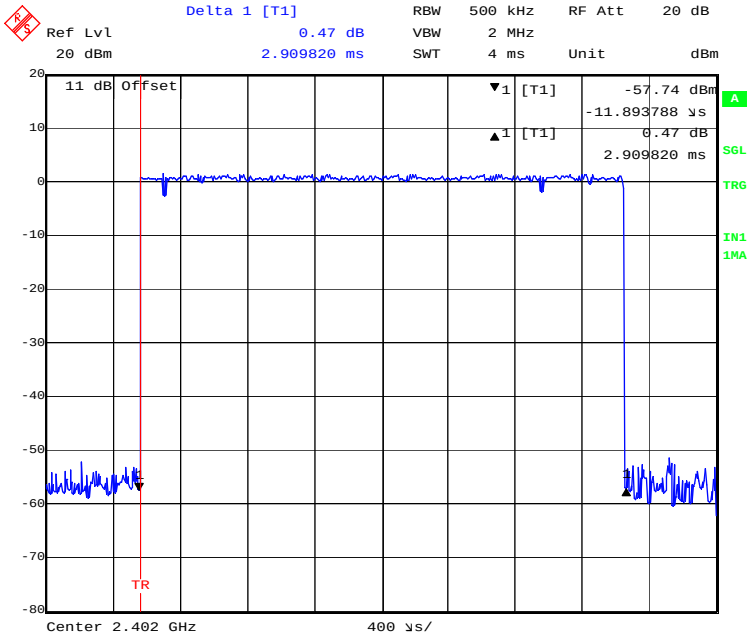
EDR (π/4-DQPSK):Pulse time, Low Channel, 2DH5



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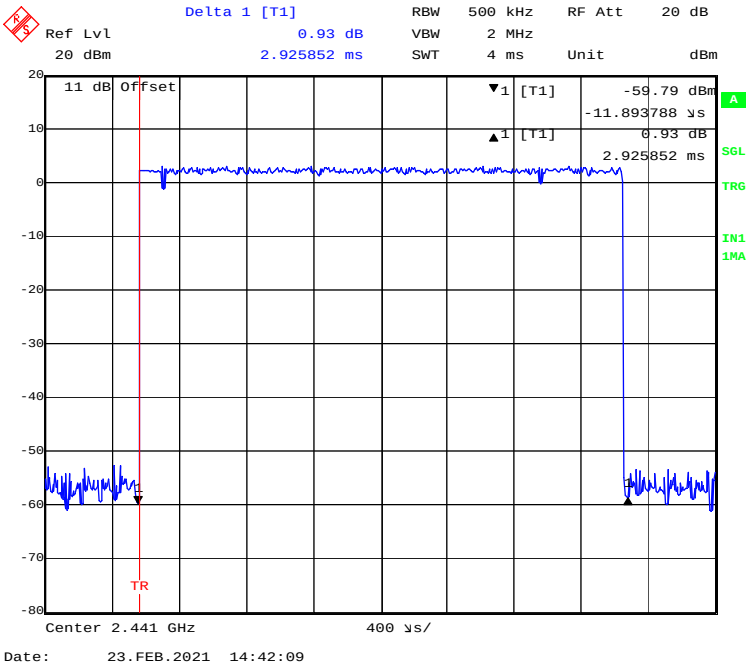
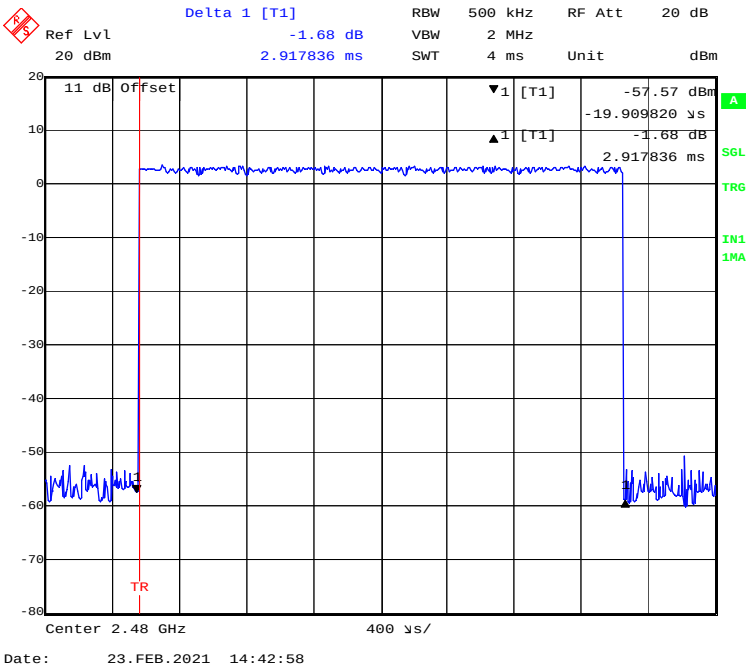
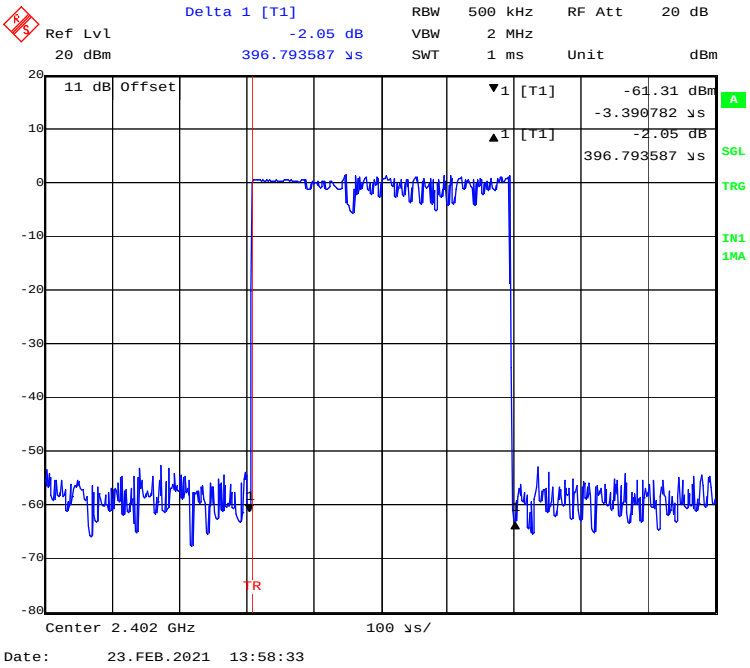
EDR (π/4-DQPSK):Pulse time, Middle Channel, 2DH5



