FCC Part 15.247

TEST REPORT

For

TOPMORE TECHNOLOGY INC.

No.1-1, Taiyuan 2nd St., Zhubei City, Hsinchu County 302, Taiwan (R.O.C.)

FCC ID: 2ANH6-D12-SPKR

Report Type:	**Product Type:**
Original Report	Crystal Cube

Report Producer : **Jane Lee** Jane Lee

Report Number : **RXZ1805011-00B**

Report Date : **2018-06-19**

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Revision History

Revision	No.	Report Number	Issue Date	Description	Author/ Revised by
1.0	RXZ1805011	RXZ1805011-00B	2018.06.19	Original Report	Jane

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1 General Information

1.1 Product Description for Equipment under Test (EUT)

Applicant	TOPMORE TECHNOLOGY INC.
	No.1-1, Taiyuan 2nd St., Zhubei City, Hsinchu County 302, Taiwan (R.O.C.)
Manufacturer	Shenzhen ABC Industrial Co., Ltd.
	Rm526, Block C, Huafeng Headquarters Bldg, Xixiang Avenue No. 288, Bao'an, Shenzhen, China
Brand(Trade) Name	TOPMORE
Product (Equipment)	Crystal Cube
Model Name	D12
Frequency Range	2402 ~ 2480 MHz
Transmit Power	BR(GFSK) Mode: -6.13dBm (0.00024W) EDR(π/4-DQPSK) Mode:-5.07 dBm(0.00031W) EDR(8DPSK) Mode: -4.59 dBm (0.00035W)
Modulation Technique	BR Mode: GFSK EDR Mode: π/4-DQPSK EDR Mode: 8DPSK
Transmit Data Rate	BR(GFSK) Mode: 1 Mbps EDR (π/4-DQPSK) Mode: 2 Mbps EDR (8DPSK) Mode: 3 Mbps
Number of Channels	79 Channels
Antenna Specification	PCB Antenna / -0.68 dBi
Module model	ATS2823
Output:	5V from USB 3.7V from Battery
Received Date	May 21, 2018
Date of Test	May 21, 2018 ~ June 19, 2018

**All measurement and test data in this report was gathered from production sample serial number: 1805011 (Assigned by BACL, Taiwan).*

1.2 Objective

This report is prepared on behalf of *TOPMORE TECHNOLOGY INC.* in accordance with Part 2, Subpart J, Part 15, Subparts A and C of the Federal Communication Commission's rules.

The tests were performed in order to determine the Bluetooth BR and EDR mode of EUT compliance with FCC Part 15, Subpart C, and section 15.203, 15.205, 15.207, 15.209 and 15.247 rules.

1.3 Related Submittal(s)/Grant(s)

FCC Part 15.247 DTS submission with FCC ID: 2ANH6-D12-SPK

1.4 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.

1.5 Test Facility

The Test site used by Bay Area Compliance Laboratories Corp. (Taiwan) to collect test data is located on

☒70, Lane 169, Sec. 2, Datong Road, Xizhi Dist., New Taipei City 22183, Taiwan, R.O.C.

☐68-3, Lane 169, Sec. 2, Datong Road, Xizhi Dist., New Taipei City 22183, Taiwan, R.O.C.

Bay Area Compliance Laboratories Corp. (Taiwan) Lab is accredited to ISO 17025 by Taiwan Accreditation Foundation (TAF code: 3180) and the FCC designation No.TW3180 under the Mutual Recognition Agreement (MRA) in FCC Test. The facility also complies with the radiated and AC line conducted test site criteria set forth in ANSI C63.10.

The Federal Communications Commission has the reports on file and is listed under FCC Registration No.: 974454. The test site has been approved by the FCC for public use and is listed in the FCC Public Access Link (PAL) database.

2 System Test Configuration

2.1 Description of Test Configuration

For BT mode, 79 channels are provided to testing:

Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	2402	40	2441
2	2403	--	--
3	2404	--	--
4	2405	77	2478
--	--	78	2479
39	2440	79	2480

2.2 Equipment Modifications

No modification was made to the EUT.

2.3 EUT Exercise Software

Test Software		FCC Test tools v1.07		
Test Frequency		2402MHz	2441MHz	2480MHz
Power Level Setting	GFSK	0	0	0
	π/4-DQPSK	0	0	0
	8DPSK	0	0	0

2.4 Support Equipment List and Details

Description	Manufacturer	Model Number	BSMI	FCC ID	S/N
NB	DELL	E6410	N/A	N/A	N/A

2.5 External Cable List and Details

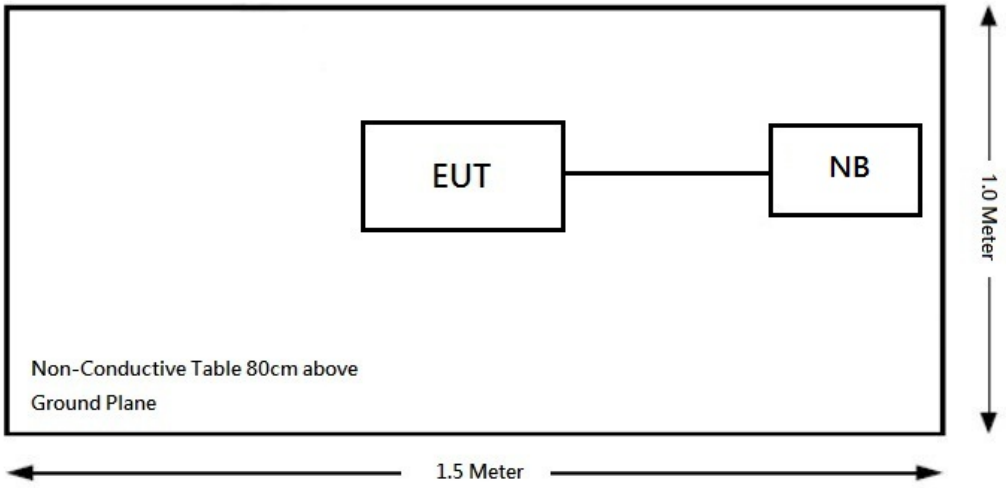
Cable Description	Length (m)	From	To
N/A	N/A	N/A	N/A

2.6 Block Diagram of Test Setup

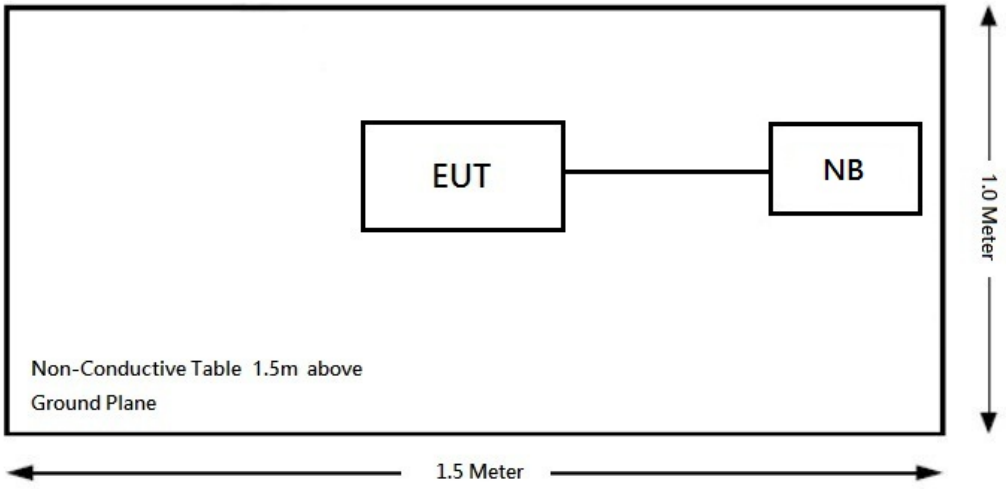
See test photographs attached in annex setup photos for the actual connections between EUT and support equipment.

Radiation:

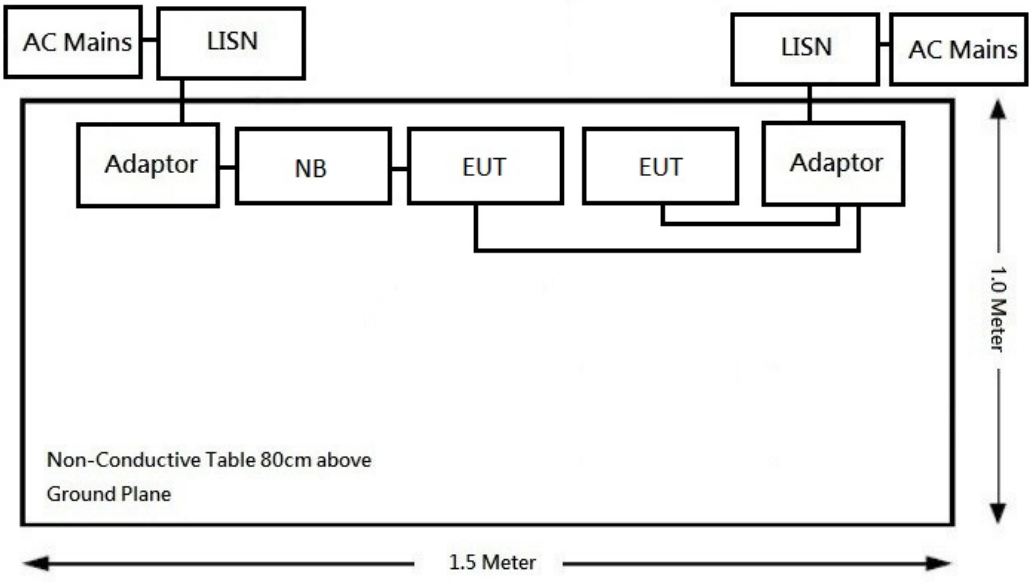
Below 1GHz:



Above 1GHz:



Conduction:


AC Mains
LISN
LISN
AC Mains
Adaptor
NB
EUT
EUT
Adaptor
1.0 Meter
Non-Conductive Table 80cm above
Ground Plane
1.5 Meter

3 Summary of Test Results

FCC Rules	Description of Test	Results
§15.247(i), §2.1093	RF Exposure	Compliance
§15.203	Antenna Requirement	Compliance
§15.207(a)	AC Line Conducted Emissions	Compliance
§15.205, §15.209, §15.247(d)	Spurious 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)(3)	Maximum Peak Output Power	Compliance
§15.247(d)	100 kHz Bandwidth of Frequency Band Edge	Compliance

4 Test Equipment List and Details

Description	Manufacturer	Model	Serial Number	Calibration Date	Calibration Due Date
AC Line Conduction Room (CON-A)					
LISN	Rohde & Schwarz	ENV216	101248	2017/07/20	2018/07/19
EMI Test Receiver	Rohde & Schwarz	ESR7	101419	2017/11/06	2018/11/05
Pulse Limiter	Rohde & Schwarz	ESH3Z2	TXZEM104	2017/08/10	2018/08/09
RF Cable	EMEC	EM-CB5D	001	2017/07/10	2018/07/09
Software	AUDIX	E3	V9.150826k	N.C.R	N.C.R
Radiated Room (966-A)					
Bilog Antenna with 6 dB Attenuator	SUNOL SCIENCES & MINI-CIRCUITS	JB6/UNAT-6+	A050115/15542_01	2017/12/20	2018/12/19
Horn Antenna	EMCO	3115	9311-4158	2018/04/20	2019/04/19
Horn Antenna	ETS-Lindgren	3116	62638	2017/09/13	2018/09/12
Preamplifier	Sonoma	310N	130602	2017/07/03	2018/07/02
Preamplifier	EM Electronics Corp.	EM01G18G	060657	2017/12/14	2018/12/13
Microware Preamplifier	EM Electronics Corporatino	EM18G40G	060656	2018/01/15	2019/01/14
EMI Test Receiver	Rohde & Schwarz	ESR7	101419	2017/11/06	2018/11/05
Spectrum Analyzer	Rohde & Schwarz	FSV40	101203	2017/07/13	2018/07/12
Microflex Cable	UTIFLEX	UFB311A-Q-1440-300300	220490-006	2017/10/31	2018/10/30
Microflex Cable	UTIFLEX	UFA210A-1-3149-300300	MFR64639 226389-001	2017/11/10	2018/11/09
Microflex Cable	ROSNOL	K1K50-UP0264-K1K50-450CM	160309-1	2018/03/05	2019/03/04
Microflex Cable	ROSNOL	K1K50-UP0264-K1K50-80CM	160309-2	2018/01/17	2019/01/16
Turn Table	Champro	TT-2000	060772-T	N.C.R	N.C.R
Antenna Tower	Champro	AM-BS-4500-B	060772-A	N.C.R	N.C.R
Controller	Champro	EM1000	60772	N.C.R	N.C.R
Software	Farad	EZ_EMC	BACL-03A1	N.C.R	N.C.R
NSA	BACL	966-A	N/A	2017/07/24	2018/07/23
VSWR	BACL	966-A	N/A	2017/07/25	2018/07/24

Conducted Room					
Spectrum Analyzer	Rohde & Schwarz	FSU26	200268	2018/05/04	2019/05/03
Cable	WOKEN	SFL402	S02-160323-07	2018/02/12	2019/02/11
Power Sensor	KEYSIGHT	U2021XA	MY54080018	2018/03/07	2019/03/06

***Statement of Traceability:** BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to the SI System of Units via the R.O.C. Center for Measurement Standards of the Electronics Testing Center, Taiwan (ETC) or to another internationally recognized National Metrology Institute (NMI), and were compliant with the current Taiwan Accreditation Foundation (TAF) requirements*

5 FCC §15.247(i) & 2.1093 - RF Exposure

5.1 Applicable Standard

According to FCC §15.247(i)

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 KDB 447498 D01 General RF Exposure Guidance, 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:

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

1. f(GHz) is the RF channel transmit frequency in GHz.
2. Power and distance are rounded to the nearest mW and mm before calculation.
3. The result is rounded to one decimal place for comparison.
4. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test Exclusion.

