

FCC PART 15.247 TEST REPORT

For

Shanghai HowayGIS Co., Ltd

RM230, Fawkes Building, No. 1985, Road Chunshen, Shanghai, China

FCC ID: 2AAZD-TGU1-S3

Report Type: Original Report	Product Type: High Precision Mobile GNSS Receiver
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Report Number: RKSA171222002-00A	
Report Date: 2018-10-17	
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TABLE OF CONTENTS

GENERAL INFORMATION.....	4
PRODUCT DESCRIPTION FOR EQUIPMENT UNDER TEST (EUT)	4
OBJECTIVE	4
RELATED SUBMITTAL(S)/GRANT(S).....	4
TEST METHODOLOGY	4
MEASUREMENT UNCERTAINTY	5
TEST FACILITY	5
SYSTEM TEST CONFIGURATION.....	6
DESCRIPTION OF TEST CONFIGURATION	6
EUT EXERCISE SOFTWARE	6
SPECIAL ACCESSORIES	6
EQUIPMENT MODIFICATIONS	6
SUPPORT EQUIPMENT LIST AND DETAILS	7
EXTERNAL I/O CABLE.....	7
BLOCK DIAGRAM OF TEST SETUP	7
SUMMARY OF TEST RESULTS.....	9
TEST EQUIPMENT LIST	10
FCC §15.247 (I) & §1.1310 & §2.1093 - RF EXPOSURE	11
MEASUREMENT RESULT	11
FCC §15.203 - ANTENNA REQUIREMENT.....	12
APPLICABLE STANDARD	12
ANTENNA CONNECTOR CONSTRUCTION	12
FCC §15.207 (a) - AC LINE CONDUCTED EMISSIONS.....	13
APPLICABLE STANDARD	13
EUT SETUP	13
EMI TEST RECEIVER SETUP.....	13
TEST PROCEDURE	13
CORRECTED FACTOR & MARGIN CALCULATION	14
TEST RESULTS SUMMARY	14
TEST DATA	14
FCC §15.205, §15.209 & §15.247(d) - RADIATED EMISSIONS	17
APPLICABLE STANDARD	17
EUT SETUP	17
EMI TEST RECEIVER SETUP.....	18
TEST PROCEDURE	18
CORRECTED AMPLITUDE & MARGIN CALCULATION	18
TEST RESULTS SUMMARY	18
TEST DATA	19
FCC §15.247(a) (1) - CHANNEL SEPARATION TEST	30
APPLICABLE STANDARD	30
TEST PROCEDURE	30
TEST DATA	30
FCC §15.247(a) (1) - 20 dB EMISSION BANDWIDTH	36
APPLICABLE STANDARD	36
TEST PROCEDURE	36
TEST DATA	36
FCC §15.247(a) (1) (iii) - QUANTITY OF HOPPING CHANNEL TEST	42
APPLICABLE STANDARD	42

TEST PROCEDURE	42
TEST DATA	42
FCC §15.247(a) (1) (iii) - TIME OF OCCUPANCY (DWELL TIME).....	45
APPLICABLE STANDARD	45
TEST PROCEDURE	45
TEST DATA	45
FCC §15.247(b) (1) - PEAK OUTPUT POWER MEASUREMENT	61
APPLICABLE STANDARD	61
TEST PROCEDURE	61
TEST DATA	61
FCC §15.247(d) - BAND EDGES TESTING	67
APPLICABLE STANDARD	67
TEST PROCEDURE	67
TEST DATA	67

GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Applicant	Shanghai HowayGIS Co., Ltd
Tested Model	TG-U2
Series Model	TG-U1, TG-U3, X1
Product Type	High Precision Mobile GNSS Receiver
Dimension	210 mm(L)×60 mm(W)×110 mm(H)
Power Supply	DC 7.2V from battery and DC 12V charging by adapter

Adapter Information:

Model: A122-1201000ID

Input: AC100-240 V 50/60Hz 0.4A

Output: 12V, 1000mA

Note: The differences between the tested model and series models were explained in the declaration letter.

*All measurement and test data in this report was gathered from production sample serial number: 20171222002.
(Assigned by the BACL. The EUT supplied by the applicant was received on 2017-12-22)

Objective

This test report is prepared on behalf of *Shanghai HowayGIS Co., Ltd* in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commissions 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 and Part 15B JBP submittals with FCC ID: 2AAZD-TGU1-S3.

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 FCC 558074 D01 15.247 Meas Guidance v05.

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°C
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. 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 V3.0:

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 tool: Blue Test 3

GFSK Power level: 50

$\pi/4$ -DQPSK Power level: 50

8DPSK Power level: 50

Special Accessories

No special accessory.

Equipment Modifications

No modification was made to the EUT tested.

Support Equipment List and Details

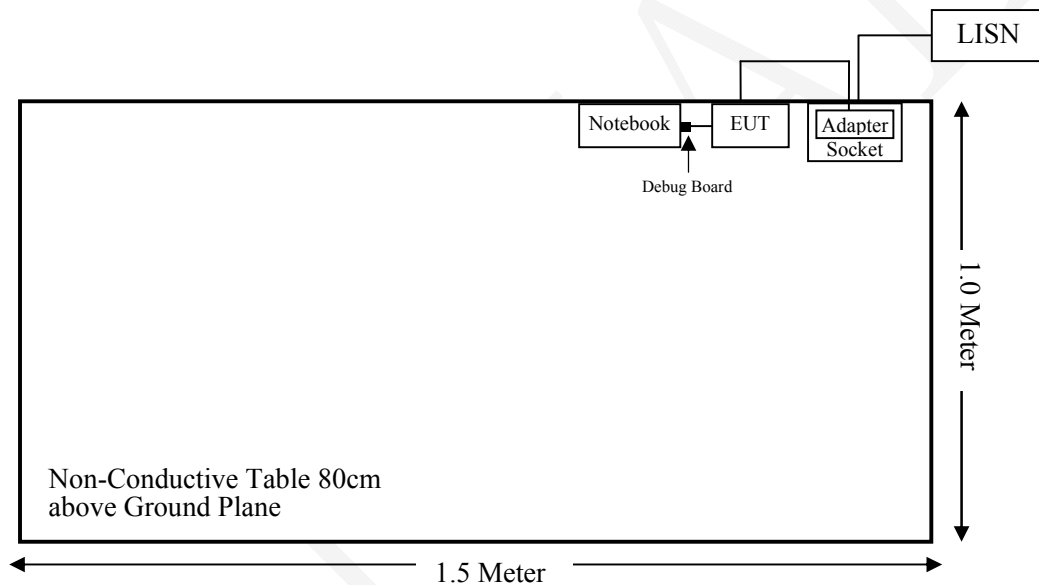
Manufacturer	Description	Model	Serial Number
DELL	Notebook	GX620	D65874152
Shanghai HowayGIS	Debug Board	/	/

External I/O Cable

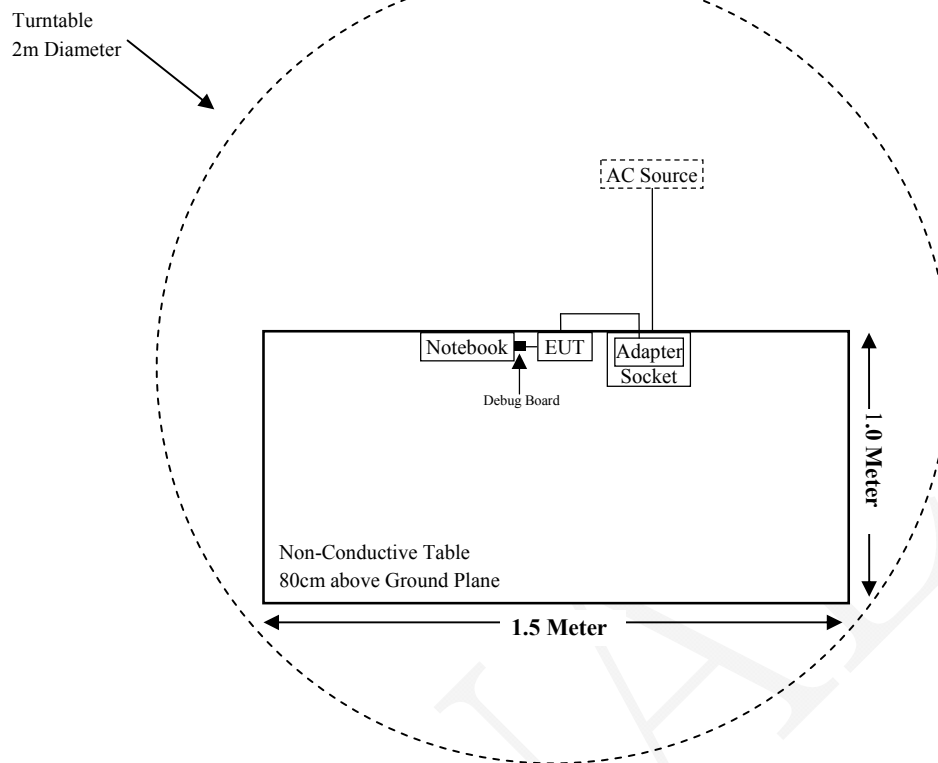
Cable Description	Length (m)	From Port	To
Data Cable	0.2	Debug Board	EUT
Power Cable	1.5	EUT	Adapter

Block Diagram of Test Setup

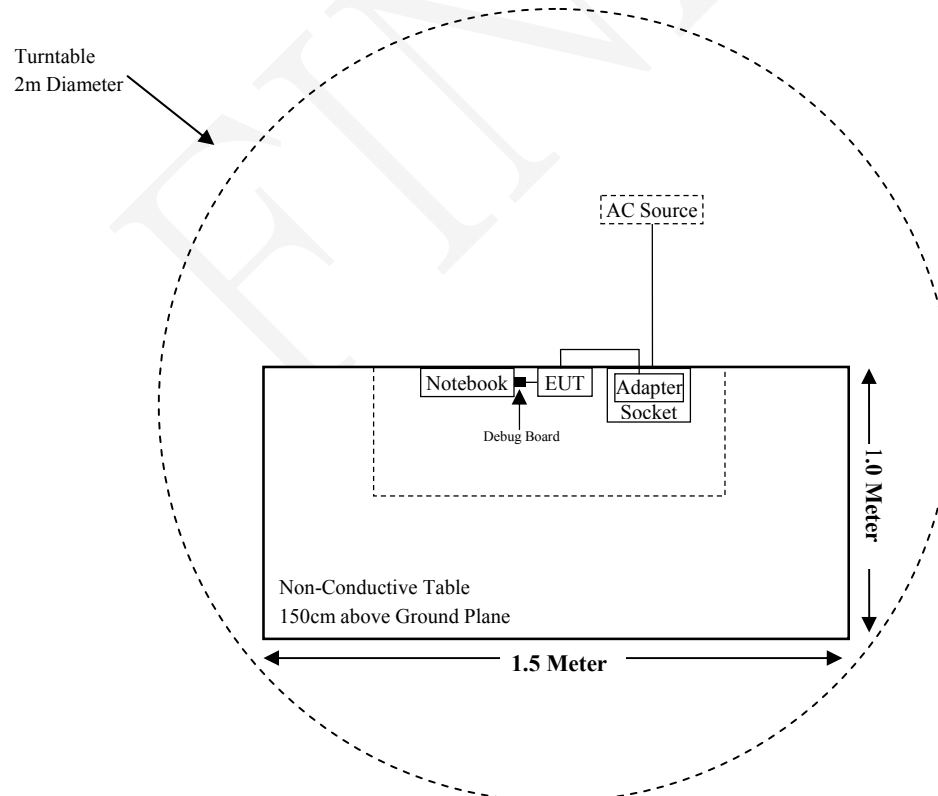
For Conducted Emissions:



For Radiated Emissions(Below 1GHz):



For Radiated Emissions(Above 1GHz):



SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
§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	2017-11-12	2018-11-11
Sunol Sciences	Broadband Antenna	JB3	A090413-1	2016-12-26	2019-12-25
Sonoma Instrunent	Pre-amplifier	310N	171205	2018-08-15	2019-08-14
Rohde & Schwarz	Auto test Software	EMC32	100361	/	/
MICRO-COAX	Coaxial Cable	Cable-8	008	2018-08-15	2019-08-14
MICRO-COAX	Coaxial Cable	Cable-9	009	2018-08-15	2019-08-14
MICRO-COAX	Coaxial Cable	Cable-10	010	2018-08-15	2019-08-14
Radiated Emission Test (Chamber 2#)					
Rohde & Schwarz	EMI Test Receiver	ESU40	100207	2018-08-27	2019-08-26
ETS-LINDGREN	Horn Antenna	3115	6229	2016-01-11	2019-01-10
ETS-LINDGREN	Horn Antenna	3116	00084159	2016-10-18	2019-10-17
Mini-Circuits	Amplifier	ZVA-183W-S+	220701818	2018-05-20	2019-05-19
EM Electronics Corporation	Amplifier	EM18G40G	060726	2018-03-22	2019-03-21
MICRO-TRONICS	Band notch Filter	BRM50702	G024	2018-08-05	2019-08-04
Narda	Attenuator/10dB	10dB	010	2018-08-15	2019-08-14
Rohde & Schwarz	Auto test Software	EMC32	100361	/	/
MICRO-COAX	Coaxial Cable	Cable-6	006	2018-08-15	2019-08-14
MICRO-COAX	Coaxial Cable	Cable-11	011	2018-08-15	2019-08-14
MICRO-COAX	Coaxial Cable	Cable-12	012	2018-08-15	2019-08-14
MICRO-COAX	Coaxial Cable	Cable-13	013	2018-08-15	2019-08-14
RF Conducted Test					
Rohde & Schwarz	Signal Analyzer	FSV40	101116	2018-07-23	2019-07-22
Rohde & Schwarz	Signal Analyzer	FSIQ26	836131/009	2017-09-21	2018-09-20
Narda	Attenuator/10dB	10dB	010	2018-08-15	2019-08-14
Shanghai HowayGIS	RF Cable	HowayGISC01	C01	Each Time	/
Conducted Emission Test					
Rohde & Schwarz	EMI Test Receiver	ESCS30	834115/007	2017-11-12	2018-11-11
Rohde & Schwarz	LISN	ESH3-Z5	862770/011	2017-11-12	2018-11-11
BACL	Auto test Software	BACL-EMC	CE001	/	/
Narda	Attenuator/6dB	10690812-2	26850-6	2018-01-10	2019-01-09
MICRO-COAX	Coaxial Cable	Cable-15	015	2018-08-15	2019-08-14

* **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 §15.247 (I) & §1.1310 & §2.1093 - RF EXPOSURE

Applicable Standard

According to §15.247(i) and §1.1310, systems operating under the provisions of this section shall be operated in a manner that ensure that the public is not exposed to radio frequency energy level in excess of the Commission's guideline.

According to KDB447498 D01 General RF Exposure Guidance v06:

The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

$[(\text{max. power of channel, including tune-up tolerance, mW})/(\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})}] \leq 3.0$ for 1-g SAR and ≤ 7.5 for 10-g extremity SAR, where

- $f(\text{GHz})$ is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison
- 3.0 and 7.5 are referred to as the numeric thresholds in the step 2 below

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm according to 5) in section 4.1 is applied to determine SAR test exclusion.

Measurement Result

Mode	Frequency Range (MHz)	Target Output Power		Minimum test separation distance required for the exposure conditions (mm)
		(dBm)	(mW)	
BT3.0	2402-2480	4.50	2.82	5.00
BLE	2402-2480	4.60	2.88	5.00

Note: The target output power was declared by the manufacturer.

Result:

BT3.0: $[(\text{max. power of channel, including tune-up tolerance, mW})/(\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})}] = 2.82/5 \cdot \sqrt{2.48} = 0.9 < 3.0$

BLE: $[(\text{max. power of channel, including tune-up tolerance, mW})/(\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})}] = 2.88/5 \cdot \sqrt{2.48} = 0.9 < 3.0$

So the stand-alone SAR evaluation is not necessary.

FCC §15.203 - ANTENNA REQUIREMENT

Applicable Standard

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

Antenna Connector Construction

The EUT has an internal ceramic antenna for Bluetooth and the antenna gain is 1dBi, which was permanently attached; fulfill the requirement of this section. Please refer to the EUT photos.

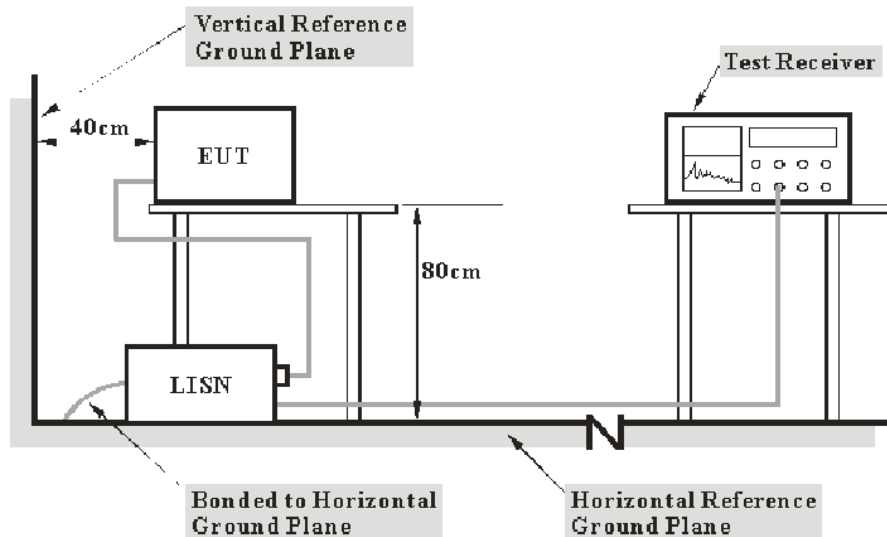
Result: Compliance.

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.

Corrected Factor & Margin Calculation

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

$$\text{Corrected Factor (dB)} = \text{LISN VDF (dB)} + \text{Cable Loss (dB)} + \text{Transient Limiter Attenuation (dB)}$$

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

$$\text{Margin (dB)} = \text{Limit (dB}\mu\text{V)} - \text{Corrected Amplitude (dB}\mu\text{V)}$$

Test Results Summary

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

Test Data

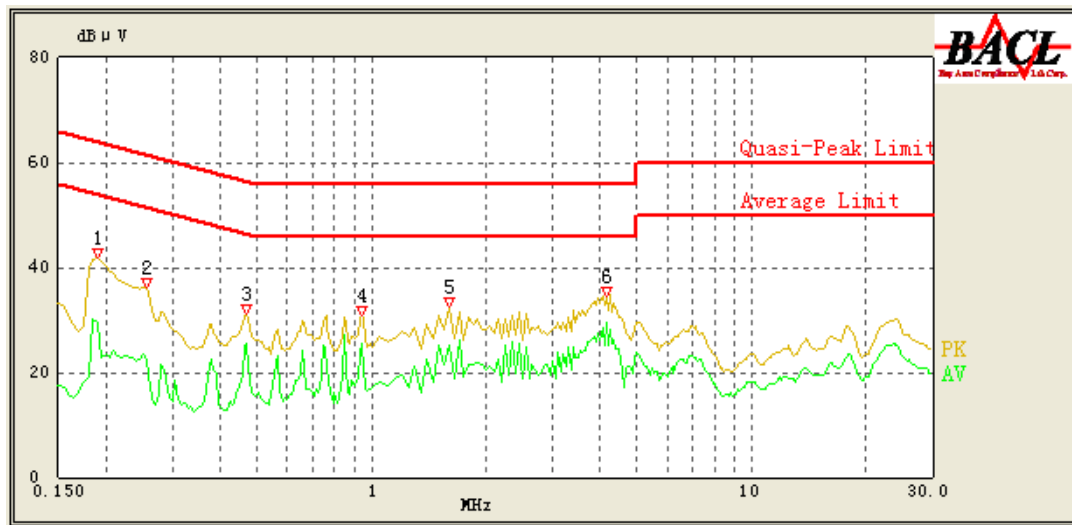
Environmental Conditions

Temperature:	23.4 °C
Relative Humidity:	49 %
ATM Pressure:	101.1 kPa

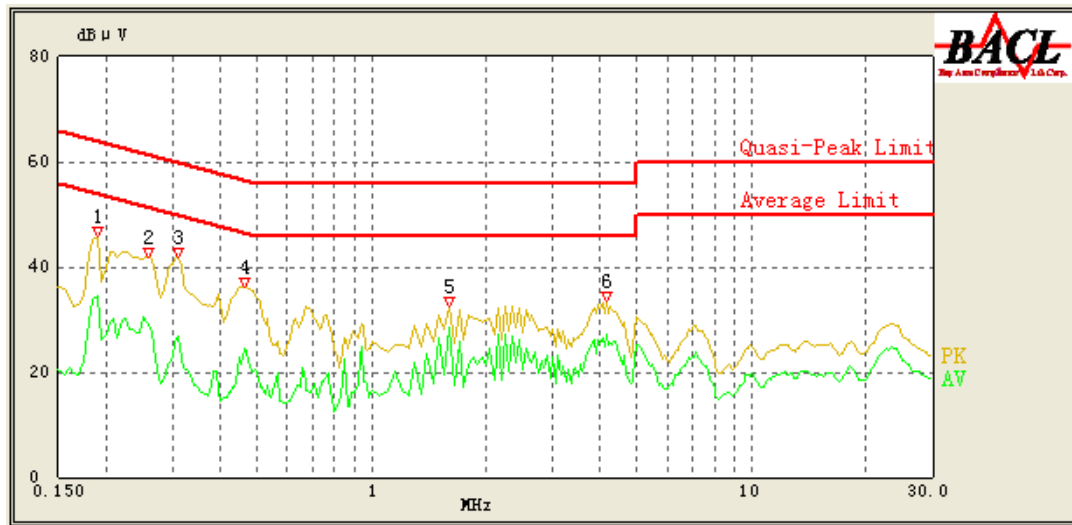
The testing was performed by Hope Zhang on 2018-09-09.

