FCC PART 15.247
TEST REPORT

For

ESPRESSIF SYSTEMS (SHANGHAI) PTE LTD

456 Bibo Road Room A201, Shanghai, China

FCC ID: 2AC7Z-ESP32PICOKIT

Report Type:	Product Type:
Original Report	WIFI & Bluetooth Development Board

Test Engineer:	Ada Yu
Report Number:	RSHA171024001-00A
Report Date:	2017-11-21
Reviewed By:	Oscar Ye RF Leader
Prepared By:	Bay Area Compliance Laboratories Corp. (Kunshan) No.248 Chenghu Road,Kunshan,Jiangsu province,China Tel: +86-0512-86175000 Fax: +86-0512-88934268 www.baclcorp.com.cn

TABLE OF CONTENTS

GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Applicant	ESPRESSIF SYSTEMS (SHANGHAI) PTE LTD
Tested Model	ESP32-PICO-KIT
Product Type	WIFI & Bluetooth Development Board
Dimension	52.0 mm(L)×20.3 mm(W)×10.0 mm(H)
Power Supply	DC 5V from USB Port

**All measurement and test data in this report was gathered from production sample serial number: 20171024001. (Assigned by the BACL. The EUT supplied by the applicant was received on 2017-10-24)*

Objective

This test report is prepared on behalf of ESPRESSIF SYSTEMS (SHANGHAI) PTE 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 Part15.247 DTS submission with FCC ID: 2AC7Z-ESP32PICOKIT.

Test Methodology

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

All emissions measurement was performed 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
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. 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	…	…
…	…	…	…
…	…	77	2479
39	2441	78	2480

EUT was tested with Channel 0, 39 and 78.

EUT Exercise Software

RF Test Tool: SecureCRT

GFSK Power level: 6
π/4-DQPSK Power level: 6
8-DPSK Power level: 6

Special Accessories

No special accessory.

Equipment Modifications

No modification was made to the EUT tested.

Support Equipment List and Details

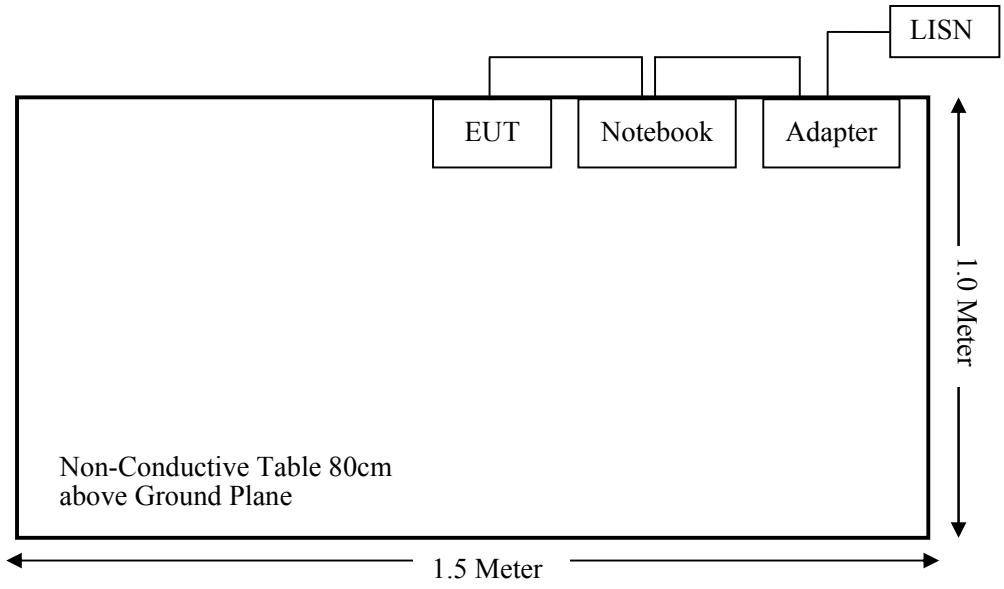
Manufacturer	Description	Model	Serial Number
DELL	Notebook	GX620	D65874152
DELL	Adapter	LA65NS0-00	DF263

External I/O Cable

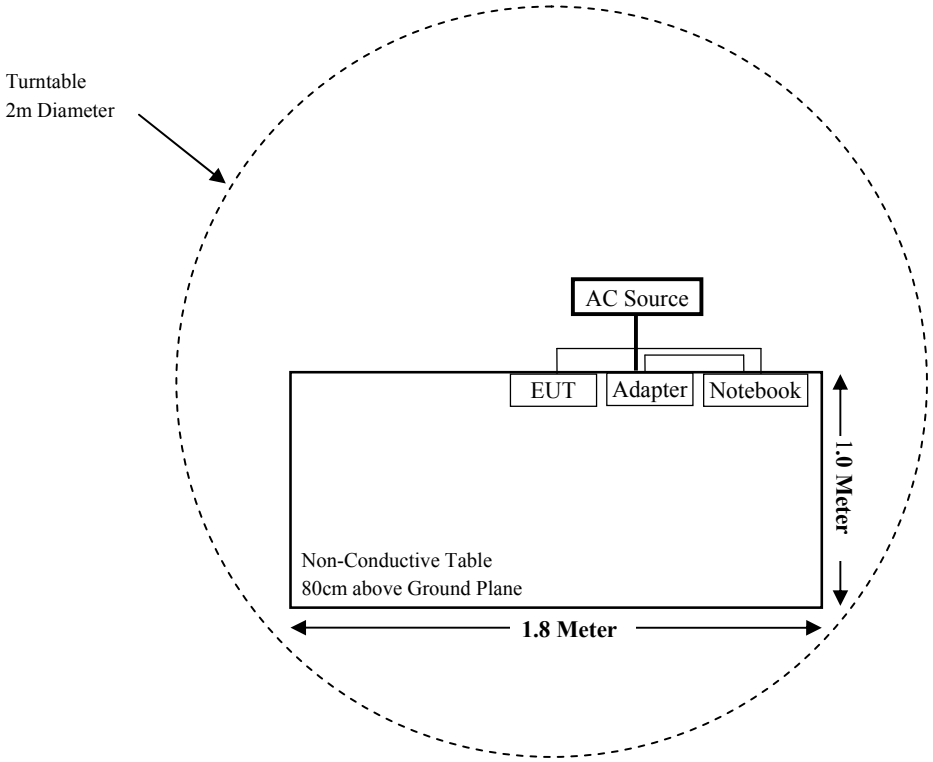
Cable Description	Length (m)	From Port	To
USB Cable	0.8	EUT	Notebook

Block Diagram of Test Setup

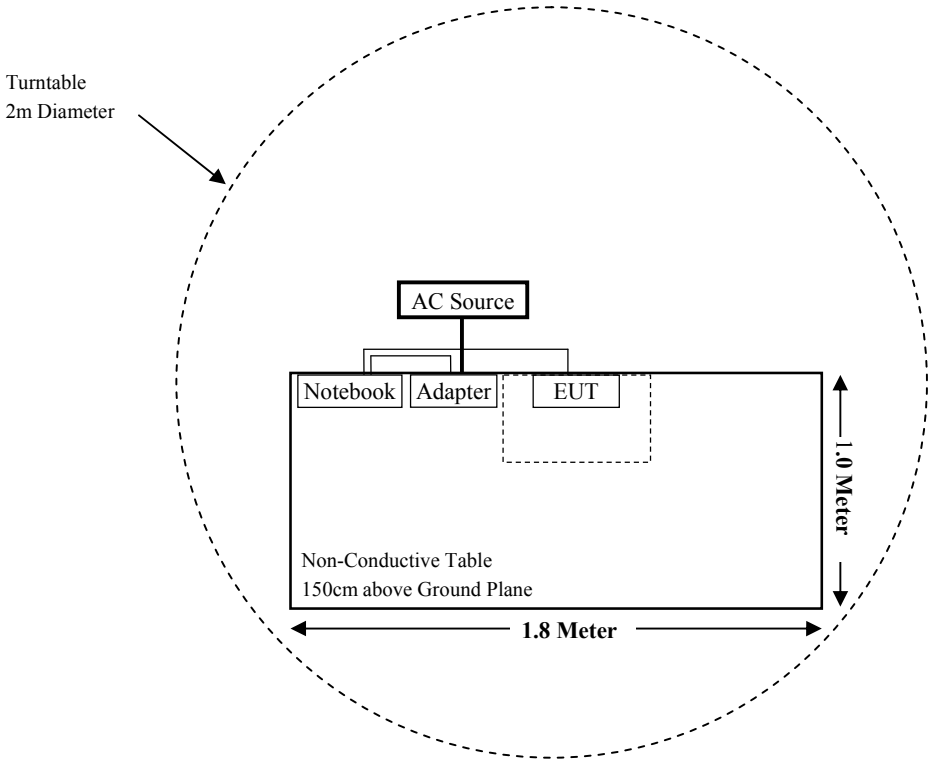
For Conducted Emissions:



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 & §2.1091	Maximum Permissible Exposure (MPE)	Compliance
§15.203	Antenna Requirement	Compliance
§15.207(a)	AC Line Conducted Emissions	Compliance
§15.205, §15.209 & §15.247(d)	Radiated Emissions	Compliance
§15.247(a)(1)	20 dB Emission Bandwidth	Compliance
§15.247(a)(1)	Channel Separation Test	Compliance
§15.247(a)(1)(iii)	Time of Occupancy (Dwell Time)	Compliance
§15.247(a)(1)(iii)	Quantity of hopping channel Test	Compliance
§15.247(b)(1)	Peak Output Power Measurement	Compliance
§15.247(d)	Band edges	Compliance

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	2016-11-25	2017-11-24
Sunol Sciences	Broadband Antenna	JB3	A040914-2	2016-01-09	2019-01-08
Sonoma Instrunent	Pre-amplifier	310N	171205	2017-08-15	2018-08-14
Rohde & Schwarz	Auto test Software	EMC32	100361	/	/
MICRO-COAX	Coaxial Cable	Cable-8	008	2017-08-15	2018-08-14
MICRO-COAX	Coaxial Cable	Cable-9	009	2017-08-15	2018-08-14
MICRO-COAX	Coaxial Cable	Cable-10	010	2017-08-15	2018-08-14
Radiated Emission Test（Chamber 2#）					
Rohde & Schwarz	EMI Test Receiver	ESU40	100207	2017-08-27	2018-08-26
ETS-LINDGREN	Horn Antenna	3115	6229	2016-01-11	2019-01-10
ETS-LINDGREN	Horn Antenna	3116	00084159	2016-10-18	2019-10-17
Narda	Pre-amplifier	AFS42-00101800	2001270	2016-12-12	2017-12-11
Heatsink Required	Amplifier	QLW-18405536-J0	15964001009	2016-12-12	2017-12-11
SINOSCITE	Band Reject Filter	BSF2402-2480MN-0898	/	2017-08-05	2018-08-04
Rohde & Schwarz	Auto test Software	EMC32	100361	/	/
MICRO-COAX	Coaxial Cable	Cable-6	006	2017-08-15	2018-08-14
MICRO-COAX	Coaxial Cable	Cable-11	011	2017-08-15	2018-08-14
MICRO-COAX	Coaxial Cable	Cable-12	012	2017-08-15	2018-08-14
MICRO-COAX	Coaxial Cable	Cable-13	013	2017-08-15	2018-08-14
RF Conducted Test					
Rohde & Schwarz	Signal Analyzer	FSV40	101116	2017-07-22	2018-07-21
Picosecond	DC Block	5500A-110	131047	2017-09-23	2018-09-22
ESPRESSIF	RF Cable	N/A	N/A	/	/
Conducted Emission Test					
Rohde & Schwarz	EMI Test Receiver	ESCI	100195	2016-11-25	2017-11-24
Rohde & Schwarz	LISN	ESH3-Z5	862770/011	2017-10-10	2018-10-09
Rohde & Schwarz	LISN	ENV216	3560655016	2016-11-25	2017-11-24
BACL	BACL-EMC	V1.0	CE001	/	/
Narda	Attenuator/6dB	10690812-2	26850-6	2017-01-10	2018-01-09
MICRO-COAX	Coaxial Cable	Cable-15	015	2017-08-15	2018-08-14

*** 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& §2.1091 –MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Applicable Standard

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

Limits for Maximum Permissible Exposure (MPE) (§1.1310, §2.1091)

(B) Limits for General Population/Uncontrolled Exposure				
Frequency Range (MHz)	**Electric Field Strength (V/m)**	**Magnetic Field Strength (A/m)**	**Power Density (mW/cm^2)**	**Averaging Time (minutes)**
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*(180/f^2)	30
30-300	27.5	0.073	0.2	30
300-1500	/		f/1500	30
1500-100,000	/		1.0	30

f = frequency in MHz; * = Plane-wave equivalent power density;
According to §1.1310 and §2.1091 RF exposure is calculated.

Calculated Formulary:

Predication of MPE limit at a given distance
$S = PG/4\pi R^2$ = power density (in appropriate units, e.g. mW/cm^2);
P = power input to the antenna (in appropriate units, e.g., mW);
G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor, is normally numeric gain;
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm);

For simultaneously transmit system, the calculated power density should comply with:

$$\sum_i \frac{S_i}{S_{Limit,i}} \leq 1$$

Measurement Result

Mode	Frequency Range	Antenna Gain		Target Output Power		Evaluation Distance	Power Density	MPE Limit	MPE Ratio
	(MHz)	(dBi)	(numeric)	(dBm)	(mW)	(cm)	(mW/cm^2)	(mW/cm^2)	
802.11b	2412~2462	4.00	2.51	20.5	112.20	20	0.0561	1.0	0.0561
802.11g		4.00	2.51	21.0	125.89	20	0.0629	1.0	0.0629
802.11 n-HT20		4.00	2.51	20.5	112.20	20	0.0561	1.0	0.0561
802.11 n-HT40	2422~2452	4.00	2.51	20.5	112.20	20	0.0561	1.0	0.0561
BT3.0	2402-2480	4.00	2.51	6.5	4.47	20	0.0022	1.0	0.0022
BLE		4.00	2.51	3.0	2.00	20	0.0010	1.0	0.0010

Note:

(1) The target output powers are all declared by the manufacturer.

(2) Wi-Fi and BT can transmit simultaneously, the worst condition is 802.11g mode of Wi-Fi & BT3.0 mode as below:

$$\sum_i \frac{S_i}{S_{Limit,i}} = 0.0629/1.00+0.0022/1=0.0629+0.0022=0.0651 < 1.0$$

Result: The device meet FCC MPE at 20 cm distance.

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 a 3D fixed antenna arrangement for Wi-Fi & Bluetooth, which the antenna gain is 4 dBi, fulfill the requirement of this section. Please refer to the EUT photos.

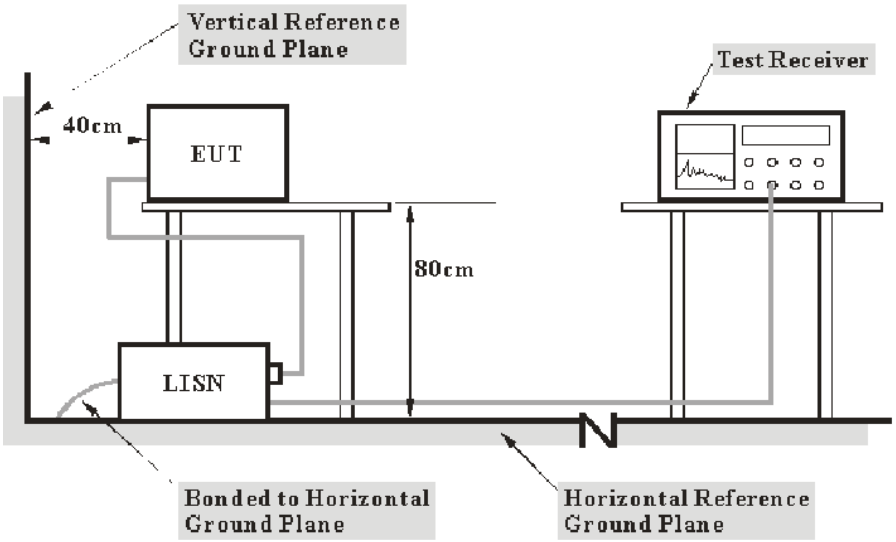
Result: Compliance.

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:

Correction Factor = LISN VDF + Cable Loss + Transient Limiter Attenuation

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:

Margin = Limit – Reading

Test Results Summary

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

Test Data

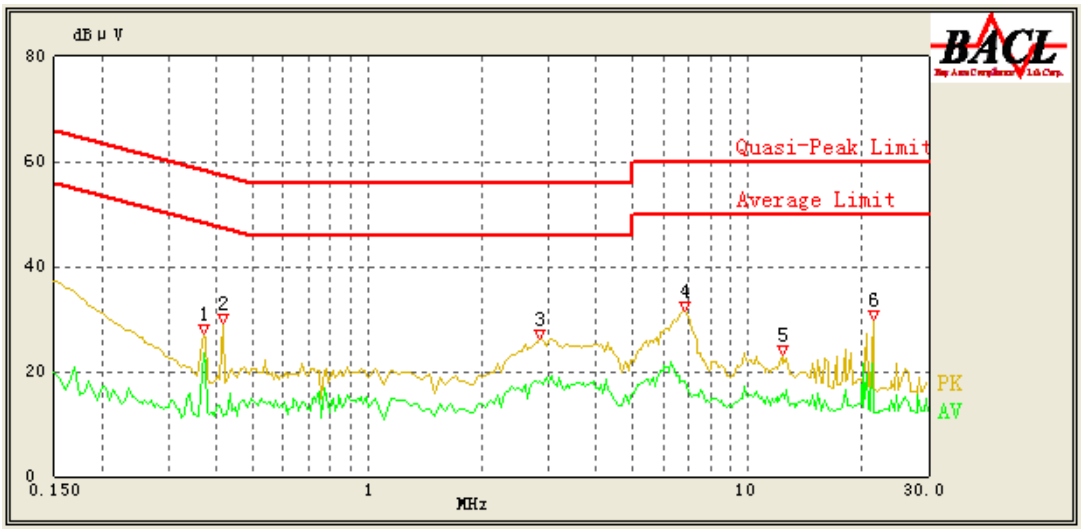
Environmental Conditions

Temperature:	23.2 ℃
Relative Humidity:	50 %
ATM Pressure:	101.3 kPa

The testing was performed by Ada Yu on 2017-11-07.