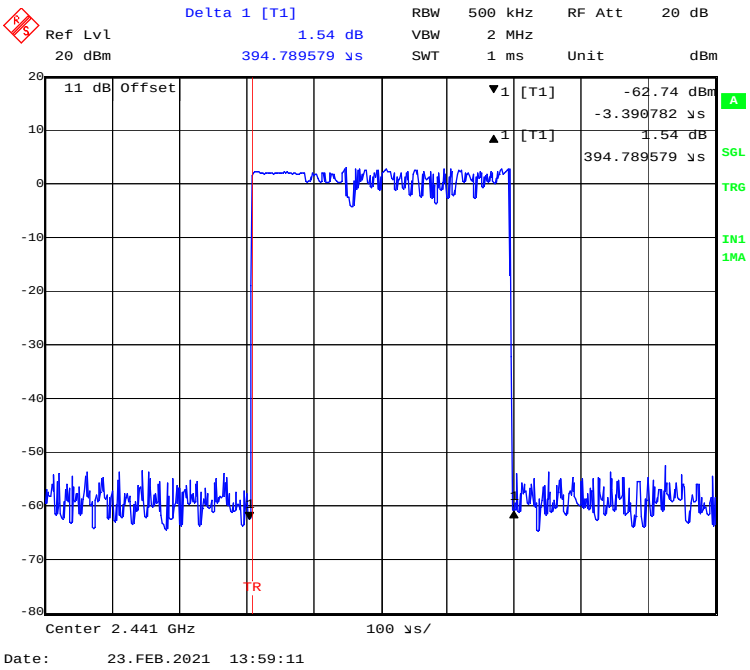
EDR (π/4-DQPSK):Pulse time, High Channel, 2DH5



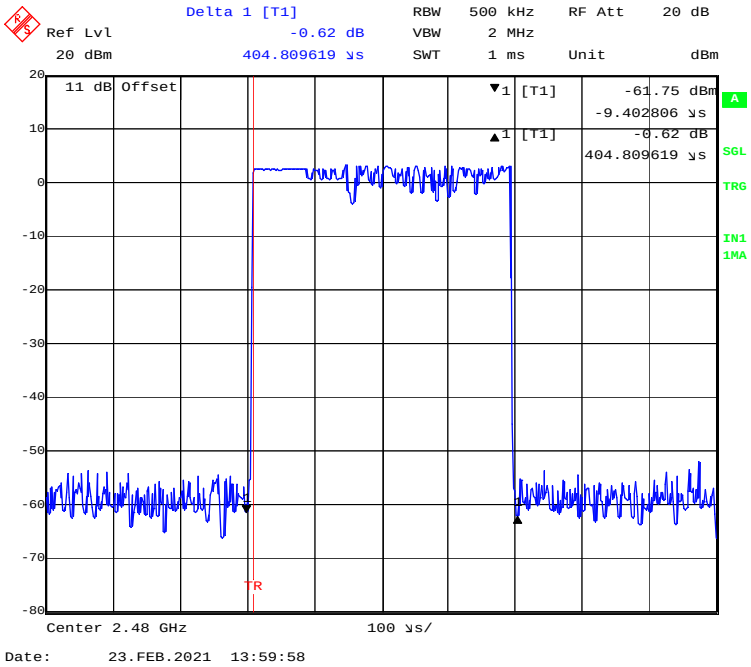
EDR (8DPSK): Pulse time, Low Channel, 3DH1



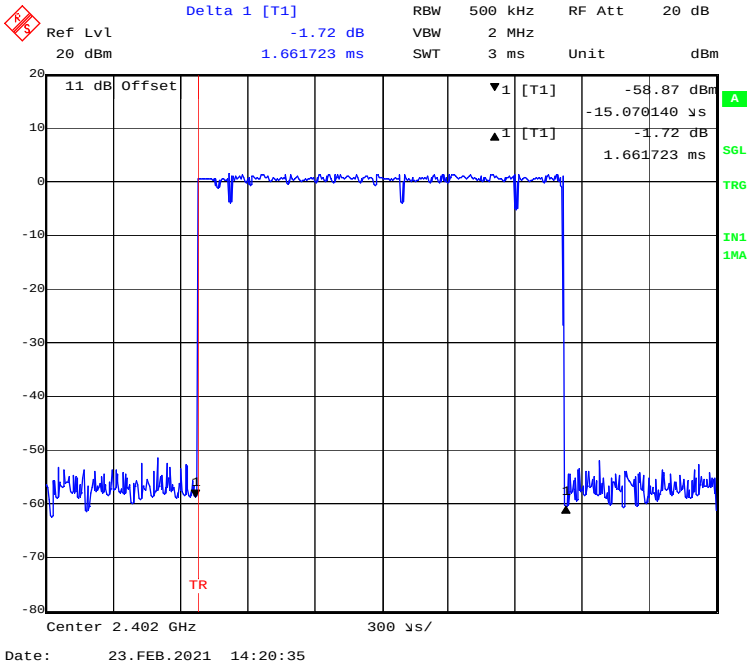
EDR (8DPSK): Pulse time, Middle Channel, 3DH1



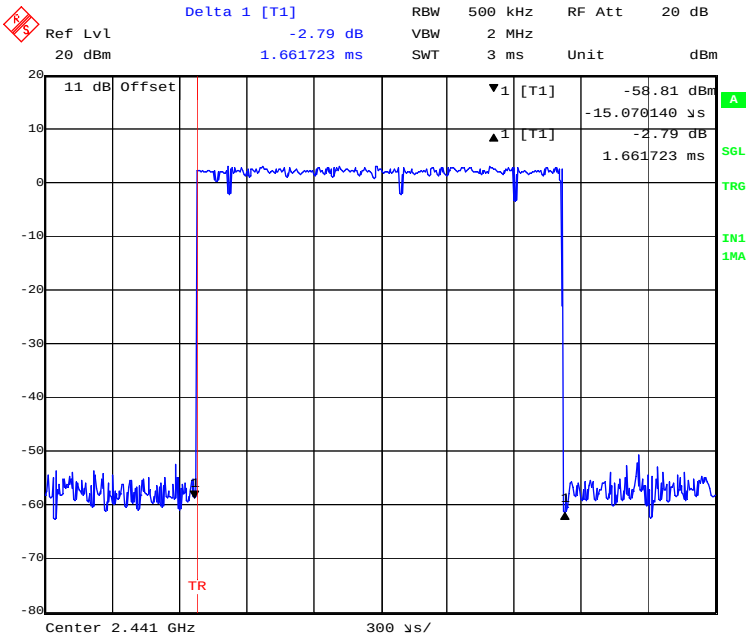
EDR (8DPSK): Pulse time, High Channel, 3DH1