5.2 RF Exposure Evaluation Result

FCC

Worse case:

SAR evaluation:

Mode	Frequency	Tunp-up Power		Evaluation Distrance	Calculated Value	Threshold	SAR Test Exclusion
	(MHz)	(dBm)	(mW)	(mm)		(1-g SAR)	
BT	2402-2480	-5.5	0.282	5	0.1	3	Yes
BLE	2402-2480	-4.5	0.355	5	0.1	3	Yes

Result: SAR test is exempted.

6 FCC §15.203 – Antenna Requirements

6.1 Applicable Standard

According to § 15.203,

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

And according to FCC 47 CFR section 15.247 (b), if the transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna does not exceed 6 dBi.

6.2 Measurement Uncertainty

Manufacturer	Type	Antenna Gain	Result
Actions(Zhuhai) Technology Co., Limited	PCB Antenna	-0.68 dBi	Compliance

The EUT has one integral antenna arrangement, which was permanently attached; fulfill the requirement of this section.

7 FCC §15.207(a) – AC Line Conducted Emissions

7.1 Applicable Standard

According to §15.207

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequencies ranges.

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-Peak	Average
0.15-0.5	66 to 56 Note 1	56 to 46 Note 2
0.5-5	56	46
5-30	60	50

Note 1: Decreases with the logarithm of the frequency.

Note 2: A linear average detector is required

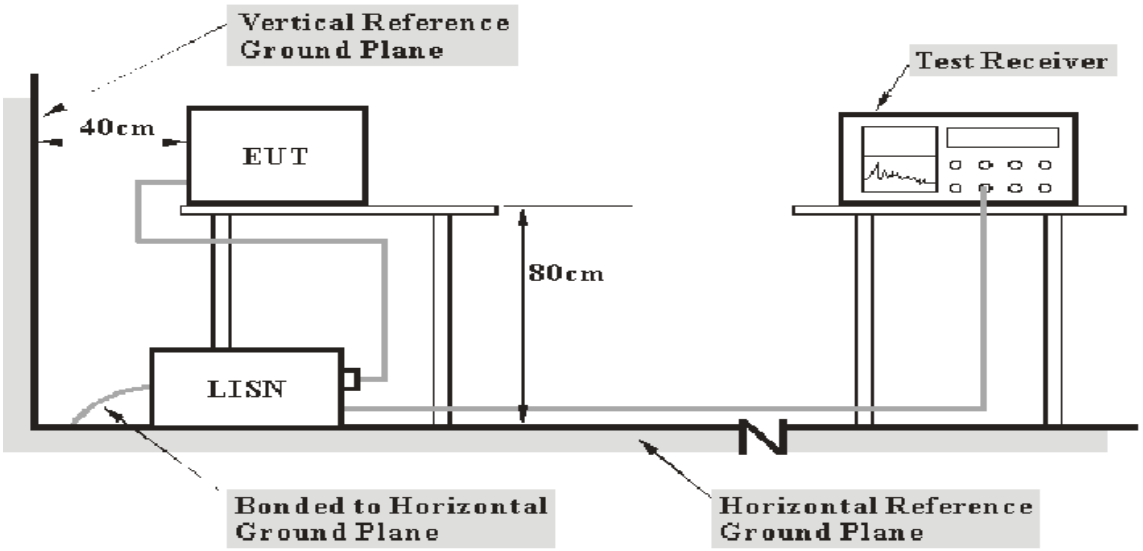
7.2 Measurement Uncertainty

Input quantities to be considered for conducted disturbance measurements maybe receiver reading, attenuation of the connection between LISN/ISN and receiver, LISN/ISN voltage division factor, LISN/ISN VDF frequency interpolation and receiver related input quantities, etc.

Based on CISPR 16-4-2:2011, the expended combined standard uncertainty of conducted disturbance test at Bay Area Compliance Laboratories Corp. (Taiwan) is shown as below. And the uncertainty will not be taken into consideration for the test data recorded in the report

Port	Expanded Measurement uncertainty
AC Mains	4.64 dB (k=2, 95% level of confidence)

7.3 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 setup of EUT is according with per ANSI C63.10-2013 measurement procedure. The specification used was with the FCC Part 15.207 limits.

7.4 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

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

7.6 Corrected Factor & Margin Calculation

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

Factor = LISN VDF + Cable Loss + Transient Limiter Attenuation

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

Over Limit = Level – Limit Line

7.7 Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	55 %
ATM Pressure:	1010 hPa

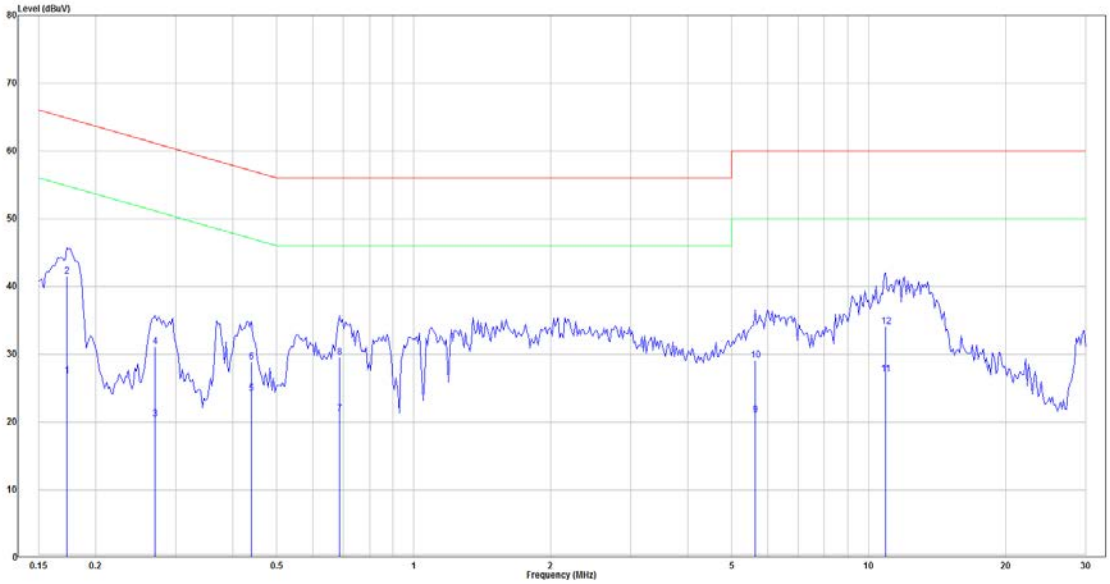
The testing was performed by Tom Hsu on 2018-06-04.

7.8 Test Results: PASS

7.9 Test Data

Test Mode: Transmitting

AC120 V, 60 Hz, Line



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.173	7.29	19.50	26.79	54.81	-28.02	Average
2	0.173	21.96	19.50	41.46	64.81	-23.35	QP
3	0.270	0.97	19.50	20.47	51.10	-30.63	Average
4	0.270	11.60	19.50	31.10	61.10	-30.00	QP
5	0.440	4.71	19.51	24.22	47.07	-22.85	Average
6	0.440	9.36	19.51	28.87	57.07	-28.20	QP
7	0.687	1.74	19.52	21.26	46.00	-24.74	Average
8	0.687	10.08	19.52	29.60	56.00	-26.40	QP
9	5.630	1.35	19.69	21.04	50.00	-28.96	Average
10	5.630	9.43	19.69	29.12	60.00	-30.88	QP
11	10.906	7.27	19.77	27.04	50.00	-22.96	Average
12	10.906	14.38	19.77	34.15	60.00	-25.85	QP

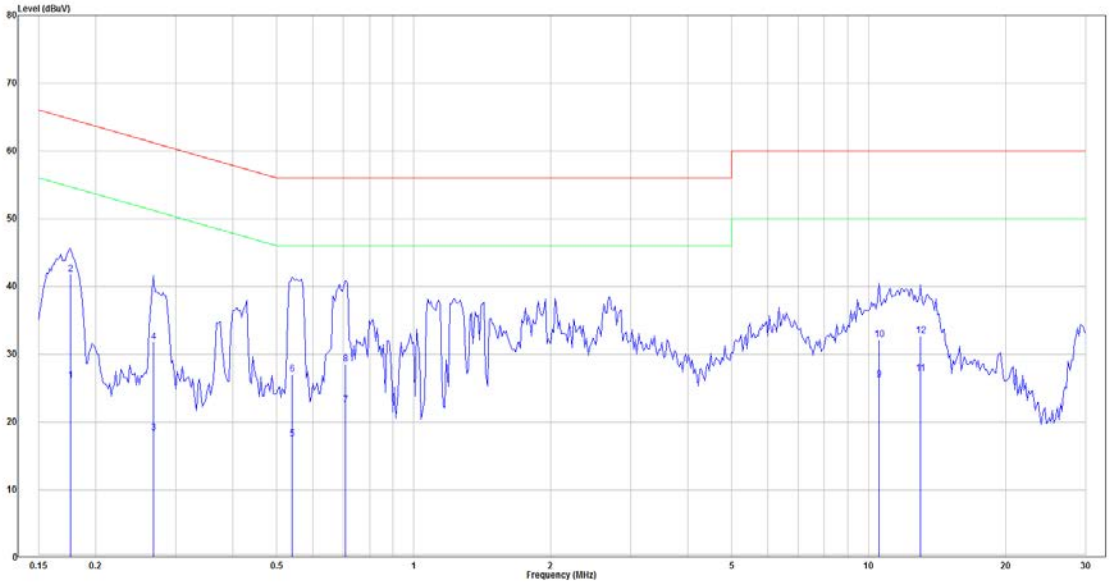
Note:

Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

AC120 V, 60 Hz, Neutral



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.176	6.51	19.63	26.14	54.68	-28.54	Average
2	0.176	22.19	19.63	41.82	64.68	-22.86	QP
3	0.268	-1.23	19.63	18.40	51.17	-32.77	Average
4	0.268	12.20	19.63	31.84	61.17	-29.33	QP
5	0.541	-2.10	19.65	17.55	46.00	-28.45	Average
6	0.541	7.44	19.65	27.09	56.00	-28.91	QP
7	0.709	2.84	19.66	22.50	46.00	-23.50	Average
8	0.709	8.86	19.66	28.52	56.00	-27.48	QP
9	10.564	6.38	19.92	26.30	50.00	-23.70	Average
10	10.564	12.23	19.92	32.15	60.00	-27.85	QP
11	12.996	7.22	19.95	27.17	50.00	-22.83	Average
12	12.996	12.80	19.95	32.75	60.00	-27.25	QP

Note:

Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

8 FCC §15.209, §15.205 , §15.247(d) – Spurious Emissions

8.1 Applicable Standard

As per FCC §15.35(d): Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz.