EUT operation mode: Transmitting in high channel of GFSK mode (Worst case)

AC 120V/60 Hz, Line



Frequency (MHz)	Corrected Amplitude (dBμV)	Detector (PK/AV/QP)	Bandwidth (kHz)	Line	Corrected Factor (dB)	Limit (dBμV)	Margin (dB)	Comment
0.190	41.98	QP	9.000	L1	16.02	64.04	22.06	Compliance
0.190	29.50	AV	9.000	L1	16.02	54.04	24.54	Compliance
0.255	36.33	QP	9.000	L1	16.02	61.59	25.26	Compliance
0.255	22.56	AV	9.000	L1	16.02	51.59	29.03	Compliance
0.470	31.19	QP	9.000	L1	16.07	56.51	25.32	Compliance
0.470	25.46	AV	9.000	L1	16.07	46.51	21.05	Compliance
0.945	30.77	QP	9.000	L1	15.89	56.00	25.23	Compliance
0.940	25.49	AV	9.000	L1	15.89	46.00	20.51	Compliance
1.600	32.41	QP	9.000	L1	15.86	56.00	23.59	Compliance
1.600	25.33	AV	9.000	L1	15.86	46.00	20.67	Compliance
4.150	34.66	QP	9.000	L1	15.85	56.00	21.34	Compliance
4.150	29.41	AV	9.000	L1	15.85	46.00	16.59	Compliance

AC 120V/60 Hz, Neutral

Frequency (MHz)	Corrected Amplitude (dBμV)	Detector (PK/AV/QP)	Bandwidth (kHz)	Line	Corrected Factor (dB)	Limit (dBμV)	Margin (dB)	Comment
0.190	45.84	QP	9.000	N	16.05	64.04	18.20	Compliance
0.190	34.52	AV	9.000	N	16.05	54.04	19.52	Compliance
0.260	41.97	QP	9.000	N	16.06	61.43	19.46	Compliance
0.260	29.16	AV	9.000	N	16.06	51.43	22.27	Compliance
0.310	41.82	QP	9.000	N	16.07	59.97	18.15	Compliance
0.310	26.88	AV	9.000	N	16.07	49.97	23.09	Compliance
0.465	36.33	QP	9.000	N	16.10	56.60	20.27	Compliance
0.465	24.36	AV	9.000	N	16.10	46.60	22.24	Compliance
1.600	32.46	QP	9.000	N	15.92	56.00	23.54	Compliance
1.600	28.41	AV	9.000	N	15.92	46.00	17.59	Compliance
4.150	33.45	QP	9.000	N	15.88	56.00	22.55	Compliance
4.150	27.05	AV	9.000	N	15.88	46.00	18.95	Compliance

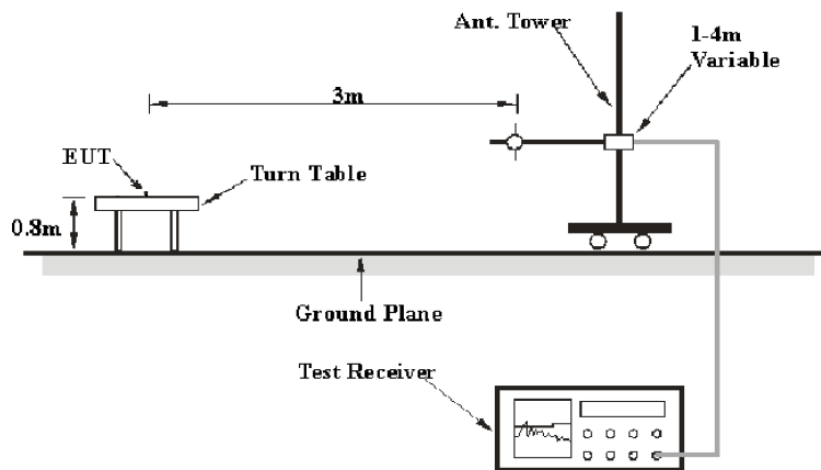
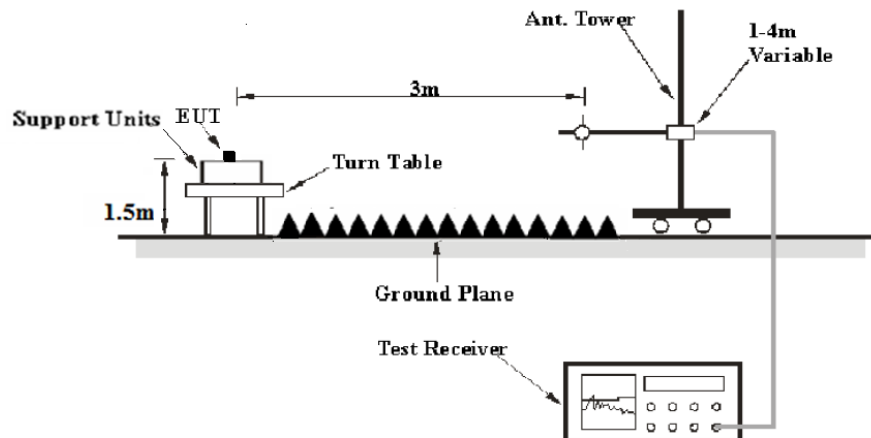
Note:

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

2) Margin (dB) = Limit (dBμV) - Corrected Amplitude (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:

$$\text{Corrected Amplitude (dB}\mu\text{V /m)} = \text{Meter Reading (dB}\mu\text{V)} + \text{Antenna Factor (dB/m)} + \text{Cable Loss (dB)} - \text{Amplifier Gain (dB)}$$

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:

$$\text{Margin (dB)} = \text{Limit (dB}\mu\text{V/m)} - \text{Corrected Amplitude (dB}\mu\text{V /m)}$$

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**

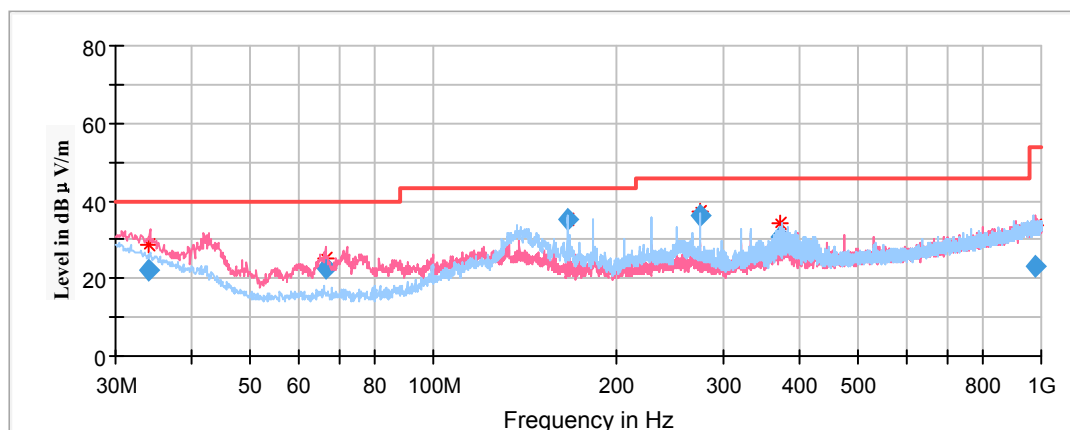
Temperature:	23.3-23.5 °C
Relative Humidity:	49-50 %
ATM Pressure:	101.1-101.2 kPa

Radiated emission test was performed by Hope Zhang on 2018-09-14 & 2018-10-17;
RF conducted test was performed by Hope Zhang on 2018-08-24.

EUT operation mode: Transmitting

Spurious Emission Test:**30MHz-1GHz:**

Pre-Scan with GFSK, $\pi/4$ -DQPSK, 8DPSK modes of operation in the X,Y and Z axes of orientation, the worst case GFSK Mode in Y-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)				
34.125850	28.87	100.0	V	98.0	-6.8	40.00	11.13
66.562500	24.98	100.0	V	175.0	-17.5	40.00	15.02
166.491550	35.23	200.0	H	0.0	-13.0	43.50	8.27
274.691450	37.19	100.0	H	0.0	-11.3	46.00	8.81
373.112000	34.34	100.0	H	176.0	-8.7	46.00	11.66
976.303700	33.75	100.0	V	353.0	1.8	53.90	20.15

1GHz-18GHz:

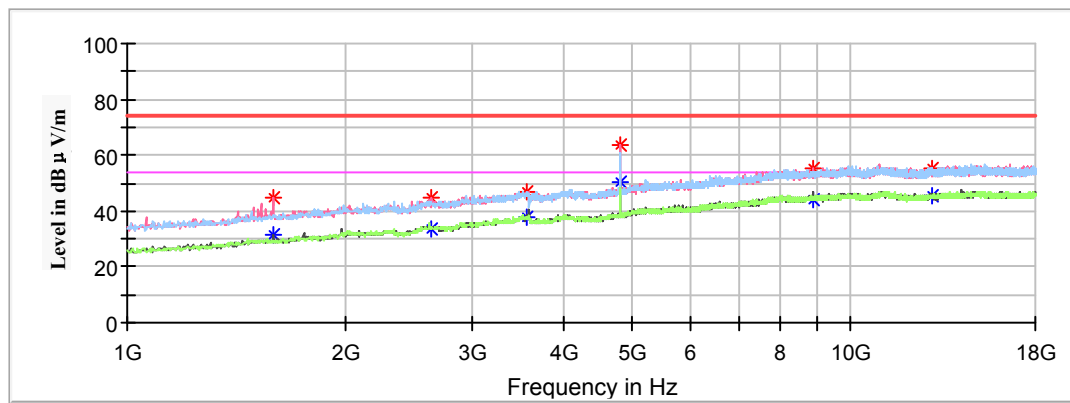
Pre-Scan with GFSK, $\pi/4$ -DQPSK, 8DPSK modes of operation in the X,Y and Z axes of orientation, the worst case GFSK Mode in Y-axis of orientation was recorded

Note:

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

Low Channel: 2402MHz

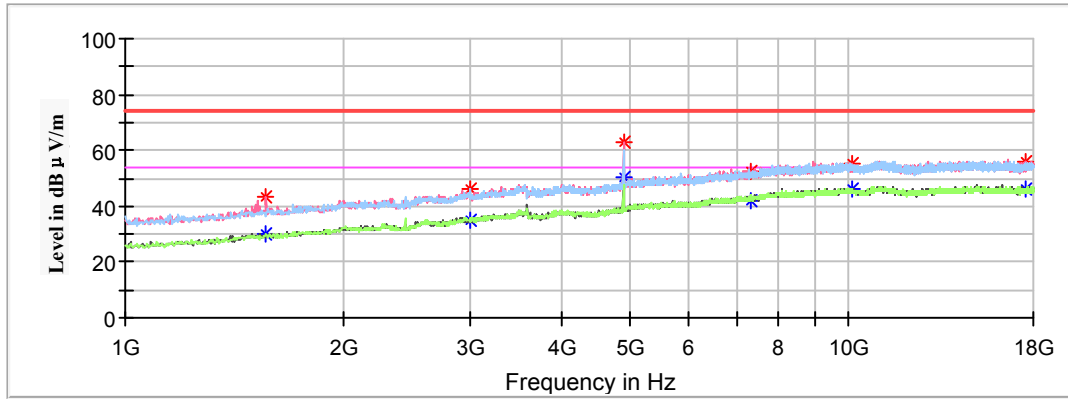
Full Spectrum



Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dB μ V/m)	Margin (dB)
	MaxPeak (dB μ V /m)	Average (dB μ V /m)	Height (cm)	Polar (H/V)				
1591.600000	---	31.73	100.0	V	99.0	-0.6	54.00	22.27
1591.600000	45.01	---	100.0	V	99.0	-0.6	74.00	28.99
2638.800000	44.63	---	100.0	V	88.0	3.9	74.00	29.37
2638.800000	---	33.70	100.0	V	88.0	3.9	54.00	20.30
3563.600000	---	37.43	200.0	V	103.0	7.5	54.00	16.57
3563.600000	47.14	---	200.0	V	103.0	7.5	74.00	26.86
4804.000000	---	50.42	100.0	V	64.0	10.7	54.00	3.58
4804.000000	63.71	---	100.0	V	64.0	10.7	74.00	10.29
8860.800000	---	44.06	200.0	V	98.0	17.4	54.00	9.94
8860.800000	55.28	---	200.0	V	98.0	17.4	74.00	18.72
12940.800000	55.30	---	100.0	V	251.0	17.7	74.00	18.70
12940.800000	---	45.56	100.0	V	251.0	17.7	54.00	8.44

Middle Channel: 2441MHz

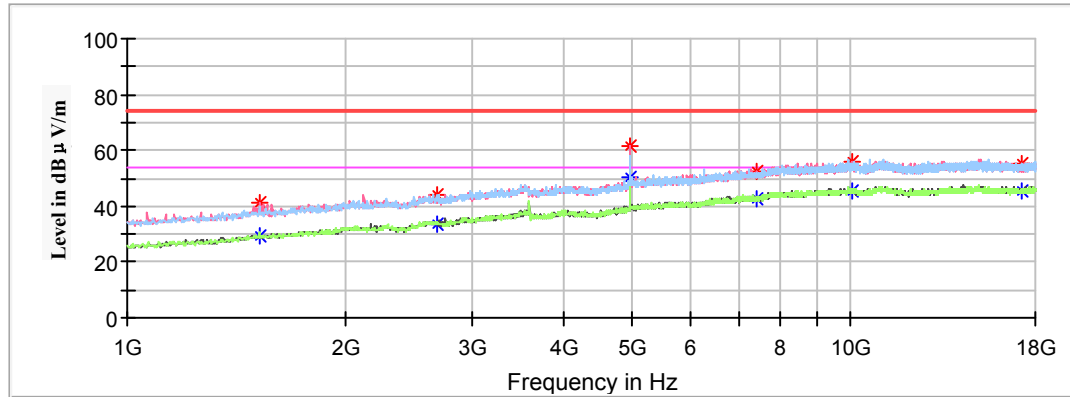
Full Spectrum



Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dB μ V/m)	Margin (dB)
	MaxPeak (dB μ V /m)	Average (dB μ V /m)	Height (cm)	Polar (H/V)				
1567.800000	---	29.98	200.0	V	293.0	-0.8	54.00	24.02
1567.800000	43.35	---	200.0	V	293.0	-0.8	74.00	30.65
2992.400000	---	35.06	150.0	H	246.0	6.0	54.00	18.94
2992.400000	45.99	---	150.0	H	246.0	6.0	74.00	28.01
4882.000000	---	50.30	100.0	V	254.0	11.1	54.00	3.70
4882.000000	63.21	---	100.0	V	254.0	11.1	74.00	10.79
7323.000000	---	42.09	200.0	V	217.0	15.4	54.00	11.91
7323.000000	52.26	---	200.0	V	217.0	15.4	74.00	21.74
10105.200000	---	45.87	150.0	V	144.0	18.2	54.00	8.13
10105.200000	55.34	---	150.0	V	144.0	18.2	74.00	18.66
17558.000000	---	45.93	250.0	V	330.0	18.5	54.00	8.07
17558.000000	55.87	---	250.0	V	330.0	18.5	74.00	18.13

High Channel: 2480MHz

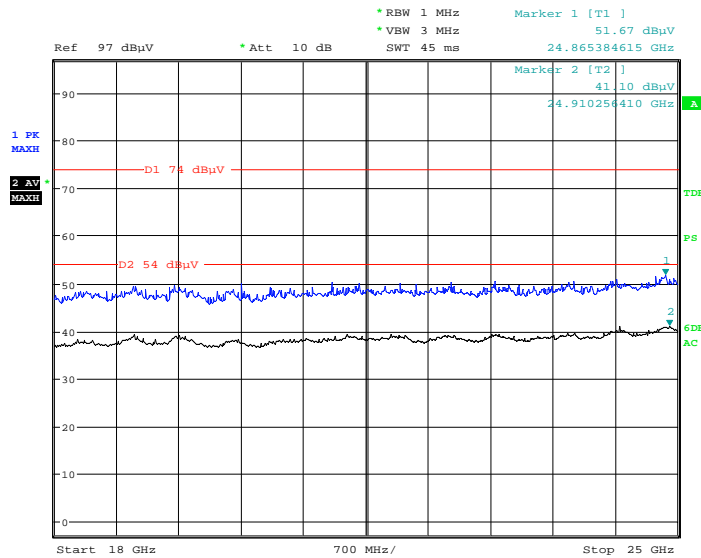
Full Spectrum



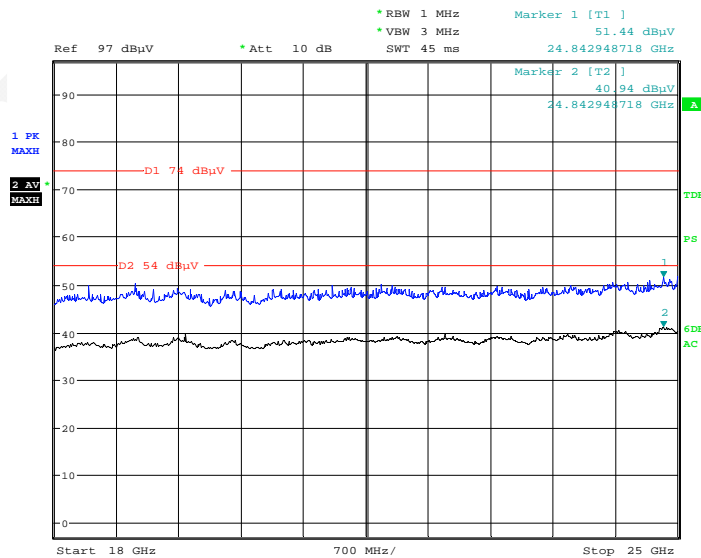
Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	MaxPeak (dBμV /m)	Average (dBμV /m)	Height (cm)	Polar (H/V)				
1527.000000	---	29.10	250.0	V	243.0	-1.1	54.00	24.90
1527.000000	41.51	---	250.0	V	243.0	-1.1	74.00	32.49
2676.200000	---	33.40	100.0	H	30.0	4.2	54.00	20.60
2676.200000	44.11	---	100.0	H	30.0	4.2	74.00	29.89
4960.000000	61.37	---	200.0	V	299.0	11.5	74.00	12.63
4960.000000	---	50.40	200.0	V	299.0	11.5	54.00	3.60
7440.000000	52.67	---	200.0	V	259.0	15.6	74.00	21.33
7440.000000	---	42.77	200.0	V	259.0	15.6	54.00	11.23
10071.200000	---	45.27	100.0	V	70.0	18.2	54.00	8.73
10071.200000	55.60	---	100.0	V	70.0	18.2	74.00	18.40
17218.000000	---	45.69	250.0	V	293.0	18.3	54.00	8.31
17218.000000	55.16	---	250.0	V	293.0	18.3	74.00	18.84

18GHz-25GHz:

Pre-Scan with GFSK, $\pi/4$ -DQPSK, 8DPSK modes of operation in the X, Y and Z axes of orientation, the worst case GFSK Mode in Y-axis of orientation was recorded

Horizontal

Date: 17.OCT.2018 16:01:43

Vertical

Date: 17.OCT.2018 16:23:21

Fundamental Test & Restricted Bands Emissions:

Pre-Scan with GFSK, $\pi/4$ -DQPSK, 8DPSK modes of operation in the X, Y and Z axes of orientation, the worst case GFSK Mode in Y-axis of orientation was recorded

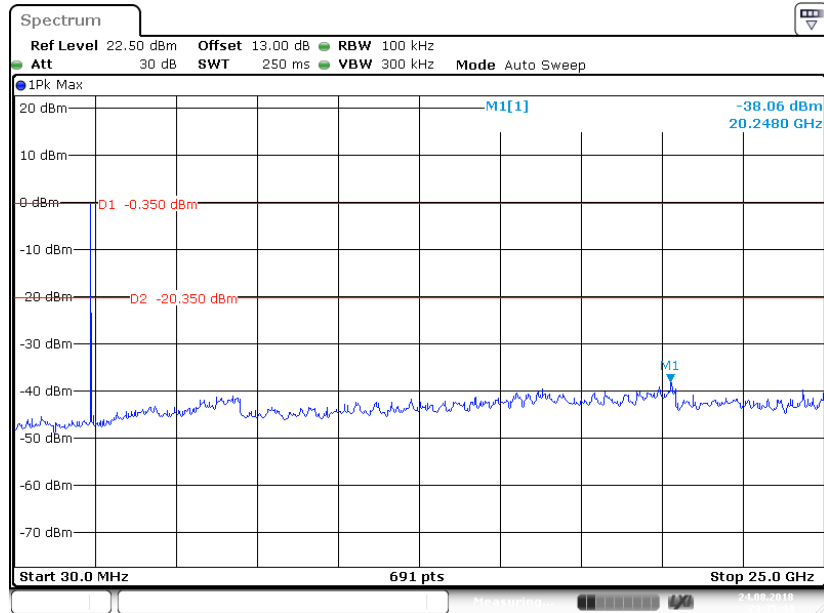
Note:

- Corrected Factor (dB/m) = Antenna factor (RX) (dB/m) + Cable Loss (dB) - Amplifier Factor (dB)
 Corrected Amplitude (dB μ V /m) = Corrected Factor (dB/m) + Reading (dB μ V)
 Margin (dB) = Limit (dB μ V/m) - Corrected Amplitude (dB μ V /m)

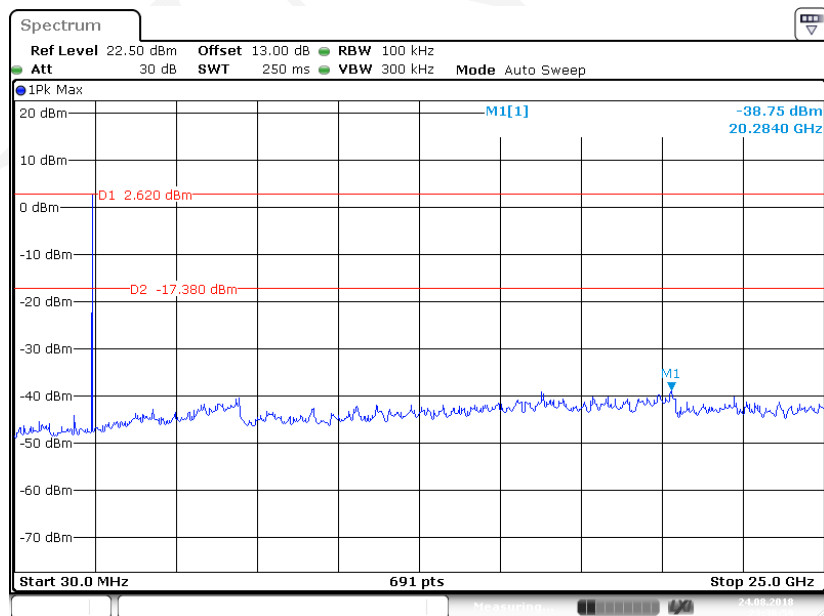
Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	MaxPeak (dBμV /m)	Average (dBμV /m)	Height (cm)	Polar (H/V)				
Low Channel: 2402MHz								
2402.000000	95.35	---	250.0	V	171.0	2.9	/	/
2402.000000	---	92.83	250.0	V	171.0	2.9	/	/
2402.000000	93.30	---	200.0	H	233.0	2.9	/	/
2402.000000	---	90.91	200.0	H	233.0	2.9	/	/
2390.000000	49.72	---	200.0	V	119.0	2.8	74.00	24.28
2390.000000	---	39.21	200.0	V	119.0	2.8	54.00	14.79
Middle Channel: 2441MHz								
2441.000000	98.39	---	250.0	V	113.0	3.0	/	/
2441.000000	---	95.88	250.0	V	113.0	3.0	/	/
2441.000000	96.30	---	150.0	H	210.0	3.0	/	/
2441.000000	---	93.87	150.0	H	210.0	3.0	/	/
High Channel: 2480MHz								
2480.000000	100.10	---	200.0	V	90.0	3.0	/	/
2480.000000	---	97.64	200.0	V	90.0	3.0	/	/
2480.000000	98.15	---	250.0	H	347.0	3.0	/	/
2480.000000	---	95.54	250.0	H	347.0	3.0	/	/
2483.500000	51.26	---	150.0	V	25.0	3.0	74.00	22.74
2483.500000	---	40.37	150.0	V	25.0	3.0	54.00	13.63