EUT operation mode: Transmitting in high channel of 8-DPSK (Worst case)

AC 120V/60 Hz, Line



Frequency (MHz)	Reading (dBµV)	Detector (PK/AV/QP)	Bandwidth (kHz)	Line	Correction (dB)	Limit (dBµV)	Margin (dB)	Comment
0.370	27.33	QP	9.000	L1	16.05	59.71	32.38	Compliance
0.370	23.56	AV	9.000	L1	16.05	49.71	26.15	Compliance
0.415	29.14	QP	9.000	L1	16.06	58.43	29.29	Compliance
0.415	11.45	AV	9.000	L1	16.06	48.43	36.98	Compliance
2.850	26.27	QP	9.000	L1	15.85	56.00	29.73	Compliance
2.850	18.31	AV	9.000	L1	15.85	46.00	27.69	Compliance
6.850	31.63	QP	9.000	L1	15.97	60.00	28.37	Compliance
6.850	18.25	AV	9.000	L1	15.97	50.00	31.75	Compliance
12.350	23.11	QP	9.000	L1	16.13	60.00	36.89	Compliance
12.350	15.77	AV	9.000	L1	16.13	50.00	34.23	Compliance
21.400	29.81	QP	9.000	L1	16.45	60.00	30.19	Compliance
21.350	21.41	AV	9.000	L1	16.45	50.00	28.59	Compliance

AC 120V/60 Hz, Neutral

Frequency (MHz)	Reading (dBµV)	Detector (PK/AV/QP)	Bandwidth (kHz)	Line	Correction (dB)	Limit (dBµV)	Margin (dB)	Comment
0.225	34.13	QP	9.000	N	16.06	63.86	29.73	Compliance
0.225	21.40	AV	9.000	N	16.06	53.86	32.46	Compliance
0.370	31.38	QP	9.000	N	16.08	59.71	28.33	Compliance
0.370	20.47	AV	9.000	N	16.08	49.71	29.24	Compliance
0.685	28.39	QP	9.000	N	16.00	56.00	27.61	Compliance
0.680	20.95	AV	9.000	N	16.00	46.00	25.05	Compliance
2.050	28.48	QP	9.000	N	15.91	56.00	27.52	Compliance
2.050	19.08	AV	9.000	N	15.91	46.00	26.92	Compliance
6.900	32.39	QP	9.000	N	15.92	60.00	27.61	Compliance
6.950	25.36	AV	9.000	N	15.92	50.00	24.64	Compliance
21.850	35.68	QP	9.000	N	16.19	60.00	24.32	Compliance
21.850	27.16	AV	9.000	N	16.19	50.00	22.84	Compliance

Note:
1) Corr.=LISN VDF (Voltage Division Factor) + Cable Loss
2) Margin = Limit – Reading

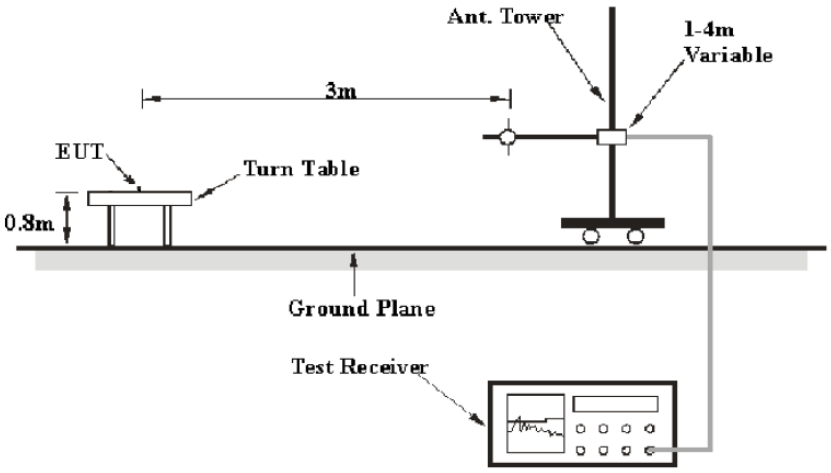
FCC §15.205, §15.209 & §15.247(d) – RADIATED EMISSIONS

Applicable Standard

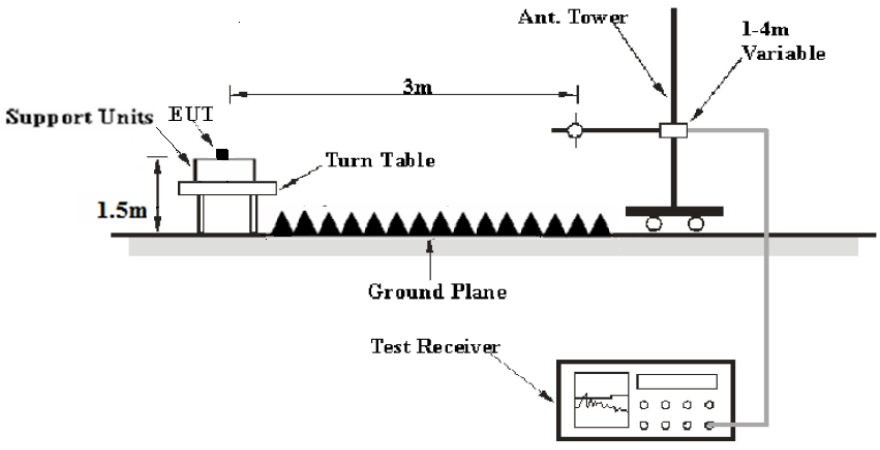
FCC §15.205; §15.209; §15.247(d)

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, peak and average detection mode 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 = Meter Reading + Antenna Factor + Cable Loss - Amplifier Gain

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 = Limit – Corrected Amplitude

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

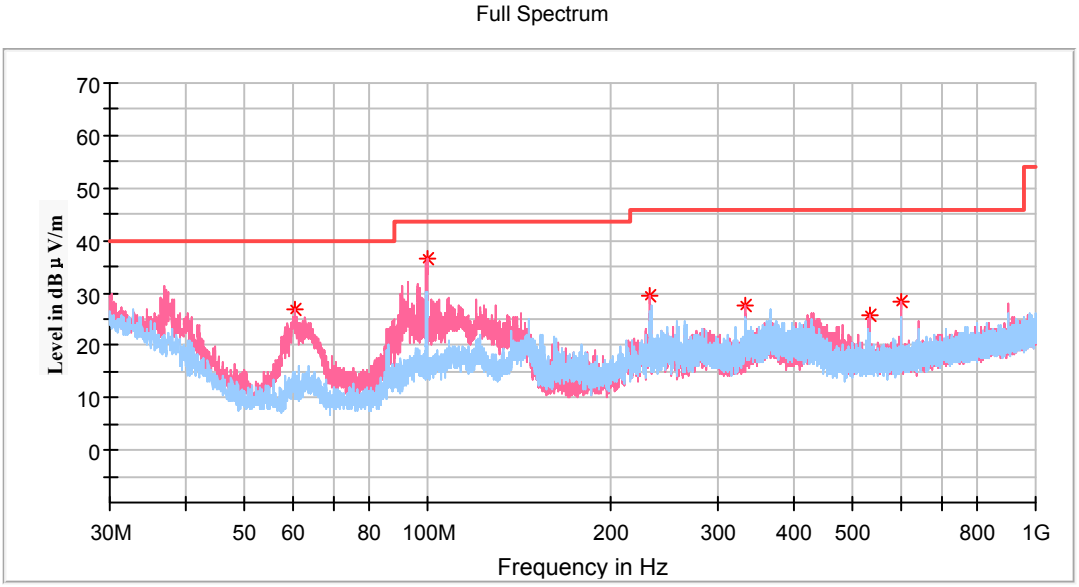
Environmental Conditions

Temperature:	23.2 ℃
Relative Humidity:	50 %
ATM Pressure:	101.3 kPa

The testing was performed by Ada Yu on 2017-11-04.

EUT operation mode: Transmitting(Scan with GFSK, π/4-DQPSK, 8-DPSK mode, the worst case is 8-DPSK Mode)

30MHz-1G

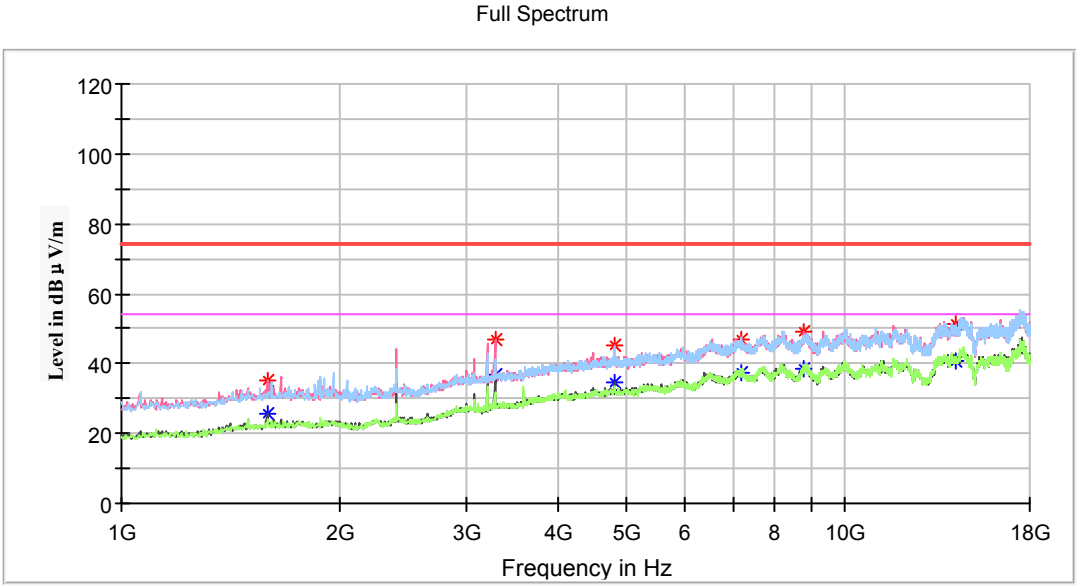


Frequency (MHz)	Corrected Amplitude	Rx Antenna		Turntable Degree	Corr. (dB)	Limit (dBµV/m)	Margin (dB)
	QuasiPeak (dBµV/m)	Height (cm)	Polar (H/V)				
60.652000	26.83	100.0	V	4.0	-23.1	40.00	13.17
99.937000	36.62	100.0	V	99.0	-21.1	43.50	6.88
232.342000	29.60	150.0	V	137.0	-19.5	46.00	16.40
331.864000	27.58	150.0	V	7.0	-17.8	46.00	18.42
533.139000	25.72	100.0	V	0.0	-13.4	46.00	20.28
600.004333	28.36	100.0	V	15.0	-13.0	46.00	17.64

Note:
1. This test is performed with the 2.4-2.4835GHz band reject filter.
2. Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor
   Corrected Amplitude = Corrected Factor + Reading
   Margin = Limit - Corrected. Amplitude
3. The other spurious emission which is 20dB to the limit was not recorded.

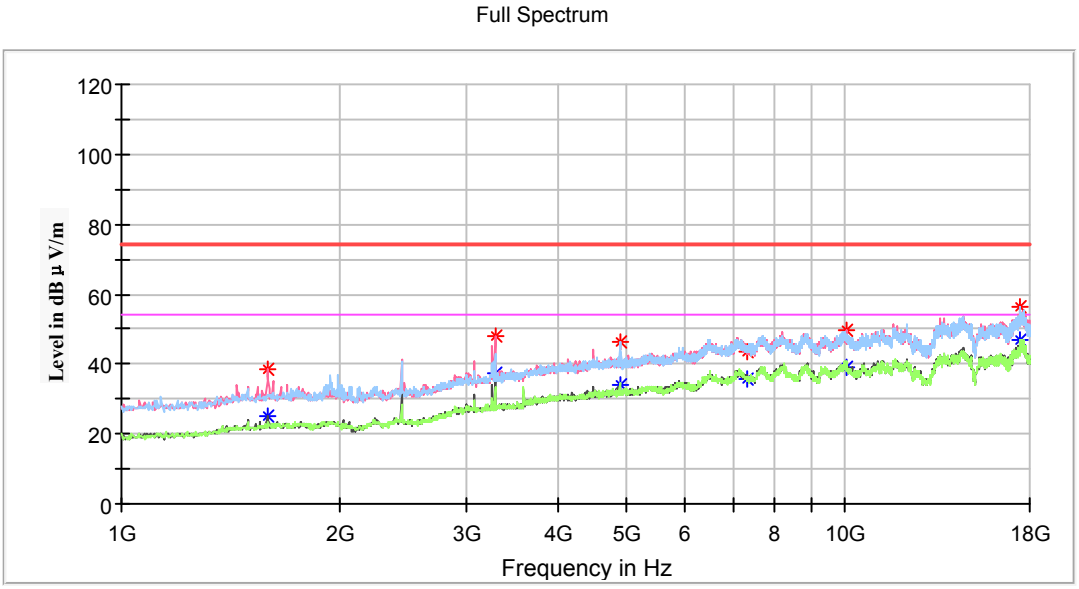
1G-25G

Low Channel: 2402MHz



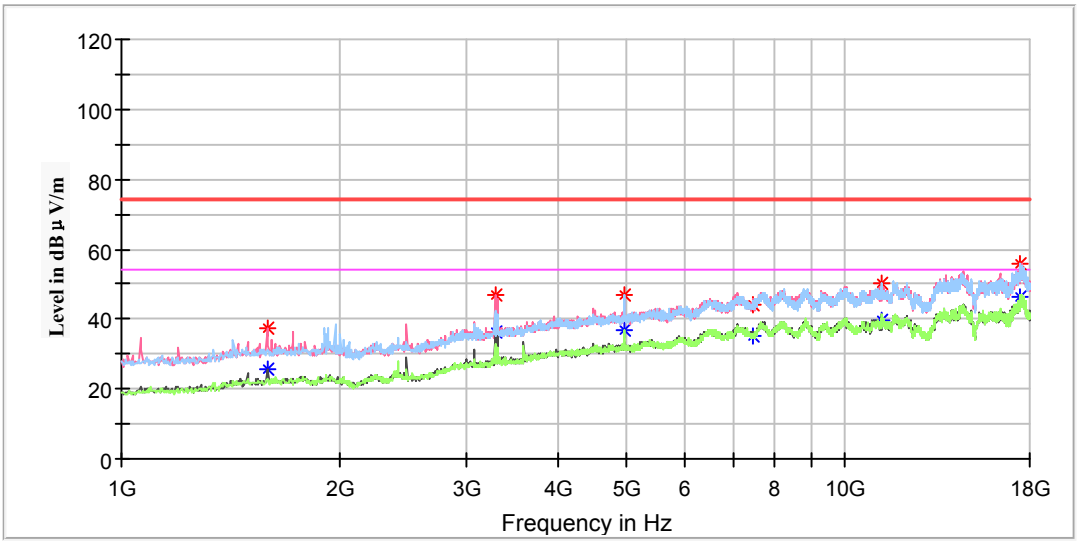
Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corr. (dB)	Limit (dBµV/m)	Margin (dB)
	MaxPeak (dBµV /m)	Average (dBµV /m)	Height (cm)	Polar (H/V)				
1591.600000	---	25.76	250.0	V	186.0	-9.8	54.00	28.24
1591.600000	34.93	---	250.0	V	186.0	-9.8	74.00	39.07
3281.400000	46.83	---	150.0	V	220.0	-4.2	74.00	27.17
3281.400000	---	36.92	150.0	V	220.0	-4.2	54.00	17.08
4804.600000	---	34.42	250.0	V	97.0	-0.6	54.00	19.58
4804.600000	45.09	---	250.0	V	97.0	-0.6	74.00	28.91
7205.000000	46.65	---	200.0	V	215.0	6.3	74.00	27.35
7205.000000	---	37.39	200.0	V	215.0	6.3	54.00	16.61
8758.800000	49.33	---	150.0	V	319.0	8.3	74.00	24.67
8758.800000	---	38.37	250.0	V	175.0	8.3	54.00	15.63
14205.600000	51.47	---	150.0	V	275.0	16.7	74.00	22.53
14205.600000	---	40.86	250.0	V	303.0	16.7	54.00	13.14

Middle Channel: 2441MHz



Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corr. (dB)	Limit (dBµV/m)	Margin (dB)
	MaxPeak (dBµV /m)	Average (dBµV /m)	Height (cm)	Polar (H/V)				
1591.600000	38.59	---	150.0	V	316.0	-9.8	74.00	35.41
1591.600000	---	24.88	200.0	V	204.0	-9.8	54.00	29.12
3281.400000	47.94	---	150.0	V	219.0	-4.2	74.00	26.06
3281.400000	---	37.29	150.0	V	219.0	-4.2	54.00	16.71
4882.800000	---	34.25	250.0	H	2.0	-0.4	54.00	19.75
4882.800000	46.43	---	250.0	H	2.0	-0.4	74.00	27.57
7324.000000	43.79	---	250.0	V	0.0	6.7	74.00	30.21
7324.000000	---	35.91	200.0	V	0.0	6.7	54.00	18.09
10061.000000	49.46	---	200.0	V	268.0	9.2	74.00	24.54
10061.000000	---	38.83	200.0	V	268.0	9.2	54.00	15.17
17462.800000	56.29	---	200.0	H	223.0	20.1	74.00	17.71
17462.800000	---	47.10	150.0	H	11.0	20.1	54.00	6.90

High Channel: 2480MHz



Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corr. (dB)	Limit (dBµV/m)	Margin (dB)
	MaxPeak (dBµV /m)	Average (dBµV /m)	Height (cm)	Polar (H/V)				
1588.200000	---	25.56	250.0	V	167.0	-9.9	54.00	28.44
1588.200000	37.48	---	250.0	V	167.0	-9.9	74.00	36.52
3281.400000	---	36.04	200.0	V	0.0	-4.2	54.00	17.96
3281.400000	46.72	---	200.0	V	0.0	-4.2	74.00	27.28
4957.600000	---	37.04	250.0	H	209.0	-0.3	54.00	16.96
4957.600000	47.11	---	150.0	H	172.0	-0.3	74.00	26.89
7439.600000	---	34.90	250.0	H	81.0	7.0	54.00	19.10
7439.600000	44.14	---	250.0	H	81.0	7.0	74.00	29.86
11210.200000	---	39.73	150.0	H	247.0	12.0	54.00	14.27
11210.200000	49.98	---	150.0	H	247.0	12.0	74.00	24.02
17466.200000	---	46.42	150.0	H	12.0	20.1	54.00	7.58
17466.200000	55.81	---	250.0	H	0.0	20.1	74.00	18.19

Radiation Spurious Restricted Band Edge:

Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corr. (dB)	Limit (dBµV/m)	Margin (dB)
	MaxPeak (dBµV /m)	Average (dBµV /m)	Height (cm)	Polar (H/V)				
Left Restricted Band								
2389.898000	---	38.31	200.0	H	235.0	2.6	54.00	15.69
2389.898000	47.92	---	200.0	H	235.0	2.6	74.00	26.08
Right Restricted Band								
2483.488000	---	36.20	250.0	V	215.0	2.8	54.00	17.80
2483.488000	47.44	---	150.0	V	111.0	2.8	74.00	26.56

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

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

Test Data

Environmental Conditions

Temperature:	23.4 ℃
Relative Humidity:	49 %
ATM Pressure:	101.1 kPa

The testing was performed by Ada Yu on 2017-11-02.

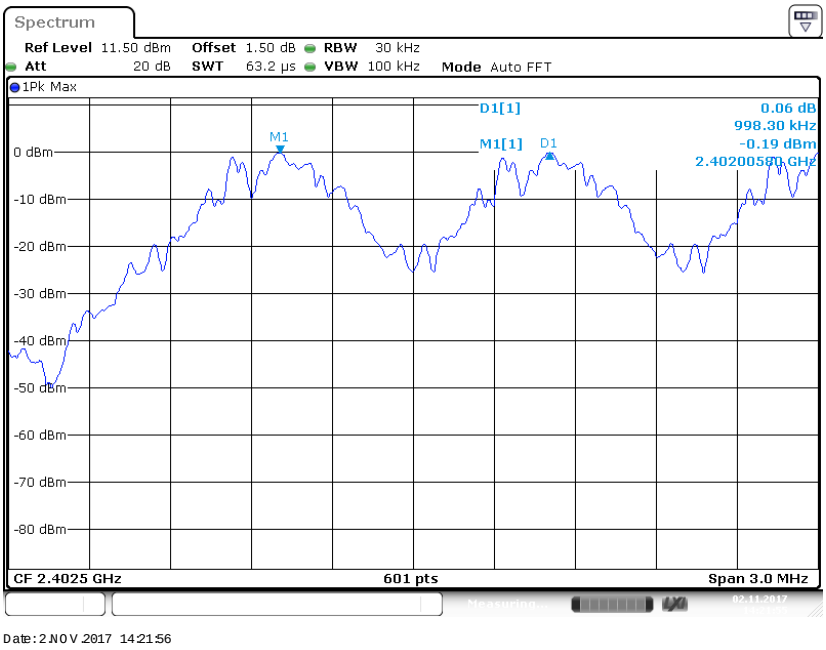
EUT operation mode: Hopping

Test Result: Compliance.