EDR (8DPSK): Pulse time, Low Channel, 3DH3



EDR (8DPSK): Pulse time, Middle Channel, 3DH3



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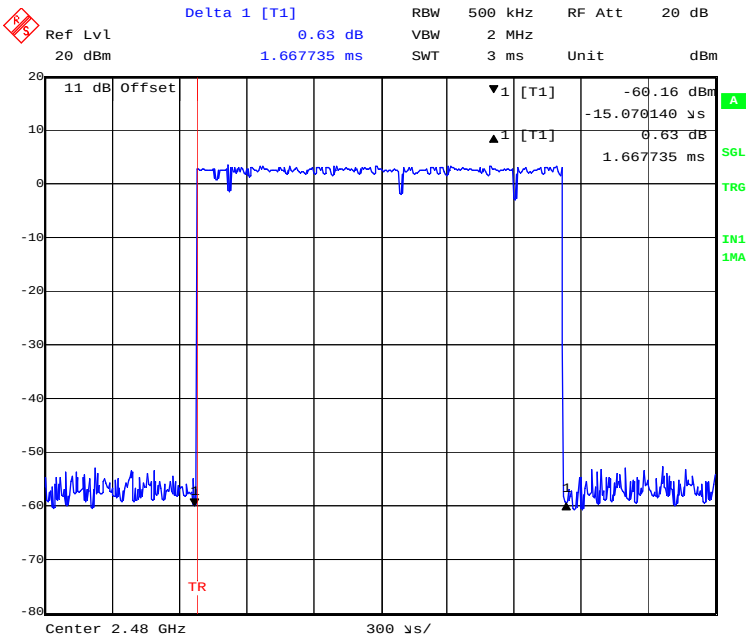
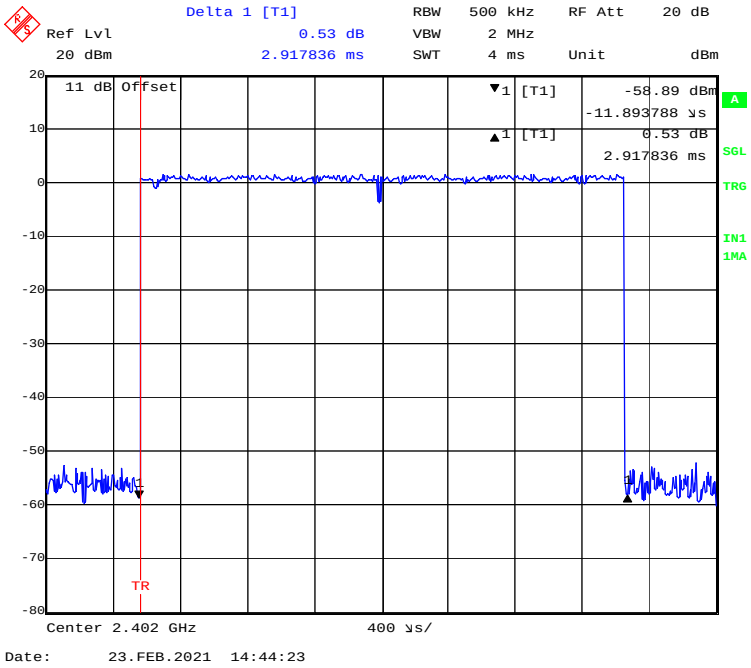
EDR (8DPSK): Pulse time, High Channel, 3DH3

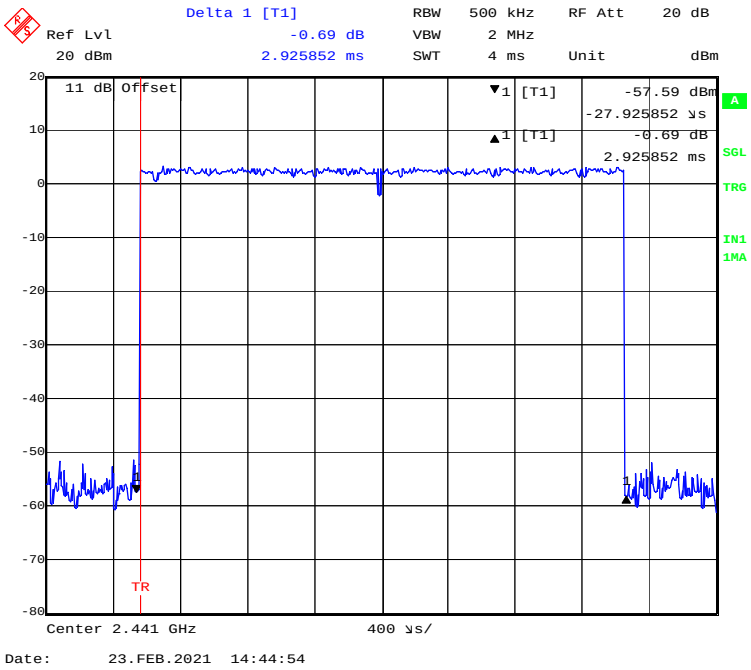


Date: 23.FEB.2021 14:22:32

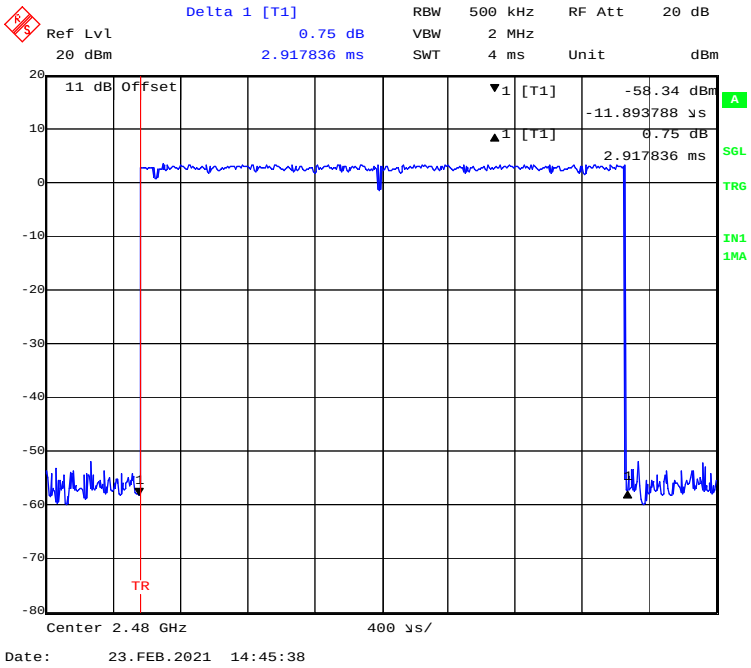
EDR (8DPSK): Pulse time, Low Channel, 3DH5



EDR (8DPSK): Pulse time, Middle Channel, 3DH5



EDR (8DPSK): Pulse time, High Channel, 3DH5



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

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

Test Data

Environmental Conditions

Temperature:	24.2 ℃
Relative Humidity:	50 %
ATM Pressure:	101.2 kPa

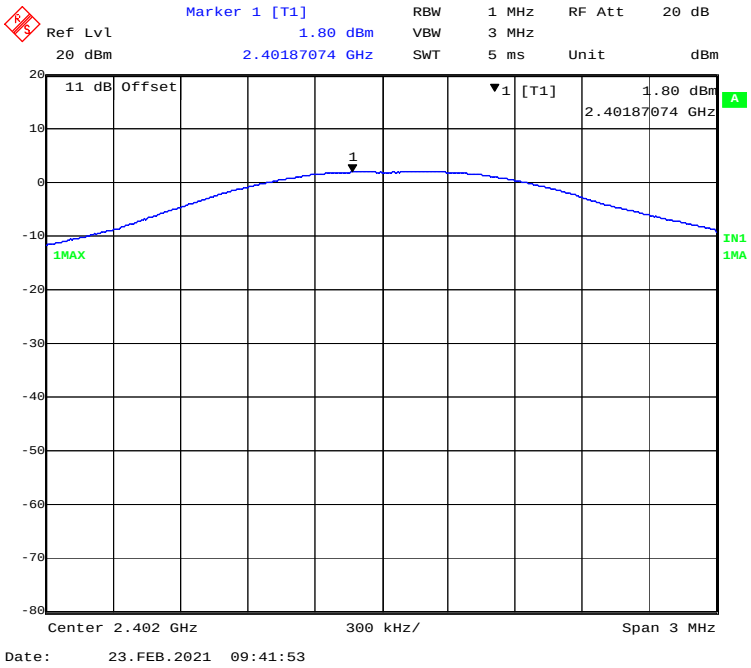
The testing was performed by Chao Gao on 2021-02-23.