Conducted Spurious Emissions at Antenna Port

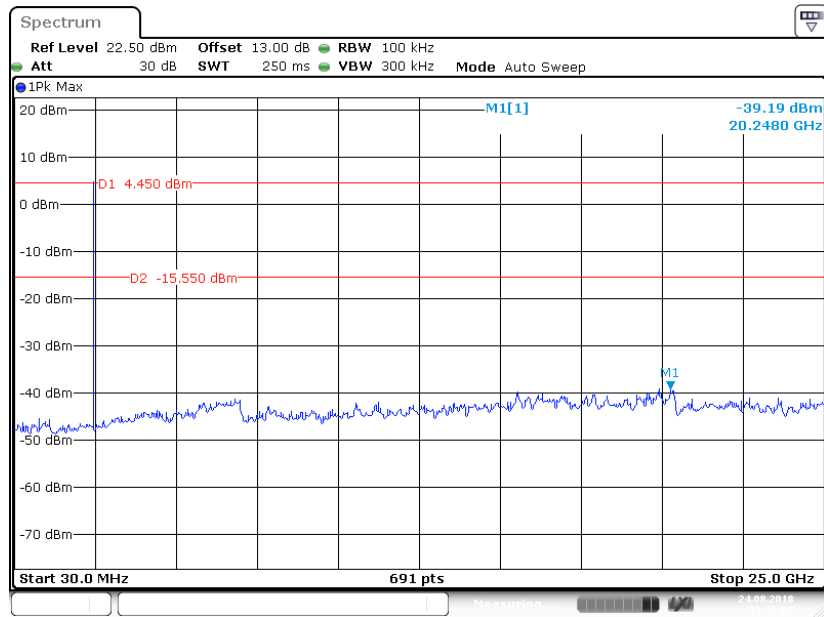
BDR (GFSK): Low Channel



BDR (GFSK): Middle Channel

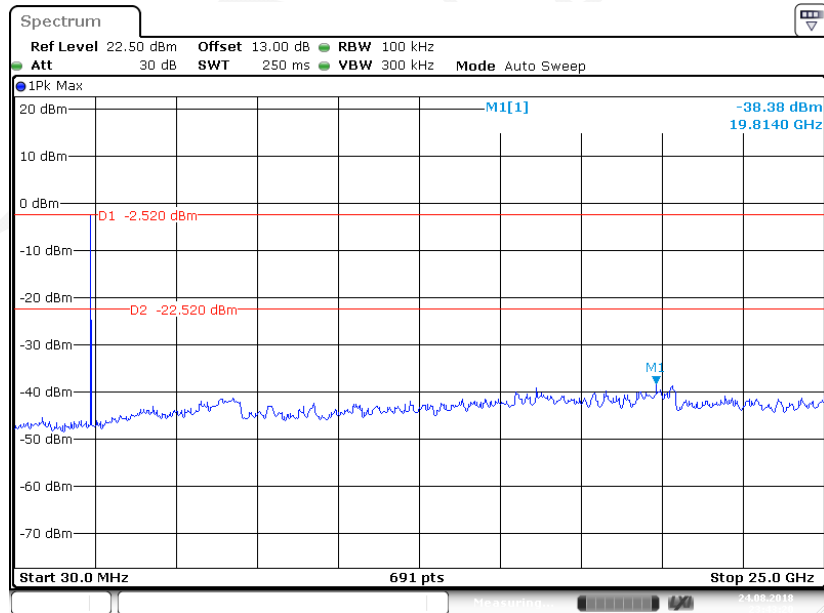


BDR (GFSK): High Channel



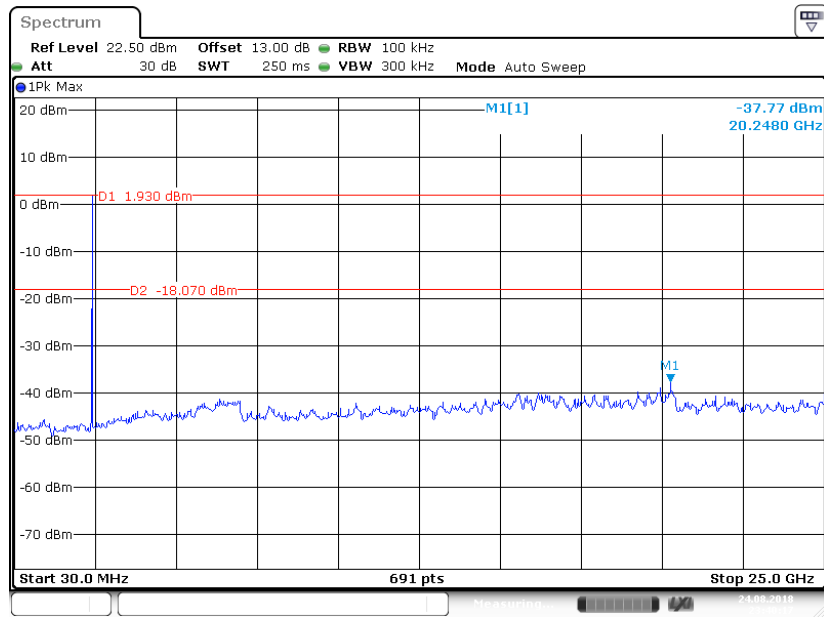
Date: 24 AUG 2018 23:38:04

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



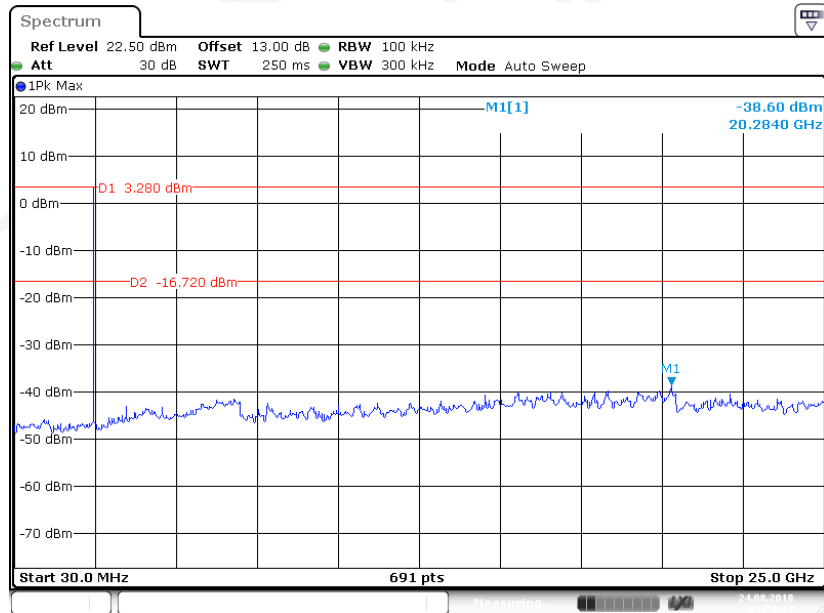
Date: 24 AUG 2018 23:43:20

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

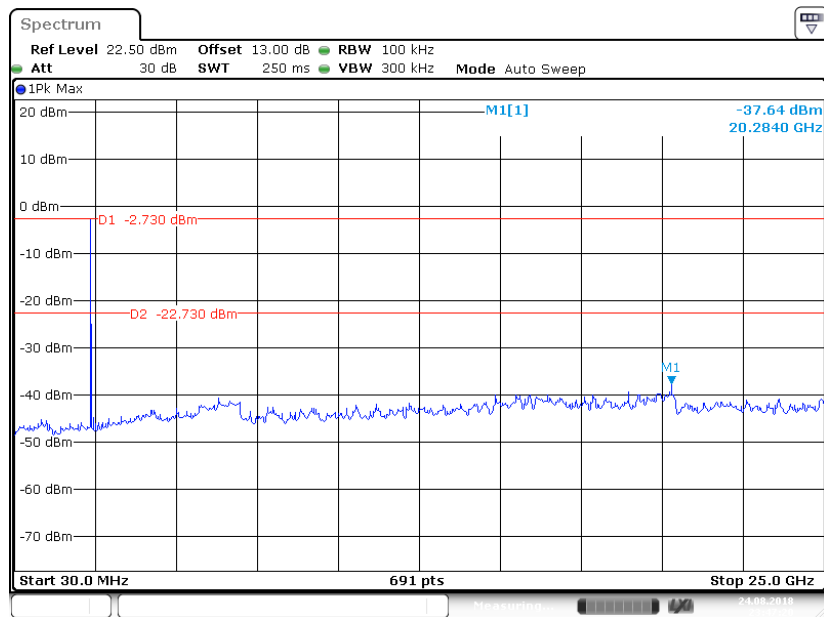


Date: 24 AUG 2018 23:40:17

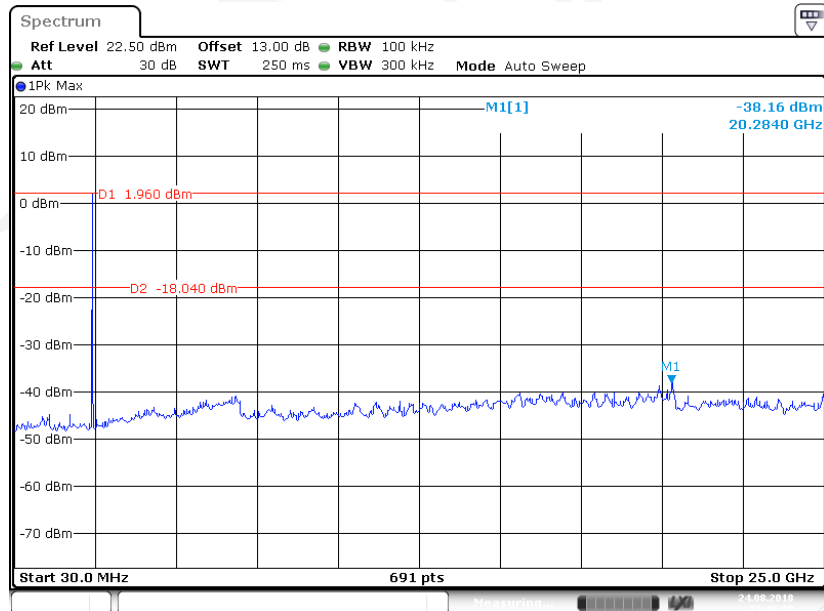
EDR ($\pi/4$ -DQPSK): High Channel



Date: 24 AUG 2018 23:39:14

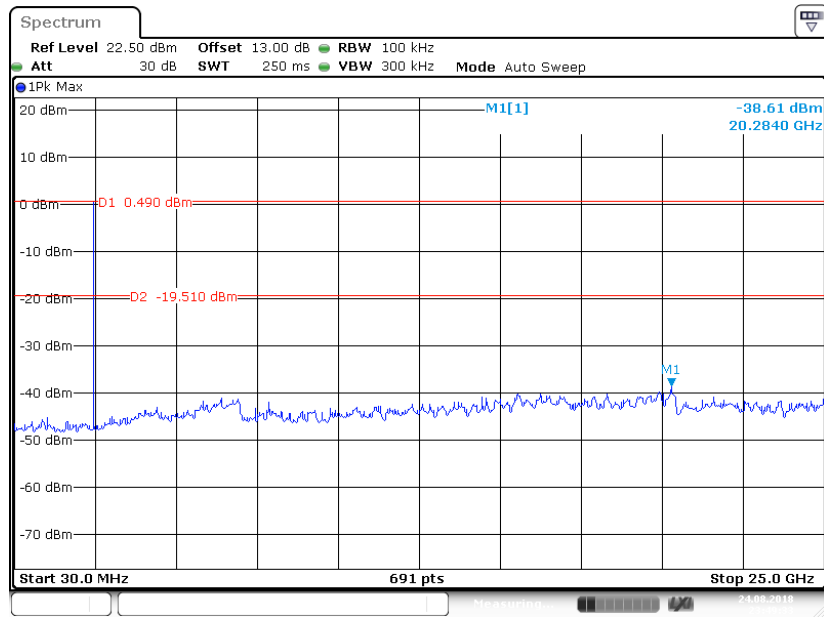
EDR (8DPSK): Low Channel

Date: 24 AUG 2018 23:47:20

EDR (8DPSK): Middle Channel

Date: 24 AUG 2018 23:48:39

EDR (8DPSK): High Channel



Date: 24.AUG.2018 23:49:33

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

Applicable Standard

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater provided the systems operate with an output power no greater than 125 mW.

Test Procedure

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

- Span: Wide enough to capture the peaks of two adjacent channels.
- RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
- Video (or average) bandwidth (VBW) \geq RBW.
- Sweep: Auto.
- Detector function: Peak.
- Trace: Max hold.
- 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:	23.3-23.5 °C
Relative Humidity:	49-50 %
ATM Pressure:	101.1-101.2 kPa

The testing was performed by Hope Zhang on 2018-08-25 & 2018-09-01.

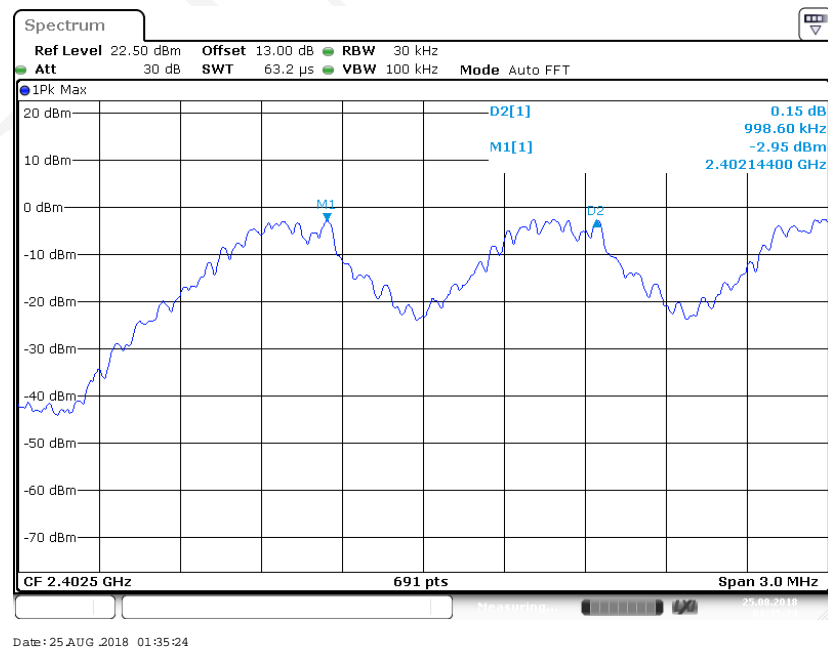
EUT operation mode: Transmitting

Test Result: Compliance.

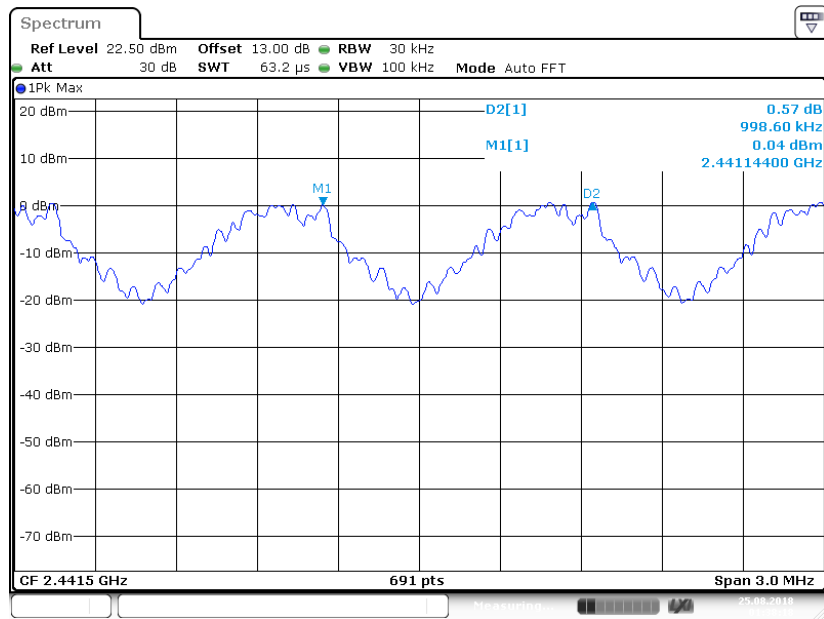
Mode	Channel	Frequency (MHz)	Channel Separation (MHz)	Limit (MHz)	Result
BDR (GFSK)	Low	2402	0.999	≥ 0.955	Pass
	Adjacent	2403			
	Middle	2441	0.999	≥ 0.955	Pass
	Adjacent	2442			
	High	2480	0.999	≥ 0.960	Pass
	Adjacent	2479			
EDR ($\pi/4$-DQPSK)	Low	2402	0.999	≥ 0.859	Pass
	Adjacent	2403			
	Middle	2441	1.003	≥ 0.886	Pass
	Adjacent	2442			
	High	2480	1.003	≥ 0.874	Pass
	Adjacent	2479			
EDR (8DPSK)	Low	2402	0.999	≥ 0.854	Pass
	Adjacent	2403			
	Middle	2441	0.999	≥ 0.869	Pass
	Adjacent	2442			
	High	2480	1.003	≥ 0.863	Pass
	Adjacent	2479			