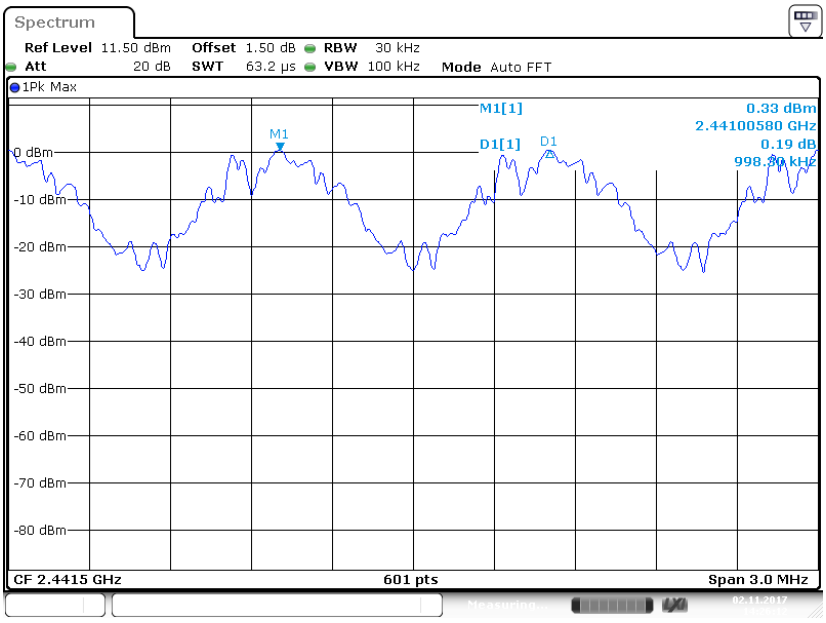
Mode	Channel	Frequency (MHz)	Channel Separation (MHz)	Limit (MHz)	Result
BDR (GFSK)	Low	2402	0.998	0.446	Pass
	Adjacent	2403			
	Middle	2441	0.998	0.443	Pass
	Adjacent	2442			
	High	2480	0.998	0.446	Pass
	Adjacent	2479			
EDR (π/4-DQPSK)	Low	2402	1.008	0.862	Pass
	Adjacent	2403			
	Middle	2441	1.003	0.862	Pass
	Adjacent	2442			
	High	2480	1.008	0.862	Pass
	Adjacent	2479			
EDR (8-DPSK)	Low	2402	1.013	0.835	Pass
	Adjacent	2403			
	Middle	2441	0.998	0.835	Pass
	Adjacent	2442			
	High	2480	1.003	0.842	Pass
	Adjacent	2479			

Note: Limit = 20 dB bandwidth*2/3

BDR (GFSK): Low Channel

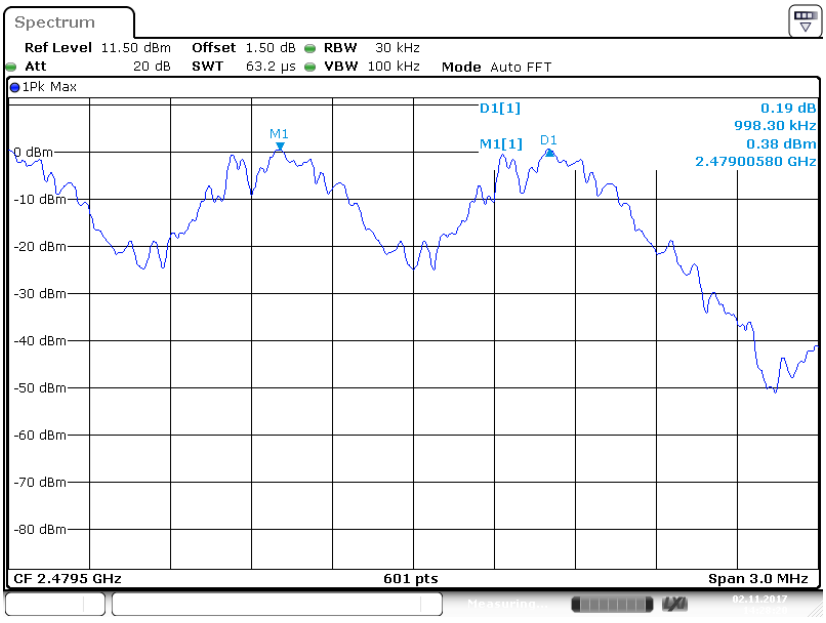


BDR (GFSK): Middle Channel



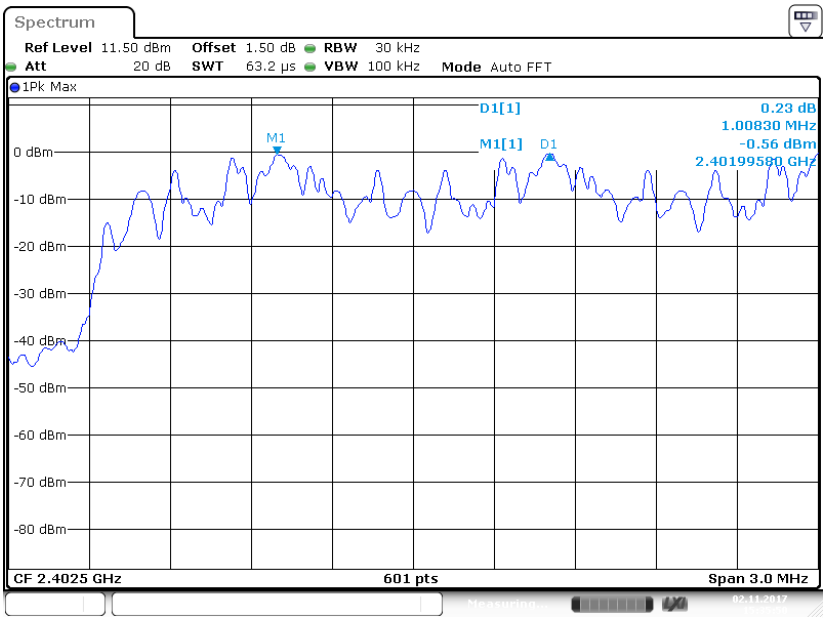
Date: 2.NOV.2017 14:26:12

BDR (GFSK): High Channel



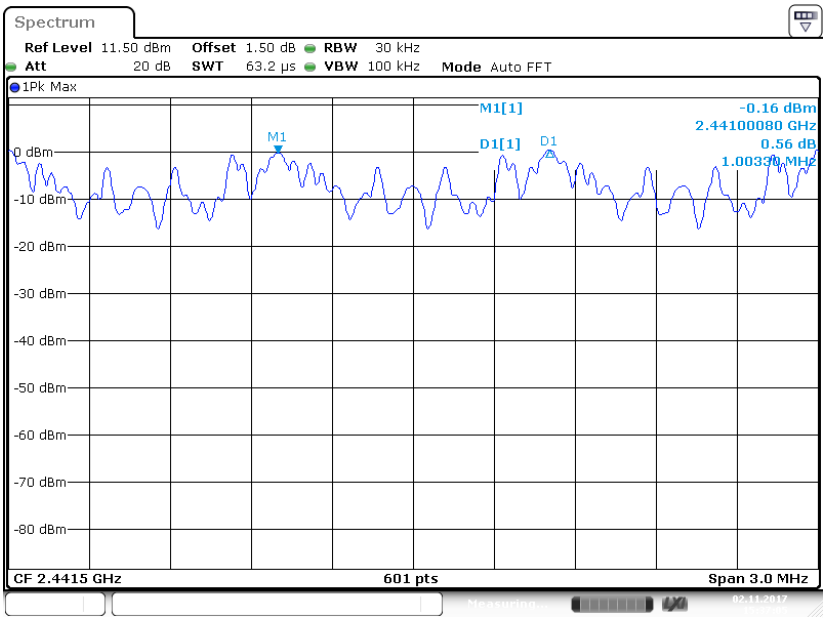
Date: 2.NOV.2017 14:28:20

EDR (π/4-DQPSK): Low Channel



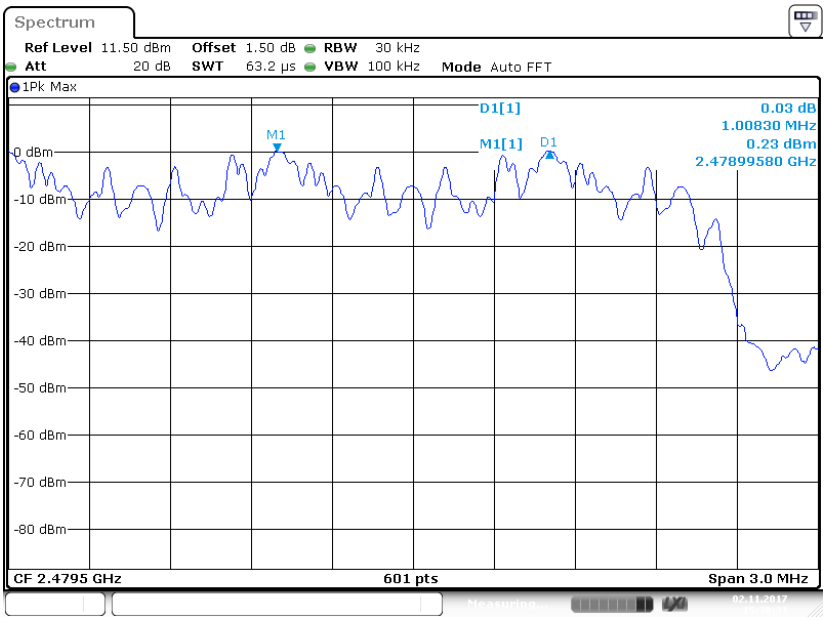
Date: 2.NOV.2017 15:35:50

EDR (π/4-DQPSK): Middle Channel



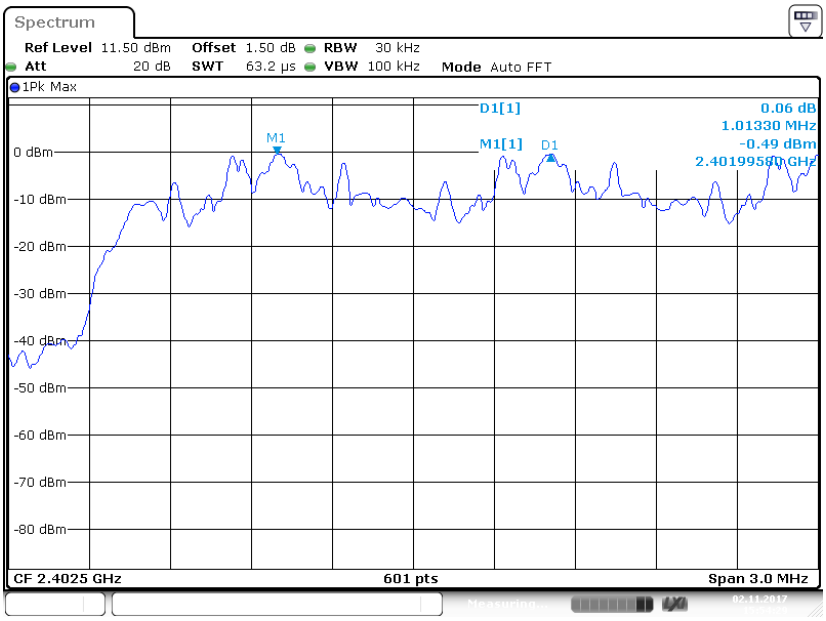
Date: 2.NOV.2017 15:37:05

EDR (π/4-DQPSK): High Channel



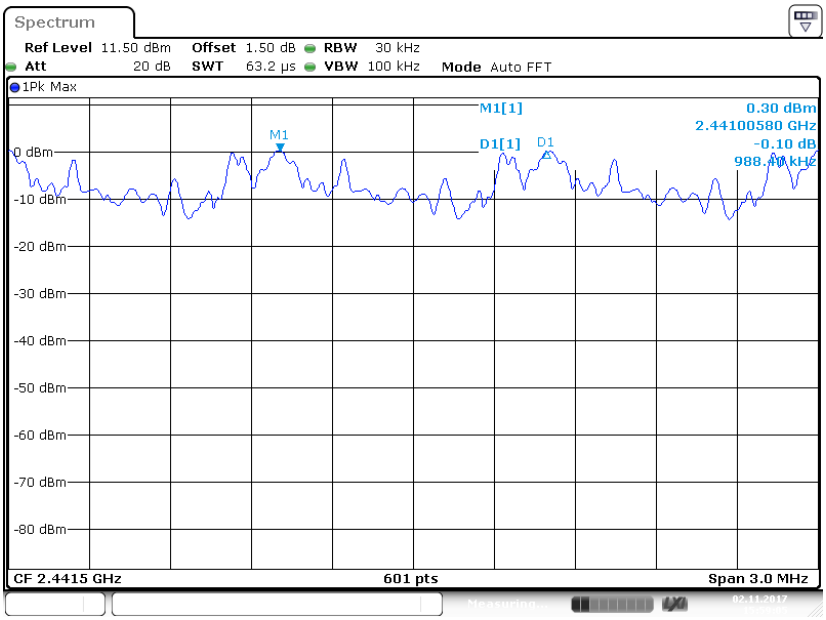
Date: 2.NOV.2017 15:38:31

EDR (8-DPSK): Low Channel



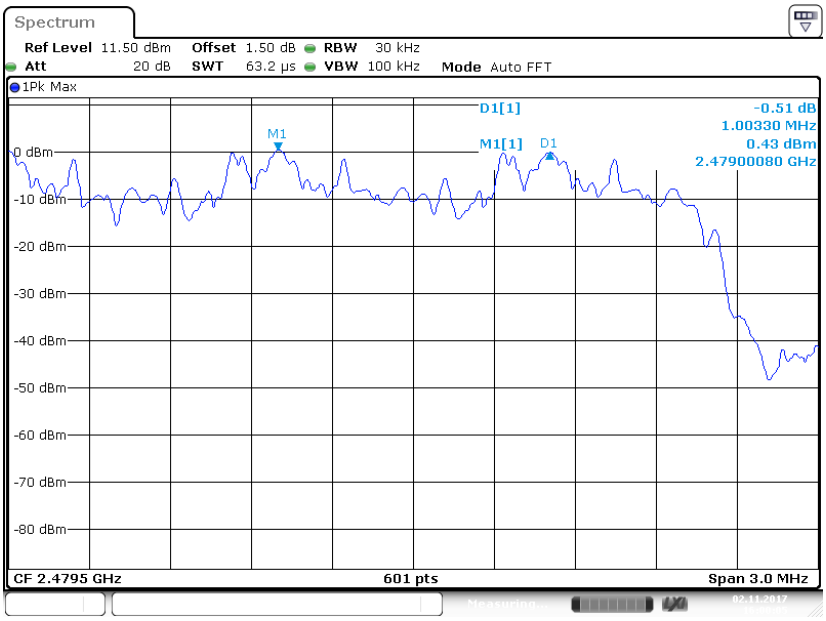
Date: 2.NOV.2017 15:54:29

EDR (8-DPSK): Middle Channel



Date: 2.NOV.2017 15:59:05

EDR (8-DPSK): High Channel



Date: 2.NOV.2017 16:00:04

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 ℃
Relative Humidity:	50 %
ATM Pressure:	101.3 kPa

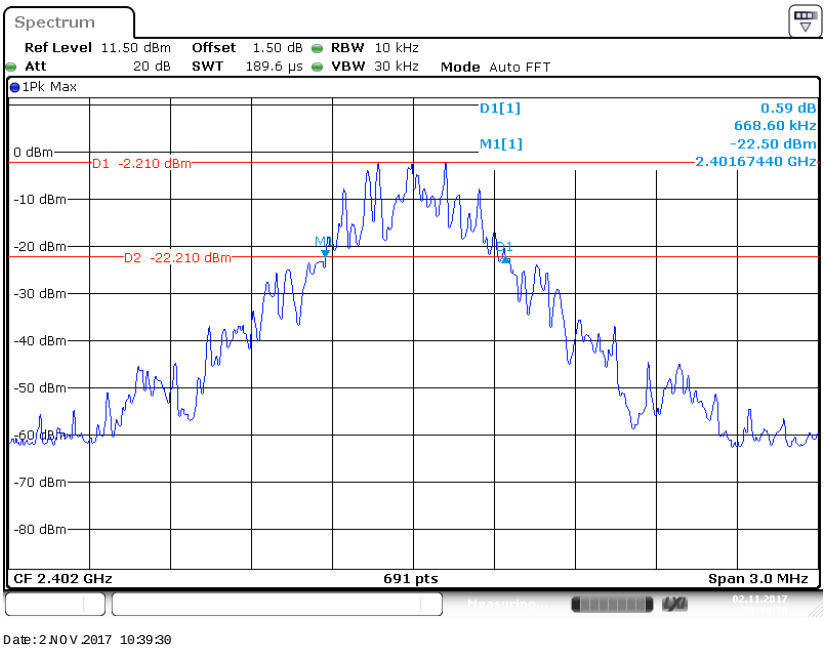
The testing was performed by Ada Yu on 2017-11-02.

EUT operation mode: Transmitting

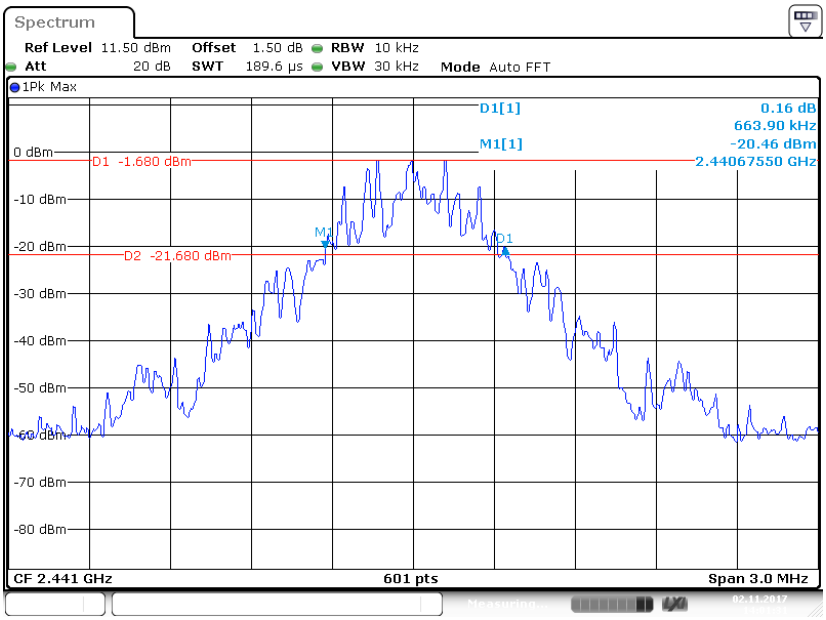
Test Result: Compliance.

Mode	Channel	Frequency (MHz)	20 dB Emission Bandwidth (MHz)
BDR (GFSK)	Low	2402	0.669
	Middle	2441	0.664
	High	2480	0.669
EDR (π/4-DQPSK)	Low	2402	1.293
	Middle	2441	1.293
	High	2480	1.293
EDR (8-DPSK)	Low	2402	1.253
	Middle	2441	1.253
	High	2480	1.263