EUT operation mode: Transmitting

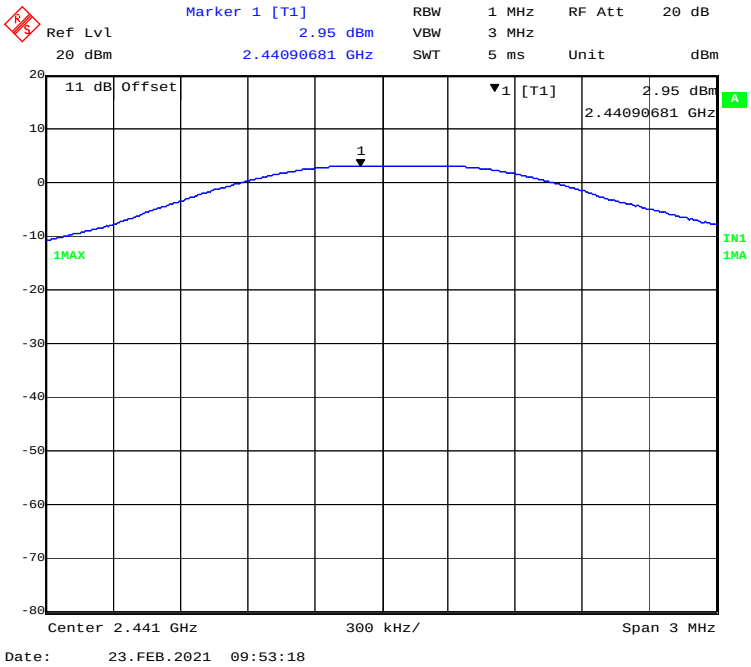
Test Result: Compliant.

Mode	Frequency (MHz)	Max Conducted Peak Output Power		Limit (mW)
		(dBm)	(mW)	
BDR (GFSK)	2402	1.80	1.51	1000
	2441	2.95	1.97	1000
	2480	3.26	2.12	1000
EDR (π/4-DQPSK)	2402	2.82	1.91	125
	2441	4.23	2.65	125
	2480	4.62	2.90	125
EDR (8DPSK)	2402	3.20	2.09	125
	2441	4.49	2.81	125
	2480	4.89	3.08	125