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

BDR (GFSK): Low Channel

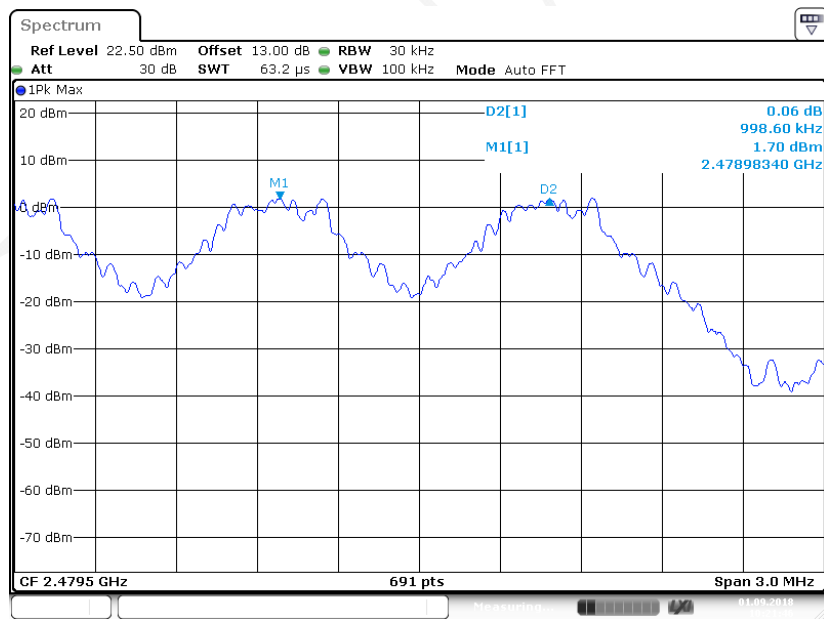


BDR (GFSK): Middle Channel



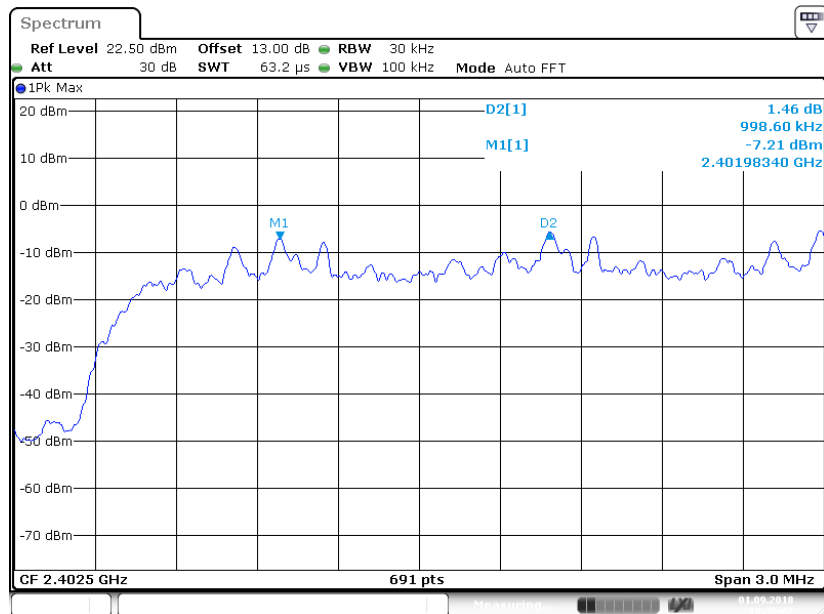
Date: 25 AUG 2018 01:38:18

BDR (GFSK): High Channel

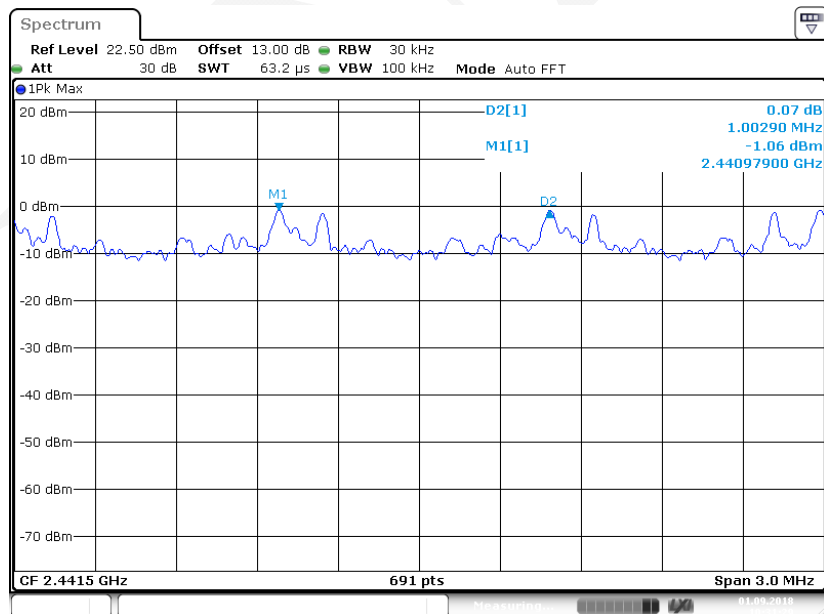


Date: 1 SEP 2018 10:21:46

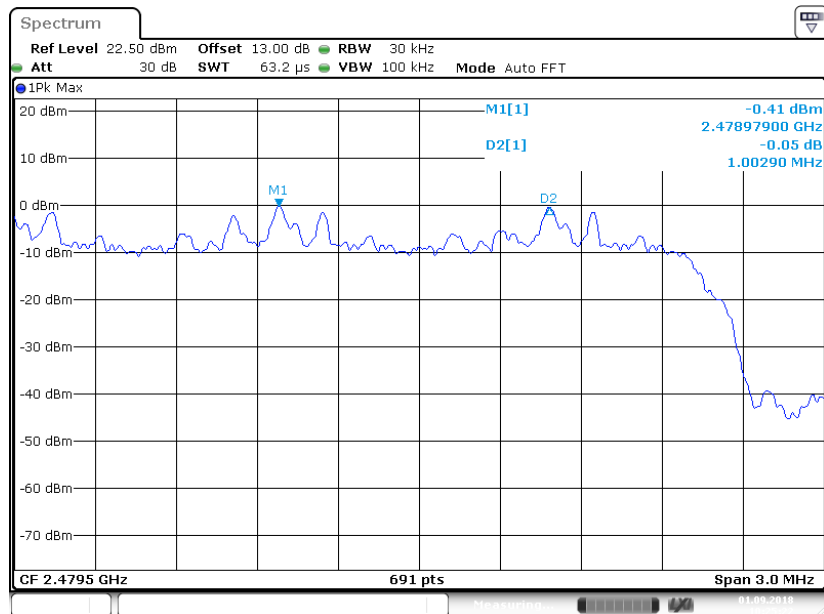
EDR ($\pi/4$ -DQPSK): Low Channel



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

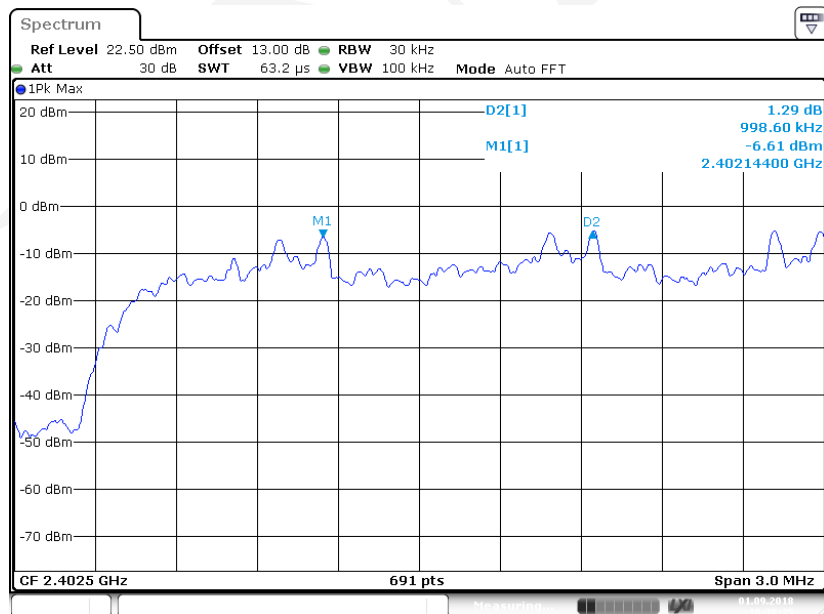


EDR ($\pi/4$ -DQPSK): High Channel



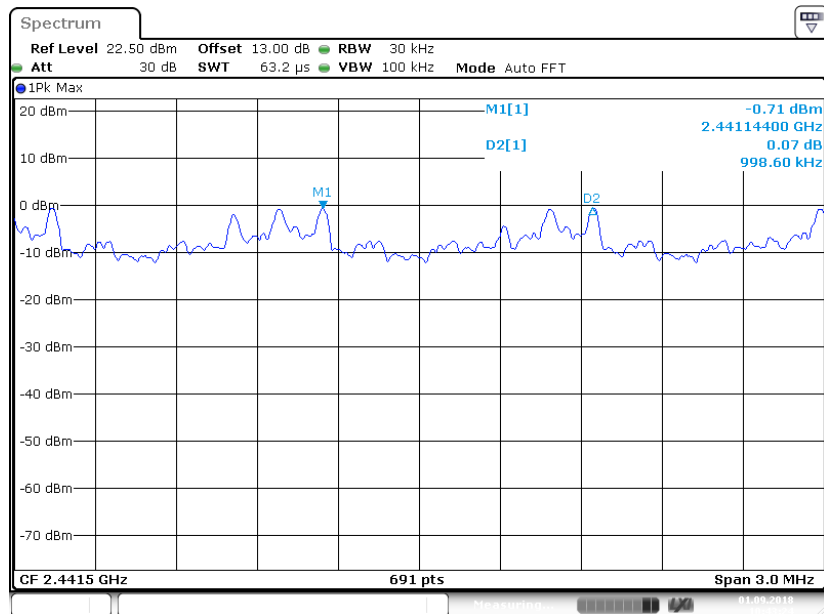
Date: 1 SEP 2018 10:25:23

EDR (8DPSK): Low Channel



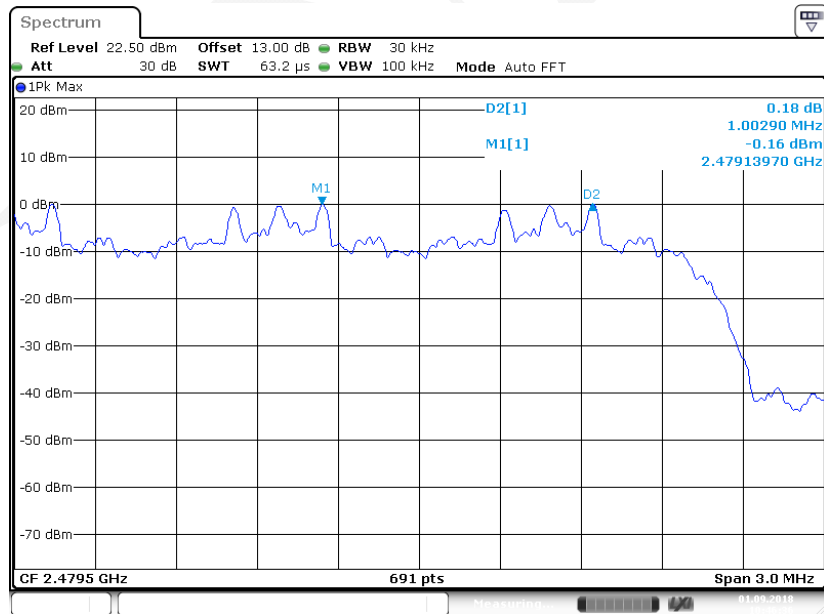
Date: 1 SEP 2018 10:38:26

EDR (8DPSK): Middle Channel



Date: 1 SEP 2018 10:43:24

EDR (8DPSK): High Channel



Date: 1 SEP 2018 10:46:36

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

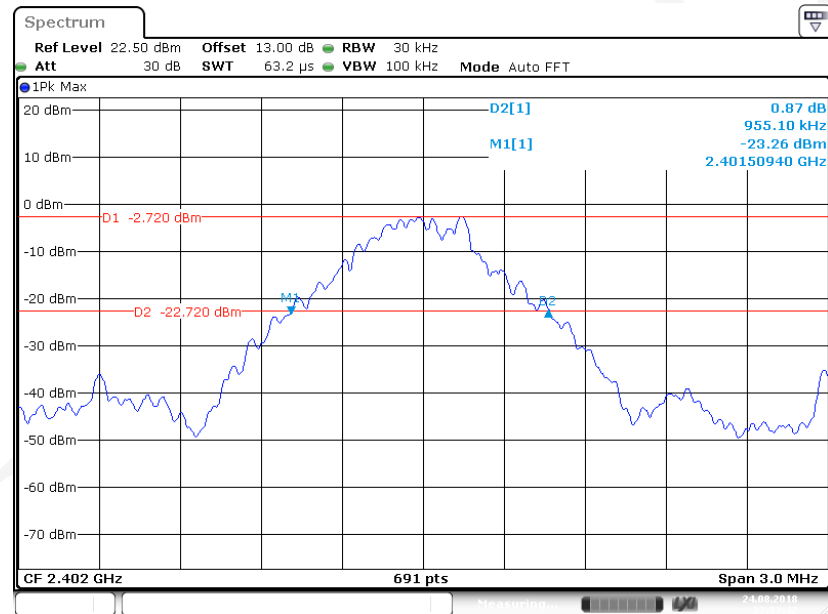
Temperature:	23.2 °C
Relative Humidity:	50 %
ATM Pressure:	101.3 kPa

The testing was performed by Hope Zhang on 2018-08-24.

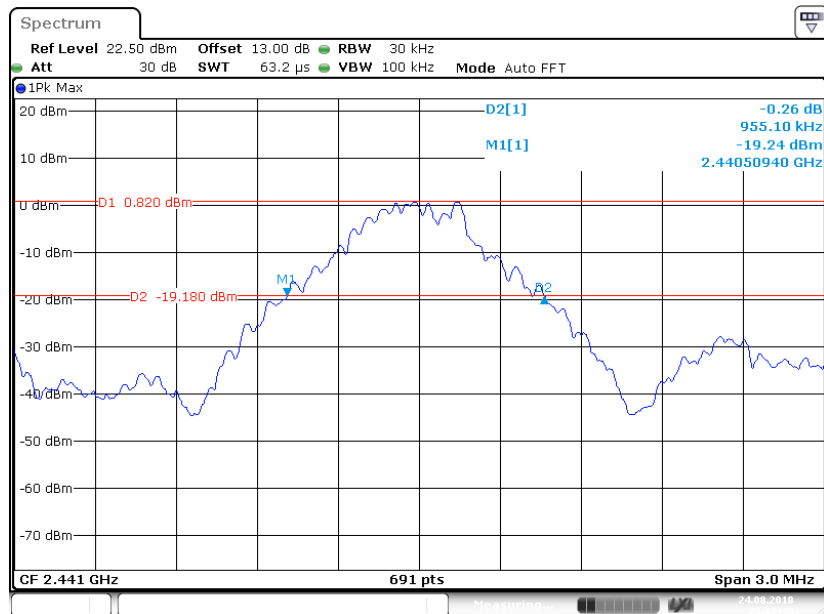
EUT operation mode: Transmitting

Test Result: Compliance.

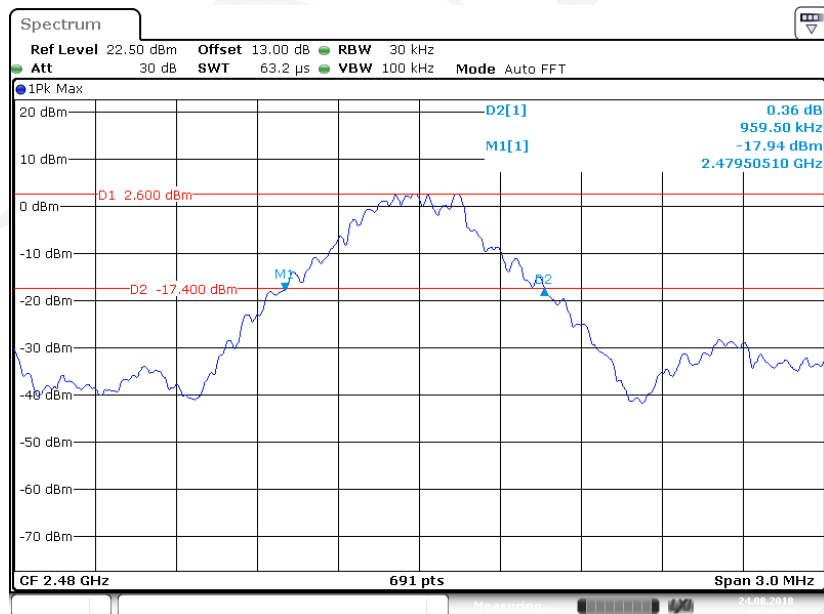
Mode	Channel	Frequency (MHz)	20 dB Emission Bandwidth (MHz)
BDR (GFSK)	Low	2402	0.955
	Middle	2441	0.955
	High	2480	0.960
EDR ($\pi/4$-DQPSK)	Low	2402	1.289
	Middle	2441	1.329
	High	2480	1.311
EDR (8DPSK)	Low	2402	1.281
	Middle	2441	1.303
	High	2480	1.294

BDR (GFSK): Low Channel

Date: 24 AUG 2018 23:33:42

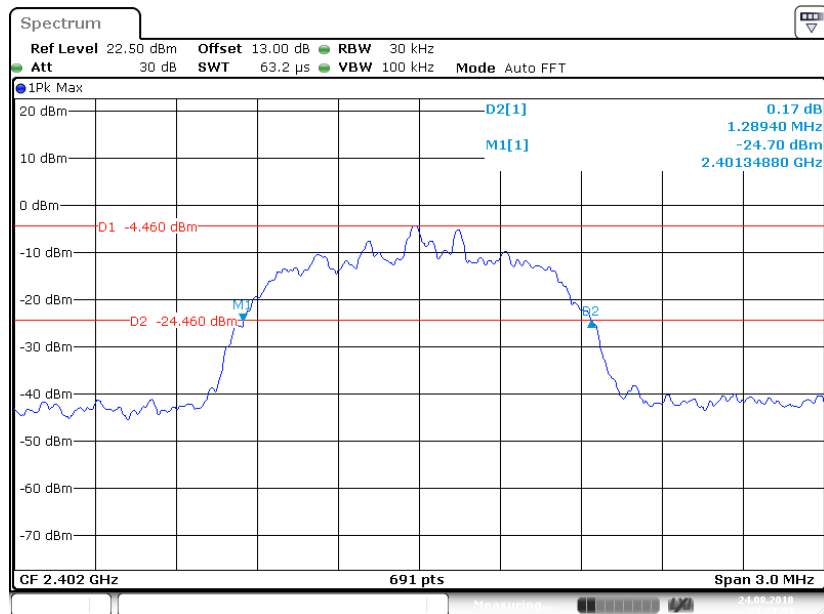
BDR (GFSK): Middle Channel

Date: 24 AUG 2018 23:32:46

BDR (GFSK): High Channel

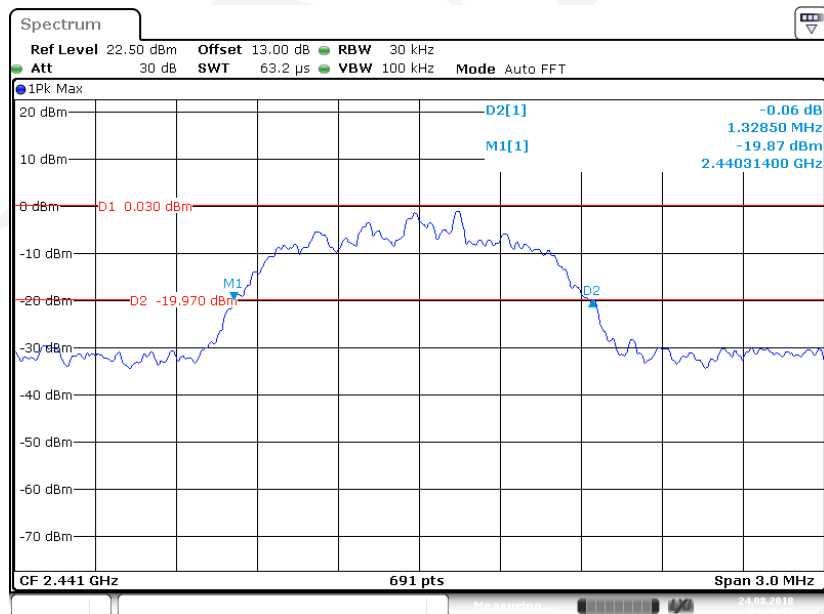
Date: 24 AUG 2018 23:31:49

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

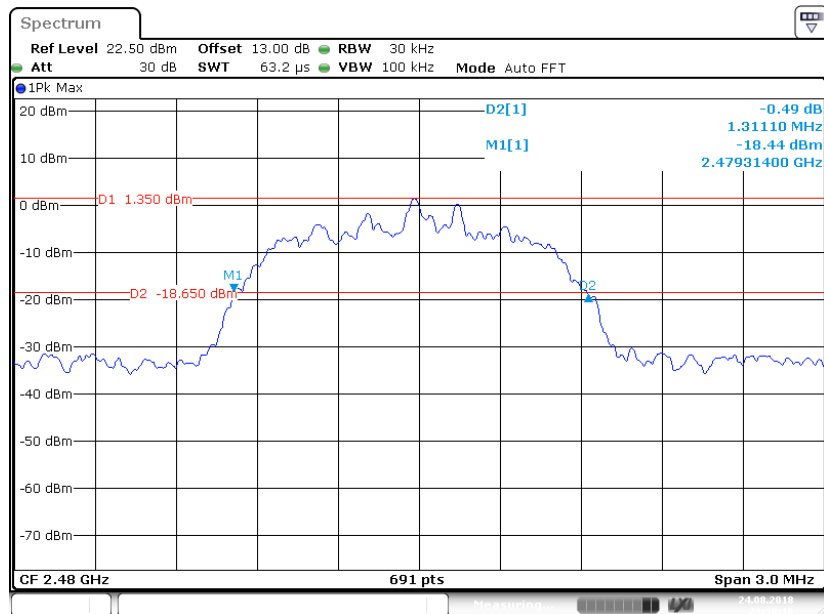


Date: 24 AUG 2018 23:27:53

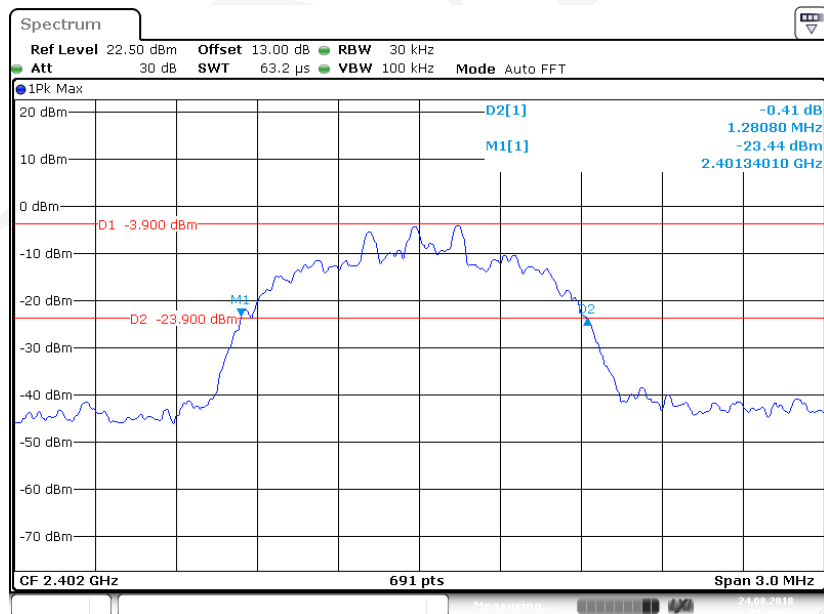
EDR($\pi/4$ -DQPSK): Middle Channel



Date: 24 AUG 2018 23:28:57

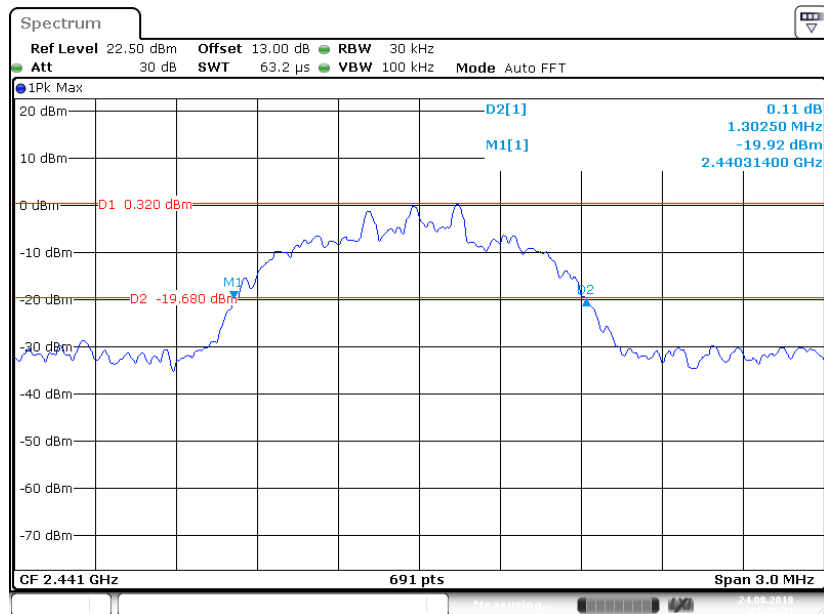
EDR ($\pi/4$ -DQPSK): High Channel

Date: 24 AUG 2018 23:30:16

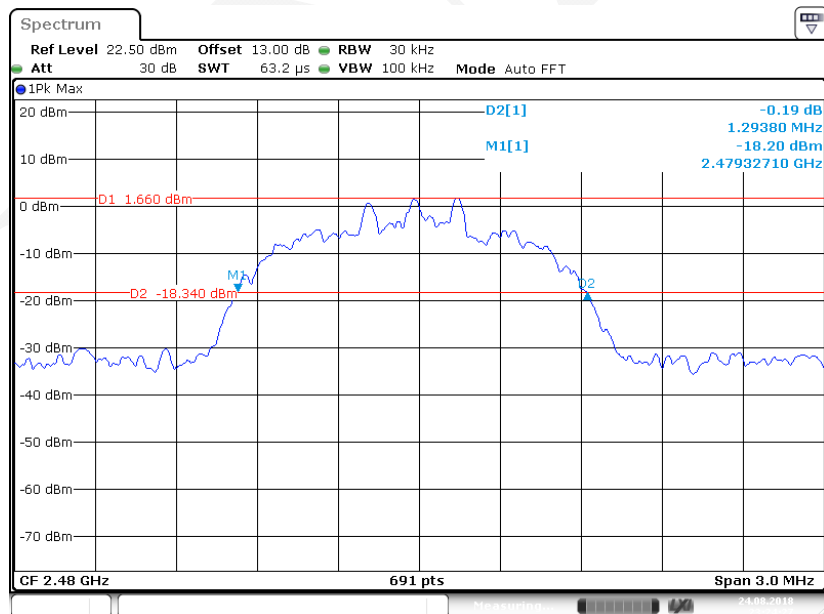
EDR (8DPSK): Low Channel

Date: 24 AUG 2018 23:26:40

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 \geq 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:	23.2 °C
Relative Humidity:	50 %
ATM Pressure:	101.3 kPa

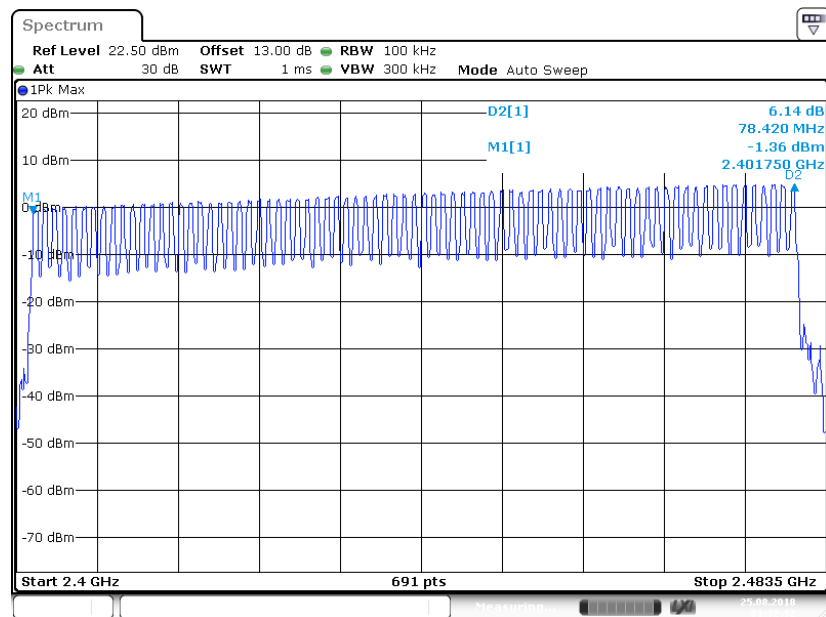
The testing was performed by Hope Zhang on 2018-08-25.