BDR (GFSK): Low Channel

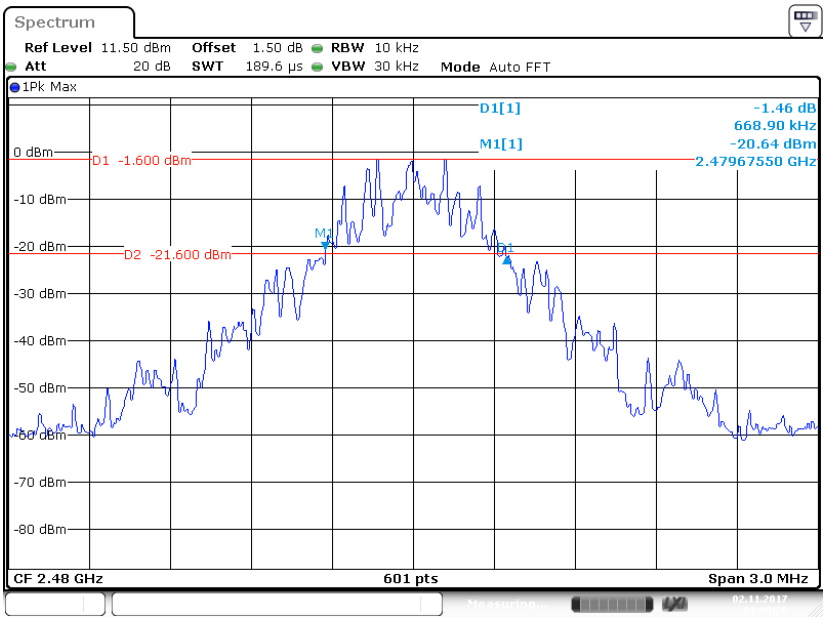


BDR (GFSK): Middle Channel



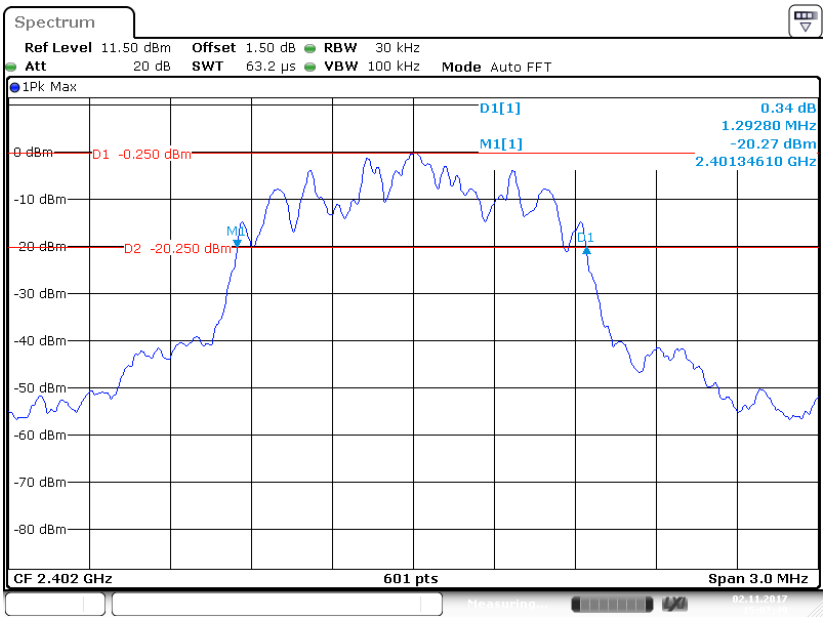
Date: 2.NOV.2017 14:01:31

BDR (GFSK): High Channel



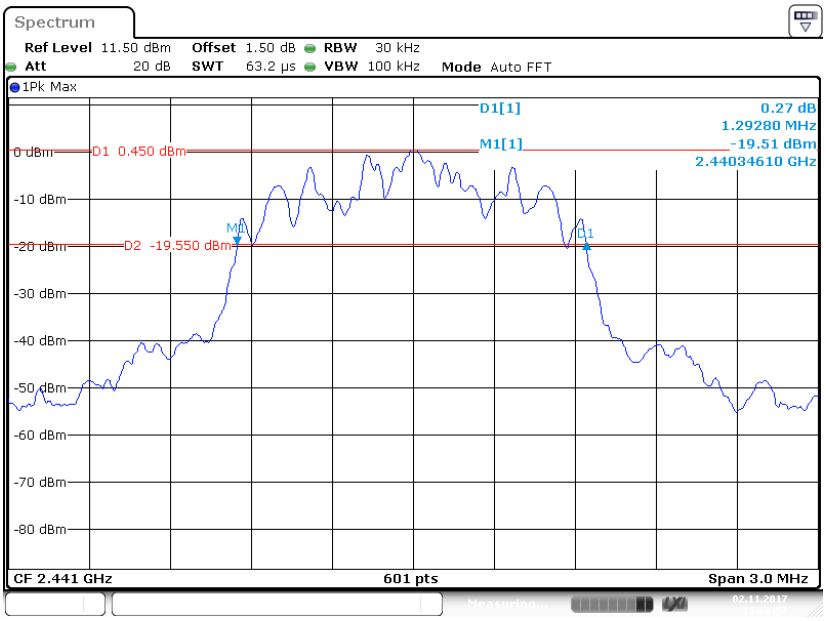
Date: 2.NOV.2017 14:00:21

EDR (π/4-DQPSK): Low Channel



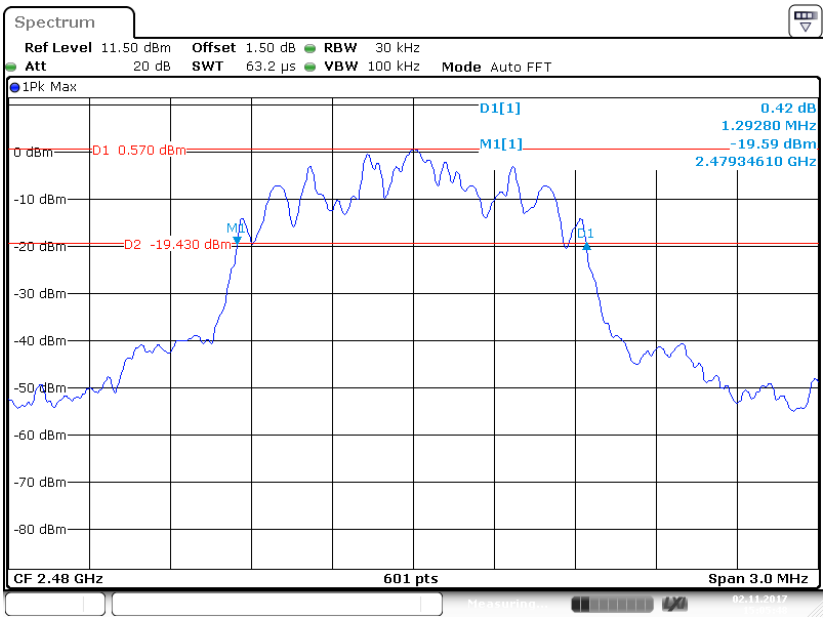
Date: 2.NOV.2017 15:07:49

EDR(π/4-DQPSK): Middle Channel



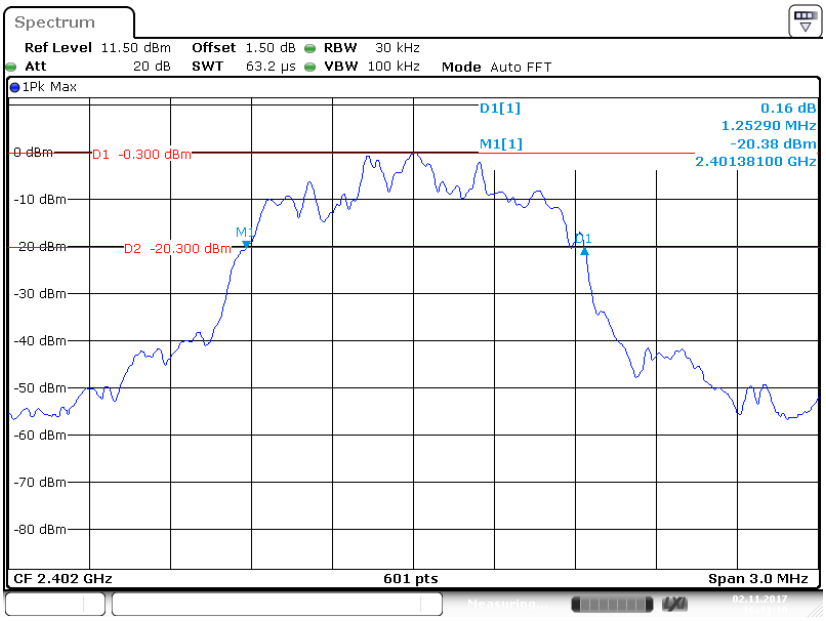
Date: 2.NOV.2017 15:06:56

EDR (π/4-DQPSK): High Channel



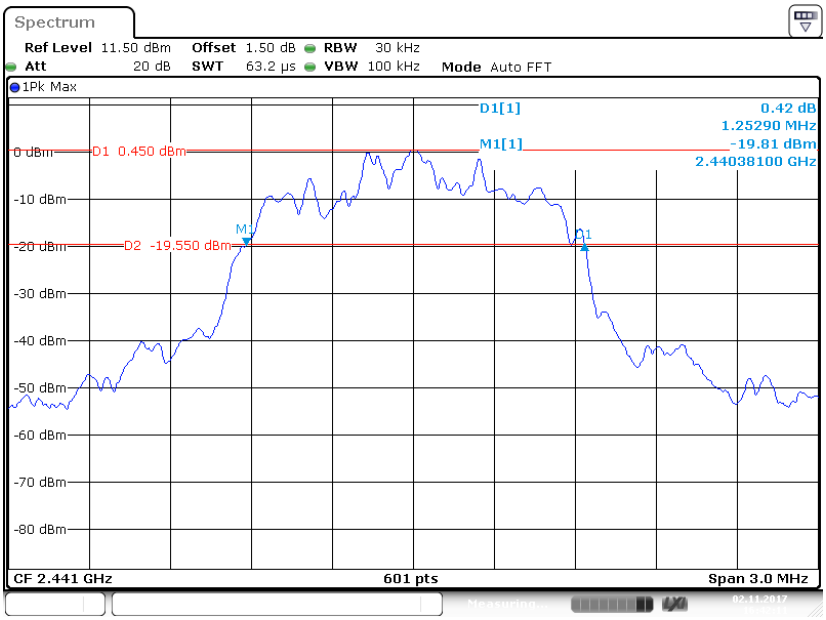
Date: 2.NOV.2017 15:05:48

EDR (8-DPSK): Low Channel



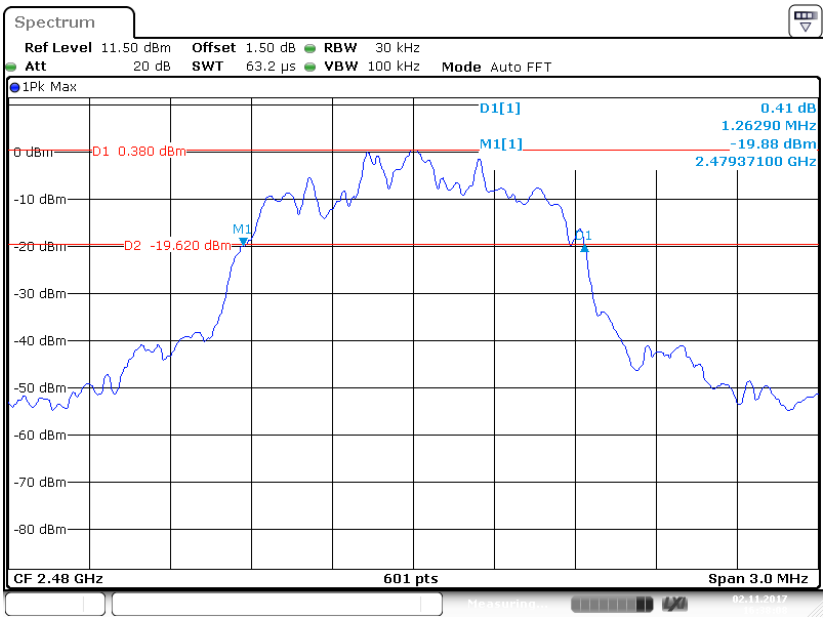
Date: 2.NOV.2017 16:43:10

EDR (8-DPSK): Middle Channel



Date: 2.NOV.2017 16:42:11

EDR (8-DPSK): High Channel



Date: 2.NOV.2017 16:38:09

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

1. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.

2. Set the EUT in hopping mode from first channel to last.

3. By using the max-hold function record the quantity of the channel.

Test Data

Environmental Conditions

Temperature:	23.2 ℃
Relative Humidity:	50 %
ATM Pressure:	101.3 kPa

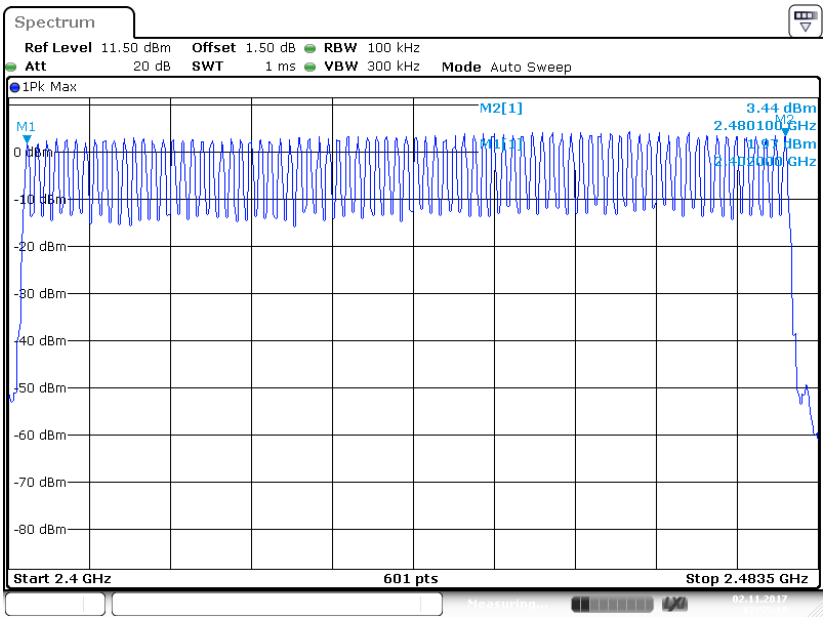
The testing was performed by Ada Yu on 2017-11-02.

EUT operation mode: Hopping

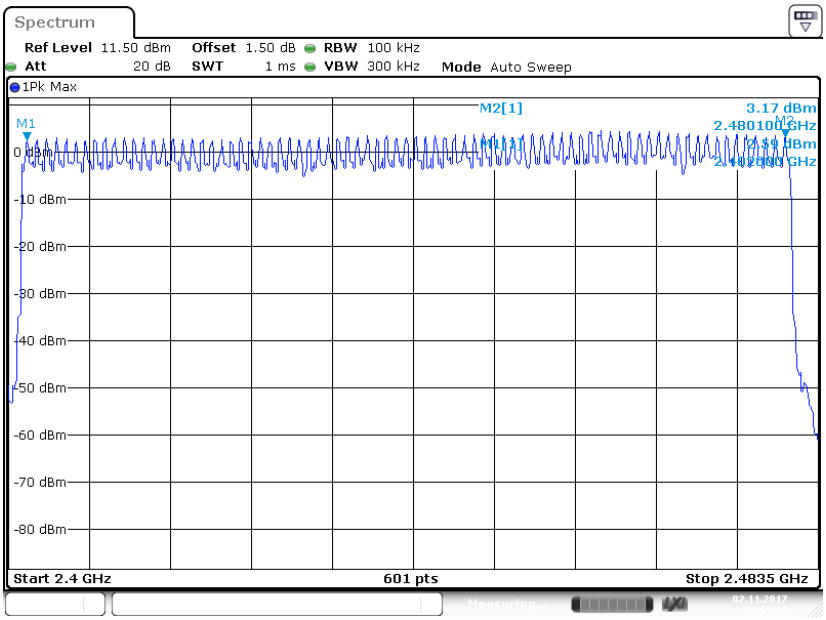
Test Result: Compliance.

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

BDR (GFSK): Number of Hopping Channels

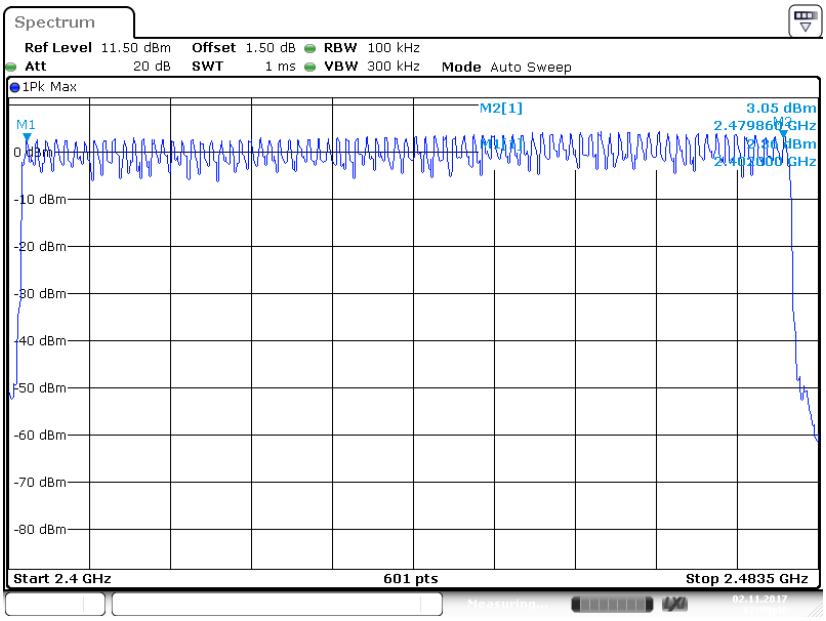


EDR (π/4-DQPSK): Number of Hopping Channels



Date: 2.NOV.2017 17:53:48

EDR (8-DPSK): Number of Hopping Channels



Date: 2.NOV.2017 17:50:47

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 ⩽ channel spacing and where possible RBW should be set >> 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

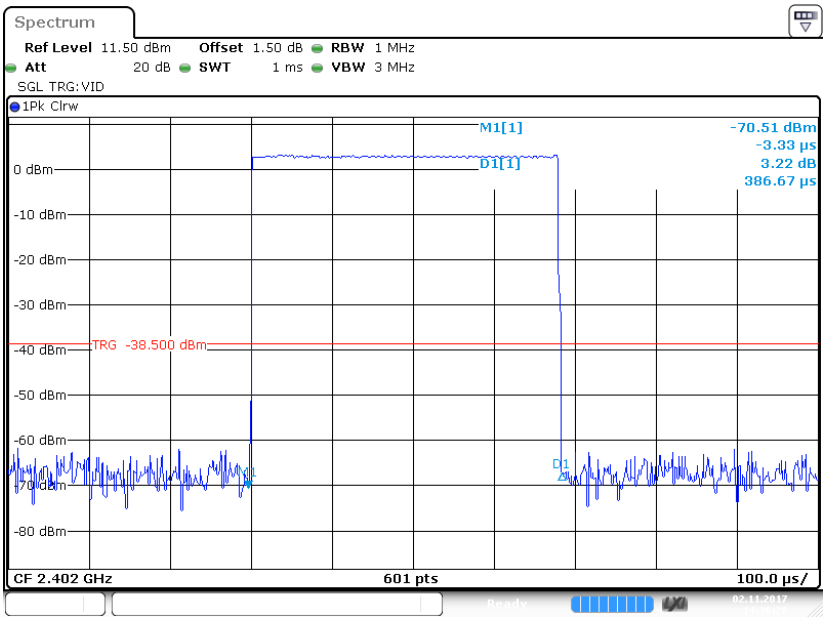
Temperature:	23.4 ℃
Relative Humidity:	51 %
ATM Pressure:	101.2 kPa

The testing was performed by Ada Yu on 2017-11-02.

EUT operation mode: Hopping

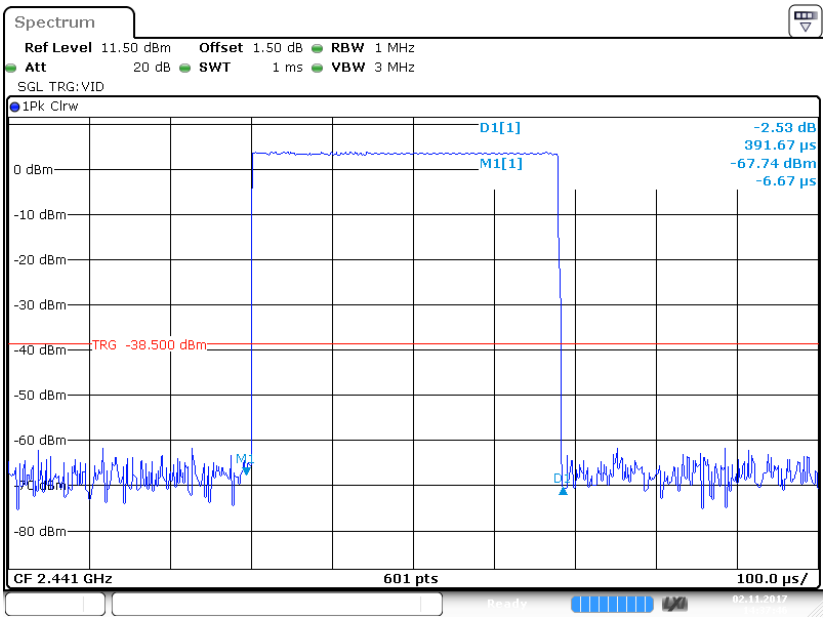
Mode		Channel	Pulse Width (ms)	Dwell Time (s)	Limit (s)	Result
BDR (GFSK)	DH1	Low	0.387	0.124	0.4	Pass
		Middle	0.392	0.125	0.4	Pass
		High	0.387	0.124	0.4	Pass
		Note: DH1:Dwell time = Pulse time*(1600/2/79)*31.6S				
	DH3	Low	1.649	0.264	0.4	Pass
		Middle	1.662	0.266	0.4	Pass
		High	1.649	0.264	0.4	Pass
		Note: DH3:Dwell time = Pulse time*(1600/4/79)*31.6S				
	DH5	Low	2.929	0.312	0.4	Pass
		Middle	2.916	0.311	0.4	Pass
		High	2.903	0.310	0.4	Pass
		Note: DH5:Dwell time = Pulse time*(1600/6/79)*31.6S				
EDR (π/4-DQPSK)	2DH1	Low	0.400	0.128	0.4	Pass
		Middle	0.400	0.128	0.4	Pass
		High	0.405	0.130	0.4	Pass
		Note: 2DH1:Dwell time = Pulse time*(1600/2/79)*31.6S				
	2DH3	Low	1.672	0.268	0.4	Pass
		Middle	1.663	0.266	0.4	Pass
		High	1.672	0.268	0.4	Pass
		Note: 2DH3:Dwell time = Pulse time*(1600/4/79)*31.6S				
	2DH5	Low	2.925	0.312	0.4	Pass
		Middle	2.938	0.313	0.4	Pass
		High	2.918	0.311	0.4	Pass
		Note: 2DH5:Dwell time = Pulse time*(1600/6/79)*31.6S				
EDR (8-DPSK)	3DH1	Low	0.401	0.128	0.4	Pass
		Middle	0.404	0.129	0.4	Pass
		High	0.403	0.129	0.4	Pass
		Note:3 DH1:Dwell time = Pulse time*(1600/2/79)*31.6S				
	3DH3	Low	1.658	0.265	0.4	Pass
		Middle	1.674	0.268	0.4	Pass
		High	1.666	0.267	0.4	Pass
		Note: 3DH3:Dwell time = Pulse time*(1600/4/79)*31.6S				
	3DH5	Low	2.925	0.312	0.4	Pass
		Middle	2.932	0.313	0.4	Pass
		High	2.925	0.312	0.4	Pass
		Note: 3DH5:Dwell time = Pulse time*(1600/6/79)*31.6S				