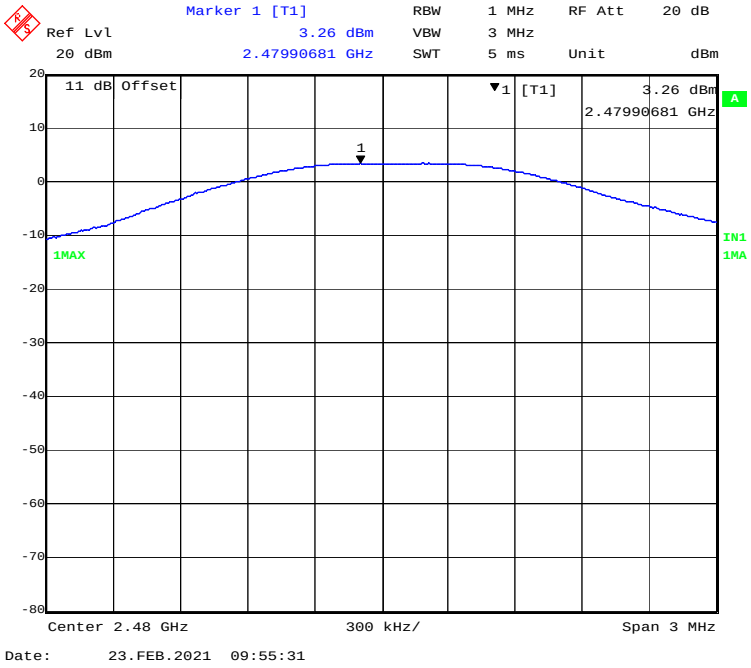
BDR (GFSK): 2402MHz



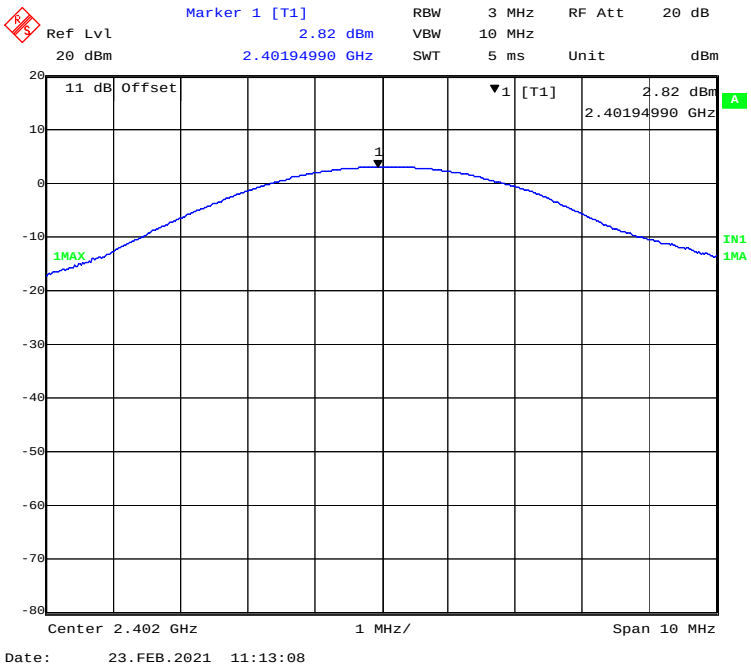
BDR (GFSK): 2441MHz



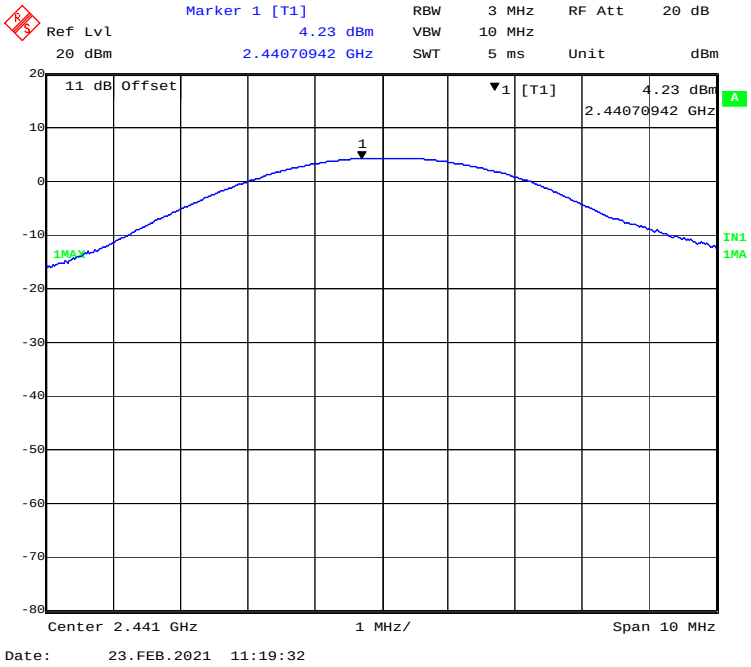
BDR (GFSK): 2480MHz



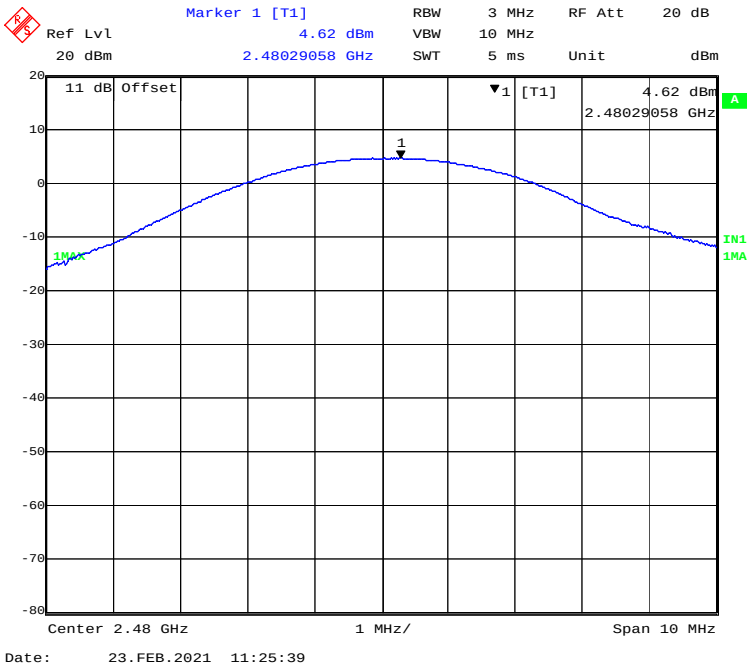
EDR(π/4-DQPSK): 2402MHz



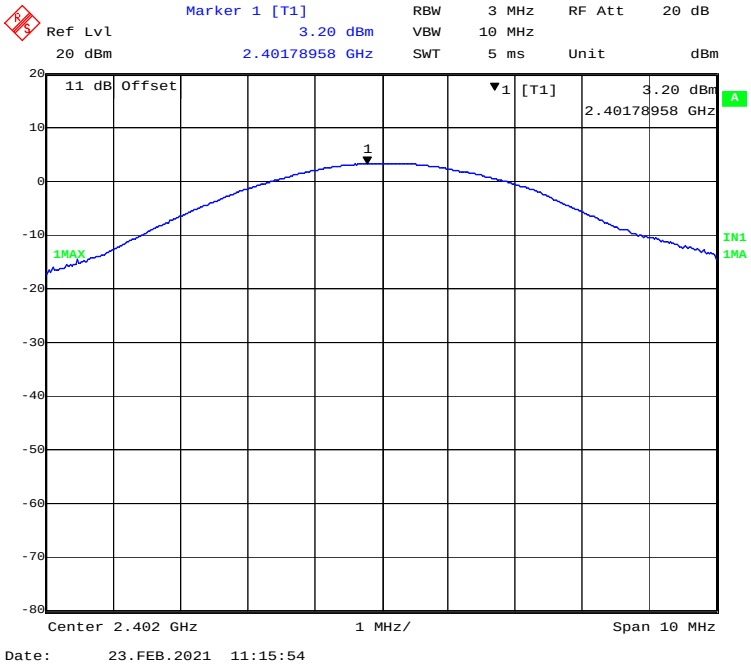
EDR(π/4-DQPSK): 2441MHz



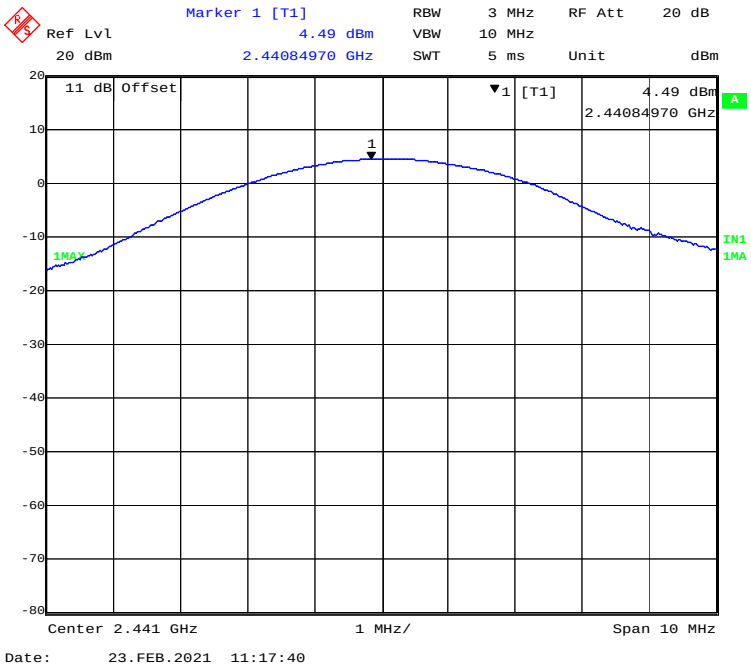
EDR(π/4-DQPSK): 2480MHz



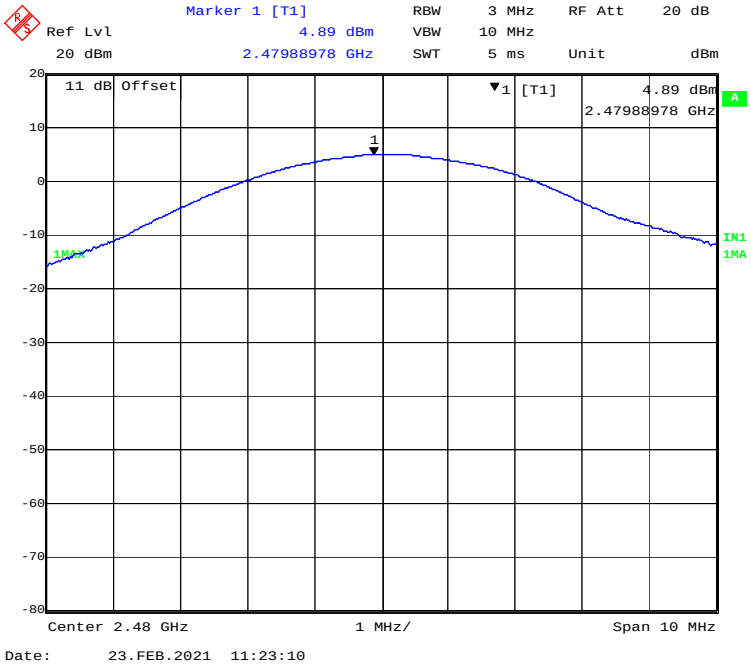
EDR(8DPSK): 2402MHz



EDR(8DPSK): 2441MHz



EDR(8DPSK): 2480MHz



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

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:	23.0~24.3 ℃
Relative Humidity:	51~53 %
ATM Pressure:	100.9~101.6 kPa