As Per FCC §15.205(a) except as show in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 – 0.110	16.42 – 16.423	960 – 1240	4. 5 – 5. 15
0.495 – 0.505	16.69475 – 16.69525	1300 – 1427	5. 35 – 5. 46
2.1735 – 2.1905	25.5 – 25.67	1435 – 1626.5	7.25 – 7.75
4.125 – 4.128	37.5 – 38.25	1645.5 – 1646.5	8.025 – 8.5
4.17725 – 4.17775	73 – 74.6	1660 – 1710	9.0 – 9.2
4.20725 – 4.20775	74.8 – 75.2	1718.8 – 1722.2	9.3 – 9.5
6.215 – 6.218	108 – 121.94	2200 – 2300	10.6 – 12.7
6.26775 – 6.26825	123 – 138	2310 – 2390	13.25 – 13.4
6.31175 – 6.31225	149.9 – 150.05	2483.5 – 2500	14.47 – 14.5
8.291 – 8.294	156.52475 – 156.52525	2690 – 2900	15.35 – 16.2
8.362 – 8.366	156.7 – 156.9	3260 – 3267	17.7 – 21.4
8.37625 – 8.38675	162.0125 –167.17	3.332 – 3.339	22.01 – 23.12
8.41425 – 8.41475	167.72 – 173.2	3 3458 – 3 358	23.6 – 24.0
12.29 – 12.293	240 – 285	3.600 – 4.400	31.2 – 31.8
12.51975 – 12.52025	322 – 335.4		36.43 – 36.5
12.57675 – 12.57725	399.9 – 410		Above 38.6
13.36 – 13.41	608 – 614		

As per FCC §15.209(a): Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength (micro volts/meter)	Measurement Distance (meters)
0.009 - 0.490	2400/F(kHz)	300
0.490 - 1.705	24000/F(kHz)	30
1.705 - 30.0	30	30
30 - 88	100**	3
88 - 216	150**	3
216 - 960	200**	3
Above 960	500	3

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

As per FCC §15.247 (d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c).

8.2 Measurement Uncertainty

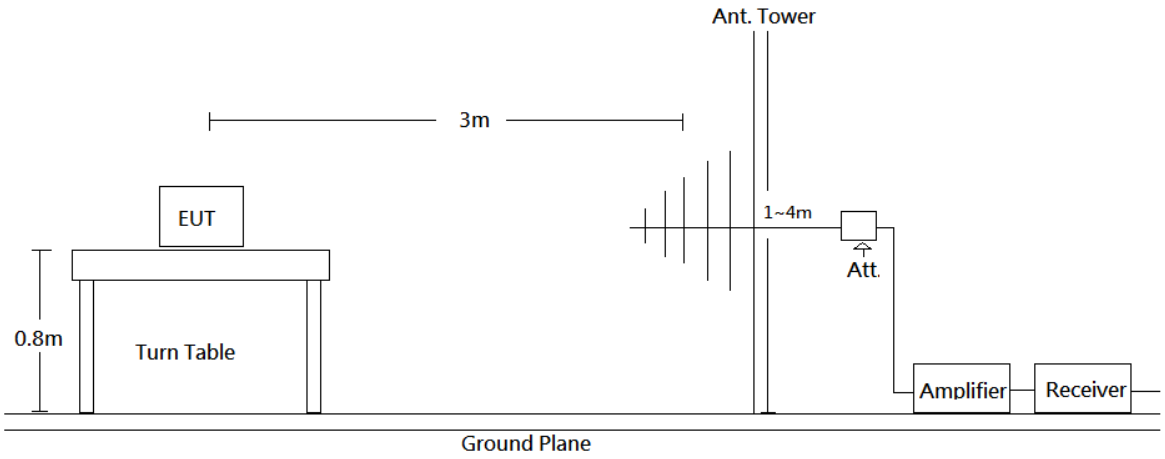
All measurements involve certain levels of uncertainties, especially in field of EMC. The factors contributing to uncertainties are spectrum analyzer, cable loss, antenna factor calibration, antenna directivity, antenna factor variation with height, antenna phase center variation, antenna factor frequency interpolation, measurement distance variation, site imperfections, mismatch (average), and system repeatability.

Based on CISPR 16-4-2:2011, the expended combined standard uncertainty of radiation emissions at Bay Area Compliance Laboratories Corp. (Taiwan) is shown in below table. And the uncertainty will not be taken into consideration for the test data recorded in the report.

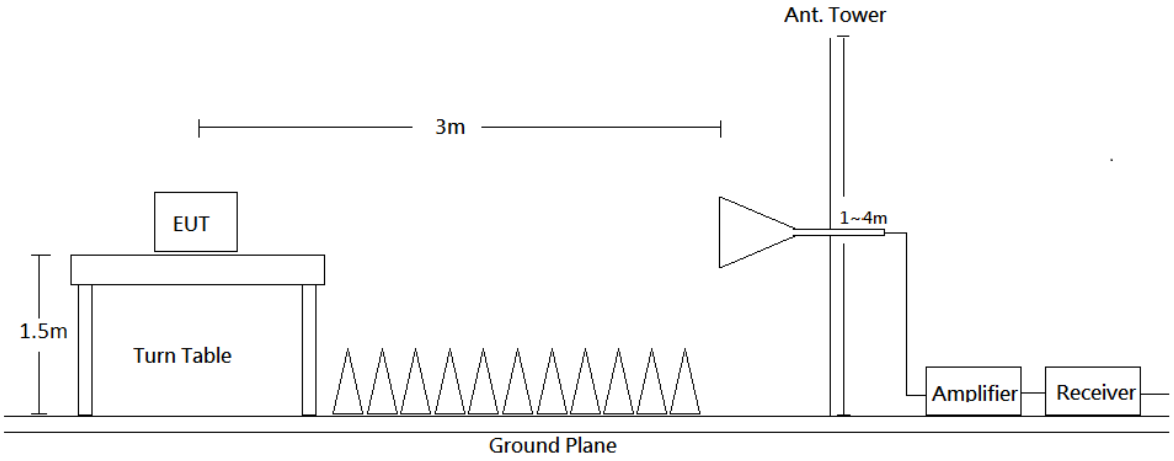
Frequency	Measurement uncertainty
30 MHz~200 MHz	4.21 dB (k=2, 95% level of confidence)
200 MHz~1 GHz	4.41 dB (k=2, 95% level of confidence)
1 GHz~6 GHz	4.51 dB (k=2, 95% level of confidence)
6 GHz~18 GHz	4.88 dB (k=2, 95% level of confidence)
18 GHz~26 GHz	4.30 dB (k=2, 95% level of confidence)
26 GHz~40 GHz	4.30 dB (k=2, 95% level of confidence)

8.3 EUT Setup

Blow 1 GHz:



Above 1 GHz:



Radiated emission tests were performed in the 3 meters chamber test site, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC Part 15.209 and FCC 15.247 Limits.

8.4 EMI Test Receiver & Spectrum Analyzer Setup

The system was investigated from 30 MHz to 26.5 GHz. During the radiated emission test, the EMI test receiver was set with the following configurations measurement method 6.3 in ANSI C63.10.

Frequency Range	RBW	VBW	Measurement method
30-1000 MHz	120 kHz	/	QP
Above 1 GHz	1 MHz	3 MHz	PK
	1 MHz	10 Hz	Ave

8.5 Test Procedure

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

All data was recorded in the Quasi-peak detector mode from 30 MHz to 1 GHz and PK and average detector modes for frequencies above 1 GHz.

8.6 Corrected Factor & Margin Calculation

The Correct Factor 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:

Correct Factor = 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 -7 dB means the emission is 7 dB below the limit. The equation for margin calculation is as follows:

Margin = Result –Limit

8.7 Test Results Summary

According to the data in the following table, the EUT complied with the FCC §15.209 Limit. Refer to CISPR16-4-2:2011 and CISPR 16-4-1:2009, the measured level complies with the limit if

$$Lm + U(Lm) \leq Llim + Ucispr$$

In BACL, U(Lm) is less than Ucispr, if Lm is less than Llim, it implies that the EUT complies with the limit.

8.8 Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	55 %
ATM Pressure:	1010 hPa

The Radiation Spurious Emissions testing was performed by Tom Hsu on 2018-05-31.

The Conducted Spurious Emissions testing was performed by Tom Hsu on 2018-06-01.

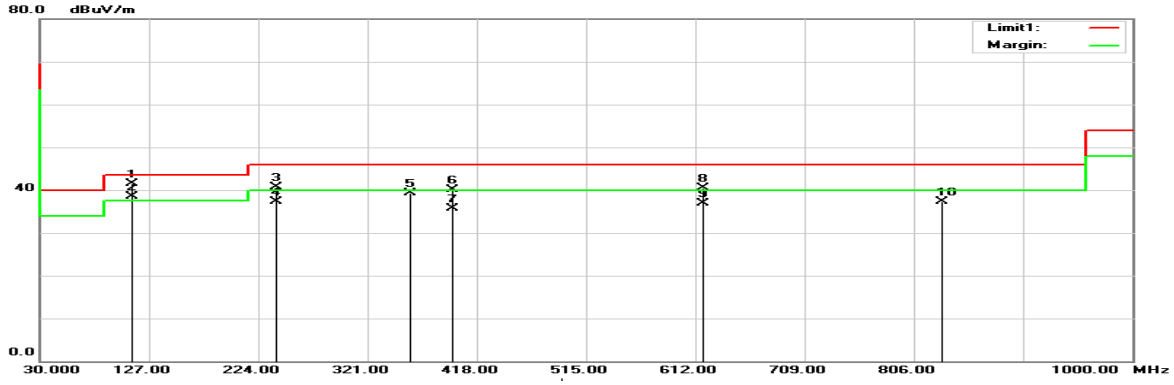
8.9 Test Results: PASS

8.10 Test Data

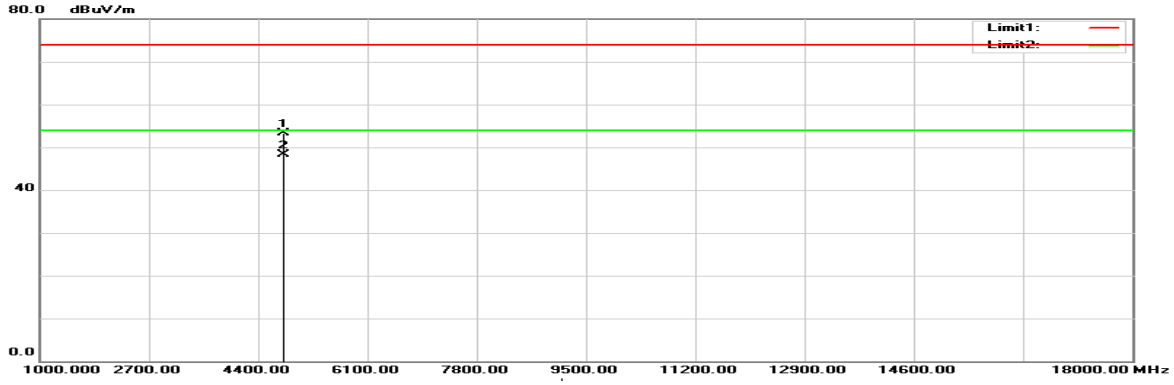
BR (GFSK) Mode

Horizontal (*worst case is BR (GFSK) mode low channel*)

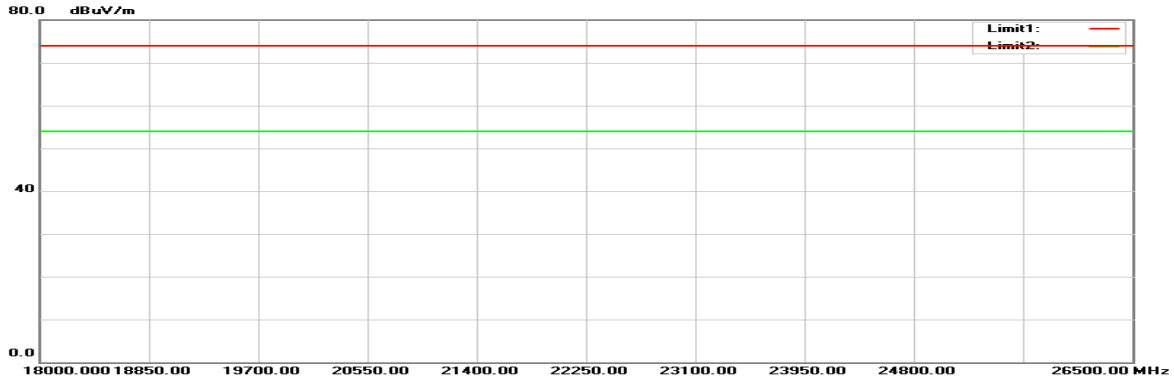
30MHz-1GHz:



1GHz-18GHz:

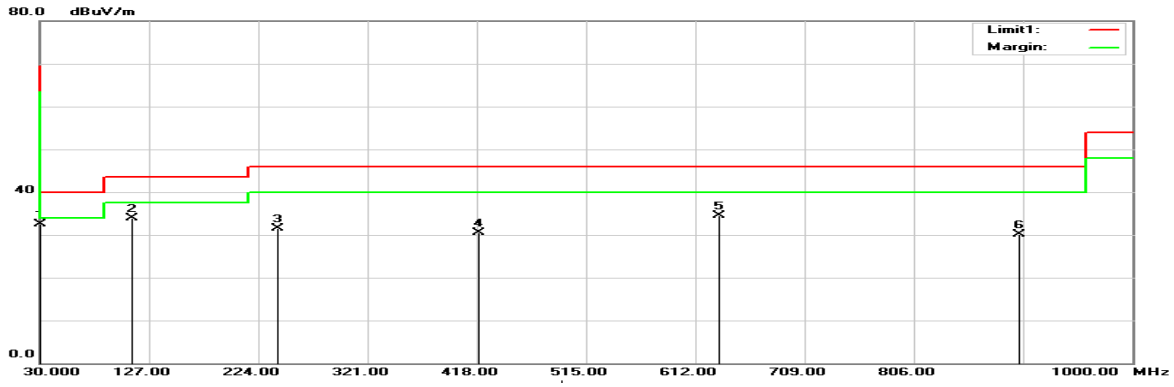


18GHz-26.5GHz:

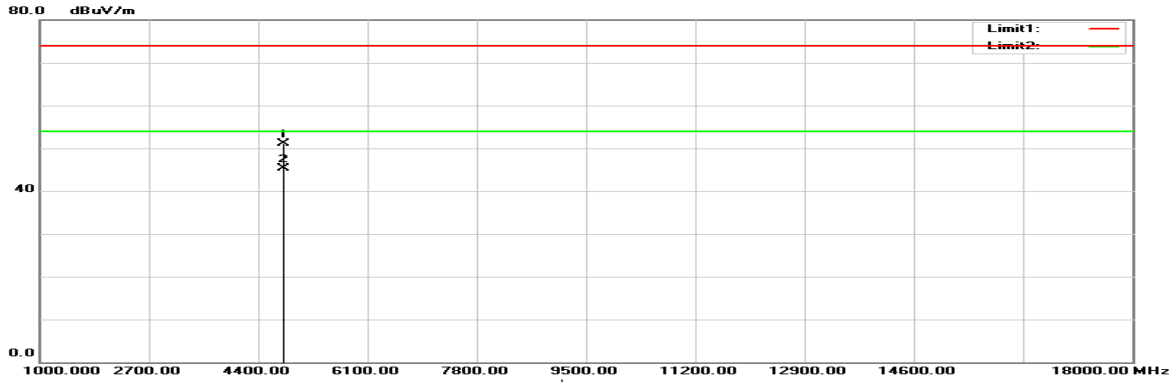


Vertical (*worst case is BR (GFSK) mode low channel*)

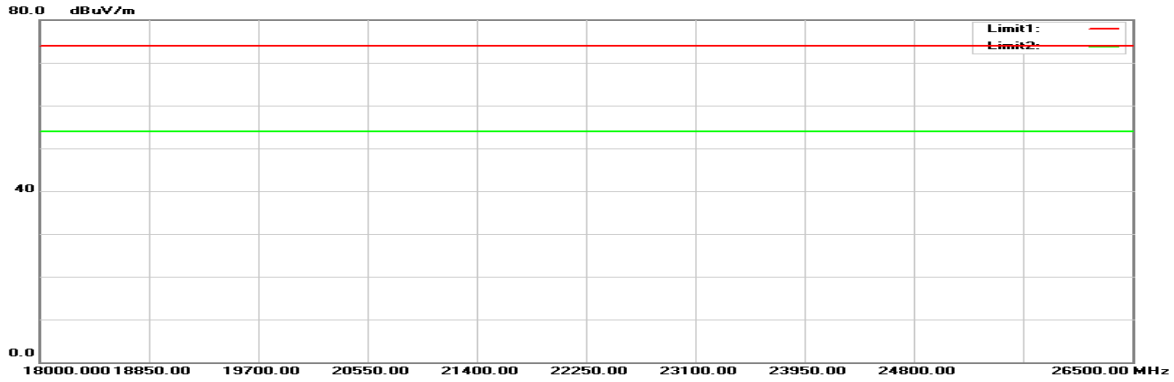
30MHz-1GHz:



1GHz-18GHz:



18GHz-26.5GHz:



Horizontal

Frequency (MHz)	Reading (dBμV)	Correct Factor(dB/m)	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
BR (GFSK), Low channel								
112.4500	52.87	-11.45	41.42	43.50	-2.08	100	4	QP
240.4900	52.76	-12.04	40.72	46.00	-5.28	100	3	QP
358.8300	47.70	-8.43	39.27	46.00	-6.73	100	92	QP
396.6600	47.81	-7.65	40.16	46.00	-5.84	100	95	QP
618.7900	44.44	-3.90	40.54	46.00	-5.46	100	53	QP
831.2200	37.51	-0.11	37.40	46.00	-8.60	100	199	QP
2390.000	63.90	-4.81	59.09	74.00	-14.91	200	336	peak
2390.000	49.37	-4.81	44.56	54.00	-9.44	200	336	AVG
2401.865	95.38	-4.78	90.60	N/A	N/A	115	335	peak
2401.865	95.28	-4.78	90.50	N/A	N/A	115	335	AVG
4804.000	52.06	1.16	53.22	74.00	-20.78	235	175	peak
4804.000	47.10	1.16	48.26	54.00	-5.74	235	175	AVG
BR (GFSK), Middle channel								
112.4500	52.67	-11.45	41.22	43.50	-2.28	100	1	QP
240.4900	52.98	-12.04	40.94	46.00	-5.06	100	134	QP
395.6900	47.52	-7.67	39.85	46.00	-6.15	100	290	QP
636.2500	45.51	-3.65	41.86	46.00	-4.14	100	56	QP
831.2200	38.05	-0.11	37.94	46.00	-8.06	100	195	QP
918.5200	34.17	1.57	35.74	46.00	-10.26	100	309	QP
2441.000	96.47	-4.67	91.80	N/A	N/A	175	336	peak
2441.000	95.91	-4.67	91.24	N/A	N/A	175	336	AVG
4882.000	51.80	1.43	53.23	74.00	-20.77	120	185	peak
4882.000	46.93	1.43	48.36	54.00	-5.64	120	185	AVG
BR (GFSK), High channel								
112.4500	52.53	-11.45	41.08	43.50	-2.42	100	3	QP
241.4600	53.59	-12.02	41.57	46.00	-4.43	100	125	QP
395.6900	48.42	-7.67	40.75	46.00	-5.25	100	299	QP
619.7600	44.06	-3.89	40.17	46.00	-5.83	100	52	QP
774.9600	37.70	-1.35	36.35	46.00	-9.65	100	200	QP
834.1300	36.69	-0.06	36.63	46.00	-9.37	100	195	QP
2480.000	97.04	-4.57	92.47	N/A	N/A	200	187	peak
2480.000	96.49	-4.57	91.92	N/A	N/A	200	187	AVG
2483.500	63.81	-4.57	59.24	74.00	-14.76	200	358	peak
2483.500	50.11	-4.57	45.54	54.00	-8.46	200	358	AVG
4960.000	50.72	1.69	52.41	74.00	-21.59	270	182	peak
4960.000	44.85	1.69	46.54	54.00	-7.46	270	182	AVG

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Vertical

Frequency (MHz)	Reading (dBμV)	Correct Factor(dB/m)	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
BR (GFSK), Low channel								
30.9700	36.44	-3.93	32.51	40.00	-7.49	100	330	QP
112.4500	45.29	-11.45	33.84	43.50	-9.66	100	73	QP
241.4600	43.55	-12.02	31.53	46.00	-14.47	100	70	QP
419.9400	37.70	-7.18	30.52	46.00	-15.48	100	1	QP
633.3400	38.29	-3.70	34.59	46.00	-11.41	100	80	QP
900.0900	29.07	1.03	30.10	46.00	-15.90	100	34	QP
2390.000	63.27	-4.81	58.46	74.00	-15.54	250	56	peak
2390.000	50.47	-4.81	45.66	54.00	-8.34	250	56	AVG
2402.000	88.96	-4.78	84.18	N/A	N/A	250	124	peak
2402.000	88.15	-4.78	83.37	N/A	N/A	250	124	AVG
4804.000	49.88	1.16	51.04	74.00	-22.96	308	118	peak
4804.000	44.05	1.16	45.21	54.00	-8.79	308	118	AVG
BR (GFSK), Middle channel								
30.9700	32.98	-3.93	29.05	40.00	-10.95	100	221	QP
112.4500	45.47	-11.45	34.02	43.50	-9.48	100	94	QP
240.4900	43.13	-12.04	31.09	46.00	-14.91	100	82	QP
493.6600	35.89	-5.75	30.14	46.00	-15.86	100	41	QP
631.4000	38.85	-3.72	35.13	46.00	-10.87	100	89	QP
746.8300	38.31	-2.15	36.16	46.00	-9.84	100	165	QP
2441.000	90.99	-4.67	86.32	N/A	N/A	323	154	peak
2441.000	90.34	-4.67	85.67	N/A	N/A	323	154	AVG
4882.000	49.54	1.43	50.97	74.00	-23.03	260	113	peak
4882.000	43.58	1.43	45.01	54.00	-8.99	260	113	AVG
BR (GFSK), High channel								
30.9700	36.08	-3.93	32.15	40.00	-7.85	100	52	QP
112.4500	44.75	-11.45	33.30	43.50	-10.20	100	65	QP
241.4600	42.77	-12.02	30.75	46.00	-15.25	100	16	QP
395.6900	38.29	-7.67	30.62	46.00	-15.38	100	258	QP
630.4300	38.67	-3.74	34.93	46.00	-11.07	100	63	QP
730.3400	37.31	-2.36	34.95	46.00	-11.05	100	196	QP
2480.000	90.90	-4.57	86.33	N/A	N/A	351	268	peak
2480.000	90.21	-4.57	85.64	N/A	N/A	351	268	AVG
2483.500	63.25	-4.57	58.68	74.00	-15.32	300	297	peak
2483.500	50.08	-4.57	45.51	54.00	-8.49	300	297	AVG
4960.000	47.96	1.69	49.65	74.00	-24.35	307	122	peak
4960.000	40.02	1.69	41.71	54.00	-12.29	307	122	AVG

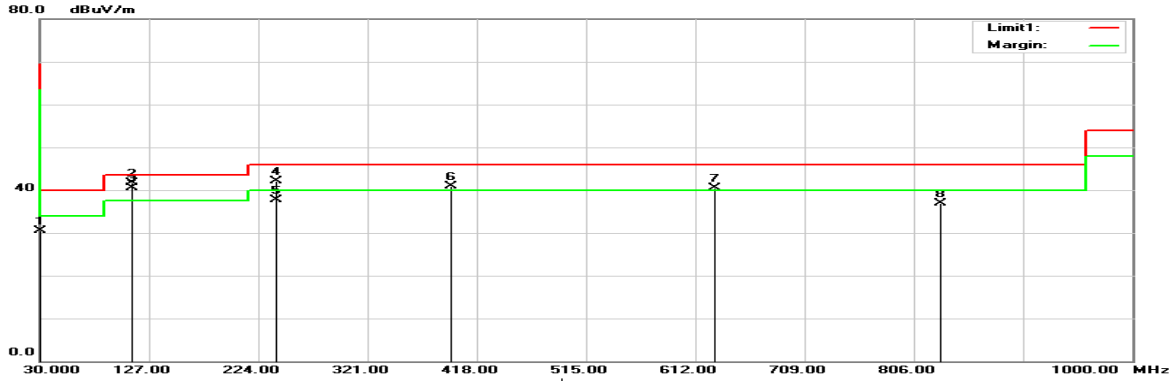
Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain

Spurious emissions more than 20 dB below the limit were not reported.