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



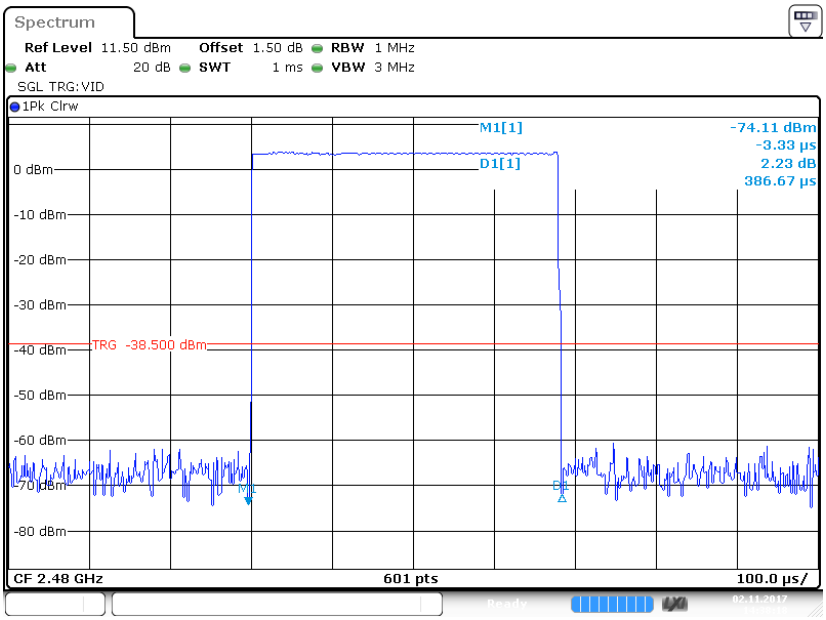
Date: 2.NOV.2017 14:36:29

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



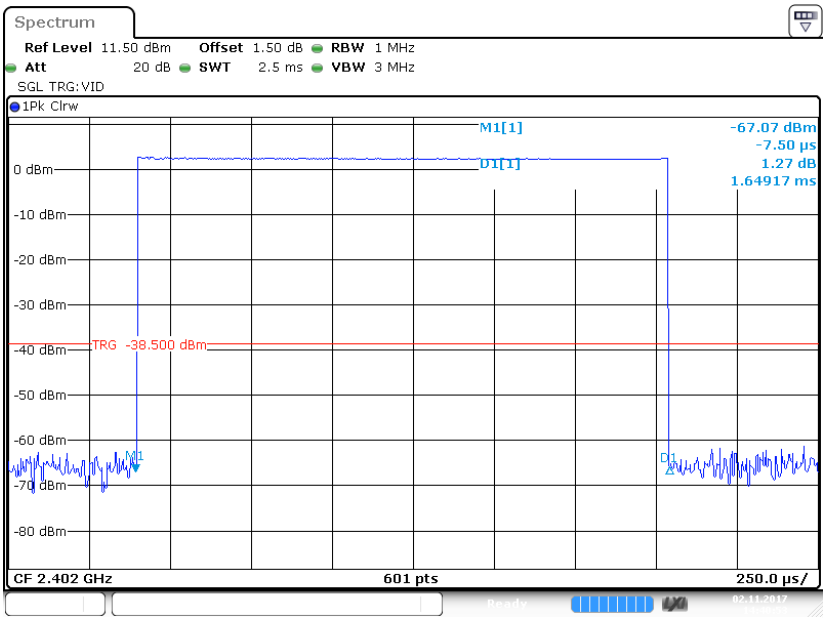
Date: 2.NOV.2017 14:37:46

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



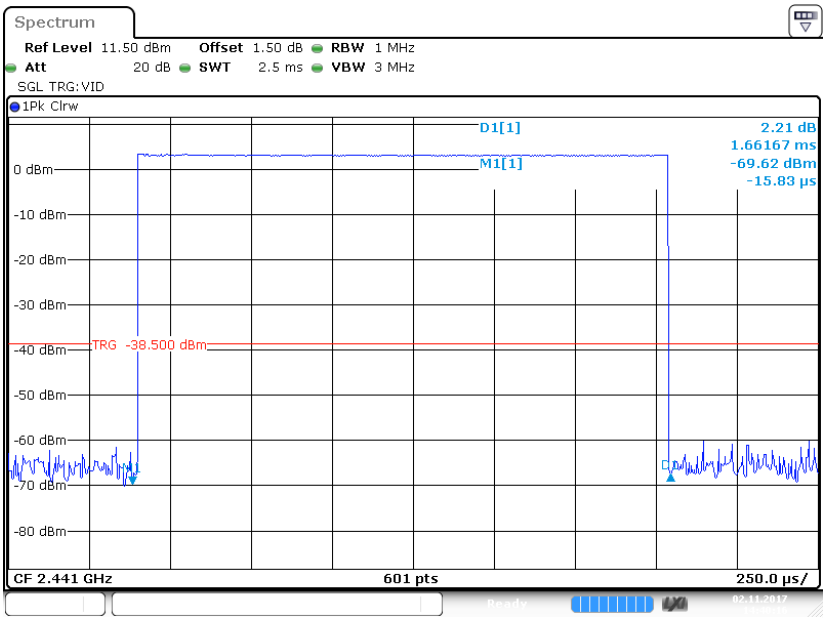
Date: 2.NOV.2017 14:38:18

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



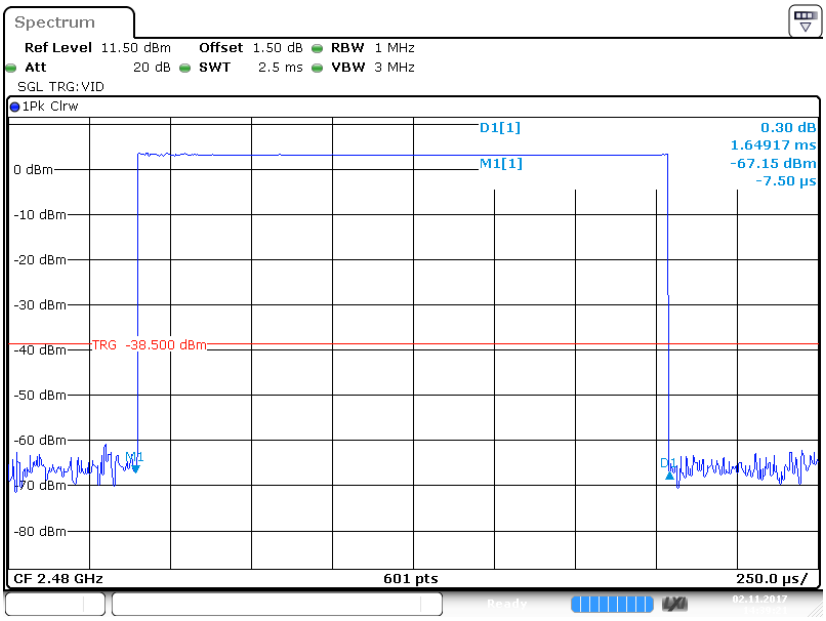
Date: 2.NOV.2017 14:40:54

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



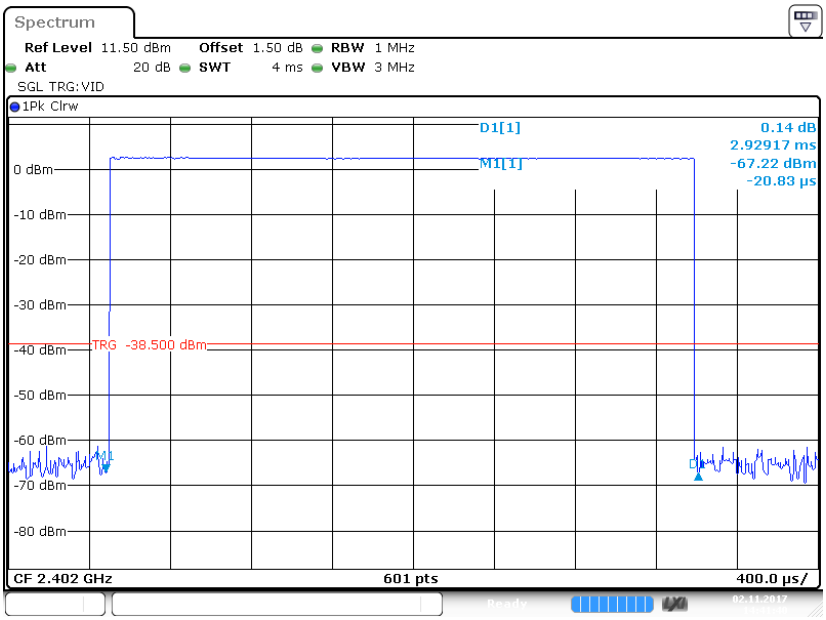
Date: 2.NOV.2017 14:40:15

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



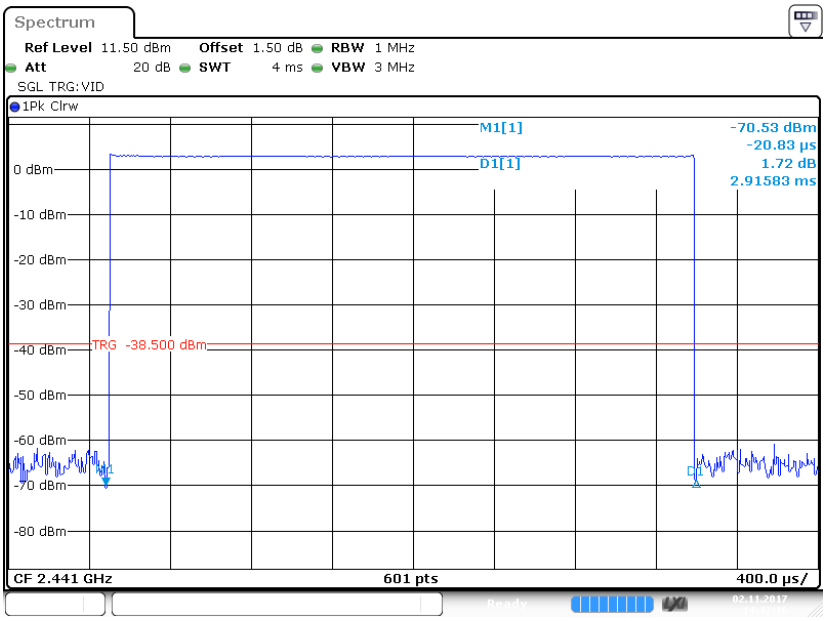
Date: 2.NOV.2017 14:39:21

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



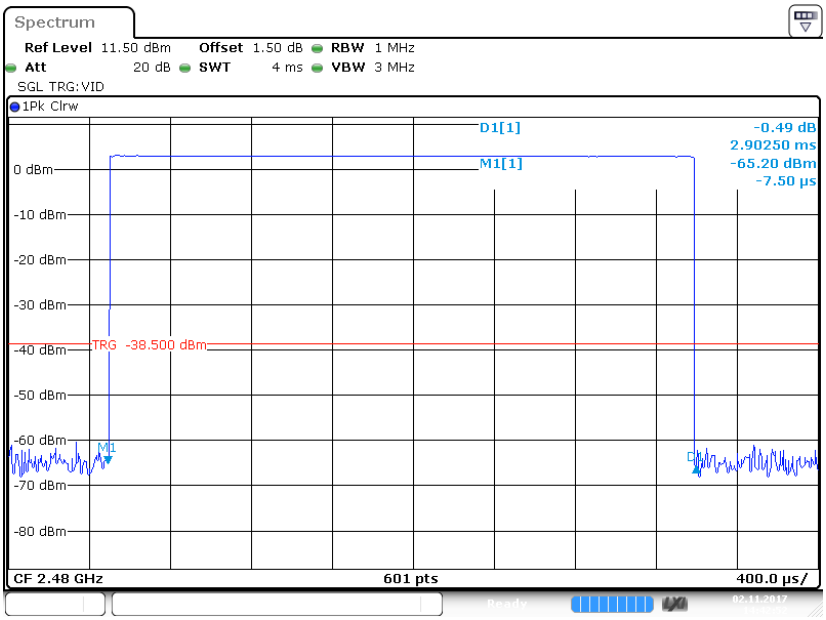
Date: 2.NOV.2017 14:41:40

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



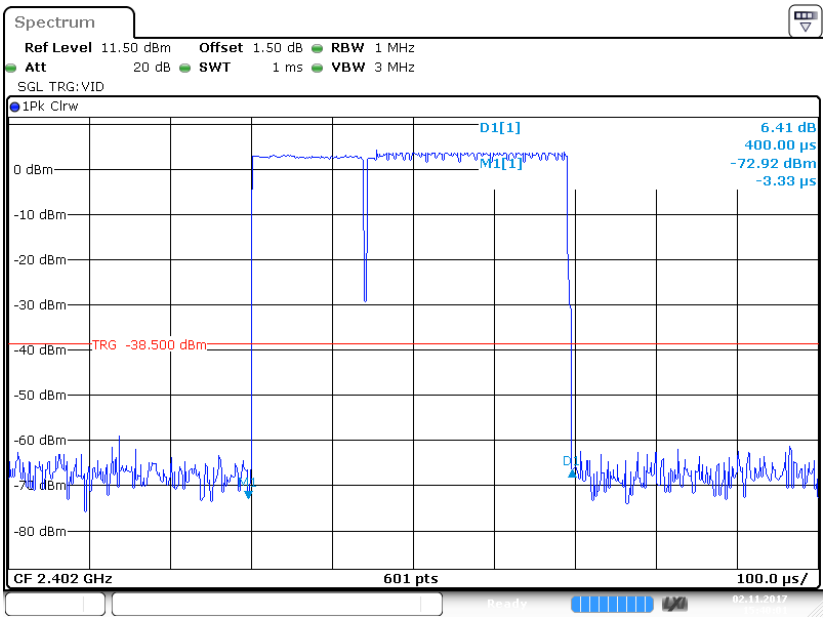
Date: 2.NOV.2017 14:42:16

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



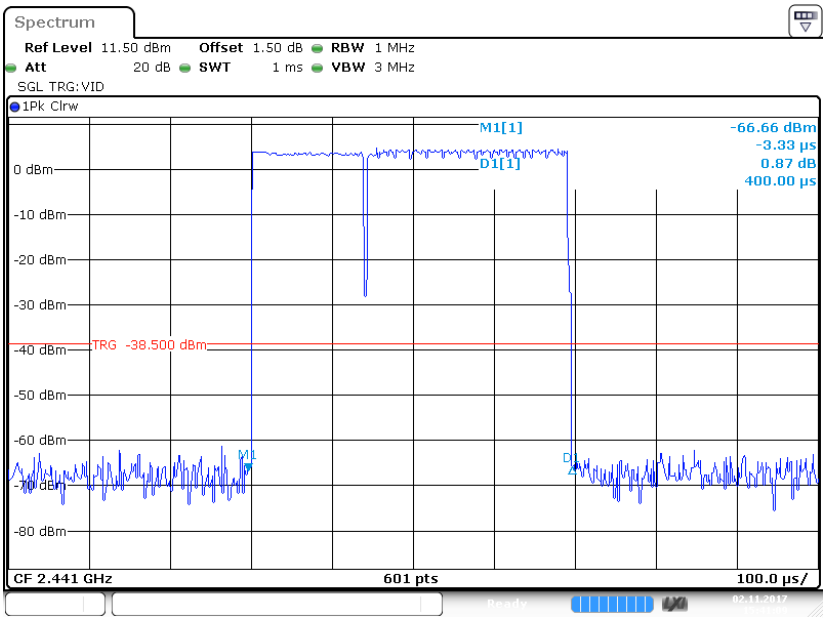
Date: 2.NOV.2017 14:42:52

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



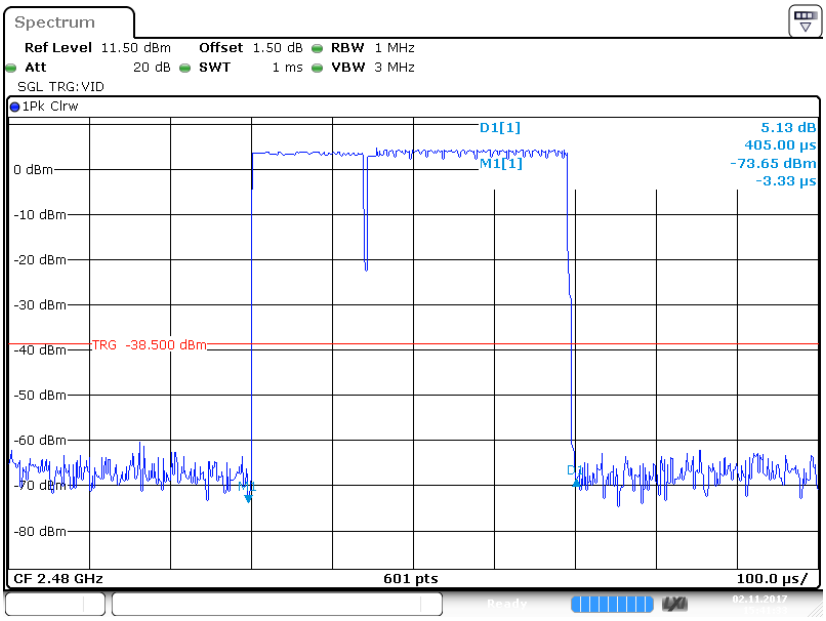
Date: 2.NOV.2017 15:40:01

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



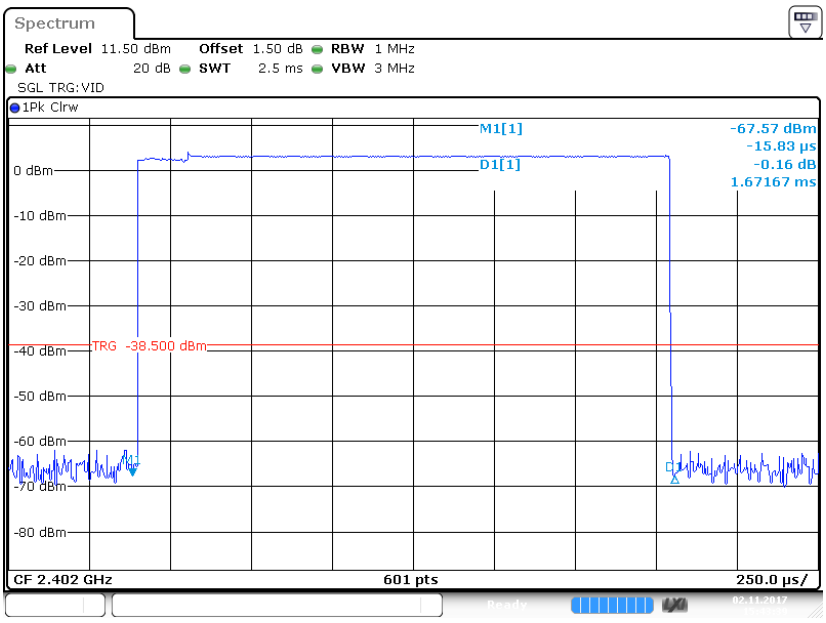
Date: 2.NOV.2017 15:41:09

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



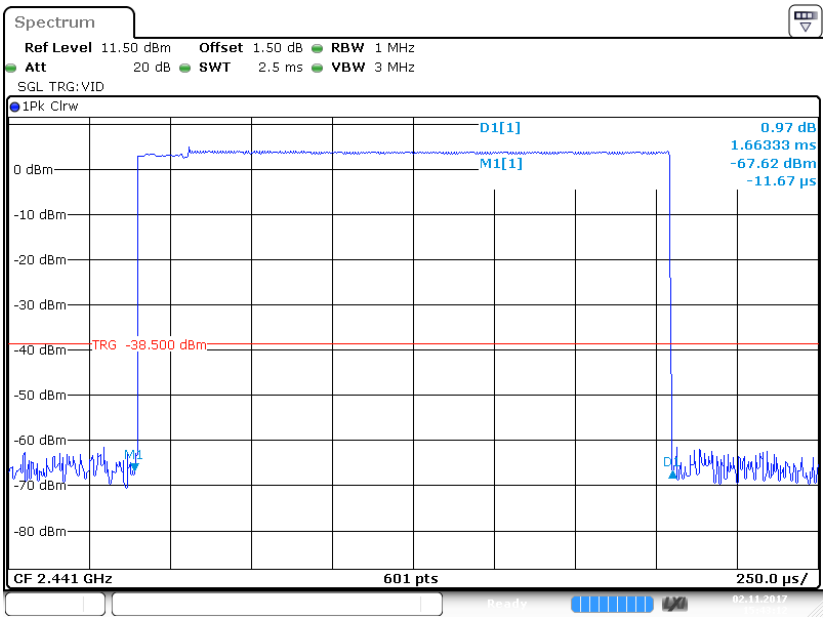