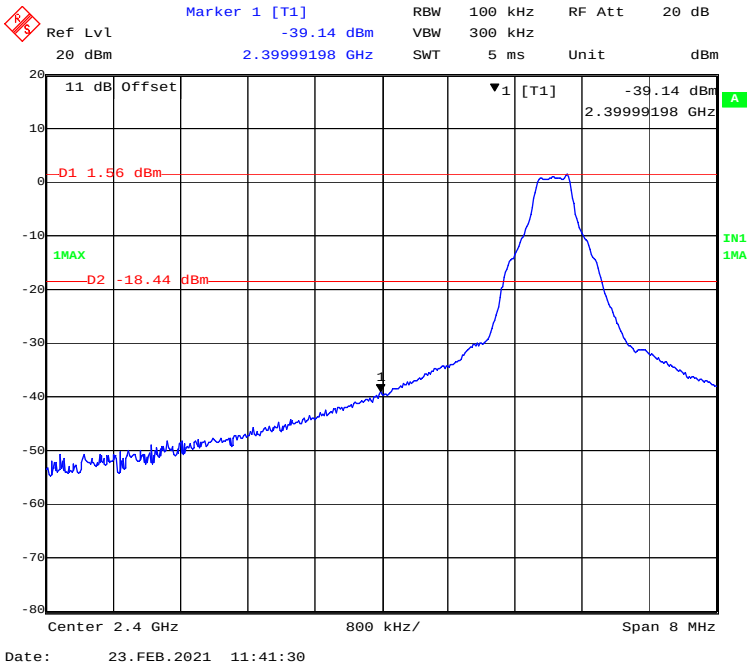
The testing was performed by Chao Gao from 2021-02-23 to 2021-03-03.

EUT operation mode: Transmitting & Hopping

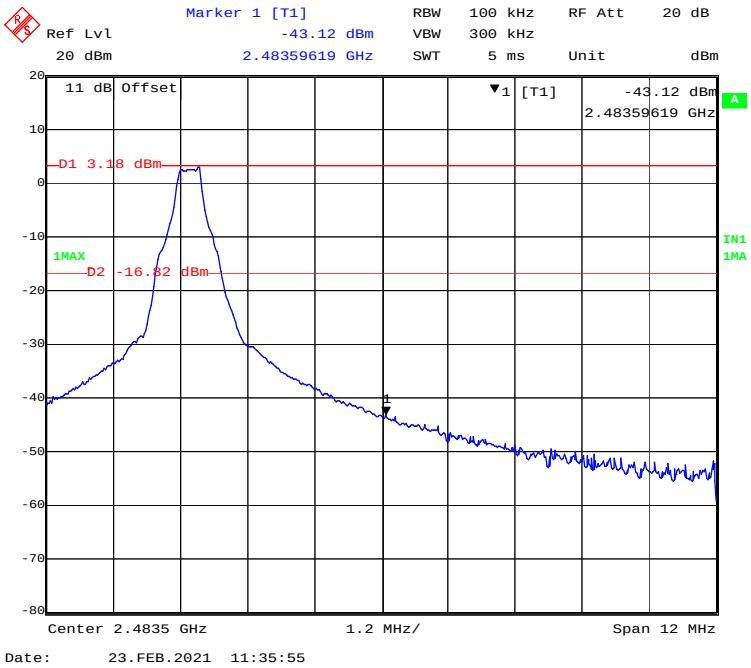
Test Result: Compliant.