EUT operation mode: Hopping

Test Result: Compliance.

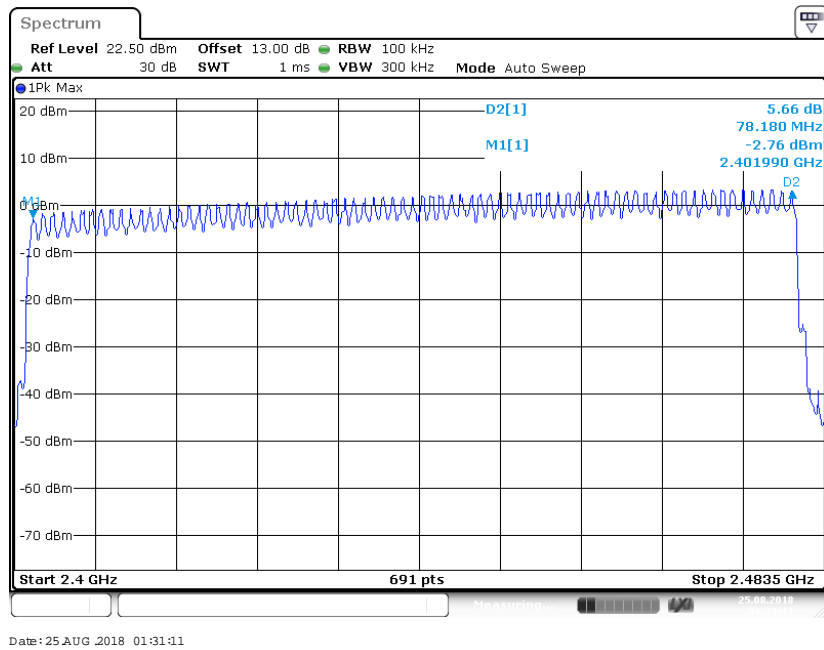
Mode	Frequency Range (MHz)	Number of Hopping Channel (CH)	Limit (CH)
BDR (GFSK)	2400 - 2483.5	79	≥ 15
EDR ($\pi/4$ -DQPSK)	2400 - 2483.5	79	≥ 15
EDR (8DPSK)	2400 - 2483.5	79	≥ 15

BDR (GFSK): Number of Hopping Channels

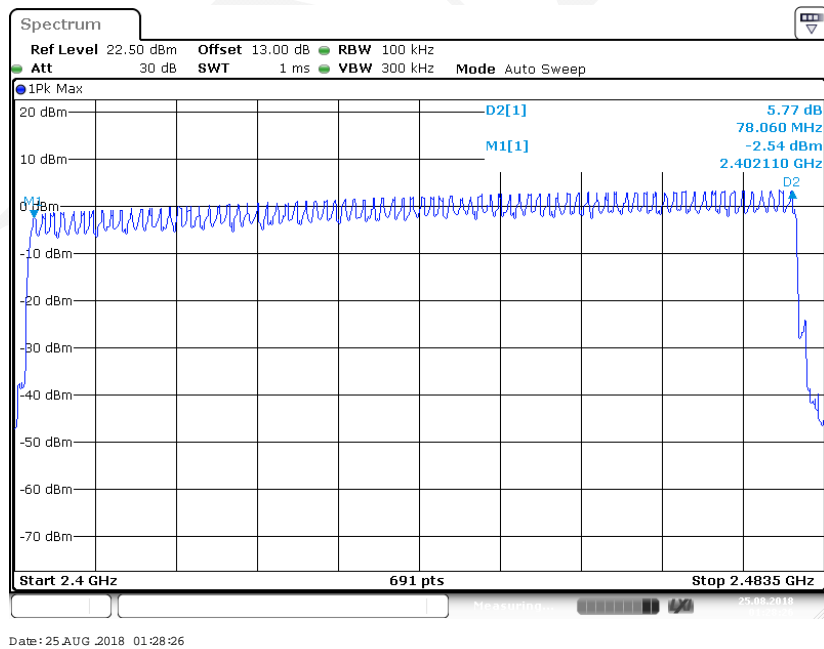


Date: 25 AUG 2018 01:32:33

EDR ($\pi/4$ -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

1 Span: Zero span, centered on a hopping channel.

2 RBW shall be \leq channel spacing and where possible RBW should be set $\geq 1 / T$, where T is the expected dwell time per channel.

3 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.

4 Detector function: Peak.

5 Trace: Max hold.

Test Data**Environmental Conditions**

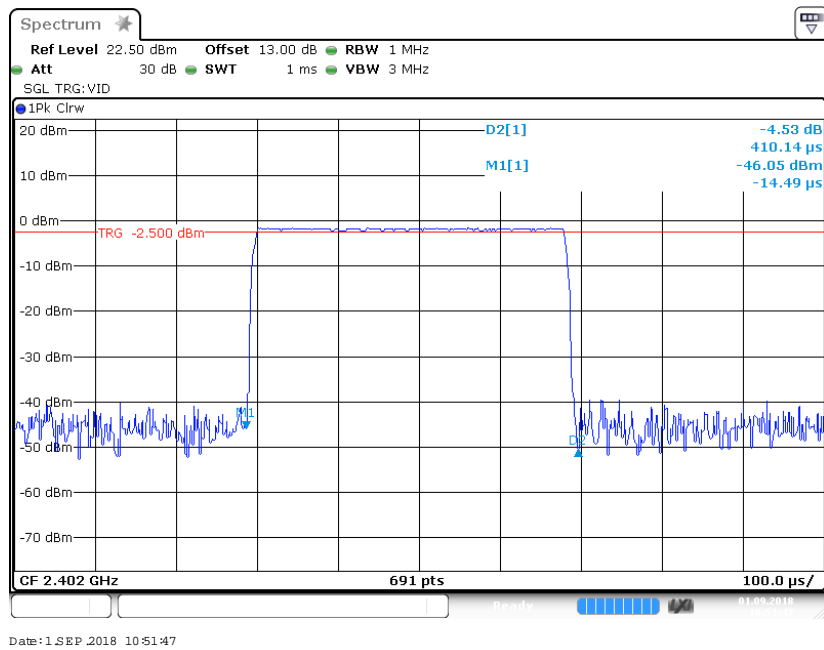
Temperature:	23.4 °C
Relative Humidity:	51 %
ATM Pressure:	101.2 kPa

The testing was performed by Hope Zhang on 2018-09-01.

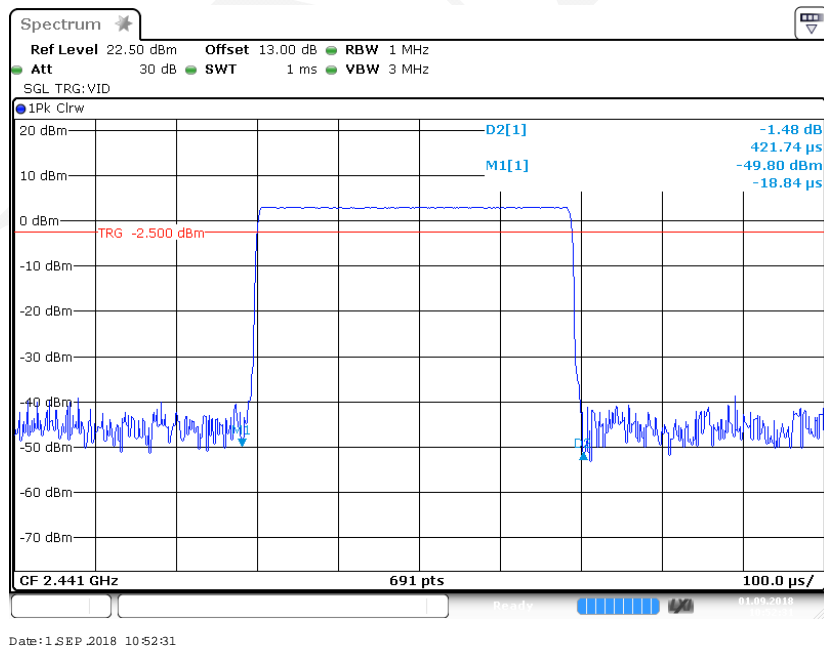
EUT operation mode: Hopping

Mode		Channel	Pulse Width (ms)	Dwell Time (s)	Limit (s)	Result
BDR (GFSK)	DH1	Low	0.410	0.131	0.4	Pass
		Middle	0.422	0.135	0.4	Pass
		High	0.419	0.134	0.4	Pass
		Note: DH1:Dwell time = Pulse time*(1600/2/79)*31.6S				
	DH3	Low	1.701	0.272	0.4	Pass
		Middle	1.683	0.269	0.4	Pass
		High	1.712	0.274	0.4	Pass
		Note: DH3:Dwell time = Pulse time*(1600/4/79)*31.6S				
	DH5	Low	2.940	0.314	0.4	Pass
		Middle	2.991	0.319	0.4	Pass
		High	2.954	0.315	0.4	Pass
		Note: DH5:Dwell time = Pulse time*(1600/6/79)*31.6S				
EDR ($\pi/4$ -DQPSK)	2DH1	Low	0.430	0.138	0.4	Pass
		Middle	0.432	0.138	0.4	Pass
		High	0.435	0.139	0.4	Pass
		Note: 2DH1:Dwell time = Pulse time*(1600/2/79)*31.6S				
	2DH3	Low	1.704	0.273	0.4	Pass
		Middle	1.693	0.271	0.4	Pass
		High	1.697	0.272	0.4	Pass
		Note: 2DH3:Dwell time = Pulse time*(1600/4/79)*31.6S				
	2DH5	Low	2.947	0.314	0.4	Pass
		Middle	2.952	0.315	0.4	Pass
		High	2.952	0.315	0.4	Pass
		Note: 2DH5:Dwell time = Pulse time*(1600/6/79)*31.6S				
EDR (8DPSK)	3DH1	Low	0.425	0.136	0.4	Pass
		Middle	0.442	0.141	0.4	Pass
		High	0.436	0.140	0.4	Pass
		Note: 3 DH1:Dwell time = Pulse time*(1600/2/79)*31.6S				
	3DH3	Low	1.697	0.272	0.4	Pass
		Middle	1.690	0.270	0.4	Pass
		High	1.722	0.276	0.4	Pass
		Note: 3DH3:Dwell time = Pulse time*(1600/4/79)*31.6S				
	3DH5	Low	3.003	0.320	0.4	Pass
		Middle	2.959	0.316	0.4	Pass
		High	2.952	0.315	0.4	Pass
		Note: 3DH5:Dwell time = Pulse time*(1600/6/79)*31.6S				

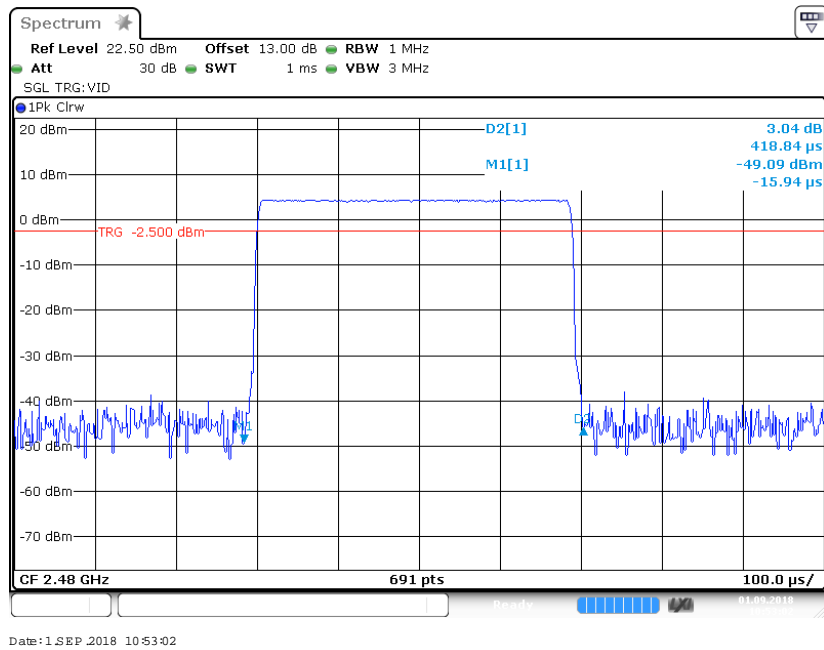
BDR (GFSK): Pulse time, Low Channel, DH1



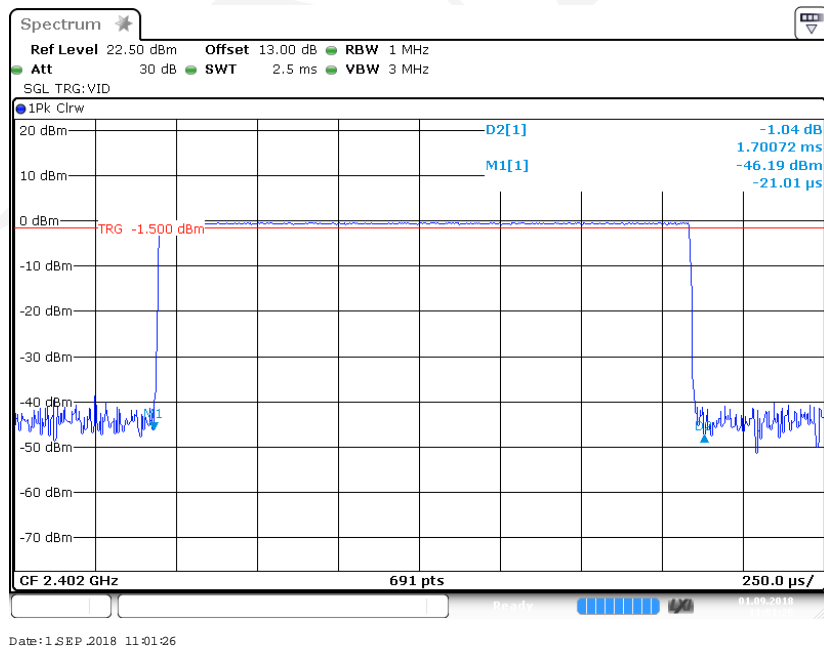
BDR (GFSK): Pulse time, Middle Channel, DH1



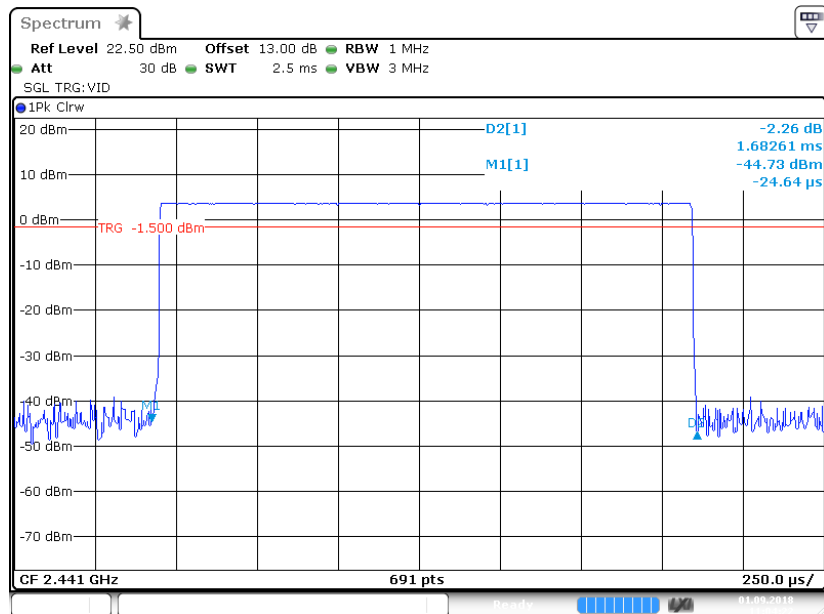
BDR (GFSK): Pulse time, High Channel, DH1



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

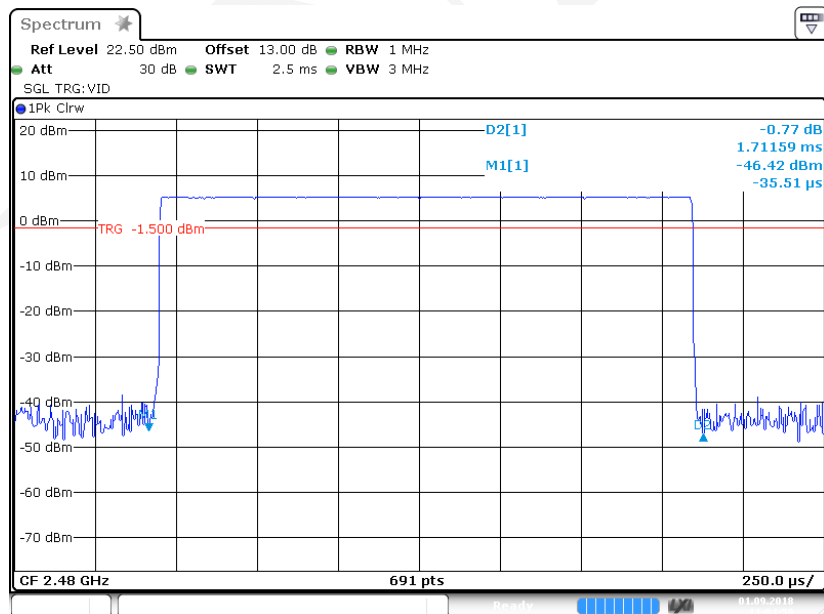


BDR (GFSK): Pulse time, Middle Channel, DH3



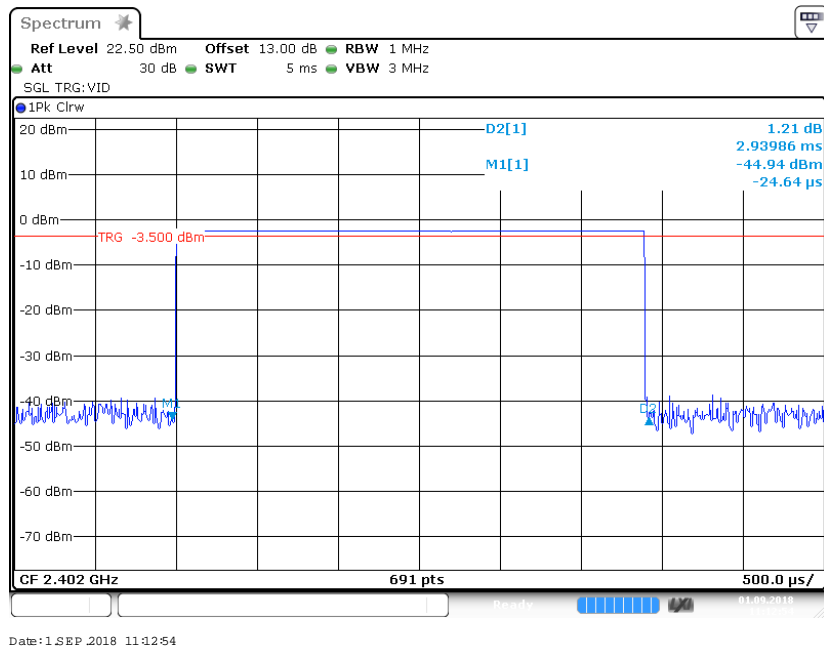
Date:1 SEP 2018 11:04:22

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

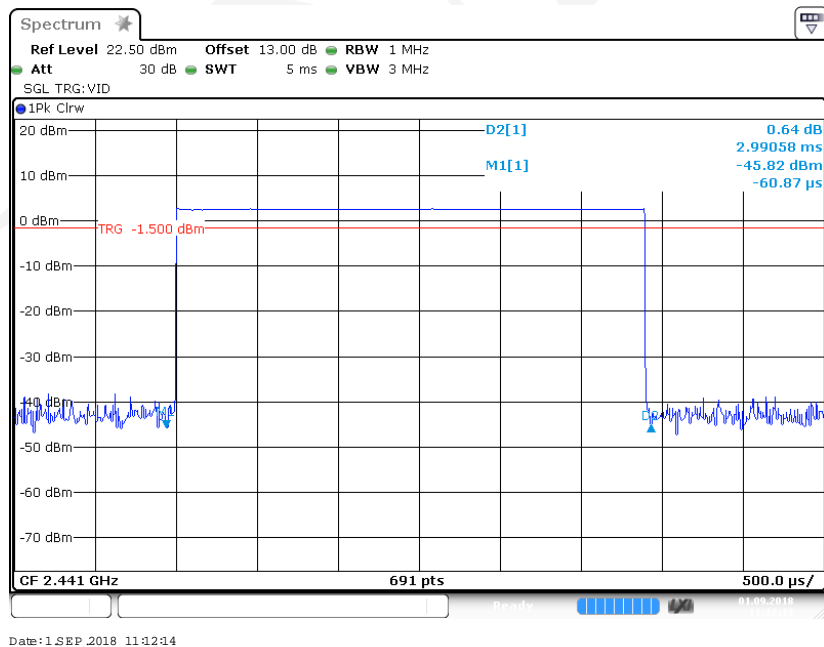


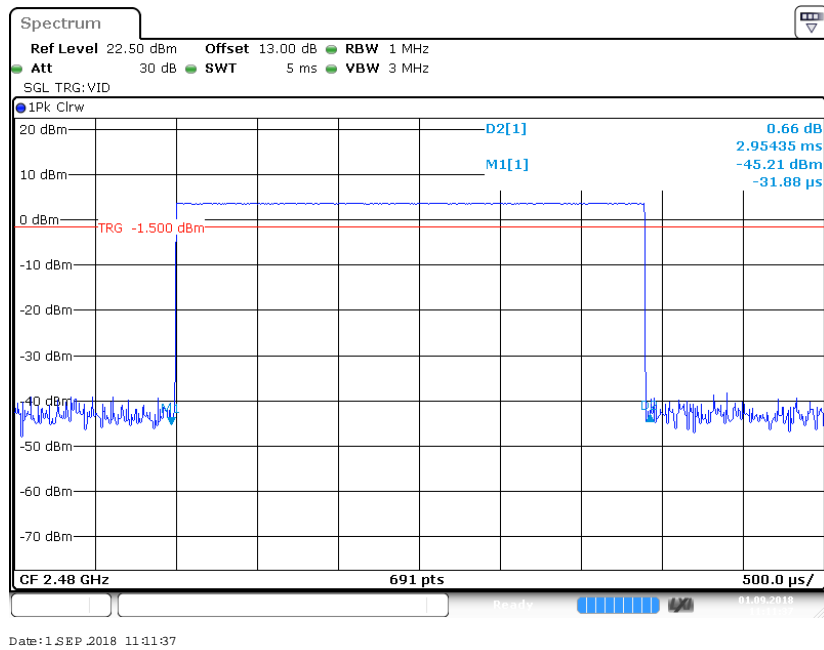
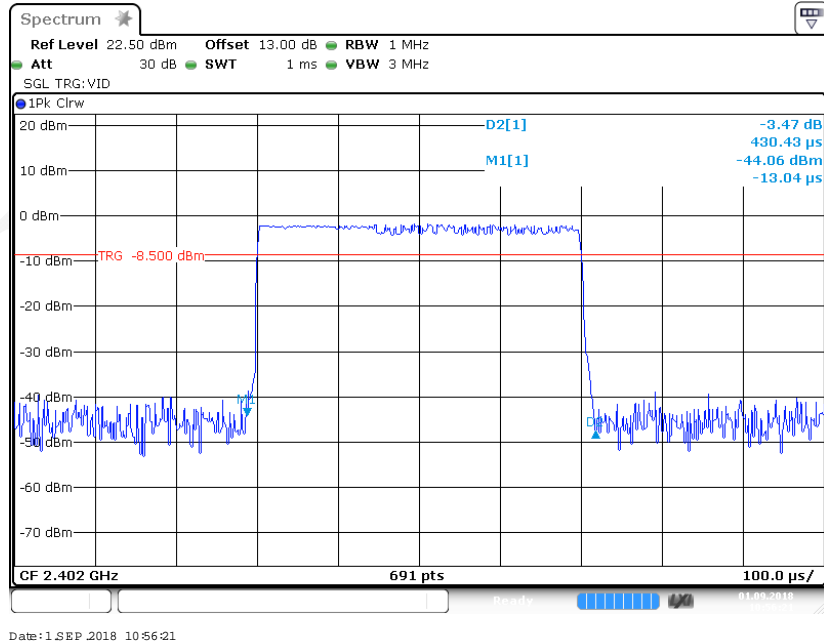
Date:1 SEP 2018 11:04:59