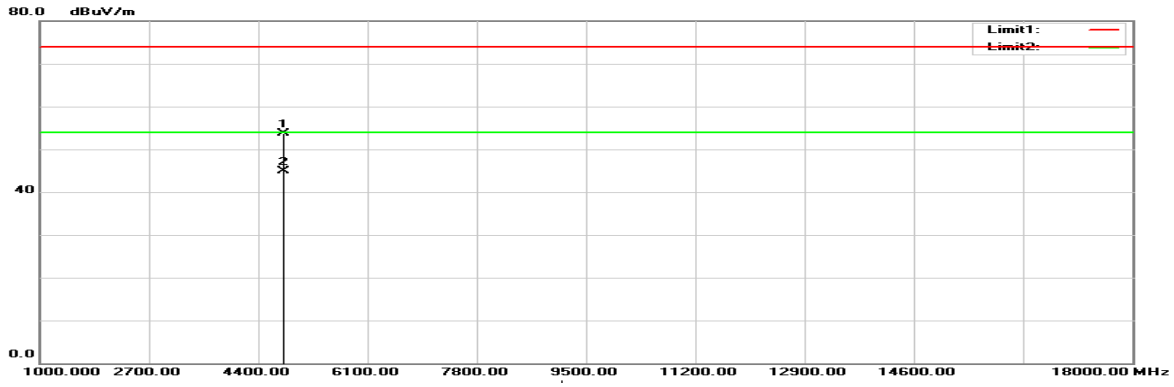
EDR (π/4-DQPSK) Mode

Horizontal (*worst case is EDR (π/4-DQPSK) mode low channel*)

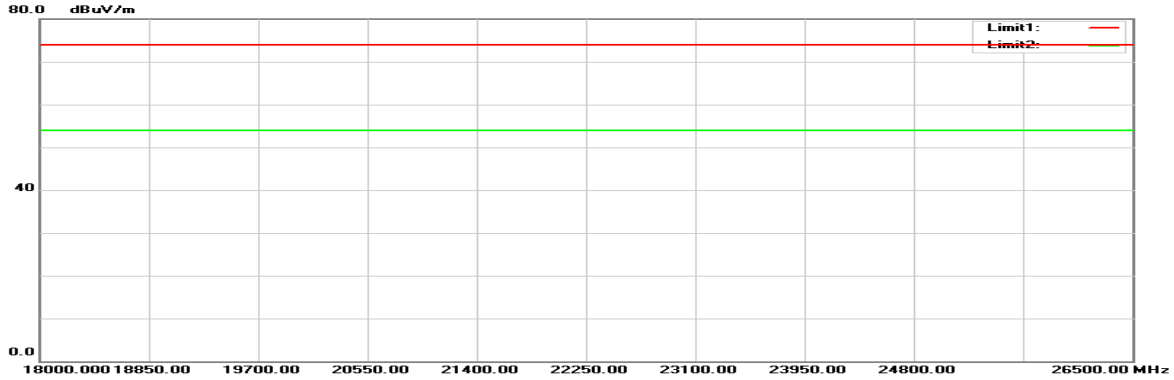
30MHz-1GHz:



1GHz-18GHz:

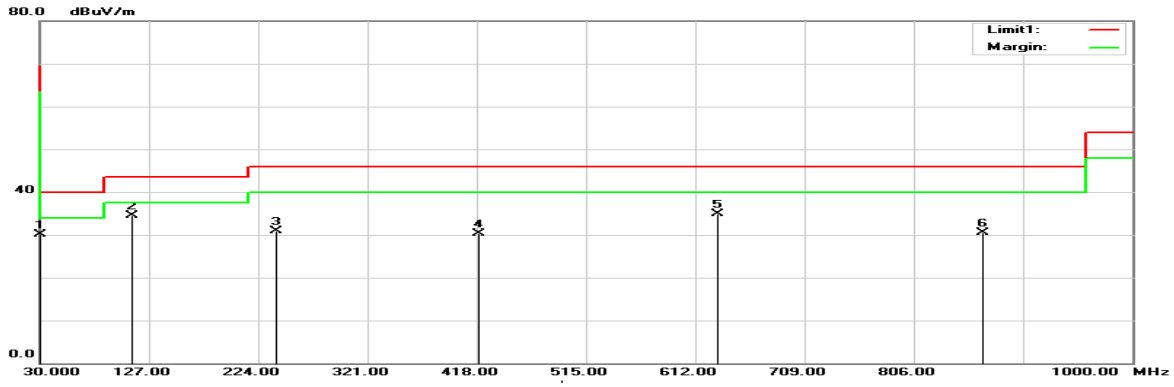


18GHz-26.5GHz:

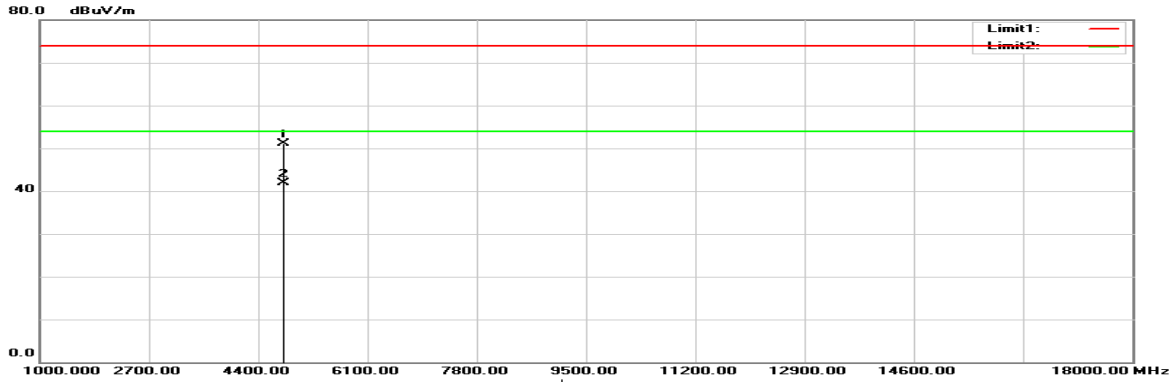


Vertical (*worst case is EDR (π/4-DQPSK) mode low channel*)

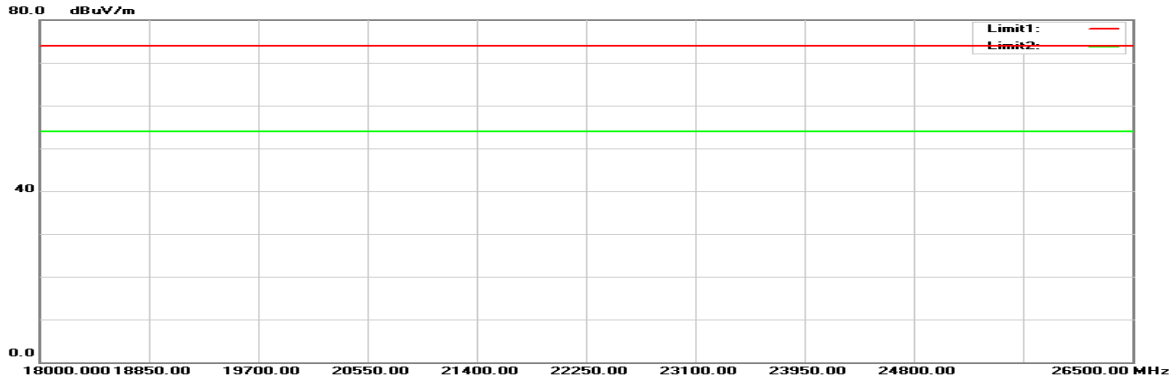
30MHz-1GHz:



1GHz-18GHz:



18GHz-26.5GHz:



Horizontal

Frequency (MHz)	Reading (dBμV)	Correct Factor(dB/m)	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
(π/4-DQPSK), Low channel								
30.9700	34.39	-3.93	30.46	40.00	-9.54	100	235	QP
112.4500	53.22	-11.45	41.77	43.50	-1.73	100	354	QP
240.4900	54.22	-12.04	42.18	46.00	-3.82	100	3	QP
394.7200	48.55	-7.70	40.85	46.00	-5.15	100	108	QP
629.4600	44.30	-3.76	40.54	46.00	-5.46	100	64	QP
830.2500	36.94	-0.12	36.82	46.00	-9.18	100	195	QP
2390.000	63.99	-4.81	59.18	74.00	-14.82	200	347	peak
2390.000	50.01	-4.81	45.20	54.00	-8.80	200	347	AVG
2402.000	96.12	-4.78	91.34	N/A	N/A	172	335	peak
2402.000	92.53	-4.78	87.75	N/A	N/A	172	335	AVG
4804.000	52.62	1.16	53.78	74.00	-20.22	200	175	peak
4804.000	43.69	1.16	44.85	54.00	-9.15	200	175	AVG
(π/4-DQPSK), Middle channel								
30.0000	33.88	-3.26	30.62	40.00	-9.38	100	298	QP
112.4500	51.95	-11.45	40.50	43.50	-3.00	100	10	QP
221.0900	51.14	-12.38	38.76	46.00	-7.24	100	360	QP
240.4900	53.87	-12.04	41.83	46.00	-4.17	100	141	QP
394.7200	47.77	-7.70	40.07	46.00	-5.93	100	303	QP
630.4300	44.11	-3.74	40.37	46.00	-5.63	100	46	QP
2441.000	97.29	-4.67	92.62	N/A	N/A	175	355	peak
2441.000	93.70	-4.67	89.03	N/A	N/A	175	355	AVG
4882.000	52.05	1.43	53.48	74.00	-20.52	290	182	peak
4882.000	43.34	1.43	44.77	54.00	-9.23	290	182	AVG
(π/4-DQPSK), High channel								
30.0000	34.79	-3.26	31.53	40.00	-8.47	100	249	QP
112.4500	52.22	-11.45	40.77	43.50	-2.73	100	360	QP
220.1200	52.53	-12.38	40.15	46.00	-5.85	100	358	QP
241.4600	54.15	-12.02	42.13	46.00	-3.87	100	360	QP
395.6900	48.05	-7.67	40.38	46.00	-5.62	100	103	QP
630.4300	44.17	-3.74	40.43	46.00	-5.57	100	47	QP
2480.000	97.65	-4.57	93.08	N/A	N/A	169	358	peak
2480.000	94.06	-4.57	89.49	N/A	N/A	169	358	AVG
2483.500	63.84	-4.57	59.27	74.00	-14.73	200	355	peak
2483.500	50.17	-4.57	45.60	54.00	-8.40	200	355	AVG
4960.000	50.64	1.69	52.33	74.00	-21.67	275	180	peak
4960.000	42.09	1.69	43.78	54.00	-10.22	275	180	AVG

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Vertical

Frequency (MHz)	Reading (dBμV)	Correct Factor(dB/m)	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
(π/4-DQPSK), Low channel								
30.9700	34.06	-3.93	30.13	40.00	-9.87	100	48	QP
112.4500	46.01	-11.45	34.56	43.50	-8.94	100	81	QP
240.4900	42.87	-12.04	30.83	46.00	-15.17	100	65	QP
419.9400	37.49	-7.18	30.31	46.00	-15.69	100	32	QP
631.4000	38.60	-3.72	34.88	46.00	-11.12	100	75	QP
867.1100	29.99	0.47	30.46	46.00	-15.54	100	71	QP
2390.000	63.47	-4.81	58.66	74.00	-15.34	300	180	peak
2390.000	49.97	-4.81	45.16	54.00	-8.84	300	180	AVG
2402.000	90.82	-4.78	86.04	N/A	N/A	337	275	peak
2402.000	87.14	-4.78	82.36	N/A	N/A	337	275	AVG
4804.000	50.01	1.16	51.17	74.00	-22.83	320	119	peak
4804.000	40.83	1.16	41.99	54.00	-12.01	320	119	AVG
(π/4-DQPSK), Middle channel								
30.9700	35.40	-3.93	31.47	40.00	-8.53	100	261	QP
112.4500	47.18	-11.45	35.73	43.50	-7.77	100	110	QP
240.4900	42.60	-12.04	30.56	46.00	-15.44	100	75	QP
394.7200	37.28	-7.70	29.58	46.00	-16.42	100	37	QP
610.0600	39.36	-4.04	35.32	46.00	-10.68	100	82	QP
729.3700	34.09	-2.37	31.72	46.00	-14.28	100	317	QP
2441.000	92.87	-4.67	88.20	N/A	N/A	304	173	peak
2441.000	89.25	-4.67	84.58	N/A	N/A	304	173	AVG
4882.000	49.04	1.43	50.47	74.00	-23.53	330	117	peak
4882.000	40.23	1.43	41.66	54.00	-12.34	330	117	AVG
(π/4-DQPSK), High channel								
31.9400	34.52	-4.60	29.92	40.00	-10.08	100	133	QP
112.4500	44.56	-11.45	33.11	43.50	-10.39	100	77	QP
241.4600	41.94	-12.02	29.92	46.00	-16.08	100	95	QP
395.6900	38.58	-7.67	30.91	46.00	-15.09	100	53	QP
471.3500	35.86	-6.18	29.68	46.00	-16.32	100	53	QP
637.2200	39.37	-3.64	35.73	46.00	-10.27	100	88	QP
2480.000	93.48	-4.57	88.91	N/A	N/A	350	170	peak
2480.000	89.84	-4.57	85.27	N/A	N/A	350	170	AVG
2483.500	64.49	-4.57	59.92	74.00	-14.08	300	178	peak
2483.500	50.11	-4.57	45.54	54.00	-8.46	300	178	AVG
4960.000	49.08	1.69	50.77	74.00	-23.23	265	121	peak
4960.000	40.32	1.69	42.01	54.00	-11.99	265	121	AVG

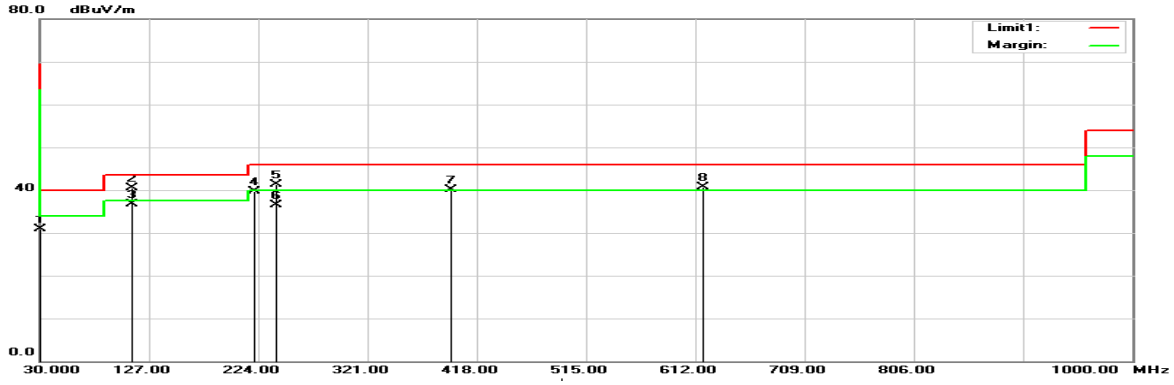
Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain

Spurious emissions more than 20 dB below the limit were not reported.