Date: 2.NOV.2017 15:41:34

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



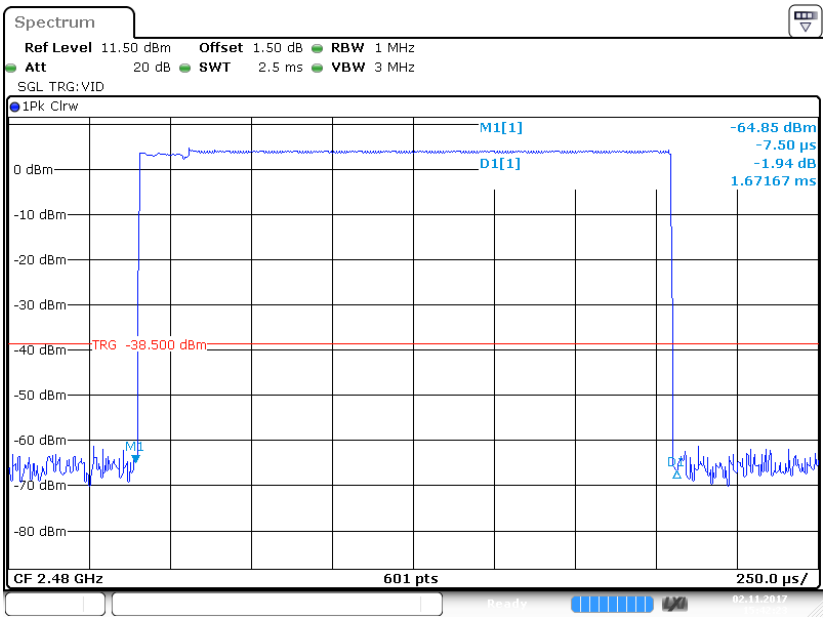
Date: 2.NOV.2017 15:43:39

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

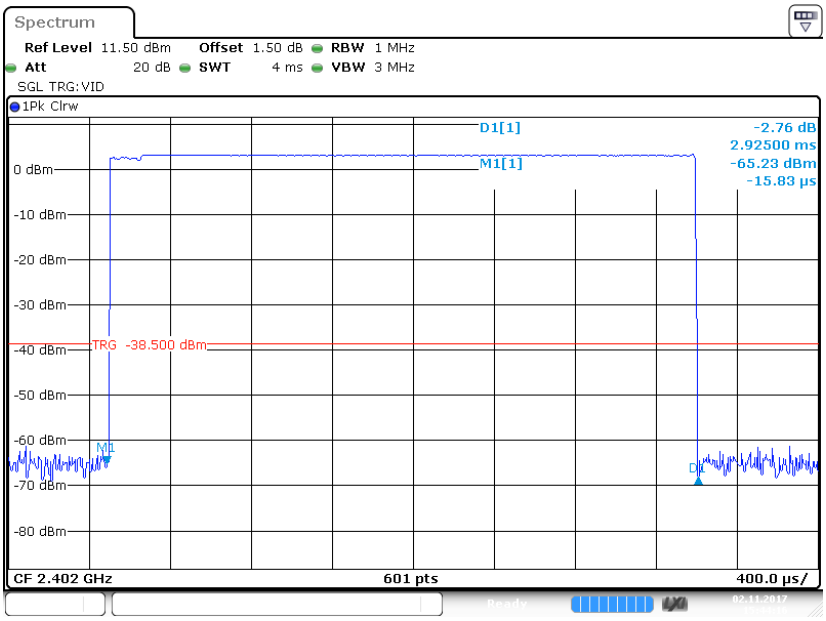


Date: 2.NOV.2017 15:43:12

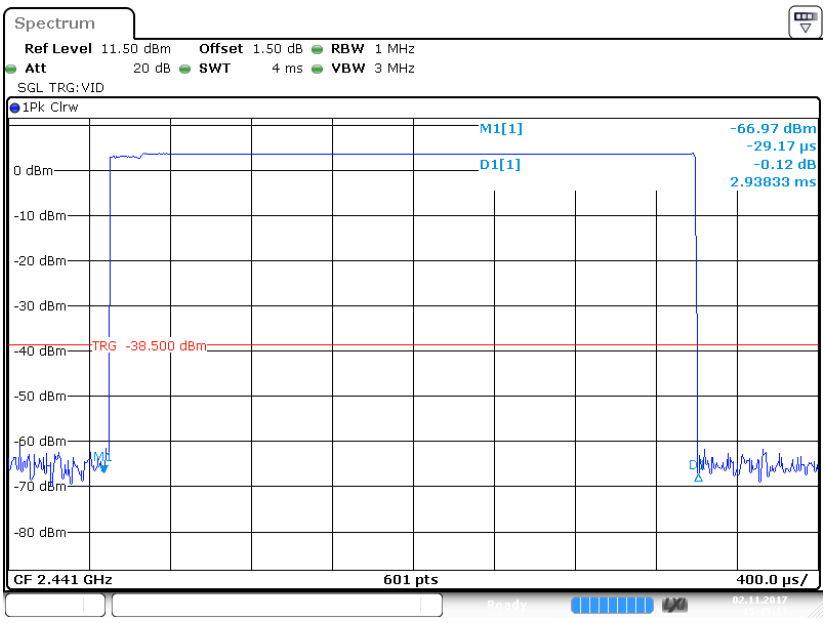
EDR (π/4-DQPSK):Pulse time, High Channel, 2DH3



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

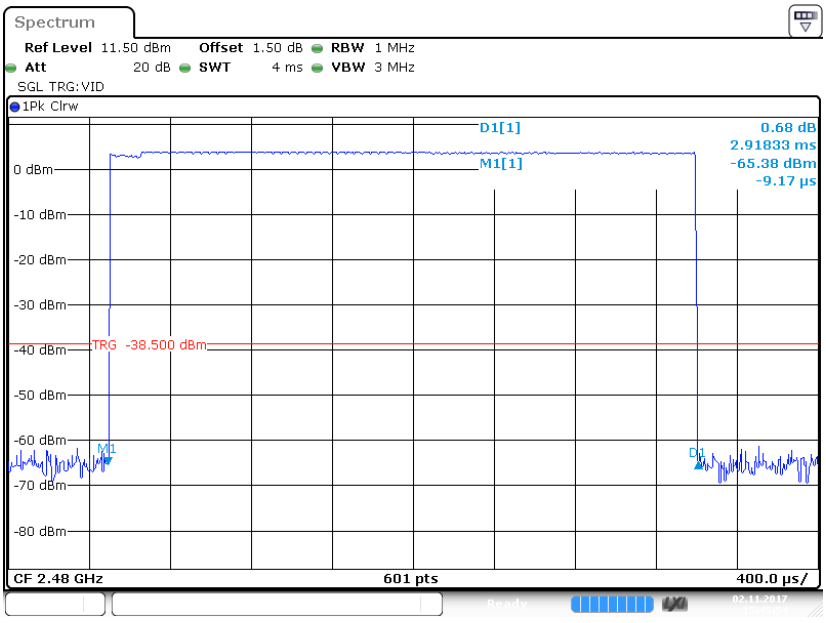


EDR (π/4-DQPSK):Pulse time, Middle Channel, 2DH5



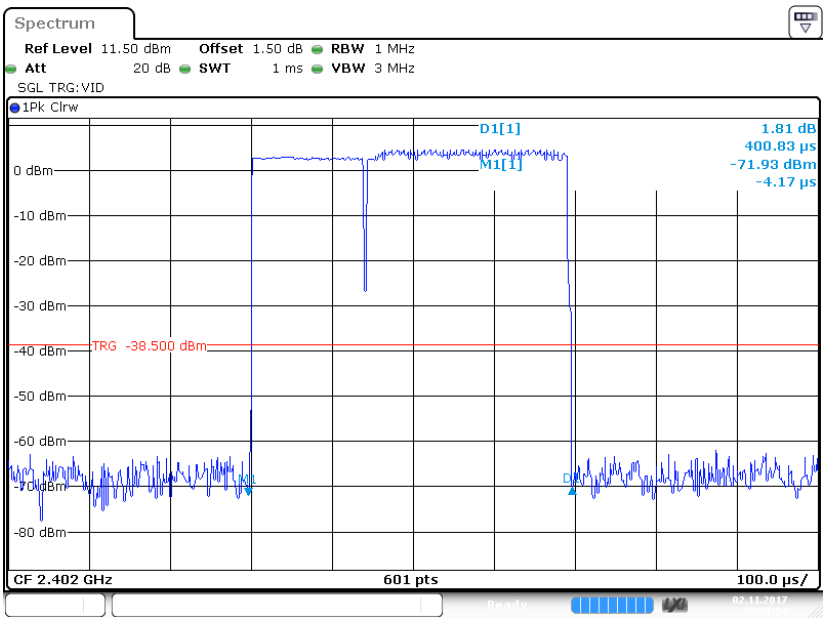
Date: 2.NOV.2017 15:45:13

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



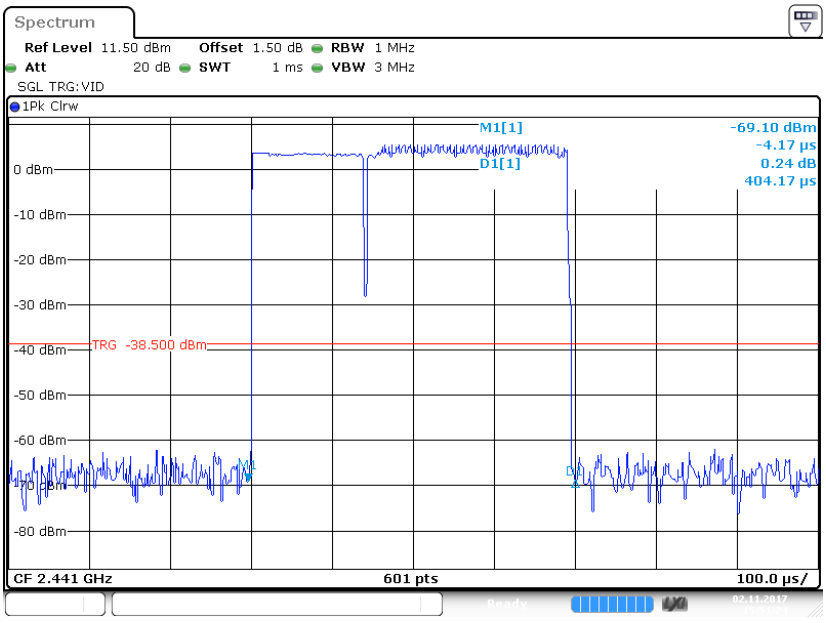
Date: 2.NOV.2017 15:45:54

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



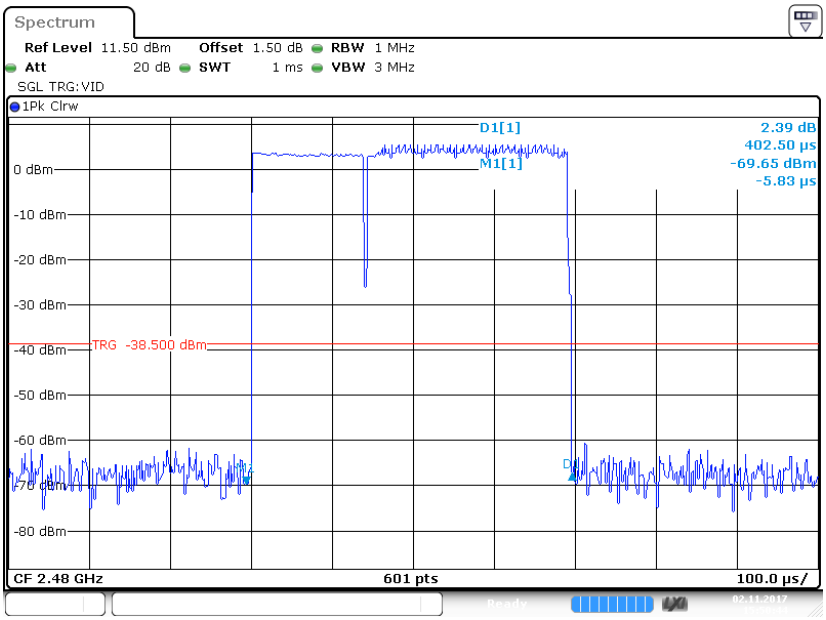
Date: 2.NOV.2017 15:51:54

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

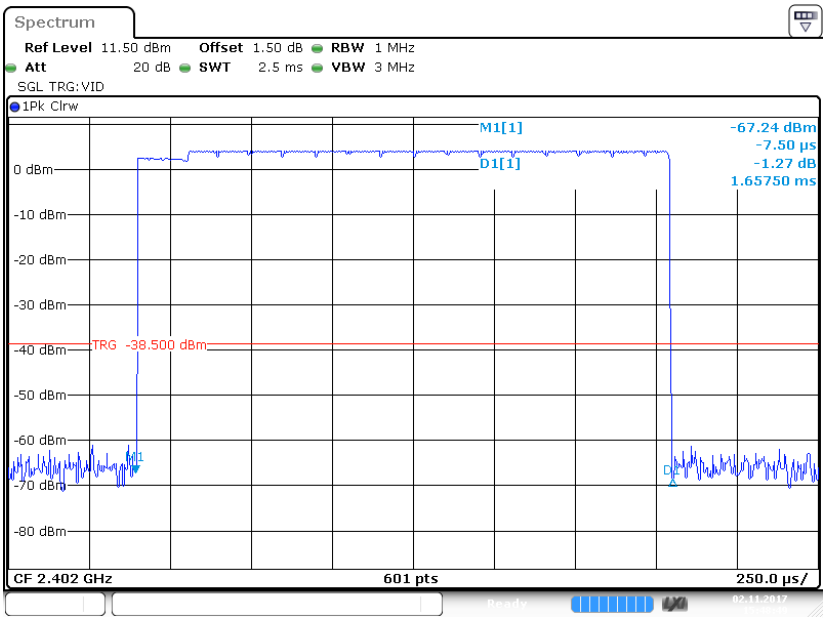


Date: 2.NOV.2017 15:51:25

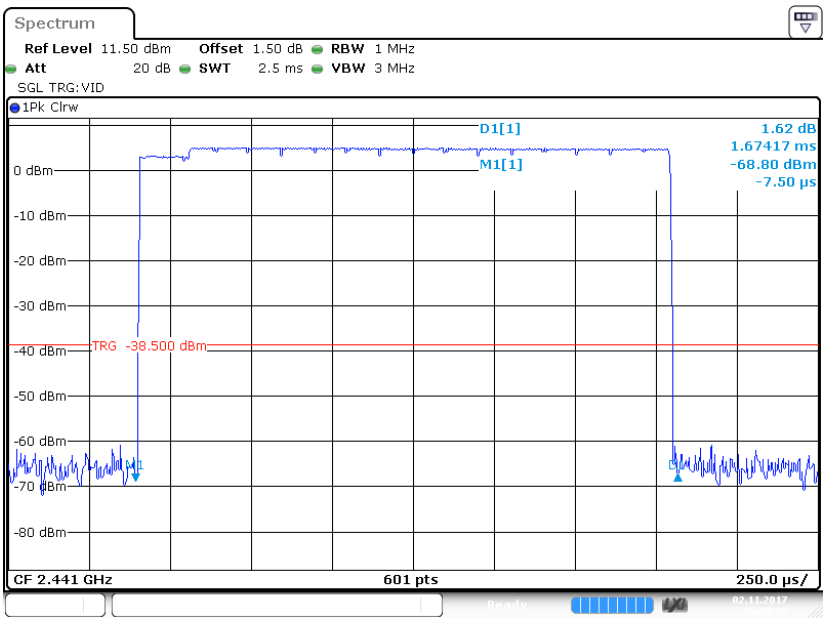
EDR (8-DPSK): Pulse time, High Channel, 3DH1



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

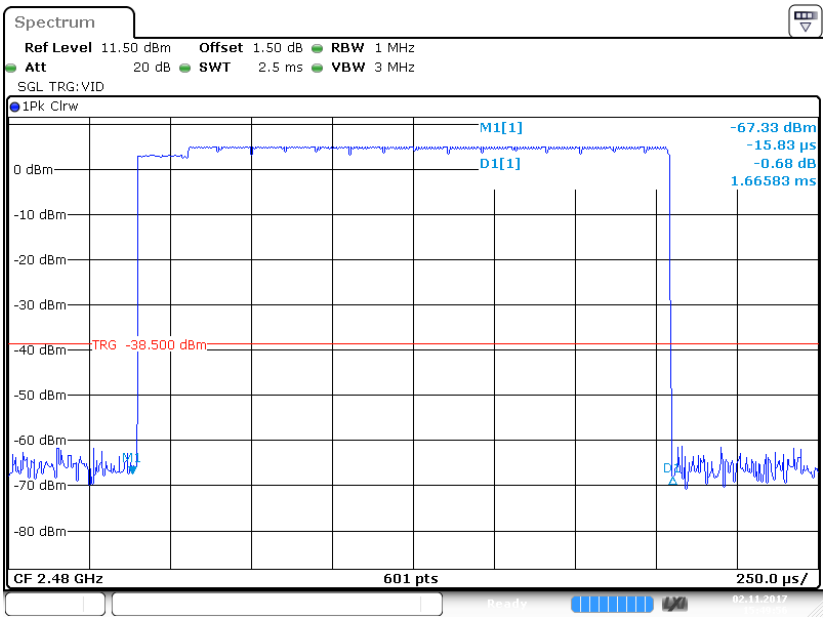


EDR (8-DPSK): Pulse time, Middle Channel, 3DH3



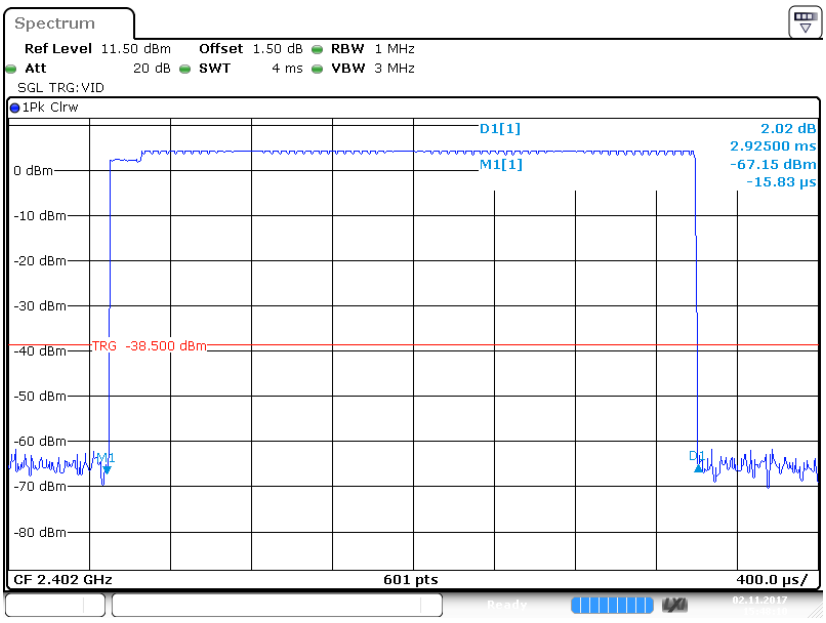
Date: 2.NOV.2017 15:49:25

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

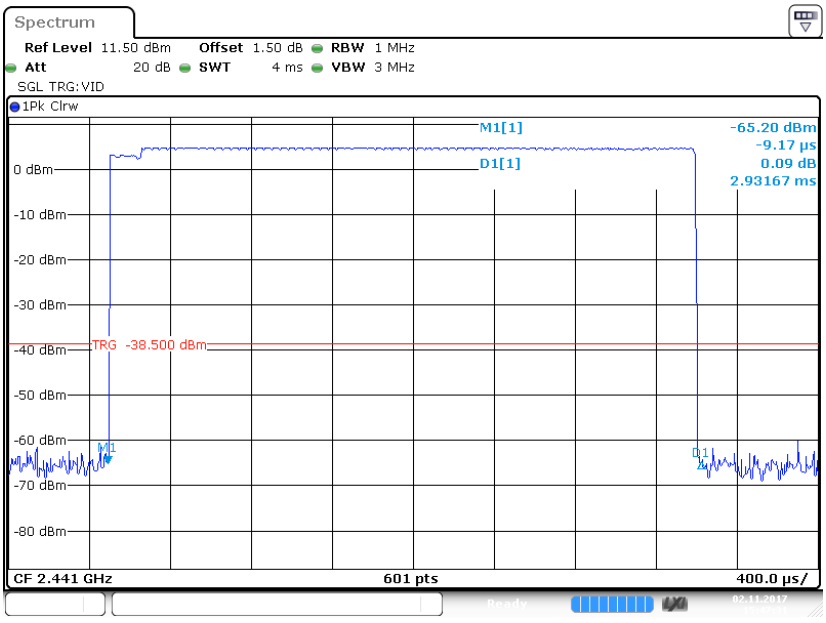


Date: 2.NOV.2017 15:49:56

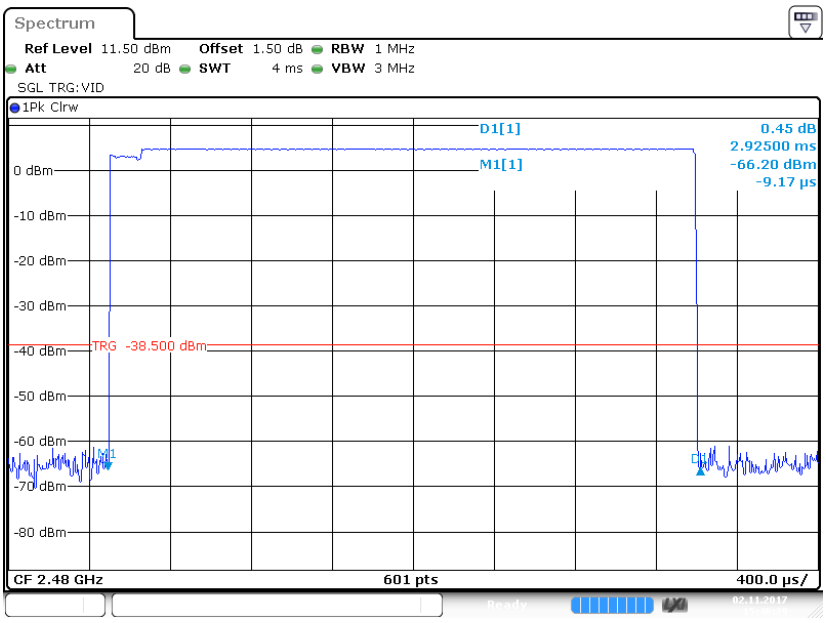
EDR (8-DPSK): Pulse time, Low Channel, 3DH5