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

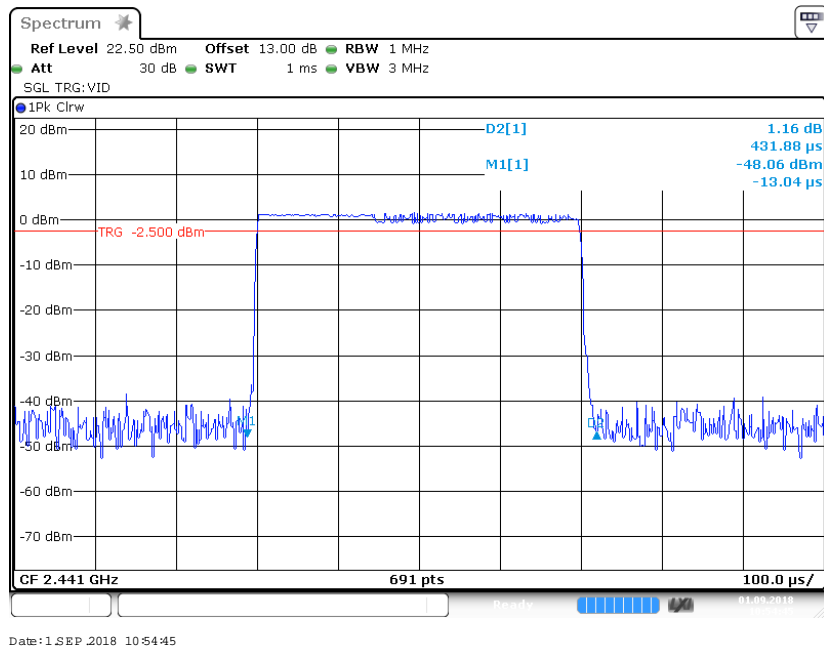


BDR (GFSK): Pulse time, Middle Channel, DH5

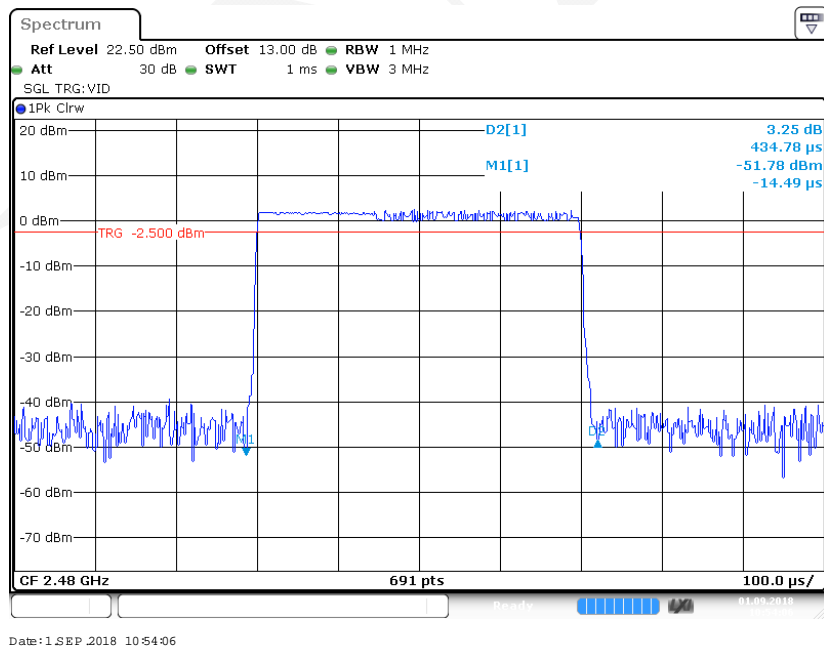


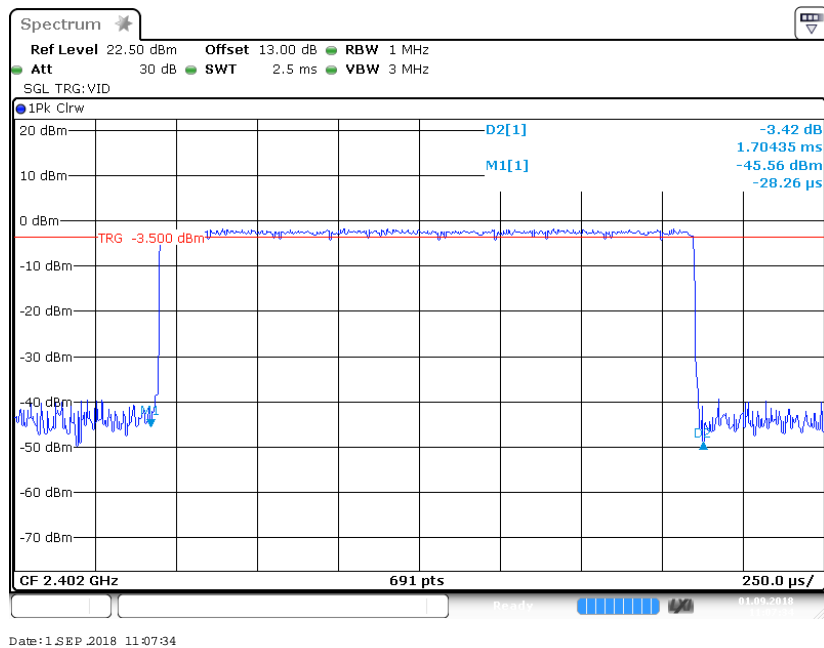
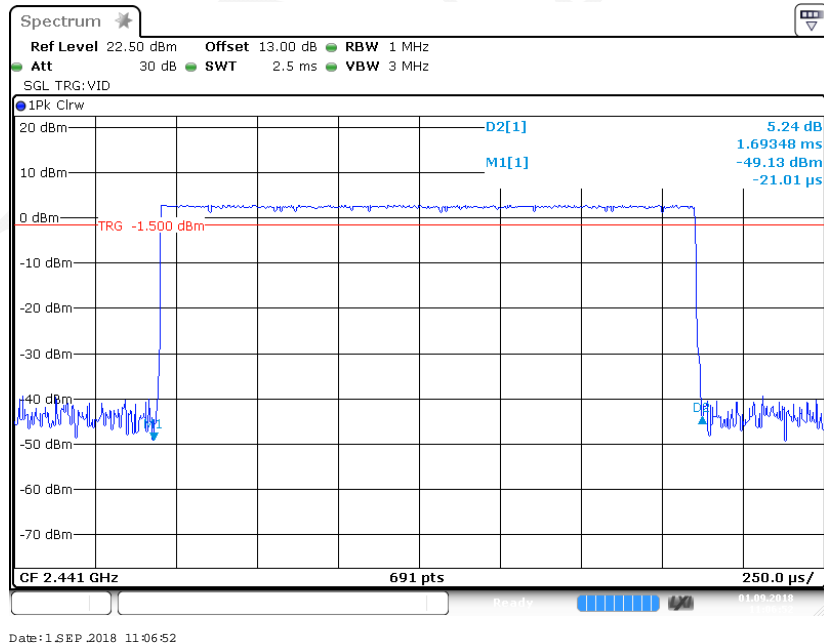
BDR (GFSK): Pulse time, High Channel, DH5**EDR ($\pi/4$ -DQPSK): Pulse time, Low Channel, 2DH1**

EDR ($\pi/4$ -DQPSK):Pulse time, Middle Channel, 2DH1

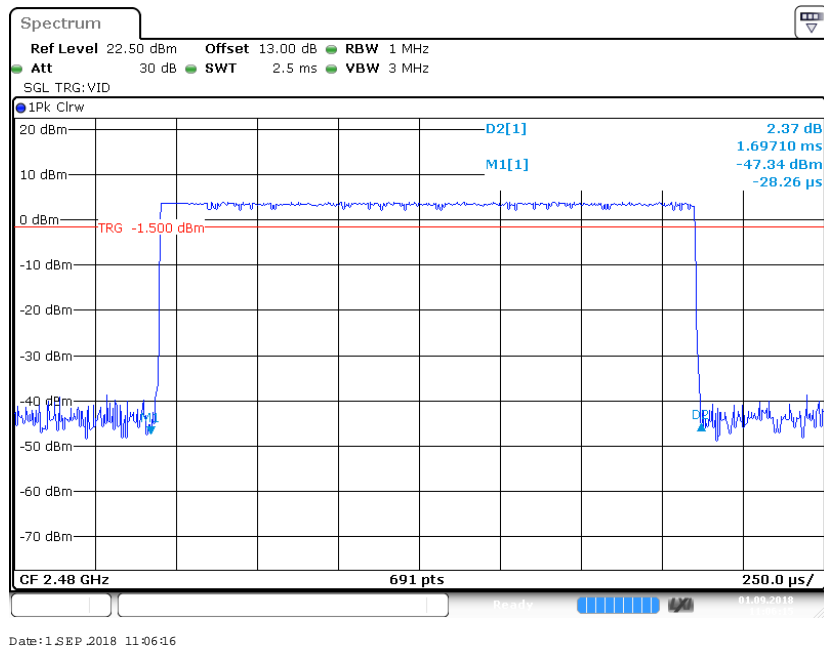


EDR ($\pi/4$ -DQPSK):Pulse time, High Channel, 2DH1

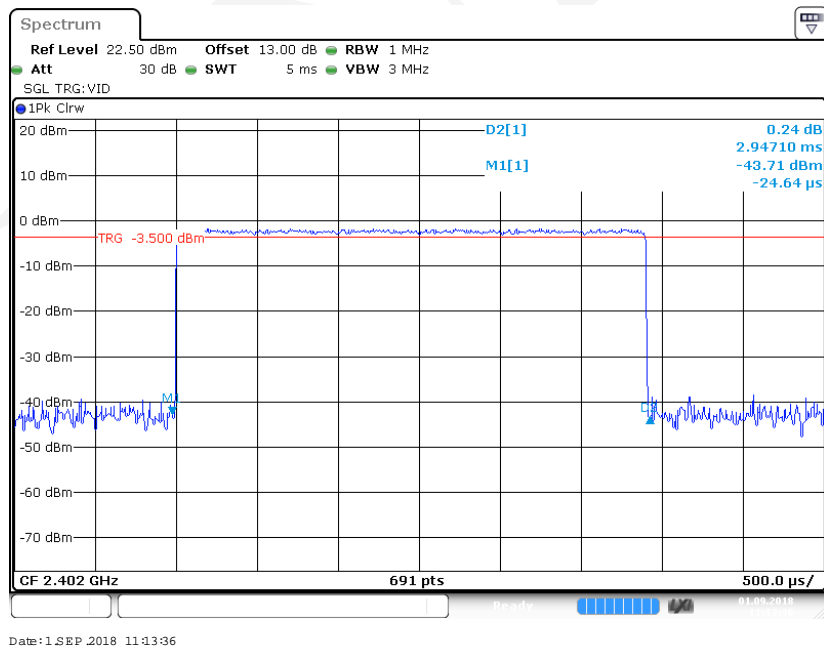


EDR ($\pi/4$ -DQPSK):Pulse time, Low Channel, 2DH3EDR ($\pi/4$ -DQPSK):Pulse time, Middle Channel, 2DH3

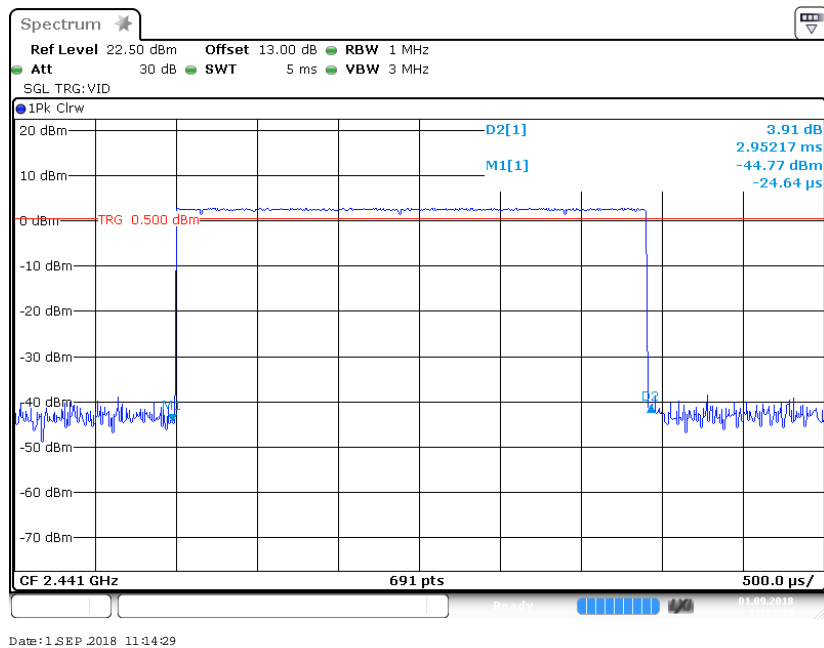
EDR ($\pi/4$ -DQPSK):Pulse time, High Channel, 2DH3



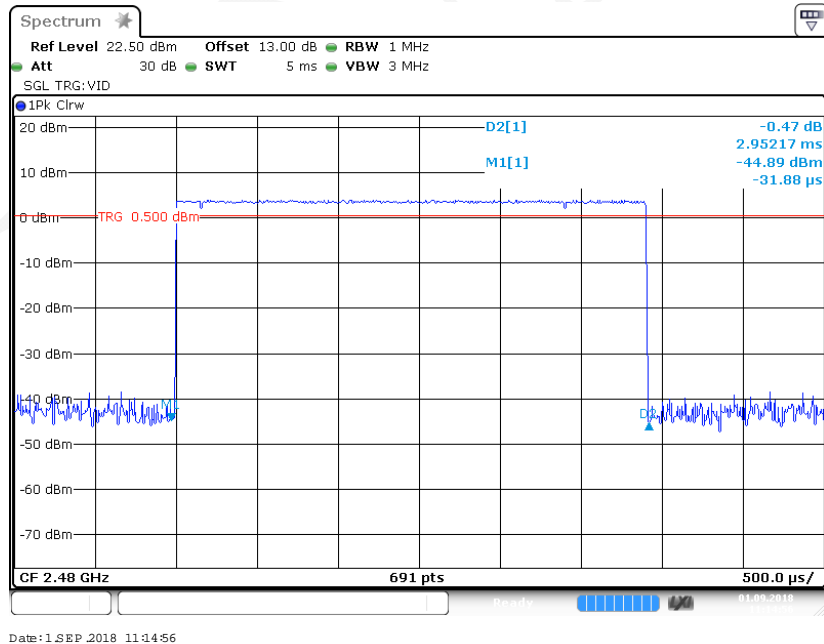
EDR ($\pi/4$ -DQPSK):Pulse time, Low Channel, 2DH5



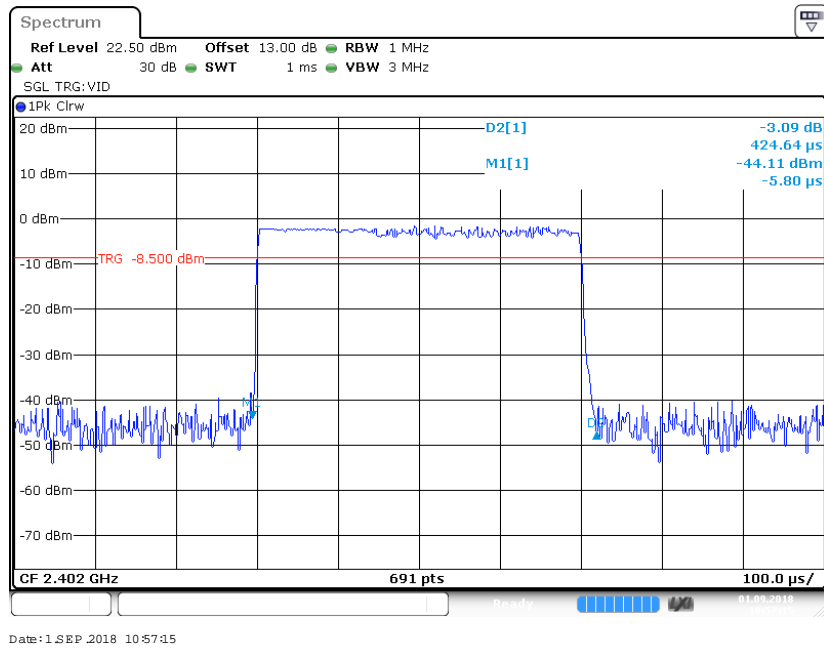
EDR ($\pi/4$ -DQPSK): Pulse time, Middle Channel, 2DH5



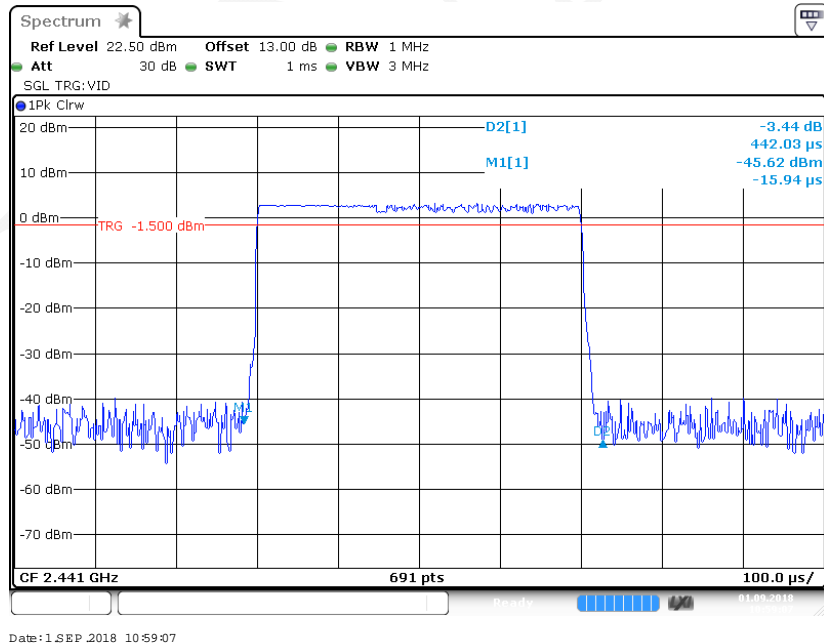
EDR ($\pi/4$ -DQPSK): Pulse time, High Channel, 2DH5



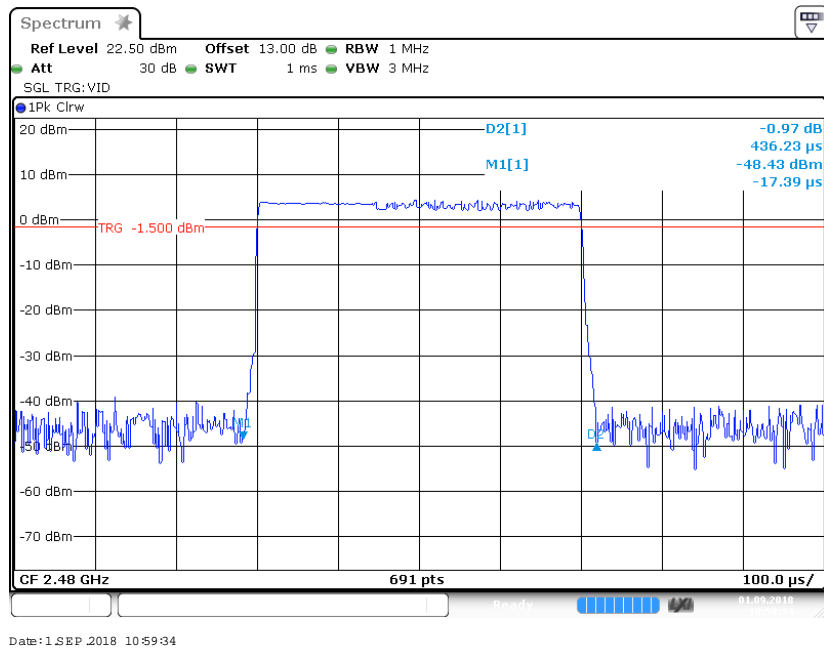
EDR (8DPSK): Pulse time, Low Channel, 3DH1