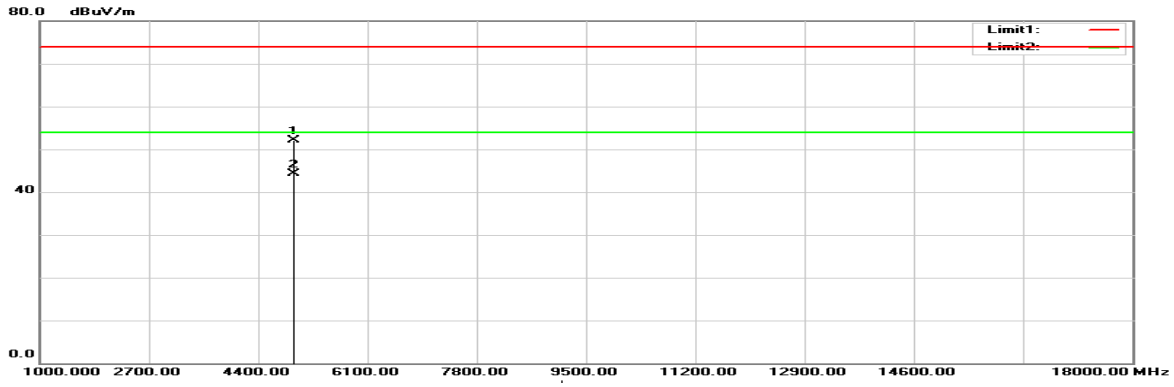
EDR (8DPSK) Mode

Horizontal (*worst case is EDR (8-DQPSK) mode High channel*)

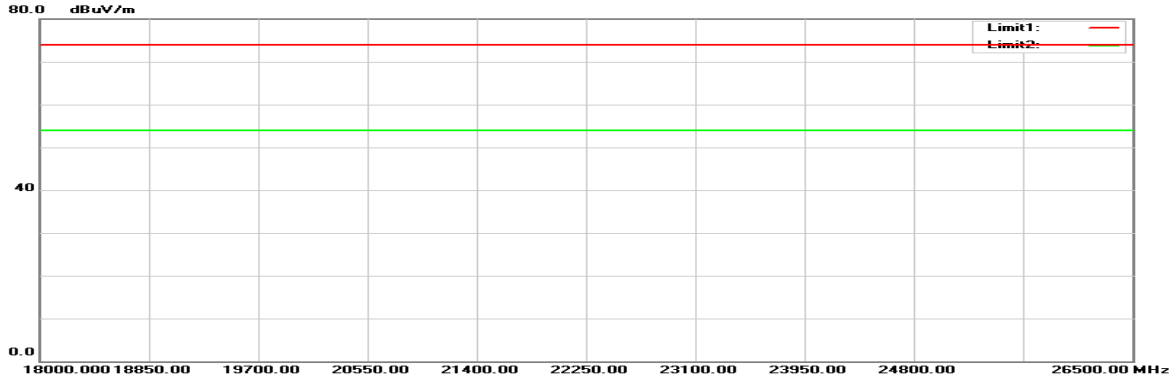
30MHz-1GHz:



1GHz-18GHz:

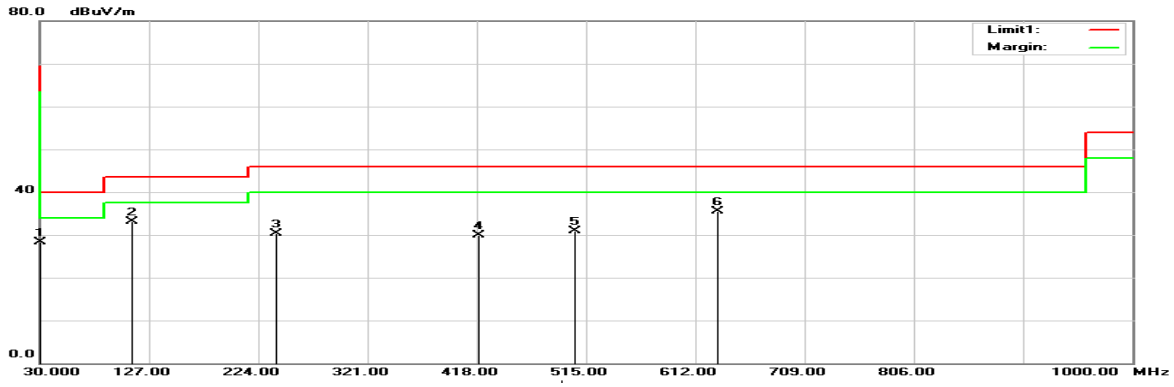


18GHz-26.5GHz:

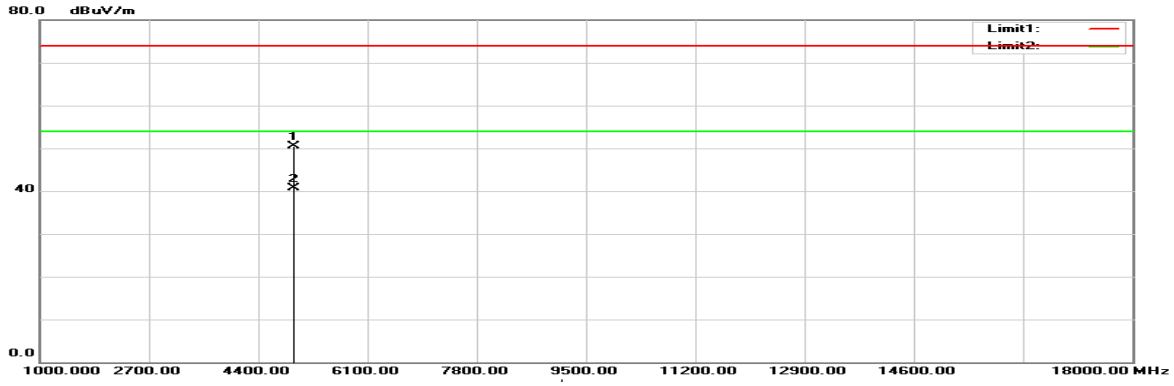


Vertical (*worst case is EDR (8-DQPSK) mode High channel*)

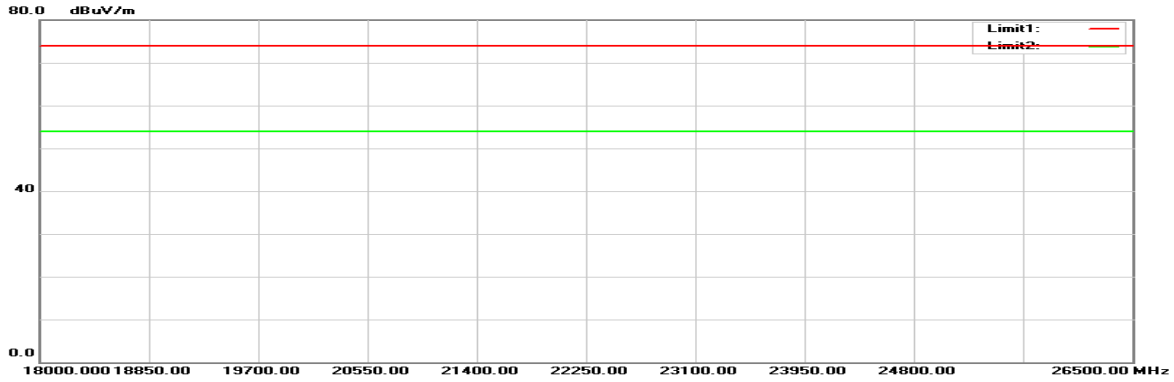
30MHz-1GHz:



1GHz-18GHz:



18GHz-26.5GHz:



Horizontal

Frequency (MHz)	Reading (dBμV)	Correct Factor(dB/m)	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
(8-DQPSK), Low channel								
30.9700	34.93	-3.93	31.00	40.00	-9.00	100	321	QP
112.4500	51.64	-11.45	40.19	43.50	-3.31	100	0	QP
221.0900	52.07	-12.38	39.69	46.00	-6.31	100	359	QP
240.4900	53.31	-12.04	41.27	46.00	-4.73	100	138	QP
395.6900	48.21	-7.67	40.54	46.00	-5.46	100	302	QP
630.4300	45.57	-3.74	41.83	46.00	-4.17	100	55	QP
2390.000	63.87	-4.81	59.06	74.00	-14.94	200	71	peak
2390.000	50.04	-4.81	45.23	54.00	-8.77	200	71	AVG
2402.000	94.36	-4.78	89.58	N/A	N/A	231	10	peak
2402.000	91.88	-4.78	87.10	N/A	N/A	231	10	AVG
4804.000	51.21	1.16	52.37	74.00	-21.63	155	136	peak
4804.000	42.36	1.16	43.52	54.00	-10.48	155	136	AVG
(8-DQPSK), Middle channel								
30.0000	33.11	-3.26	29.85	40.00	-10.15	100	264	QP
112.4500	51.56	-11.45	40.11	43.50	-3.39	100	3	QP
221.0900	50.96	-12.38	38.58	46.00	-7.42	100	14	QP
240.4900	53.66	-12.04	41.62	46.00	-4.38	100	14	QP
392.7800	47.72	-7.72	40.00	46.00	-6.00	100	101	QP
630.4300	44.65	-3.74	40.91	46.00	-5.09	100	55	QP
2441.000	95.77	-4.67	91.10	N/A	N/A	221	10	peak
2441.000	92.01	-4.67	87.34	N/A	N/A	221	10	AVG
4882.000	51.88	1.43	53.31	74.00	-20.69	175	181	peak
4882.000	43.39	1.43	44.82	54.00	-9.18	175	181	AVG
(8-DQPSK), High channel								
30.0000	34.20	-3.26	30.94	40.00	-9.06	100	22	QP
112.4500	51.88	-11.45	40.43	43.50	-3.07	100	158	QP
221.0900	52.07	-12.38	39.69	46.00	-6.31	100	150	QP
240.4900	53.42	-12.04	41.38	46.00	-4.62	100	130	QP
394.7200	47.78	-7.70	40.08	46.00	-5.92	100	303	QP
618.7900	44.52	-3.90	40.62	46.00	-5.38	100	55	QP
2480.000	97.75	-4.57	93.18	N/A	N/A	138	358	peak
2480.000	93.99	-4.57	89.42	N/A	N/A	138	358	AVG
2483.500	63.90	-4.57	59.33	74.00	-14.67	200	263	peak
2483.500	50.13	-4.57	45.56	54.00	-8.44	200	263	AVG
4960.000	50.38	1.69	52.07	74.00	-21.93	275	181	peak
4960.000	42.61	1.69	44.30	54.00	-9.70	275	181	AVG