Band Edge

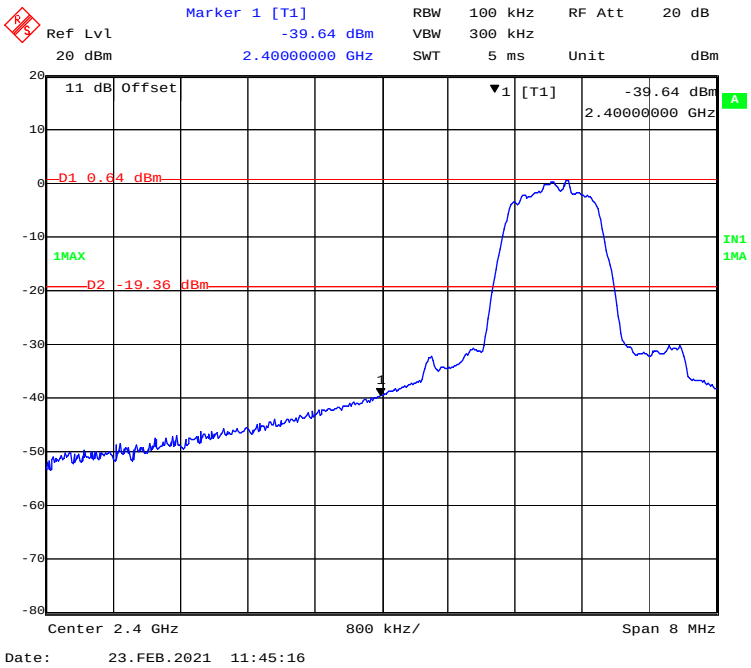
BDR (GFSK): Left Side



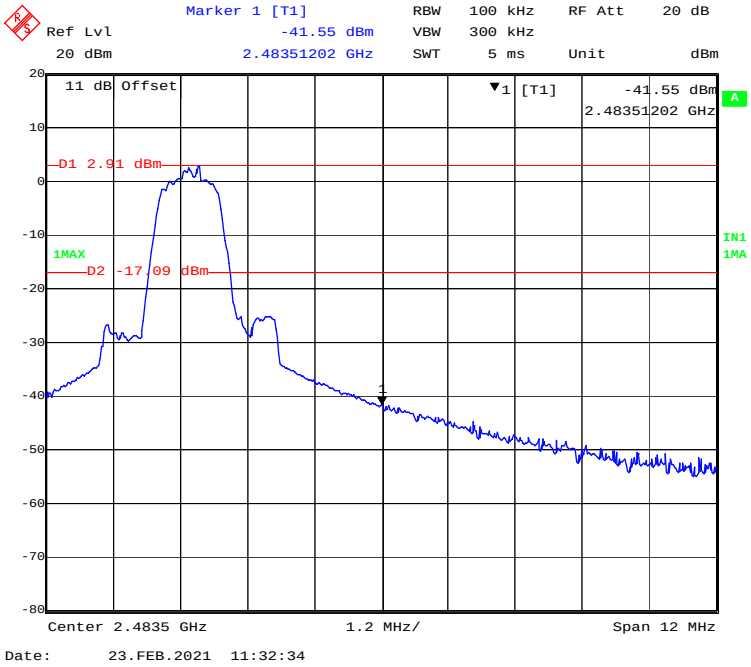
BDR (GFSK): Right Side



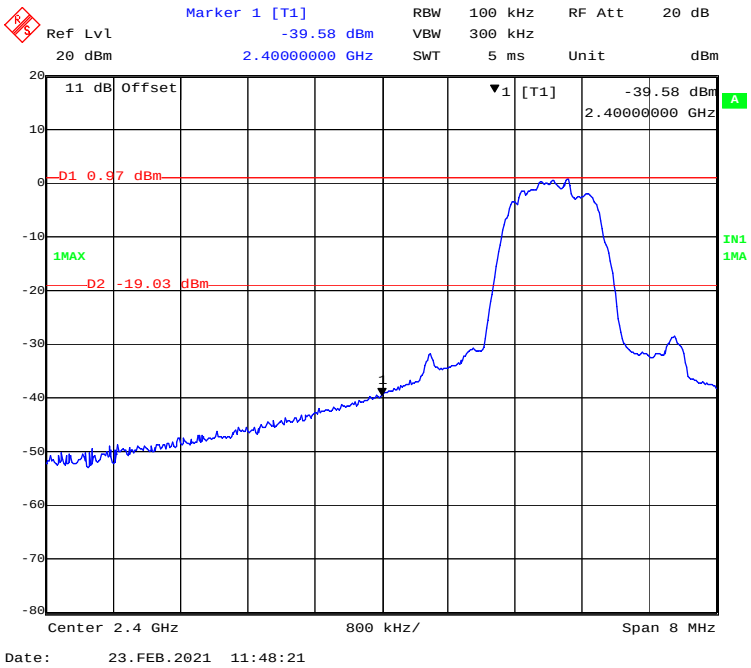
EDR (π/4-DQPSK): Left Side



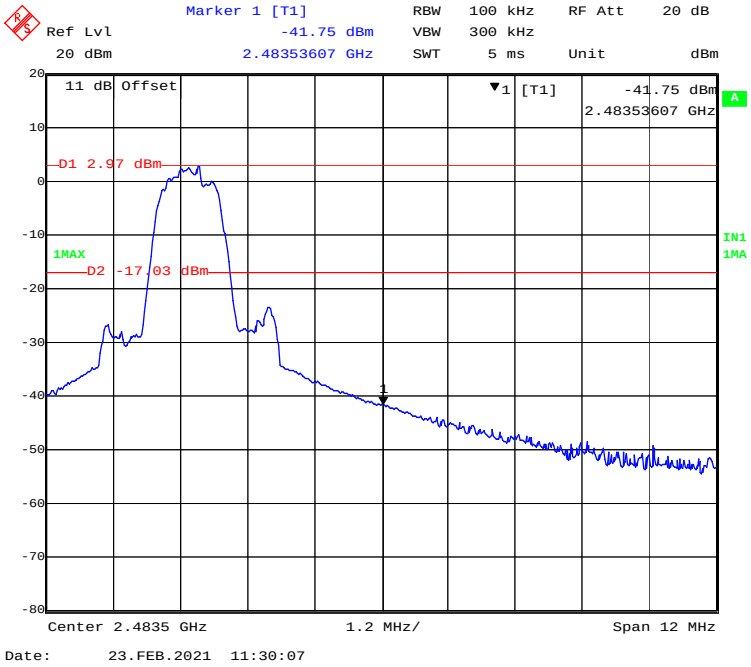
EDR (π/4-DQPSK): Right Side



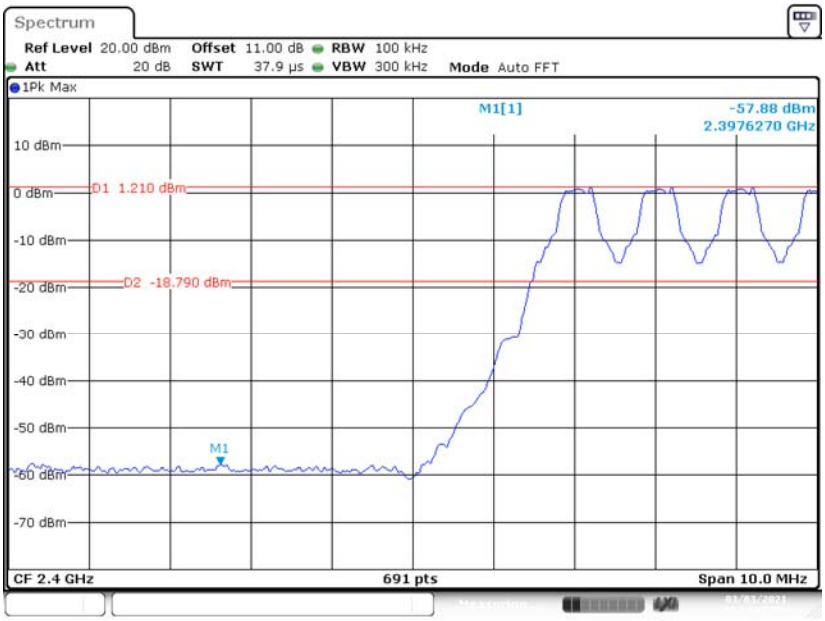
EDR (8DPSK): Left Side



EDR (8DPSK): Right Side



BDR (GFSK): Left Side - Hopping



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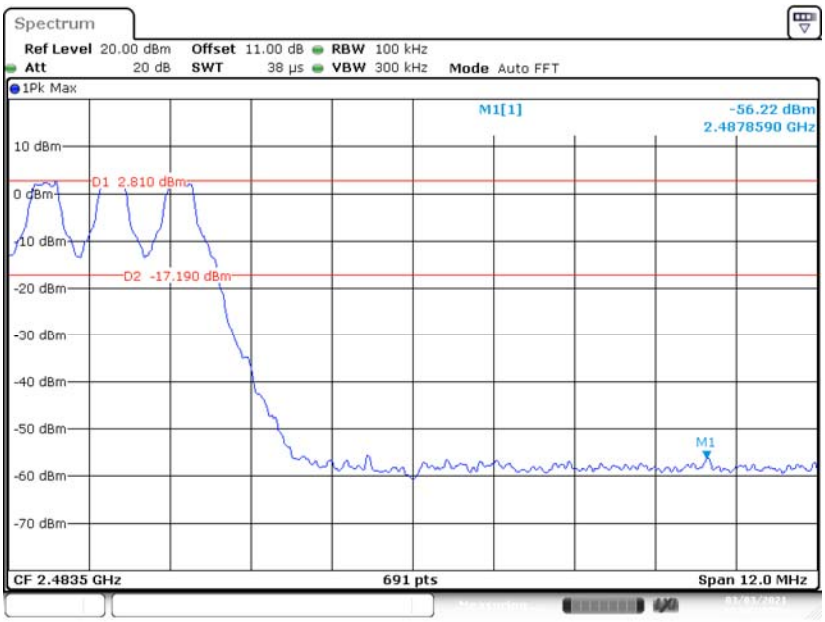
BDR (GFSK): Right Side- Hopping