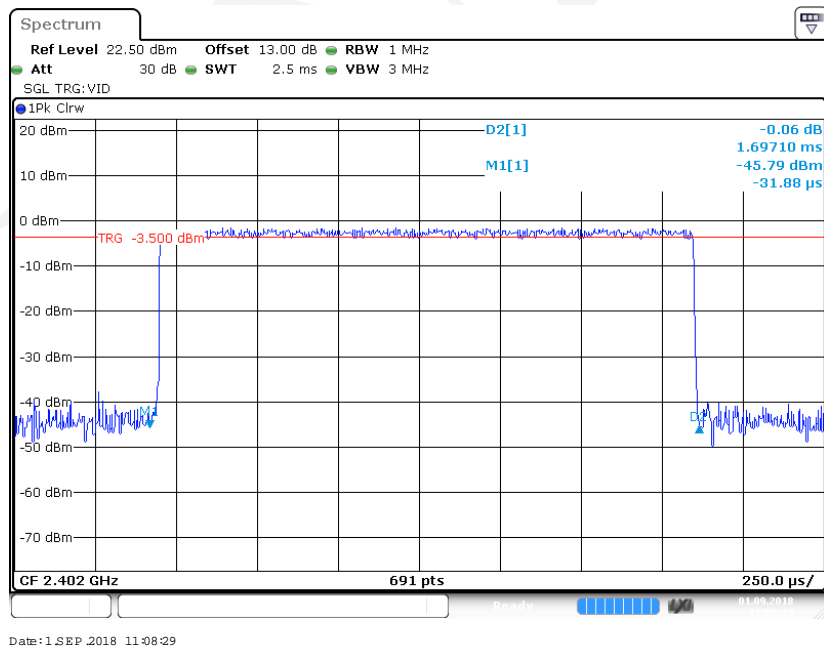
EDR (8DPSK): Pulse time, Middle Channel, 3DH1



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



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



Spectrum

Ref Level 22.50 dBm **Offset** 13.00 dB **RBW** 1 MHz

Att 30 dB **SWT** 2.5 ms **VBW** 3 MHz

SGL TRG:VID

1Pk Clrw

D2[1] -0.38 dB
1.68986 ms

M1[1] -45.48 dBm
-13.77 μs

TRG -1.500 dBm

CF 2.441 GHz **691 pts** **250.0 μs**

Date: 1 SEP 2018 11:09:18

Spectrum

Ref Level 22.50 dBm **Offset** 13.00 dB **RBW** 1 MHz

Att 30 dB **SWT** 2.5 ms **VBW** 3 MHz

SGL TRG:VID

1Pk Clrw

D2[1] -1.43 dB

M1[1] -48.90 dBm

TRG -1.500 dBm

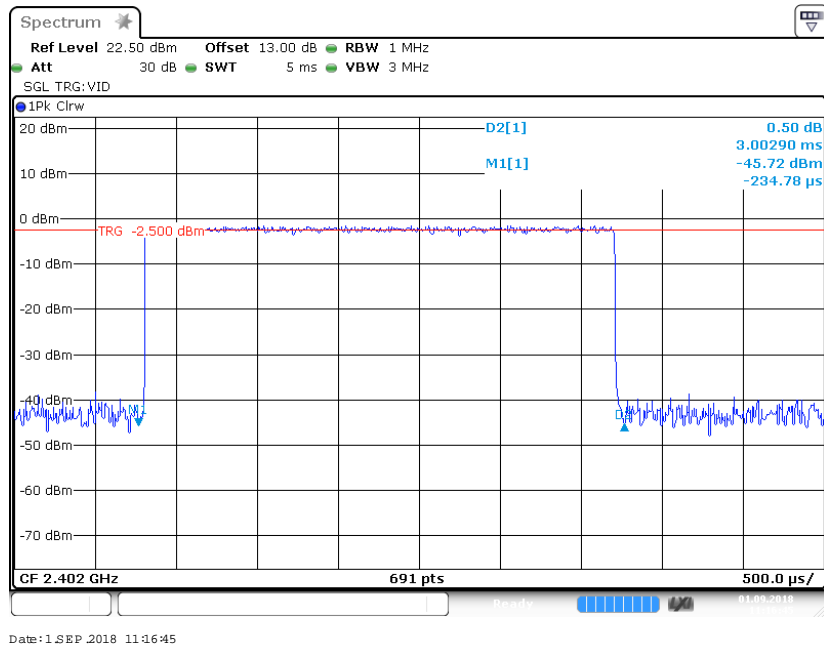
1.72246 ms

31.88 μs

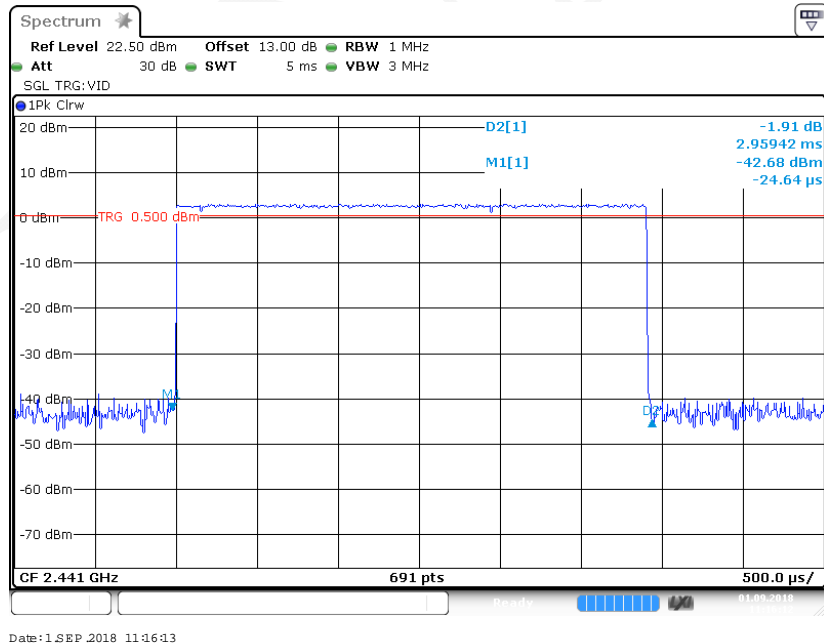
CF 2.48 GHz **691 pts** **250.0 μs**

Date:1 SEP 2018 11:10:03

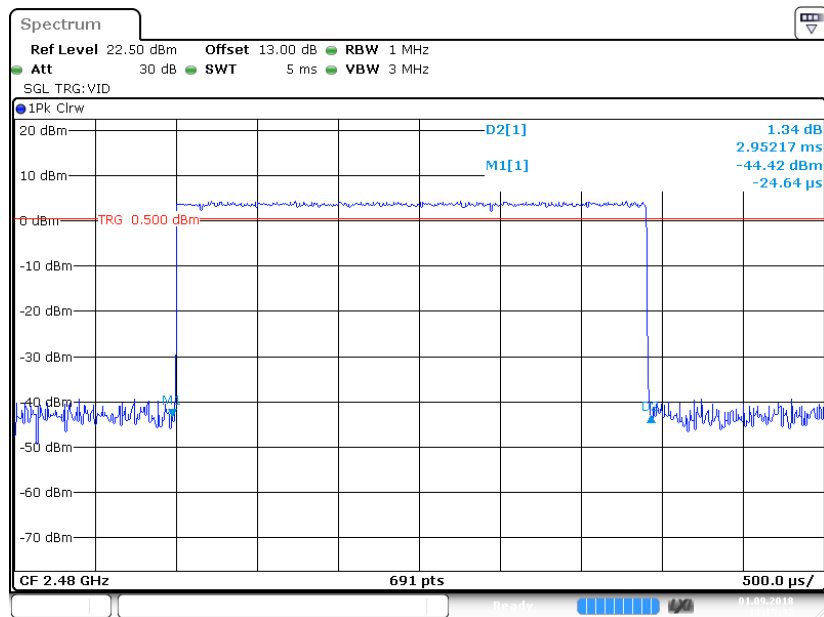
EDR (8DPSK): Pulse time, Low Channel, 3DH5



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



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



Date: 1 SEP 2018 11:15:32

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 \geq RBW.
 - 4) Sweep: Auto.
 - 5) Detector function: Peak.
 - 6) Trace: Max hold.
- b. Allow trace to stabilize.
- c. Use the marker-to-peak function to set the marker to the peak of the emission.
- d. The indicated level is the peak output power, after any corrections for external attenuators and cables.
- e. A plot of the test results and setup description shall be included in the test report.

Test Data

Environmental Conditions

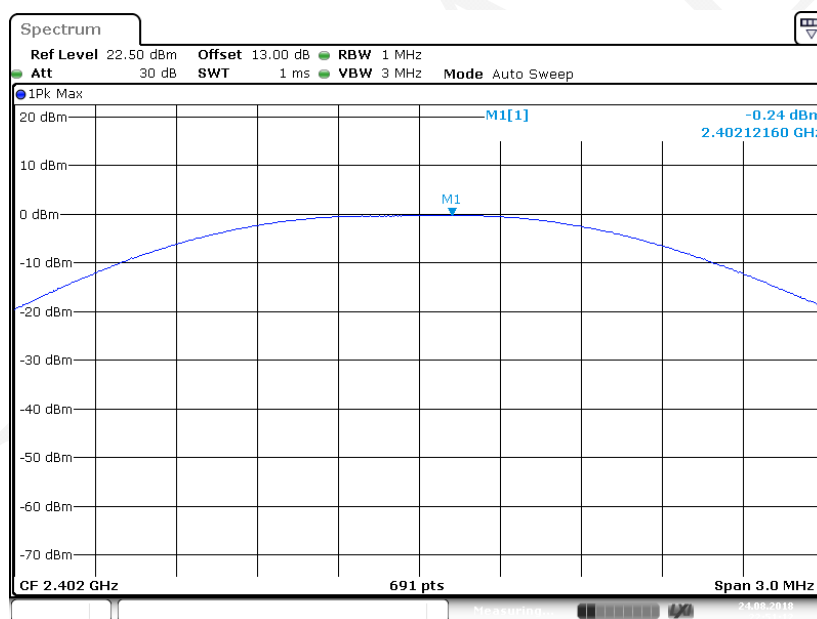
Temperature:	23.3-23.5 °C
Relative Humidity:	49-50 %
ATM Pressure:	101.1-101.2 kPa

The testing was performed by Hope Zhang on 2018-08-24 & 2018-09-14.

EUT operation mode: Transmitting

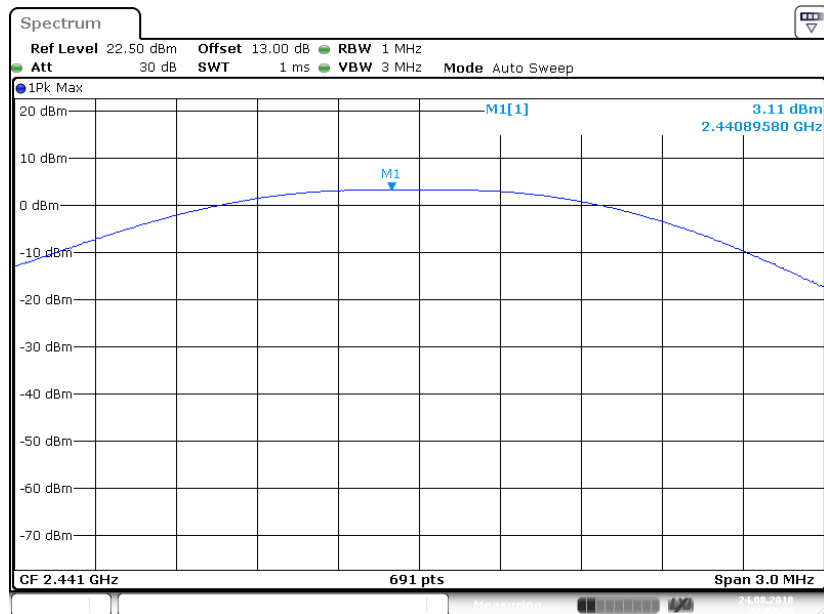
Test Result: Compliance.

Mode	Frequency (MHz)	Output Power		Limit (mW)
		(dBm)	(mW)	
BDR (GFSK)	2402	-0.24	0.95	≤ 1000
	2441	3.11	2.05	≤ 1000
	2480	4.42	2.77	≤ 1000
EDR ($\pi/4$-DQPSK)	2402	-1.19	0.76	≤ 125
	2441	2.69	1.86	≤ 125
	2480	4.37	2.74	≤ 125
EDR (8DPSK)	2402	-0.75	0.84	≤ 125
	2441	2.82	1.91	≤ 125
	2480	4.37	2.74	≤ 125

BDR (GFSK): 2402MHz

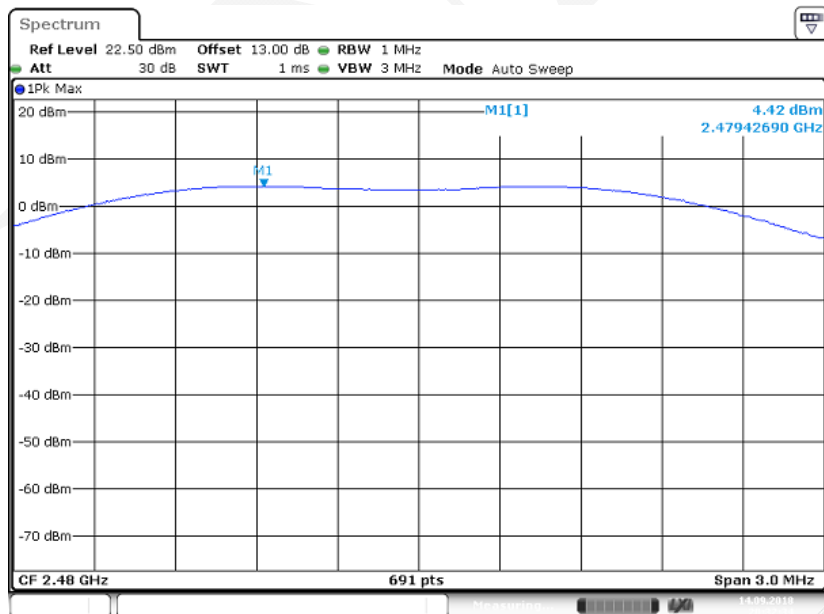
Date: 24 AUG 2018 22:51:11

BDR (GFSK): 2441MHz



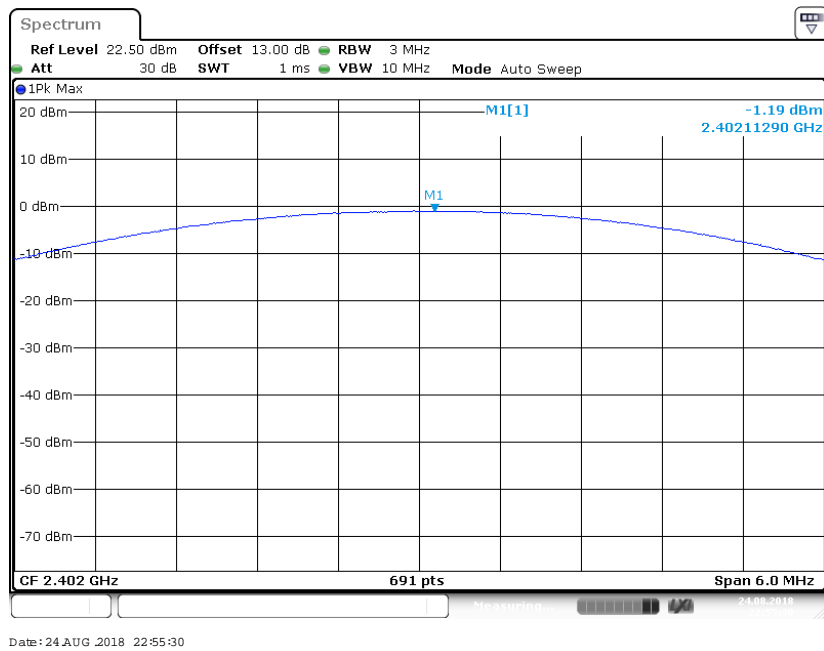
Date: 24 AUG 2018 22:52:30

BDR (GFSK): 2480MHz

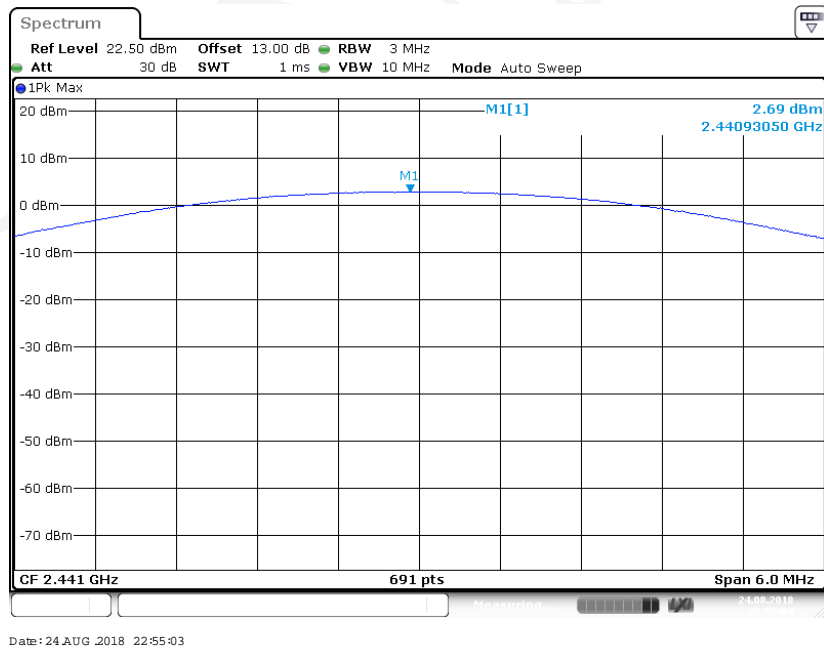


Date: 14 SEP 2018 20:22:24

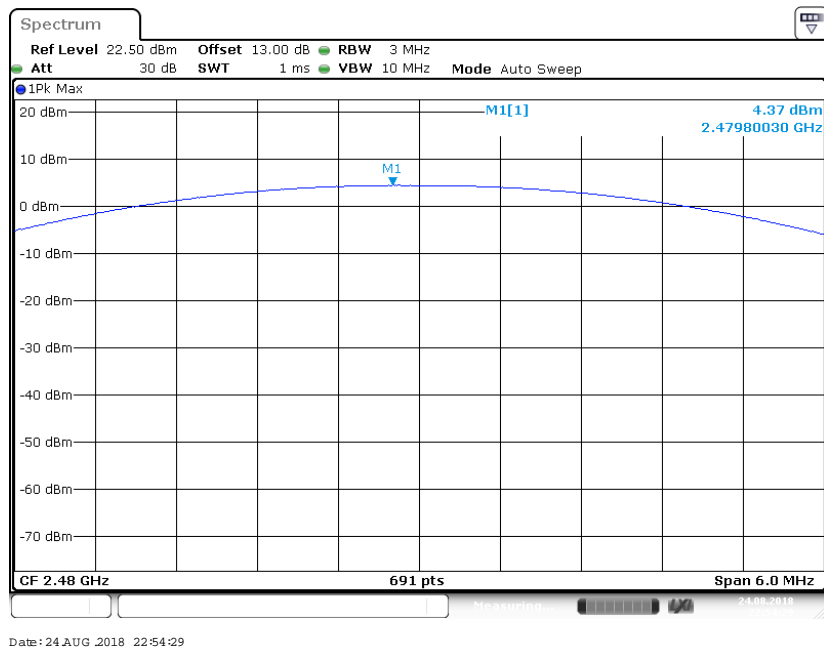
EDR($\pi/4$ -DQPSK): 2402MHz



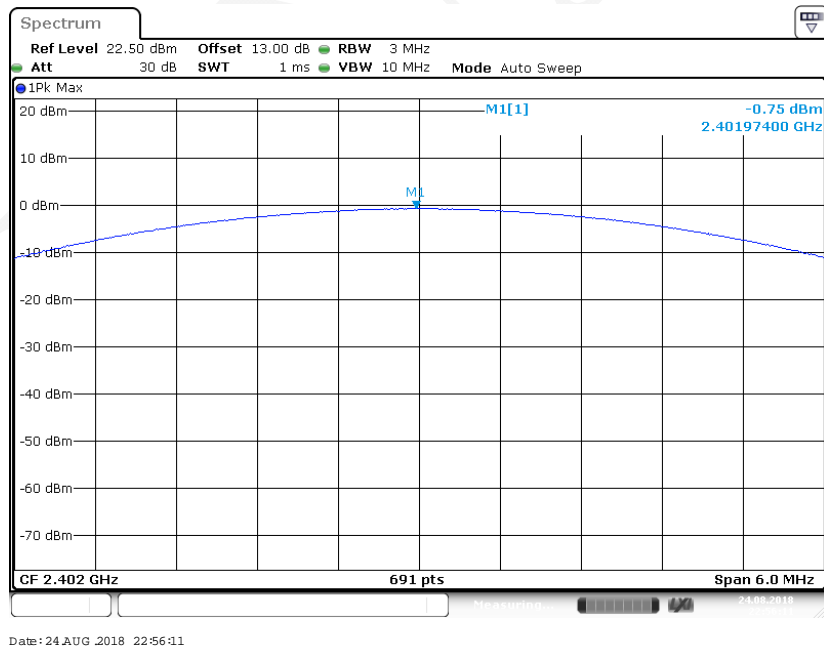
EDR($\pi/4$ -DQPSK): 2441MHz



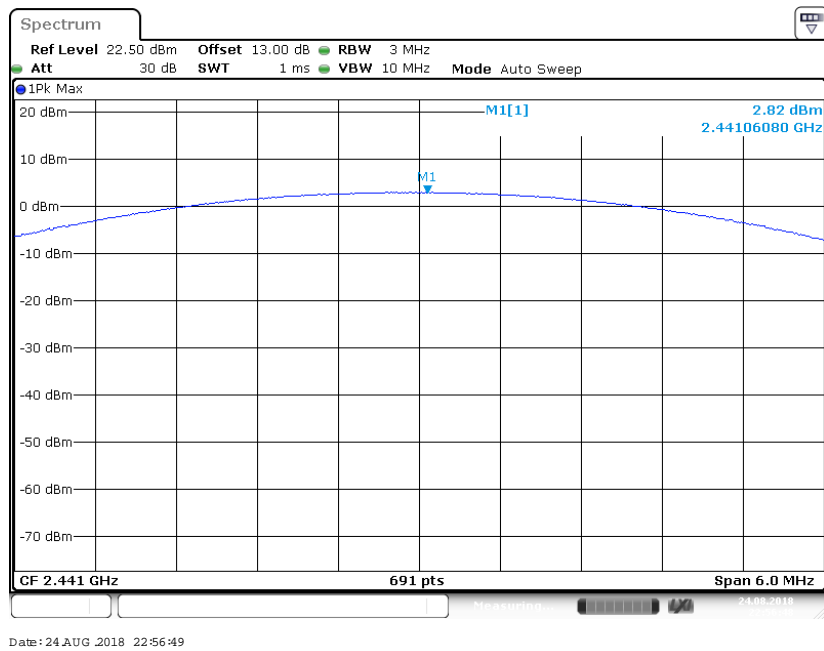
EDR($\pi/4$ -DQPSK): 2480MHz



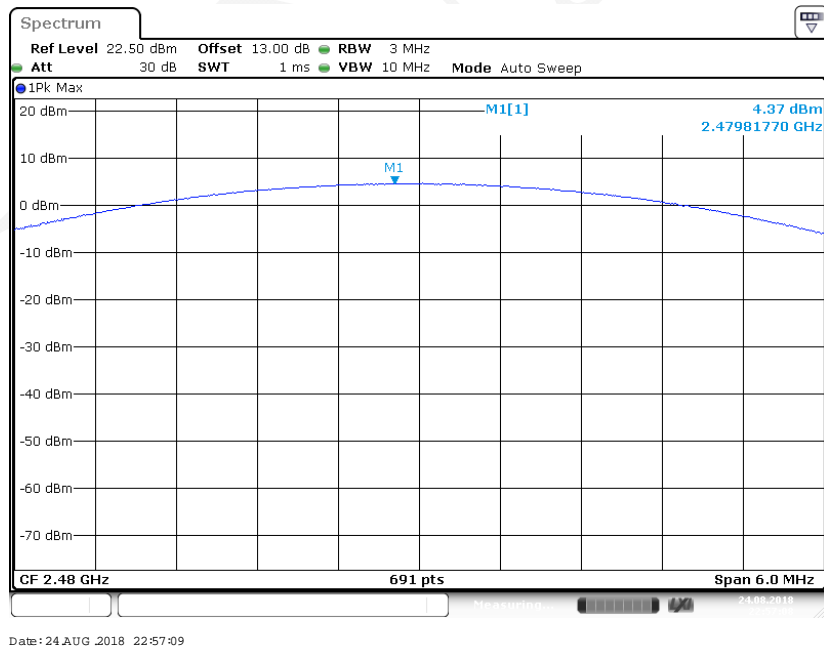
EDR(8DPSK): 2402MHz



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:	23.2 °C
Relative Humidity:	50 %
ATM Pressure:	101.3 kPa