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



EDR (8-DPSK): 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

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

Test Data

Environmental Conditions

Temperature:	23.2 ℃
Relative Humidity:	50 %
ATM Pressure:	101.2 kPa

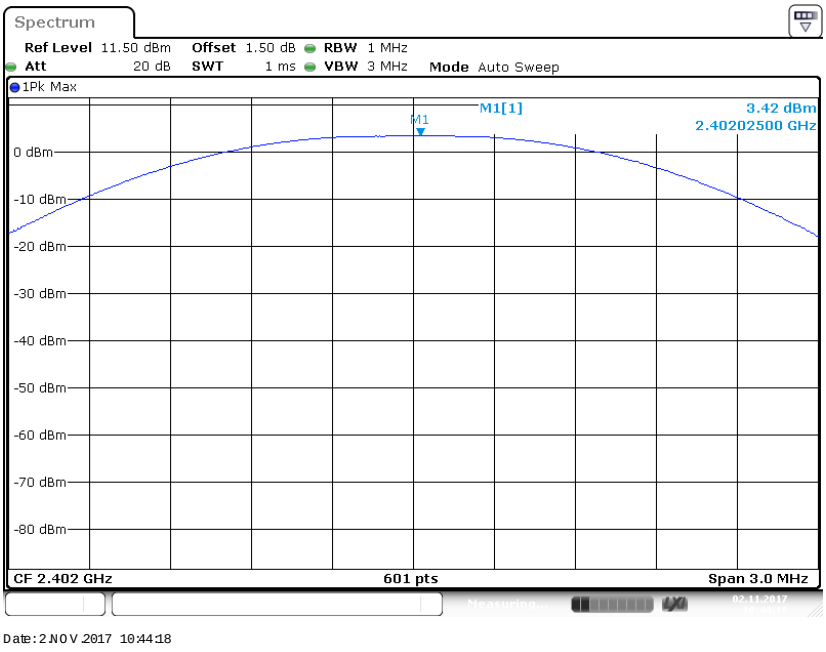
The testing was performed by Ada Yu on 2017-11-02.

EUT operation mode: Transmitting

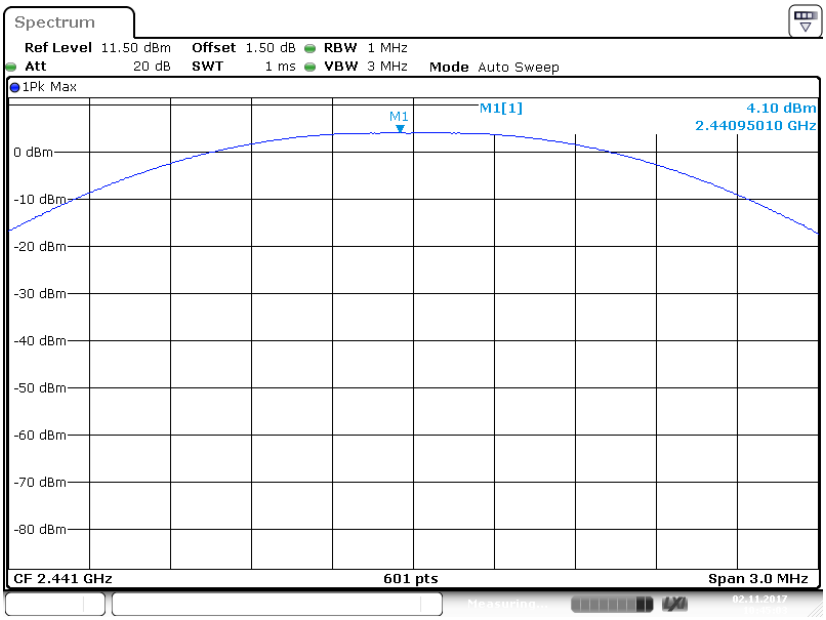
Test Result: Compliance.

Mode	Channel	Frequency (MHz)	Output Power		Limit (mW)
			(dBm)	(mW)	
BDR (GFSK)	Low	2402	3.42	2.20	1000
	Middle	2441	4.10	2.57	1000
	High	2480	4.20	2.63	1000
EDR (π/4-DQPSK)	Low	2402	5.33	3.41	1000
	Middle	2441	6.02	4.00	1000
	High	2480	6.08	4.06	1000
EDR (8-DPSK)	Low	2402	5.62	3.65	1000
	Middle	2441	6.29	4.26	1000
	High	2480	6.35	4.32	1000

BDR (GFSK): Low Channel

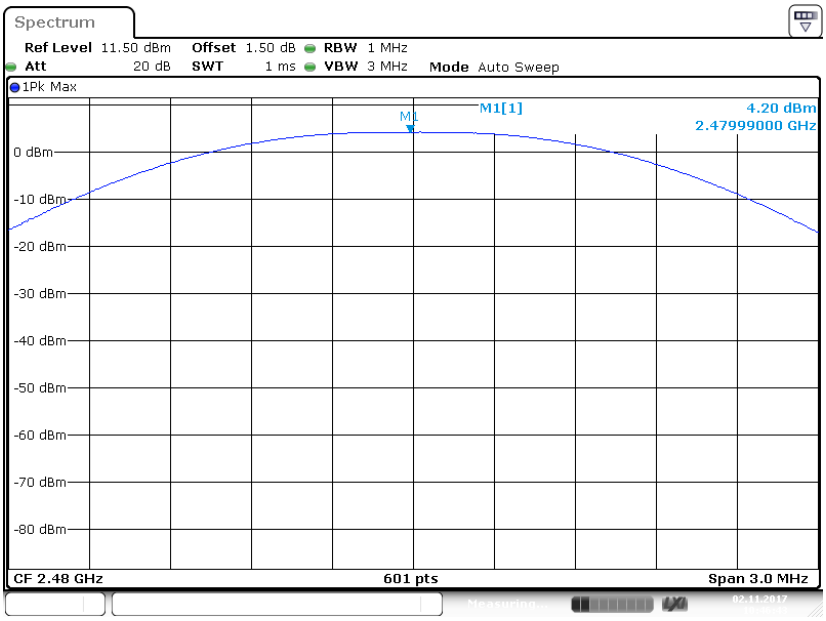


BDR (GFSK): Middle Channel



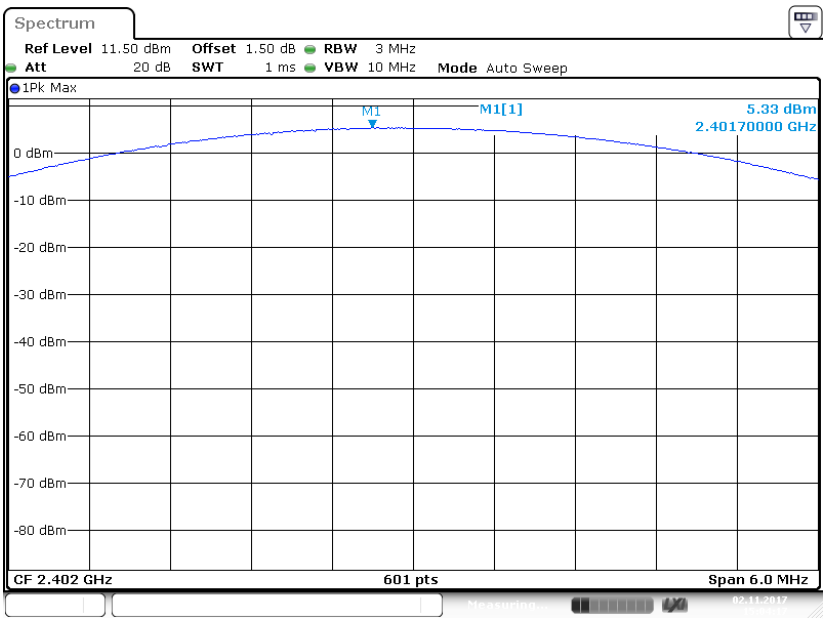
Date: 2.NOV.2017 10:45:03

BDR (GFSK): High Channel



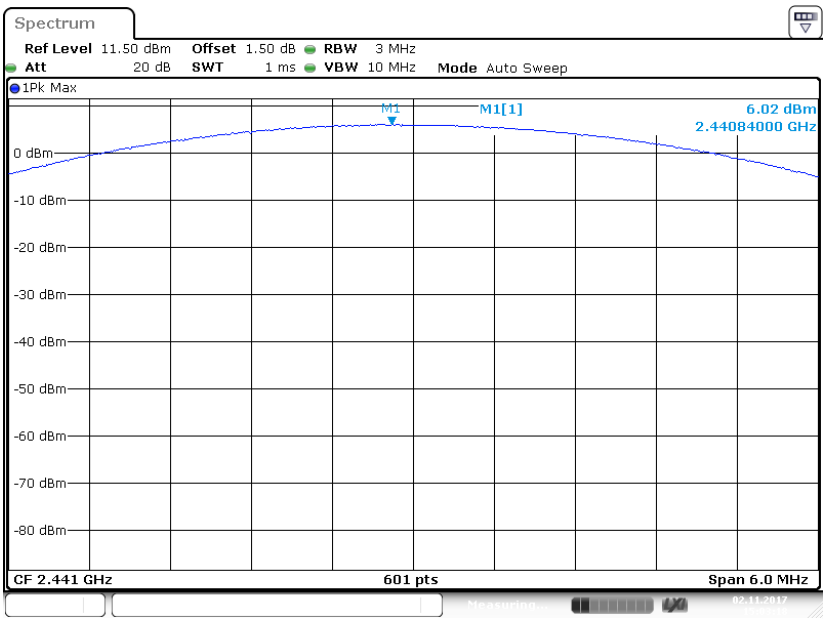
Date: 2.NOV.2017 10:46:43

EDR(π/4-DQPSK): Low Channel



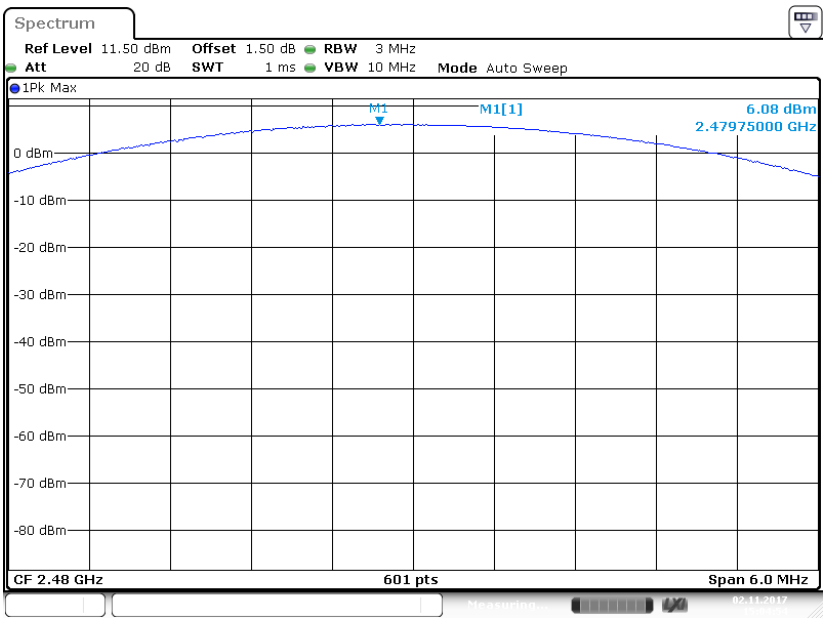
Date: 2.NOV.2017 15:04:18

EDR(π/4-DQPSK): Middle Channel



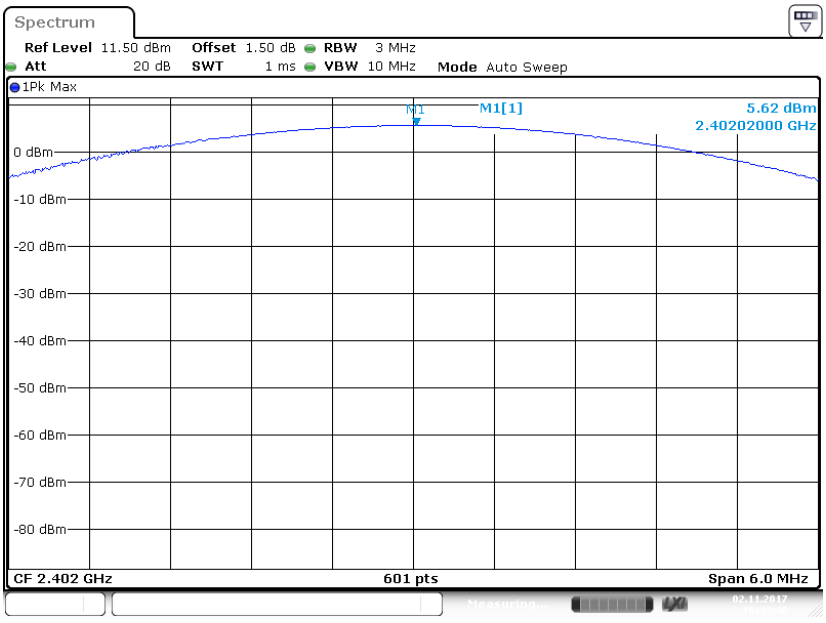
Date: 2.NOV.2017 15:03:18

EDR(π/4-DQPSK): High Channel



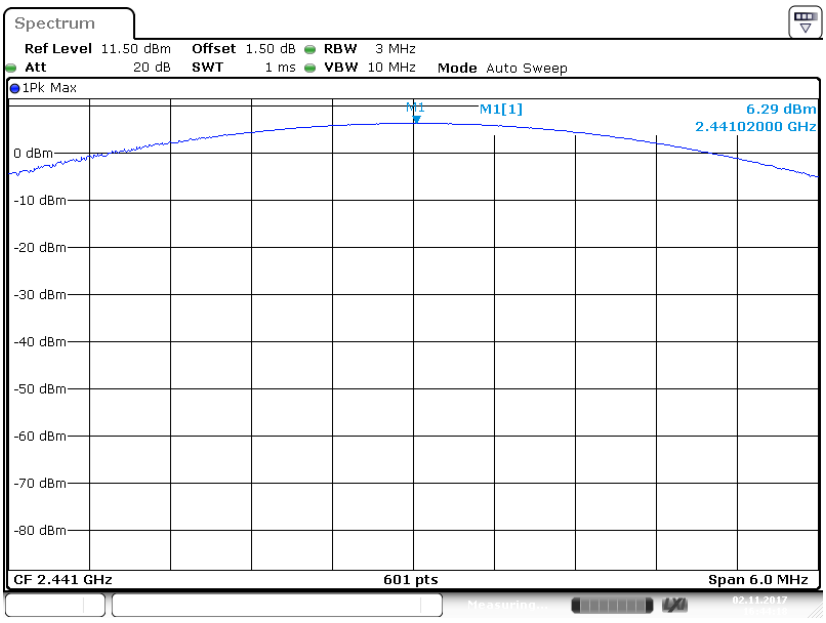
Date: 2.NOV.2017 15:04:55

EDR(8-DPSK): Low Channel



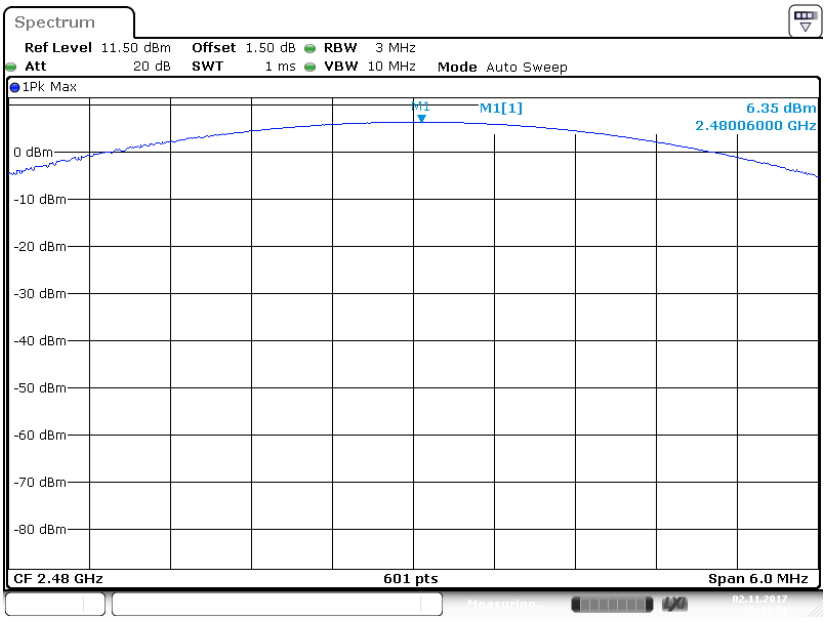
Date: 2.NOV.2017 16:43:40

EDR(8-DPSK): Middle Channel



Date: 2.NOV.2017 16:44:19

EDR(8-DPSK): High Channel



Date: 2.NOV.2017 16:44:51

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 ℃
Relative Humidity:	50 %
ATM Pressure:	101.3 kPa

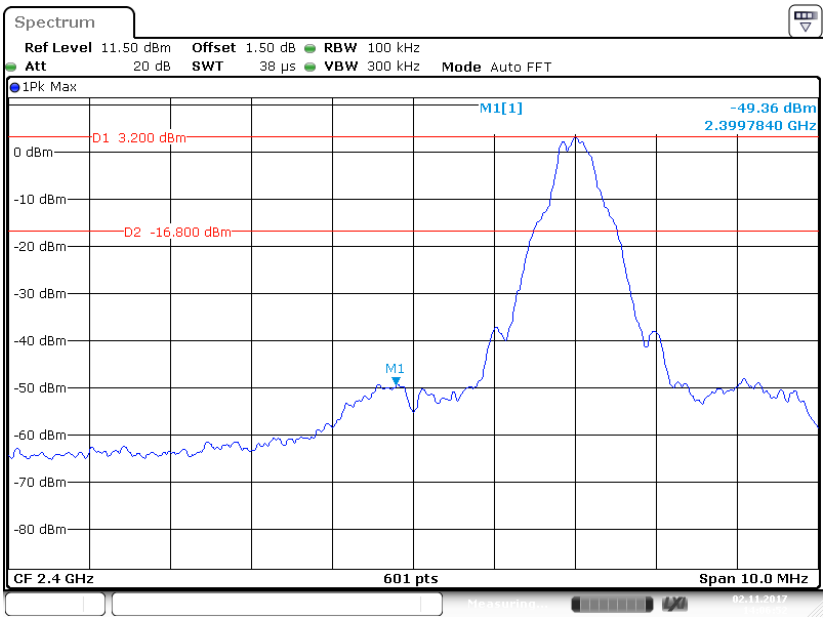
The testing was performed by Ada Yu on 2017-11-02.