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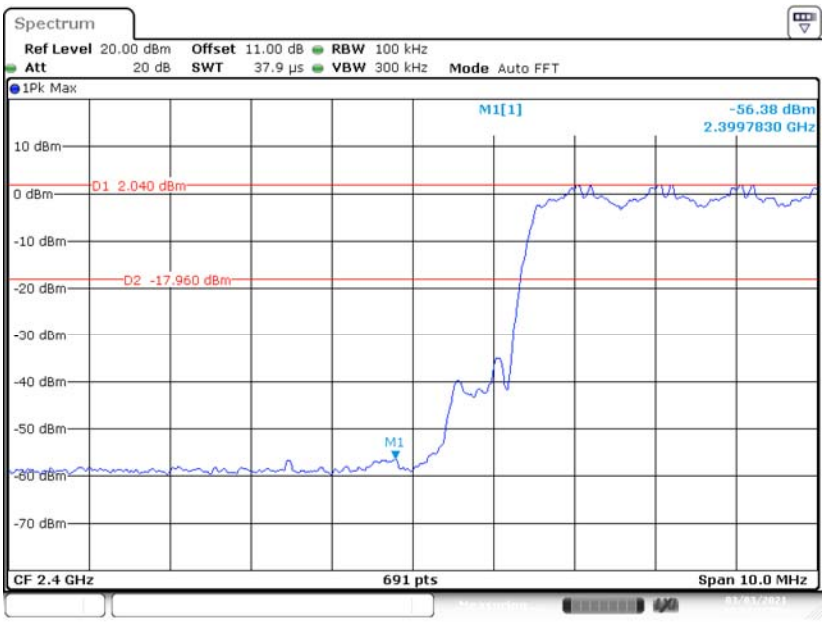

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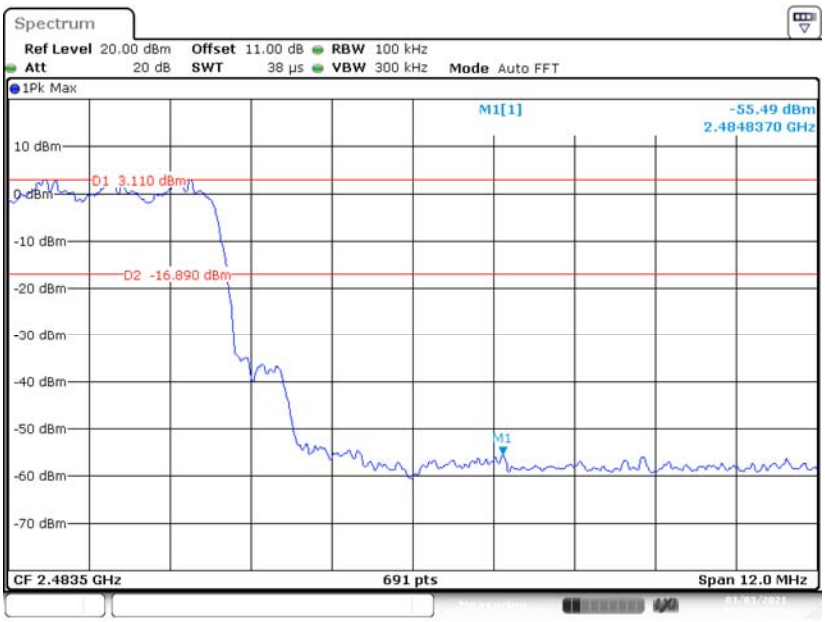

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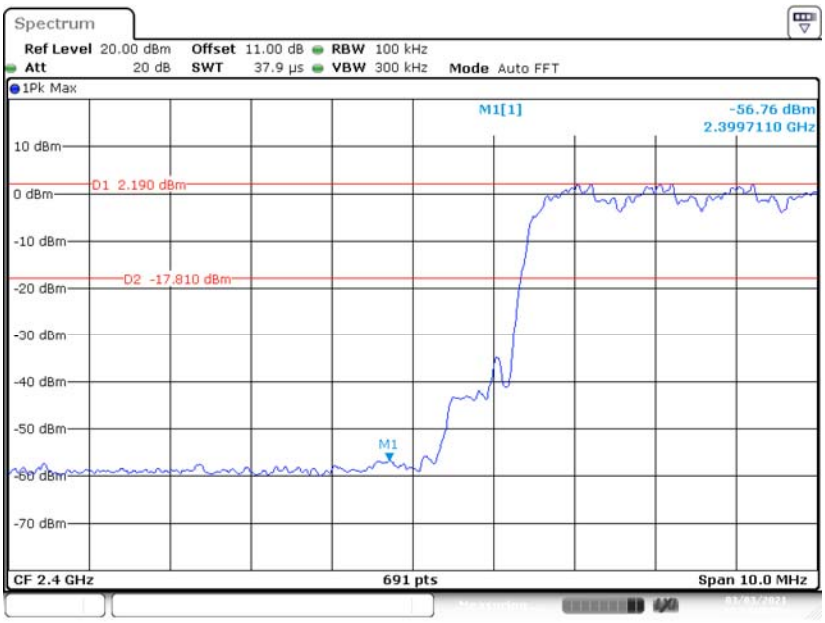
EDR (8DPSK): Left Side- Hopping



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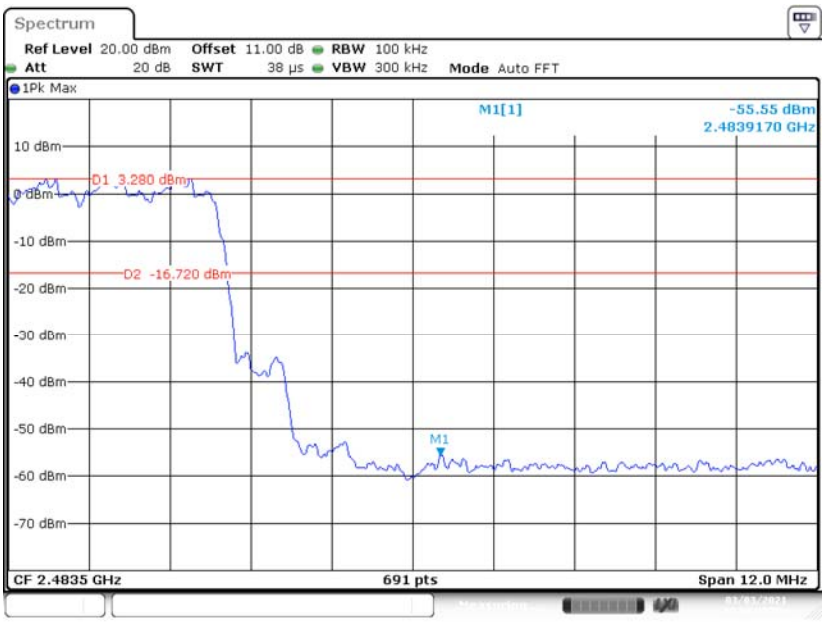

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Declarations

1: BACL is not responsible for the authenticity of any test data provided by the applicant. Data included from the applicant that may affect test results are marked with an asterisk '*'. Customer model name, addresses, names, trademarks etc. are not considered data.

2: Unless otherwise stated the results shown in this test report refer only to the sample(s) tested.

3: Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.

4: The extended uncertainty given in this report is obtained by combining the standard uncertainty times the coverage factor K with the 95% confidence interval.

5: This report cannot be reproduced except in full, without prior written approval of the Company.

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