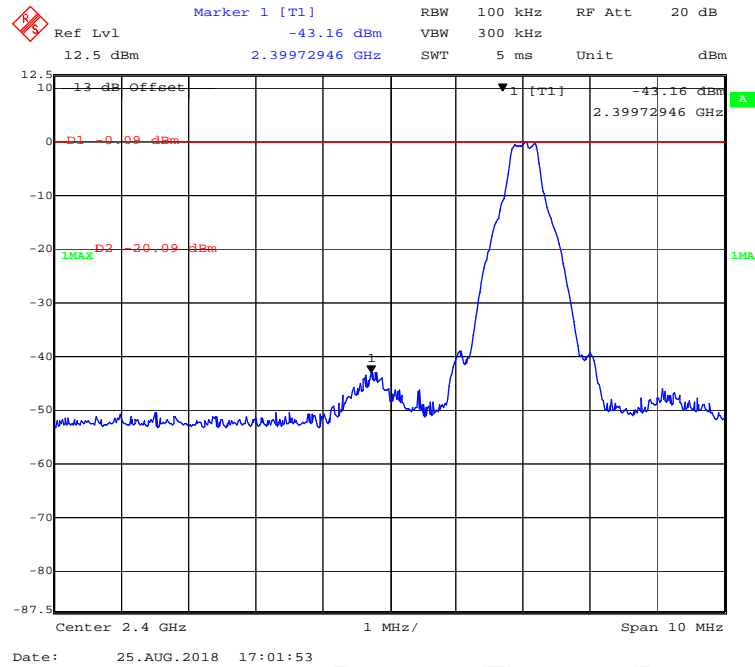
The testing was performed by Hope Zhang on 2018-08-25.

EUT operation mode: Transmitting & Hopping

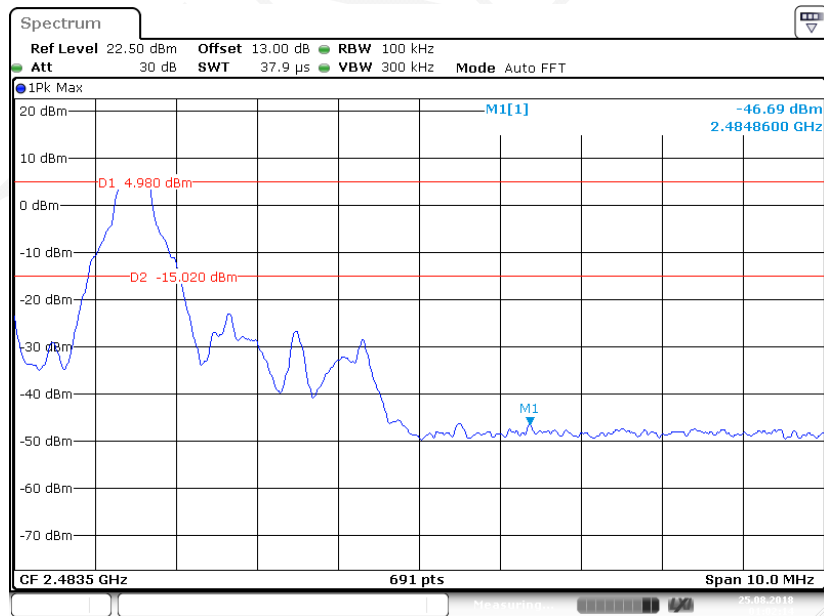
Test Result: Compliance.

Band Edge

BDR (GFSK): Left Side

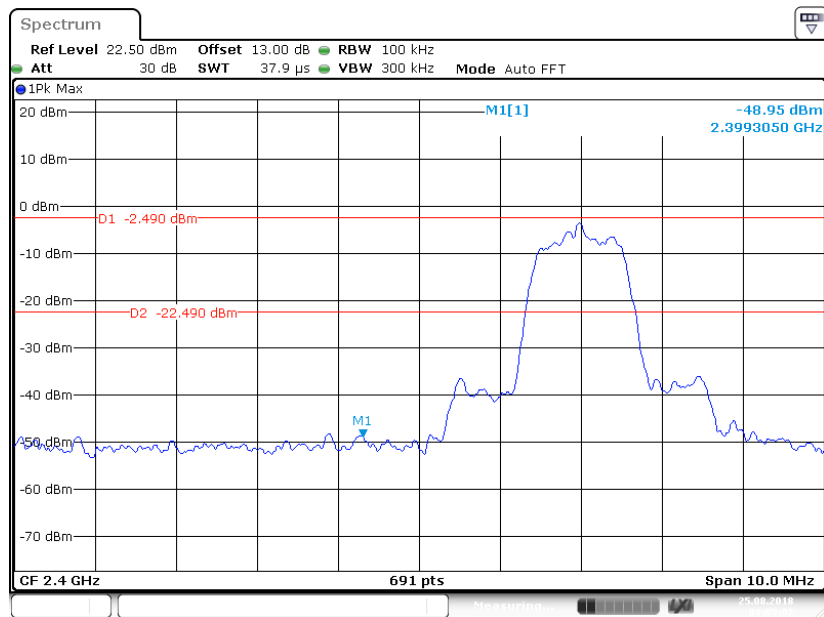


BDR (GFSK): Right Side

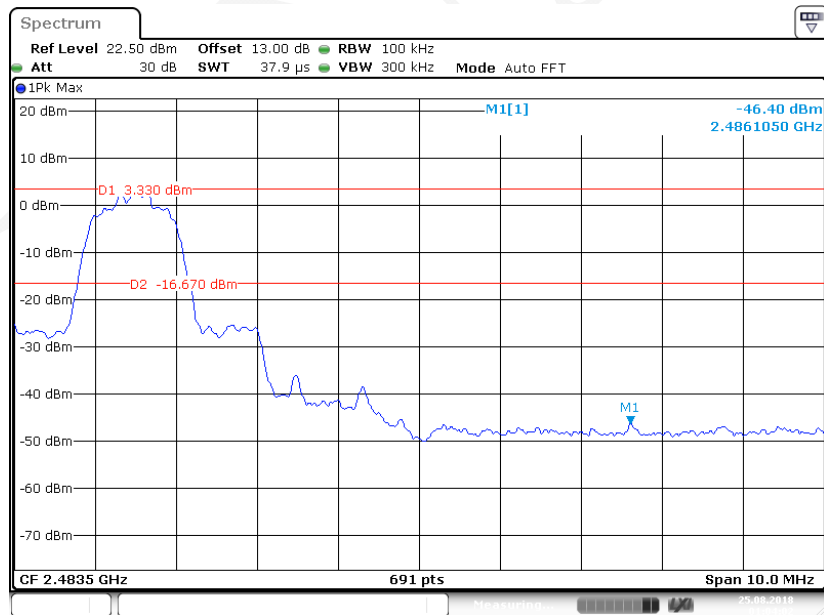


Date: 25 AUG 2018 01:02:14

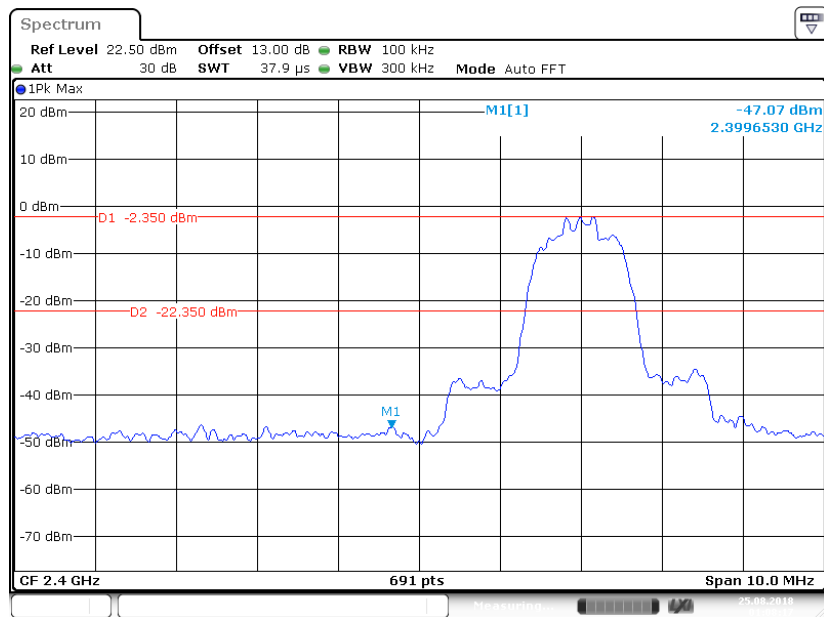
EDR ($\pi/4$ -DQPSK): Left Side



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

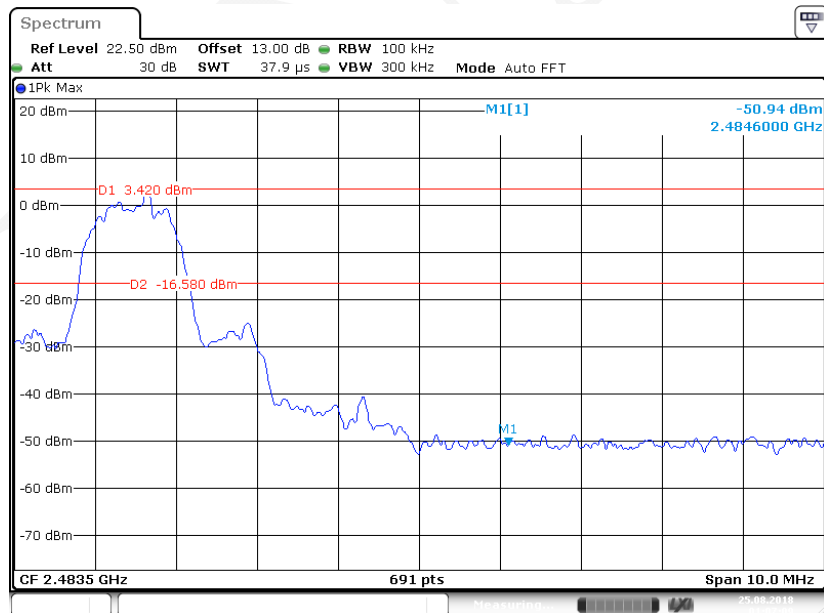


EDR (8DPSK): Left Side



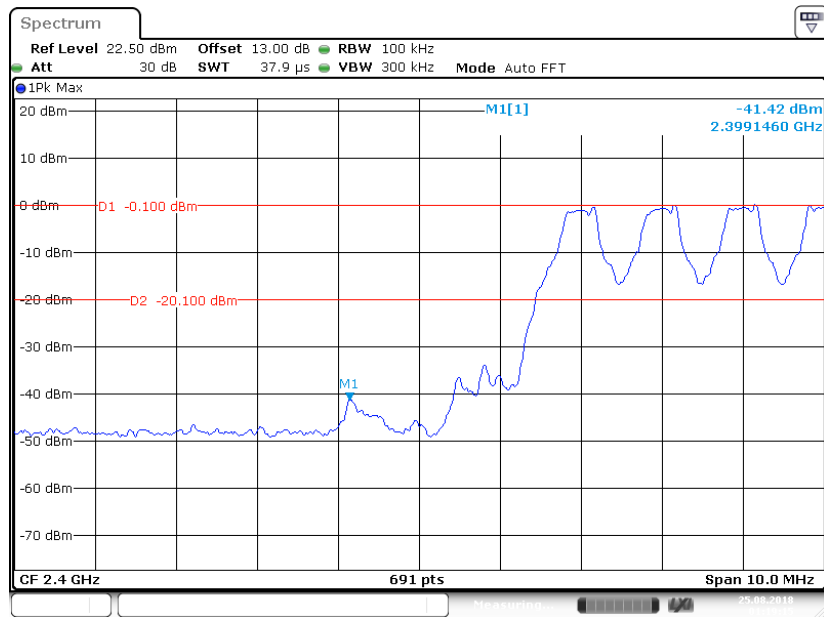
Date: 25 AUG 2018 01:08:17

EDR (8DPSK): Right Side

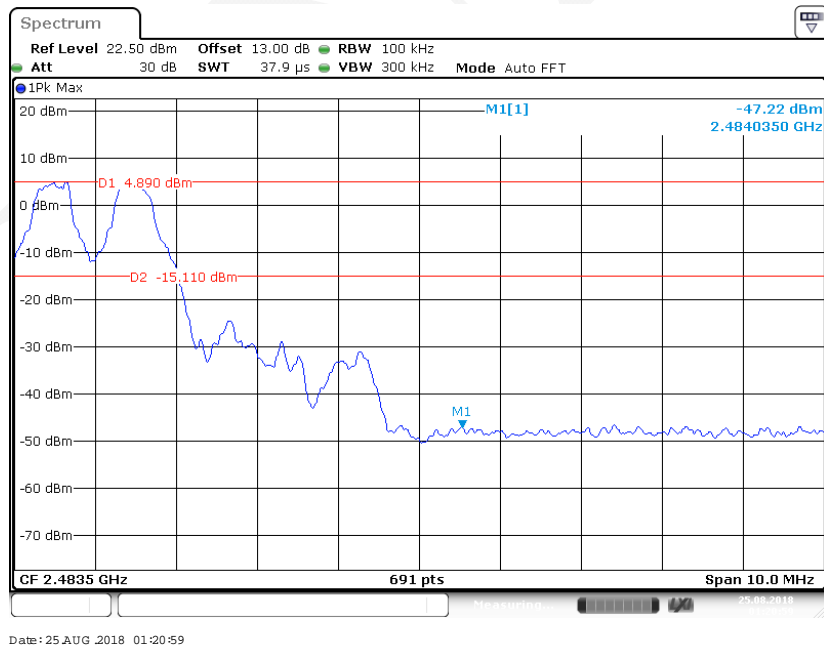


Date: 25 AUG 2018 01:07:09

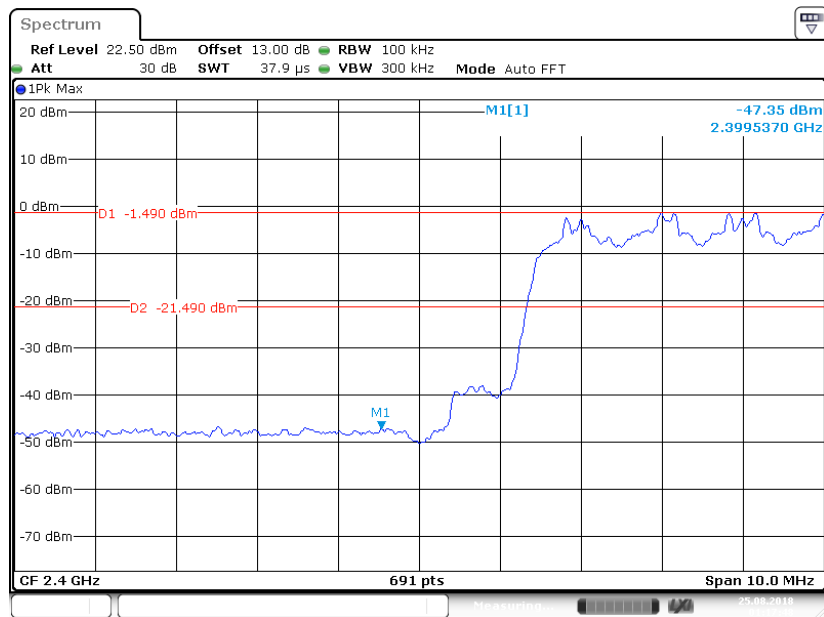
BDR (GFSK): Left Side - Hopping



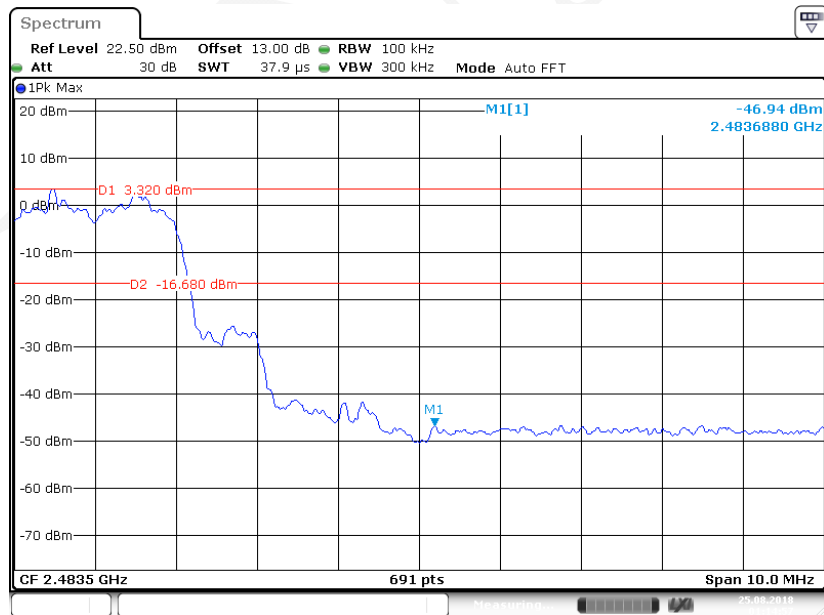
BDR (GFSK): Right Side- Hopping



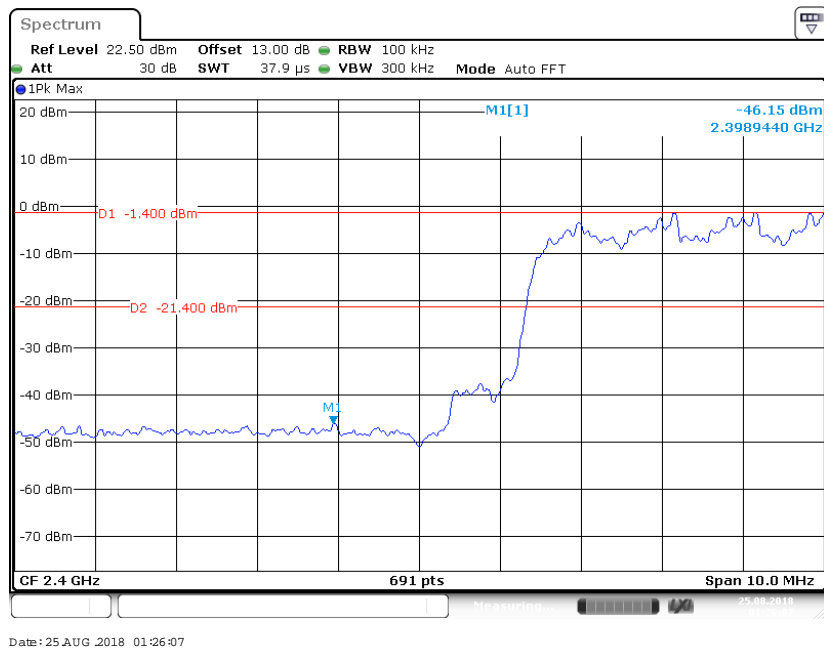
EDR ($\pi/4$ -DQPSK): Left Side- Hopping



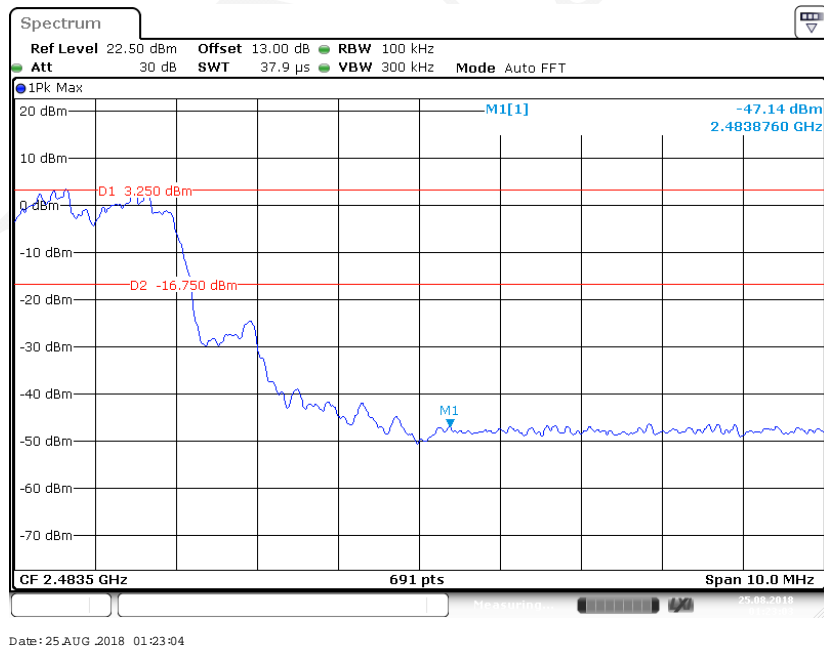
EDR ($\pi/4$ -DQPSK): Right Side- Hopping



EDR (8DPSK): Left Side - Hopping



EDR (8DPSK): Right Side - Hopping



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