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Vertical

Frequency (MHz)	Reading (dBμV)	Correct Factor(dB/m)	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
(8-DQPSK), Low channel								
30.9700	33.86	-3.93	29.93	40.00	-10.07	100	355	QP
112.4500	44.76	-11.45	33.31	43.50	-10.19	100	82	QP
240.4900	41.53	-12.04	29.49	46.00	-16.51	100	62	QP
420.9100	36.83	-7.16	29.67	46.00	-16.33	100	7	QP
507.2400	35.73	-5.54	30.19	46.00	-15.81	100	33	QP
632.3700	38.63	-3.71	34.92	46.00	-11.08	100	89	QP
2390.000	63.65	-4.81	58.84	74.00	-15.16	300	11	peak
2390.000	50.06	-4.81	45.25	54.00	-8.75	300	11	AVG
2402.000	90.65	-4.78	85.87	N/A	N/A	337	274	peak
2402.000	86.76	-4.78	81.98	N/A	N/A	337	274	AVG
4804.000	50.11	1.16	51.27	74.00	-22.73	287	115	peak
4804.000	41.35	1.16	42.51	54.00	-11.49	287	115	AVG
(8-DQPSK), Middle channel								
31.9400	33.55	-4.60	28.95	40.00	-11.05	100	346	QP
112.4500	45.05	-11.45	33.60	43.50	-9.90	100	93	QP
241.4600	42.67	-12.02	30.65	46.00	-15.35	100	66	QP
421.8800	36.80	-7.13	29.67	46.00	-16.33	100	15	QP
496.5700	35.26	-5.70	29.56	46.00	-16.44	100	35	QP
628.4900	40.63	-3.77	36.86	46.00	-9.14	100	69	QP
2441.000	93.01	-4.67	88.34	N/A	N/A	304	172	peak
2441.000	89.25	-4.67	84.58	N/A	N/A	304	172	AVG
4882.000	50.07	1.43	51.50	74.00	-22.50	315	118	peak
4882.000	41.83	1.43	43.26	54.00	-10.74	315	118	AVG
(8-DQPSK), High channel								
30.9700	32.17	-3.93	28.24	40.00	-11.76	100	304	QP
112.4500	44.61	-11.45	33.16	43.50	-10.34	100	79	QP
240.4900	42.31	-12.04	30.27	46.00	-15.73	100	104	QP
419.9400	37.04	-7.18	29.86	46.00	-16.14	100	15	QP
505.3000	36.41	-5.58	30.83	46.00	-15.17	100	23	QP
632.3700	39.19	-3.71	35.48	46.00	-10.52	100	89	QP
2480.000	93.66	-4.57	89.09	N/A	N/A	348	168	peak
2480.000	89.95	-4.57	85.38	N/A	N/A	348	168	AVG
2483.500	63.85	-4.57	59.28	74.00	-14.72	300	135	peak
2483.500	50.08	-4.57	45.51	54.00	-8.49	300	135	AVG
4960.000	48.76	1.69	50.45	74.00	-23.55	305	122	peak
4960.000	38.95	1.69	40.64	54.00	-13.36	305	122	AVG

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain

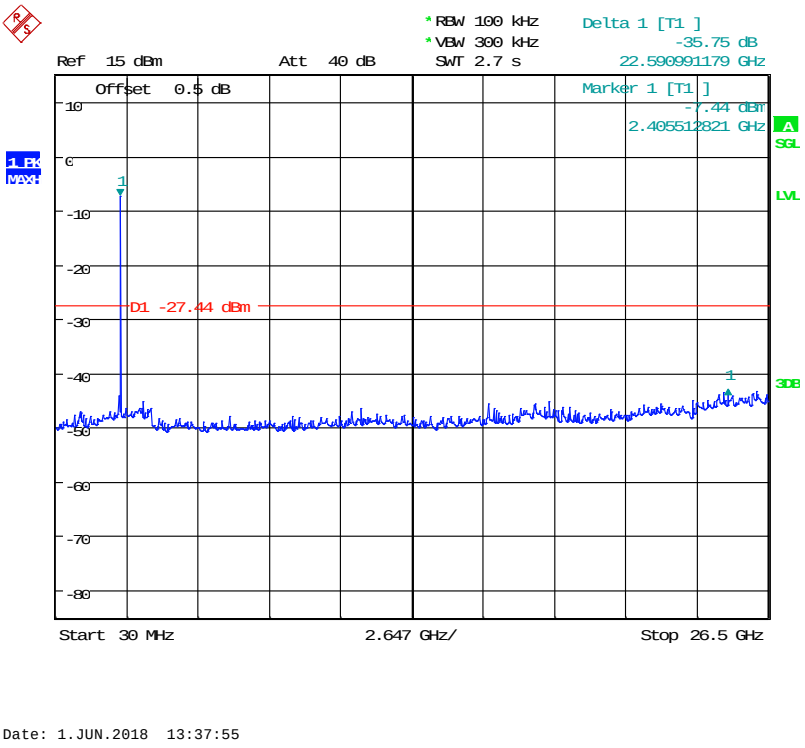
Spurious emissions more than 20 dB below the limit were not reported.

Conducted Spurious Emissions:

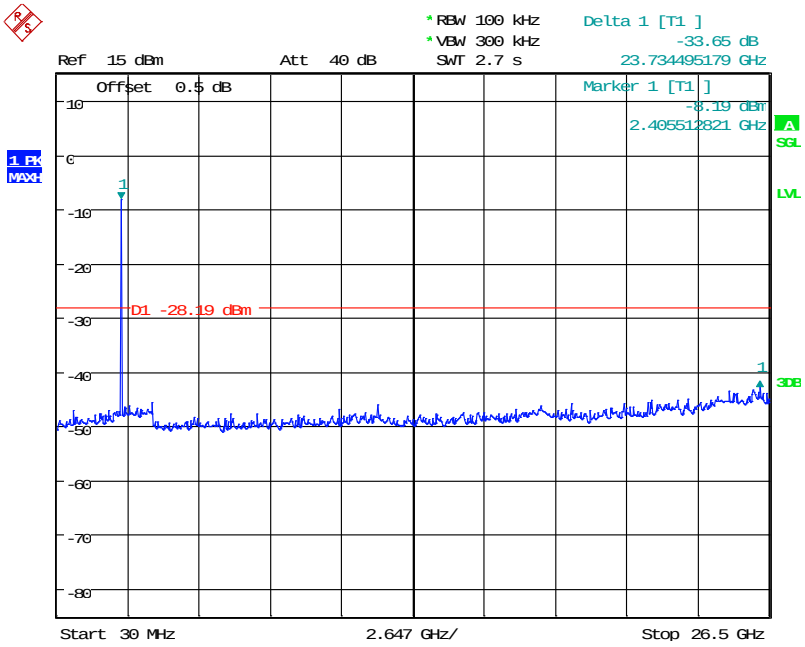
Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
BR Mode (GFSK)				
Low	2402	35.75	≥ 20	PASS
Mid	2441	33.65	≥ 20	PASS
High	2480	34.86	≥ 20	PASS
EDR Mode (π/4-DQPSK):				
Low	2402	32.38	≥ 20	PASS
Mid	2441	31.70	≥ 20	PASS
High	2480	32.09	≥ 20	PASS
EDR Mode (8DPSK):				
Low	2402	33.80	≥ 20	PASS
Mid	2441	30.08	≥ 20	PASS
High	2480	33.11	≥ 20	PASS

BR Mode (GFSK)

Low Channel

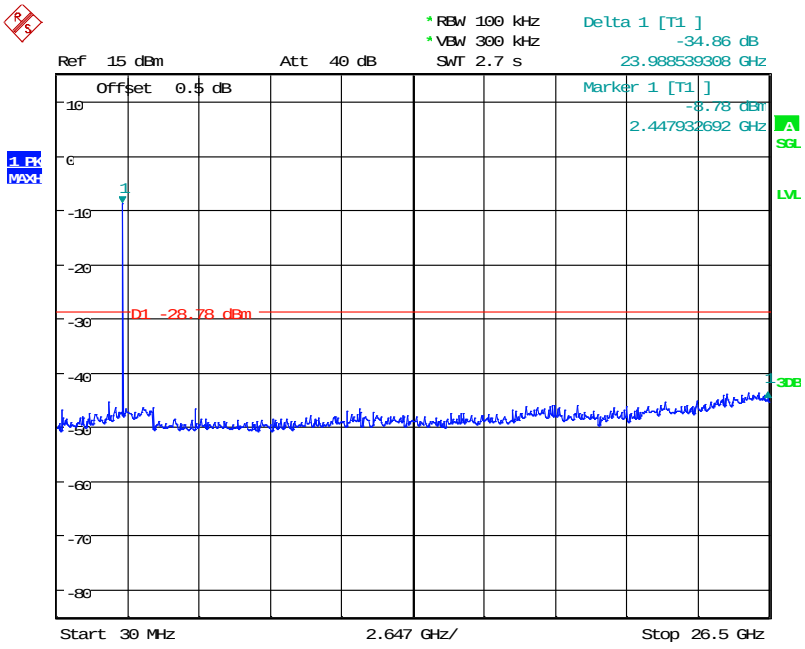


Middle Channel



Date: 1.JUN.2018 13:40:29

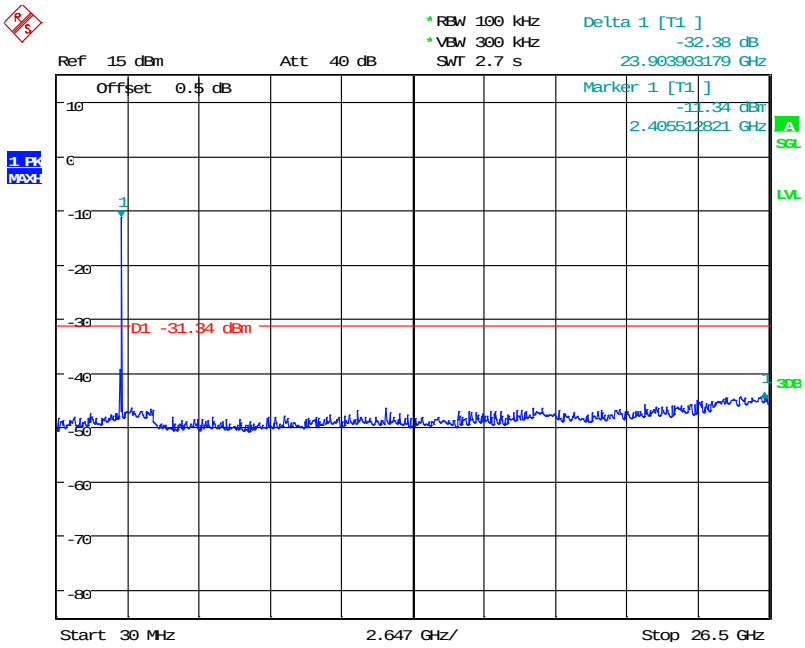
High Channel



Date: 1.JUN.2018 13:42:28

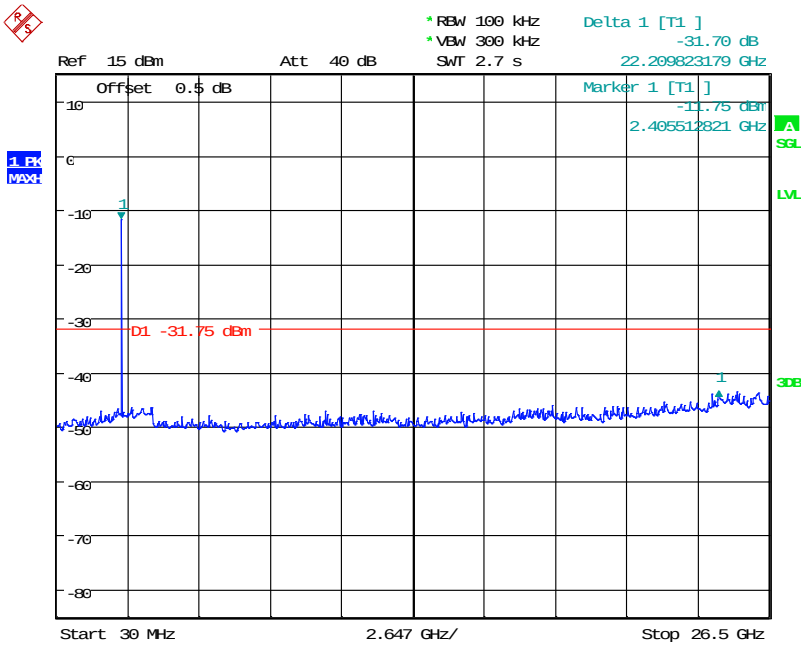
EDR Mode (π/4-DQPSK)