EUT operation mode: Transmitting & Hopping

Test Result: Compliance.

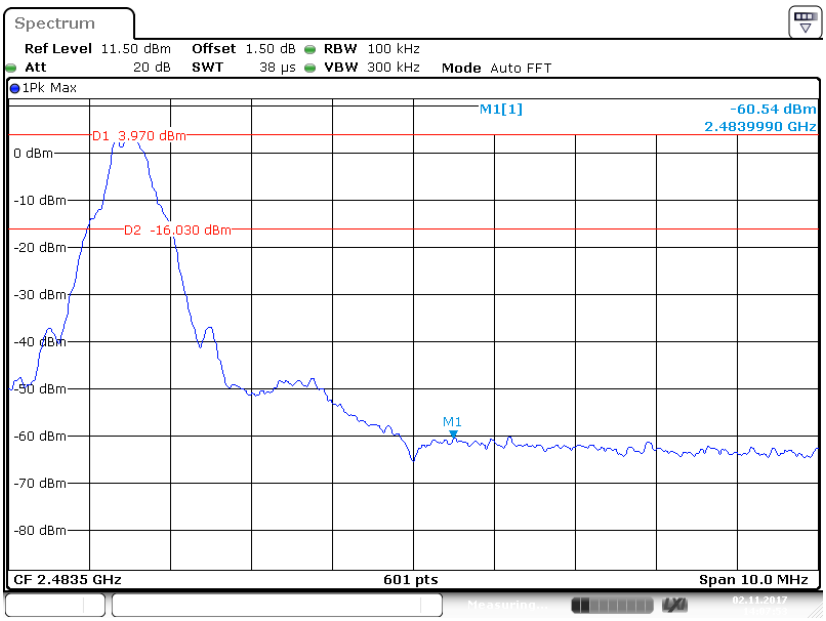
Band Edge

BDR (GFSK): Left Side



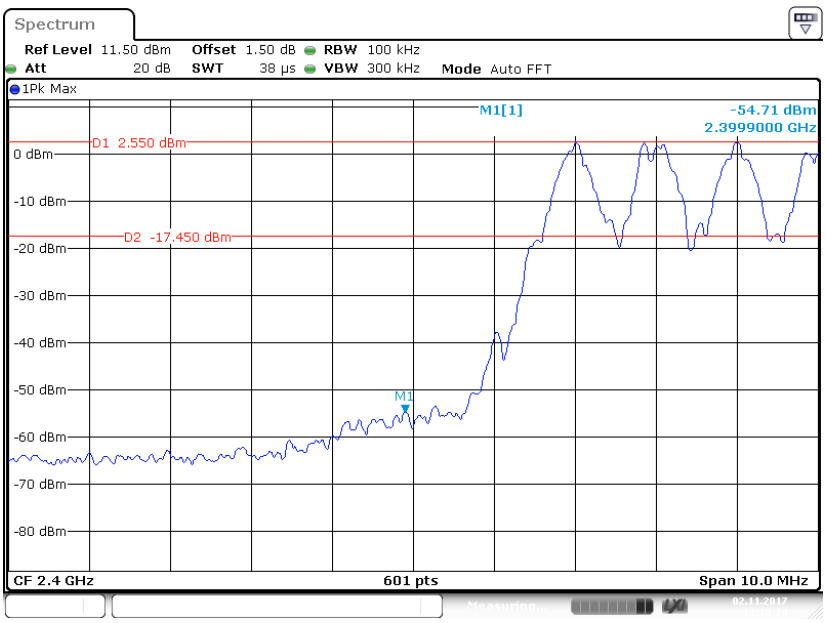
Date: 2.NOV.2017 14:06:52

BDR (GFSK): Right Side

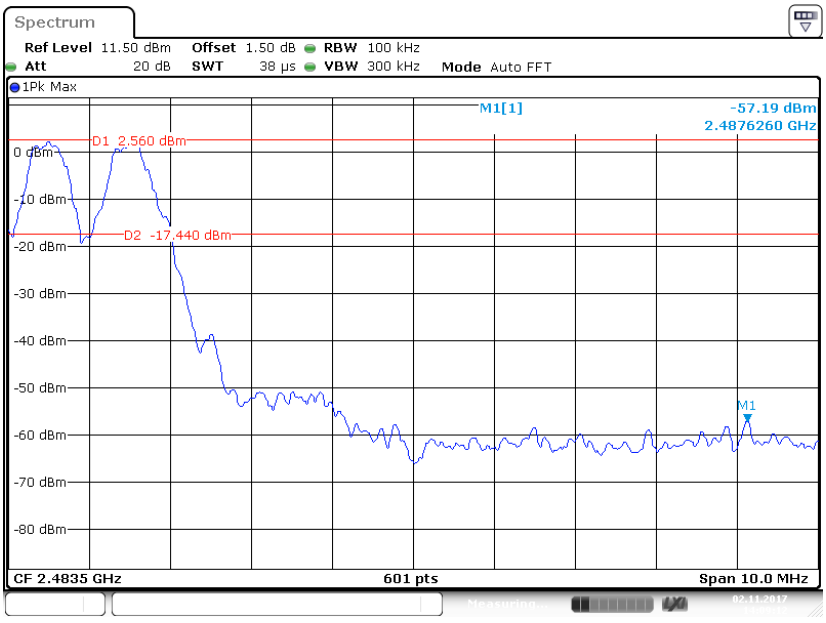


Date: 2.NOV.2017 14:07:53

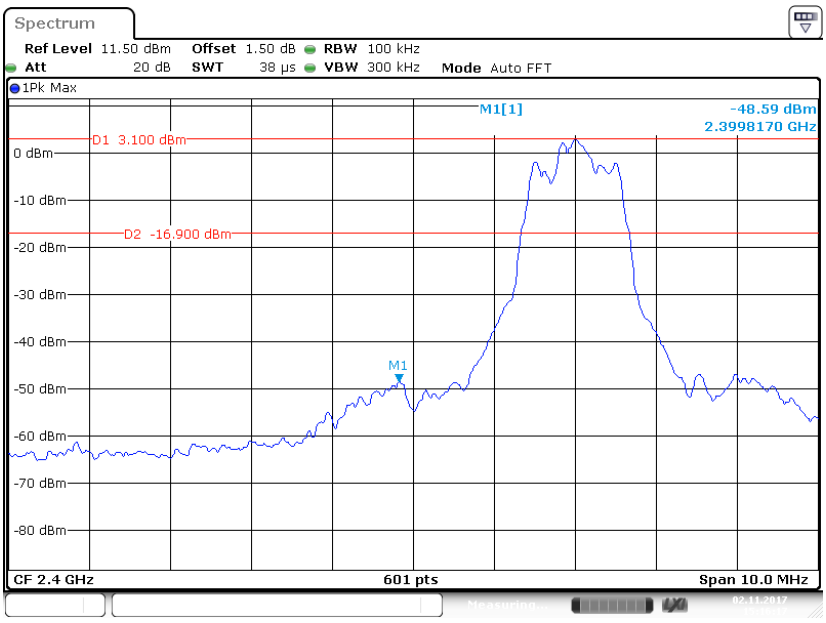
BDR (GFSK): Left Side-Hopping



BDR (GFSK): Right Side-Hopping

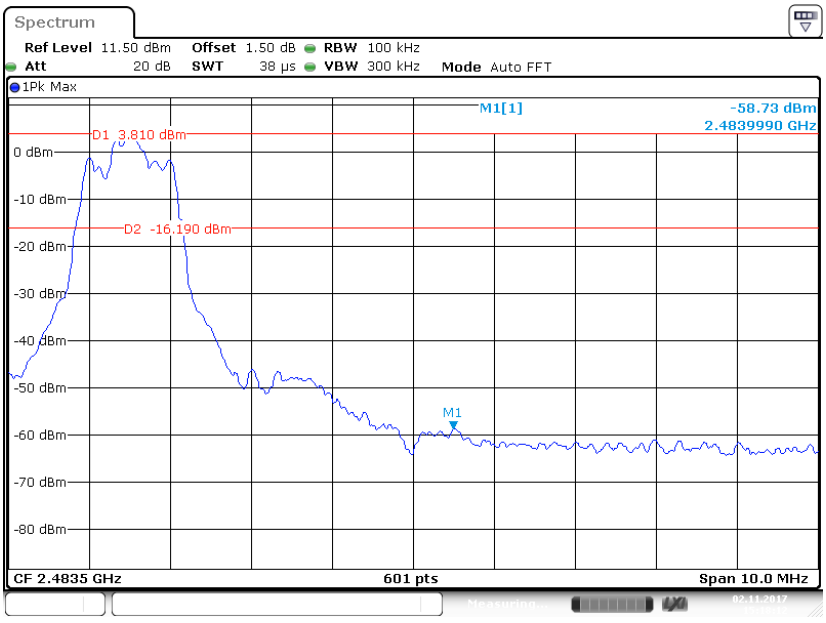


EDR (π/4-DQPSK): Left Side



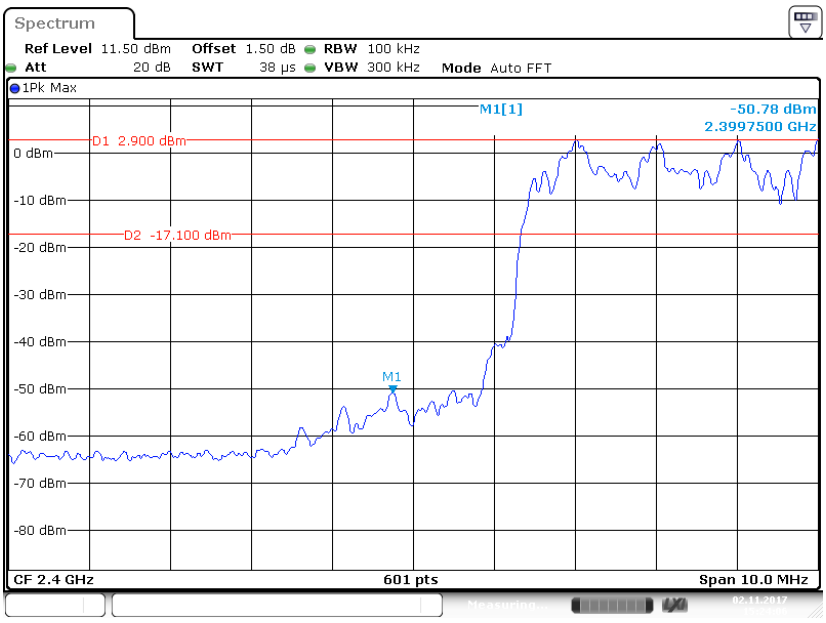
Date: 2.NOV.2017 15:16:18

EDR (π/4-DQPSK): Right Side

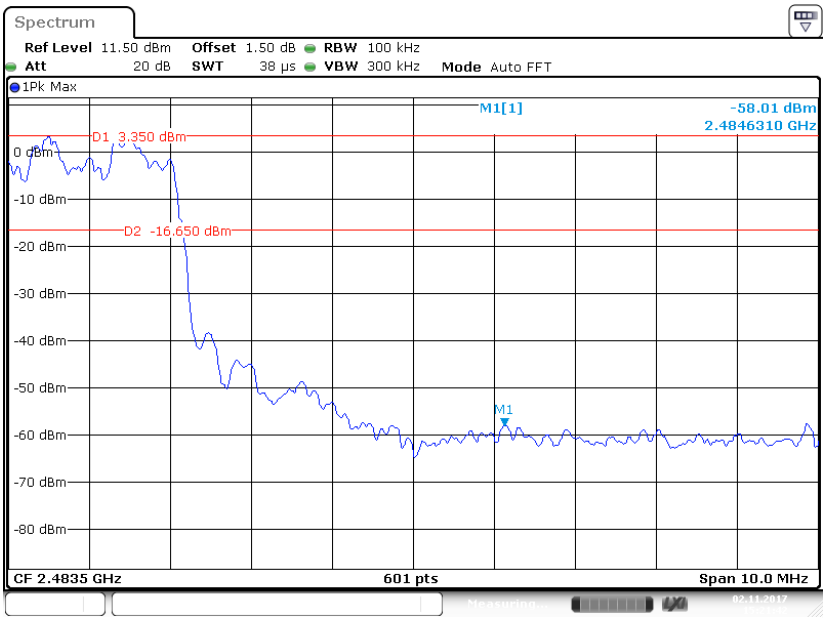


Date: 2.NOV.2017 15:18:12

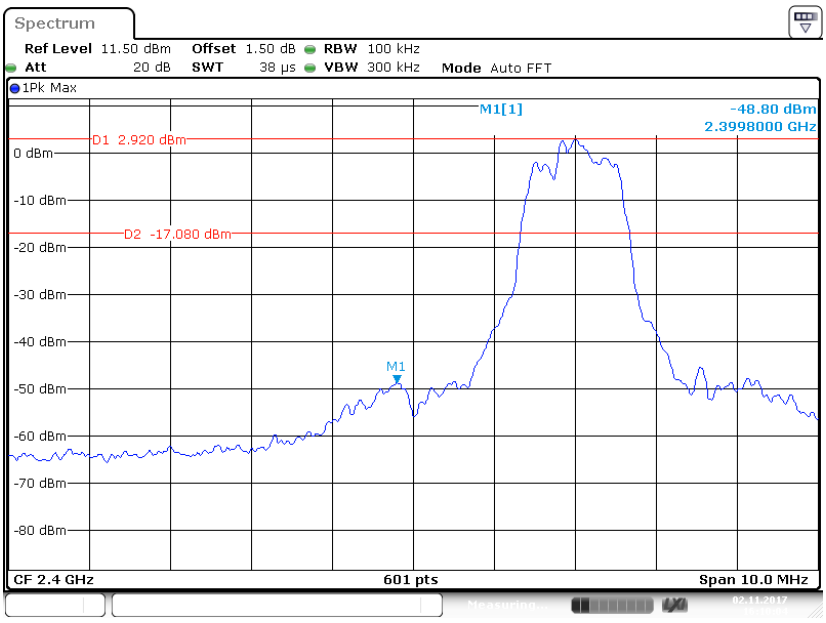
EDR (π/4-DQPSK): Left Side-Hopping



EDR (π/4-DQPSK): Right Side-Hopping

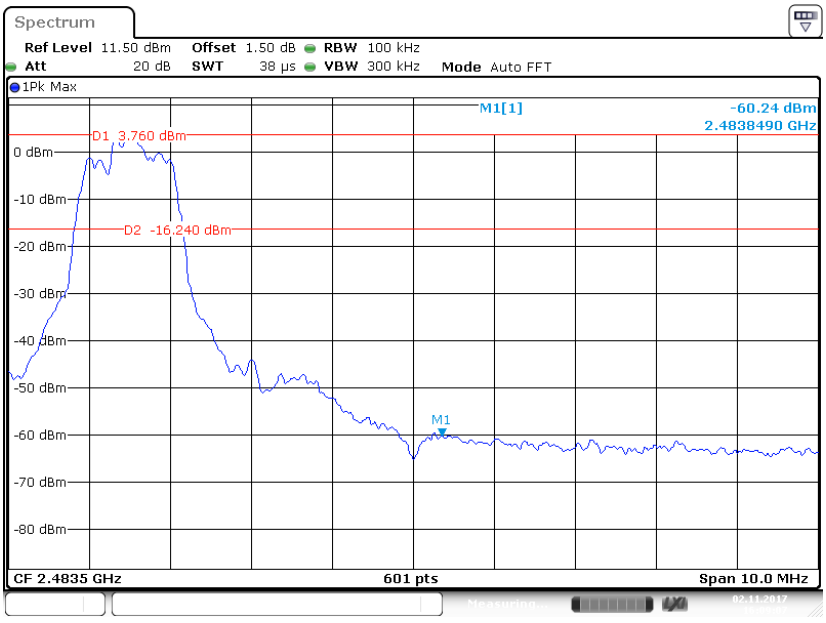


EDR (8-DPSK): Left Side



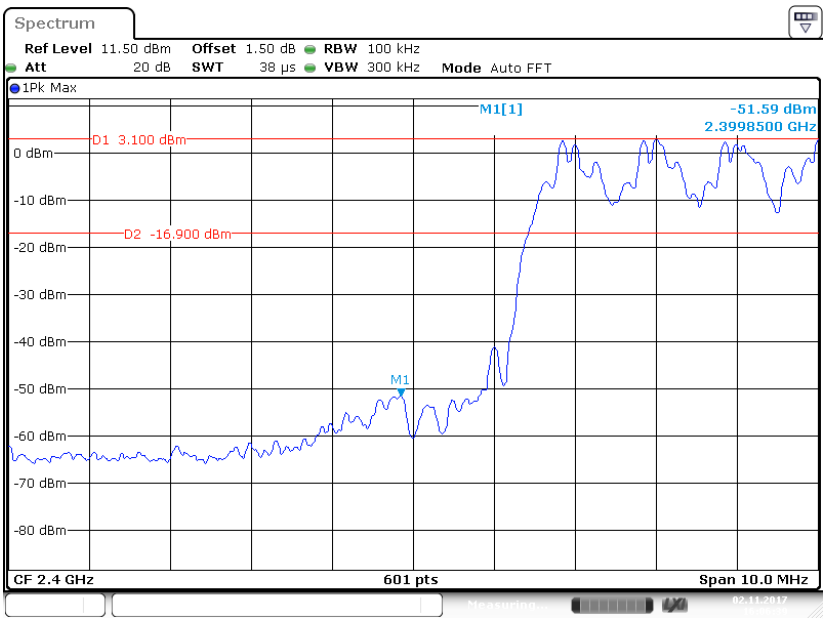
Date: 2.NOV.2017 16:10:04

EDR (8-DPSK): Right Side

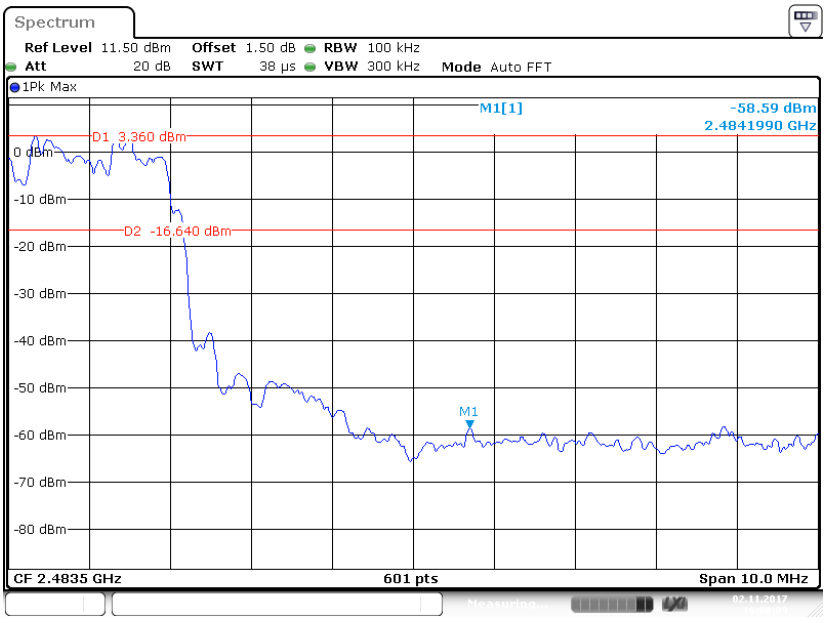


Date: 2.NOV.2017 16:09:07

EDR (8-DPSK): Left Side-Hopping



EDR (8-DPSK): Right Side-Hopping



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