Low Channel



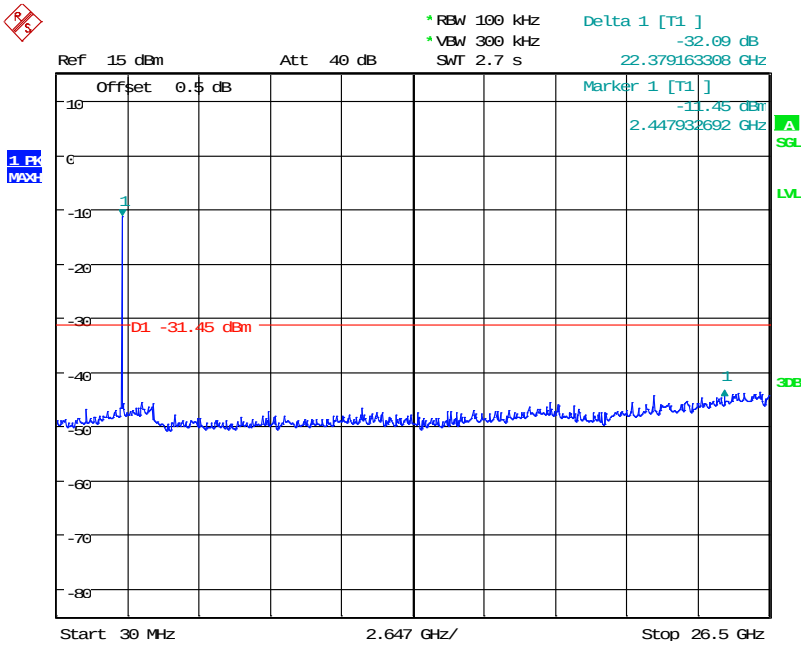
Date: 1.JUN.2018 13:51:37

Middle Channel



Date: 1.JUN.2018 13:54:08

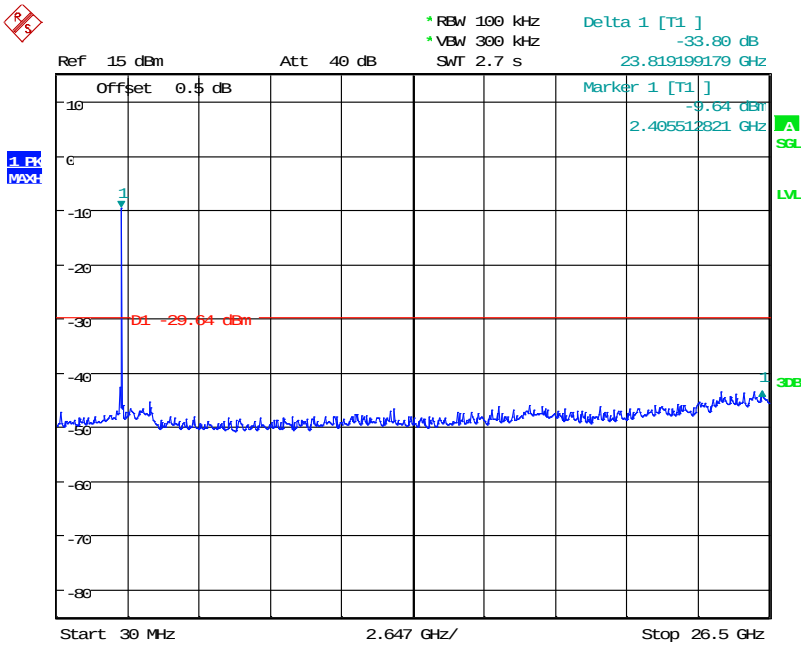
High Channel



Date: 1.JUN.2018 13:56:01

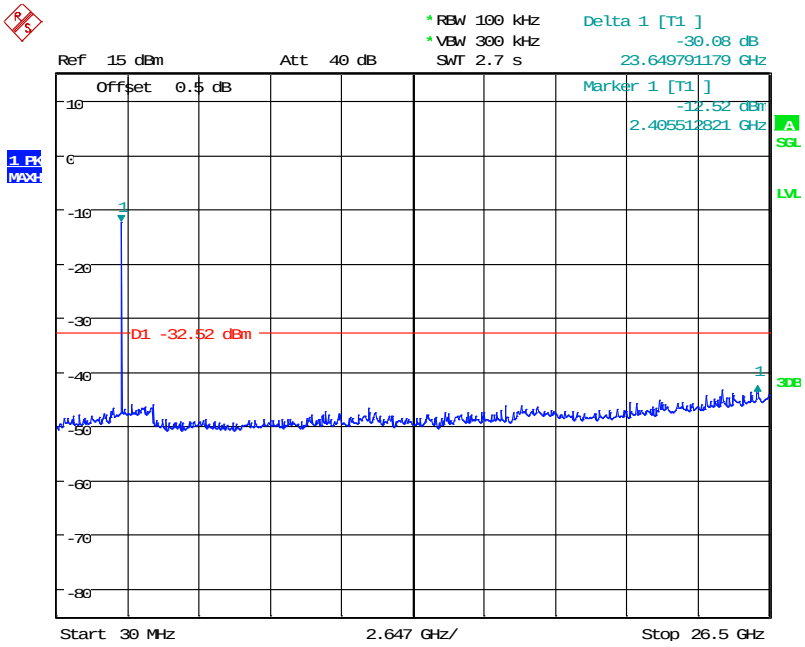
EDR Mode (8DPSK)

Low Channel



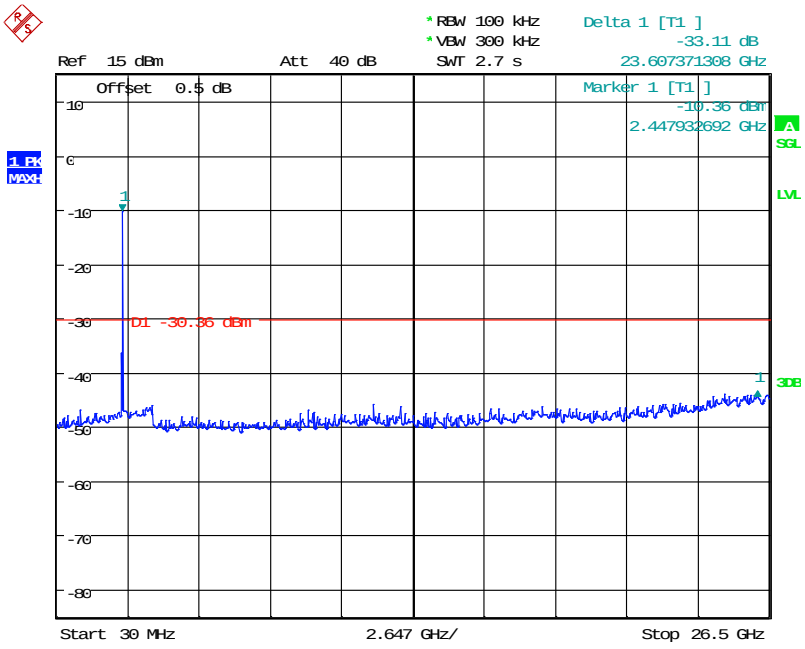
Date: 1.JUN.2018 14:03:37

Middle Channel



Date: 1.JUN.2018 14:06:13

High Channel



Date: 1.JUN.2018 14:08:12

9 FCC §15.247(a)(1) – 20 dB Emission Bandwidth

9.1 Applicable Standard

According to FCC §15.247(a) (1) the maximum 20 dB bandwidth of the hopping channel shall be presented.

9.2 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.

9.3 Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	55 %
ATM Pressure:	1010 hPa

The testing was performed by Tom Hsu on 2018-06-01 ~ 2018-06-19.

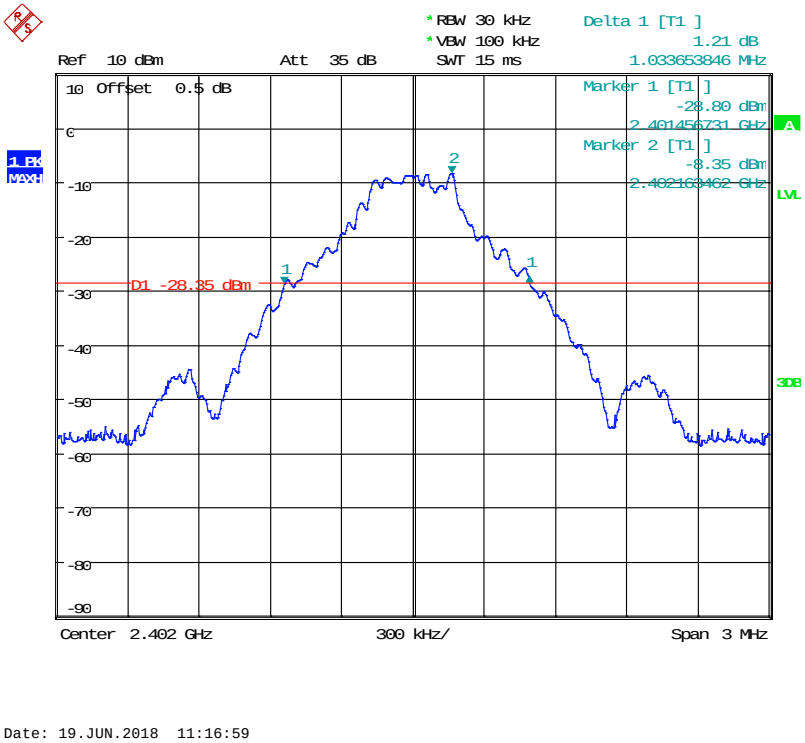
9.4 Test Results

Channel	Frequency (MHz)	20 dBc BW (MHz)
BR Mode (GFSK)		
Low	2402	1.03
Middle	2441	1.04
High	2480	1.02
EDR Mode (π/4-DQPSK)		
Low	2402	1.37
Middle	2441	1.37
High	2480	1.38
EDR Mode (8DPSK)		
Low	2402	1.30
Middle	2441	1.31
High	2480	1.31

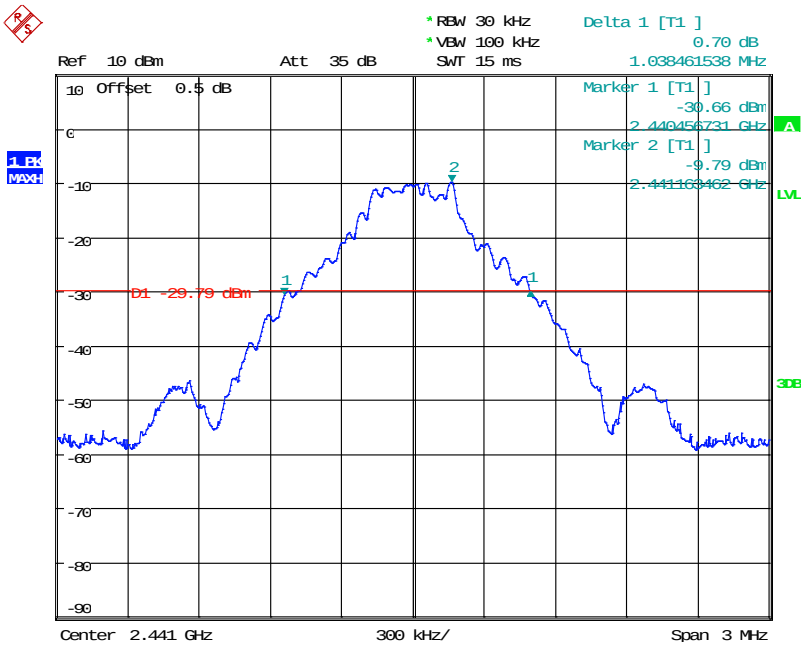
Please refer to the following plots

BR Mode (GFSK)

Low Channel

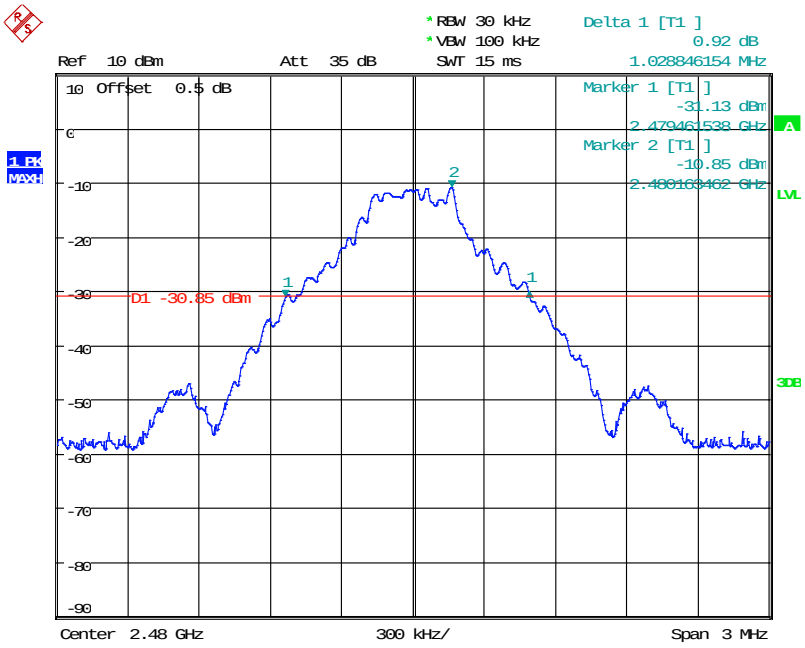


Middle Channel



Date: 19.JUN.2018 11:28:58

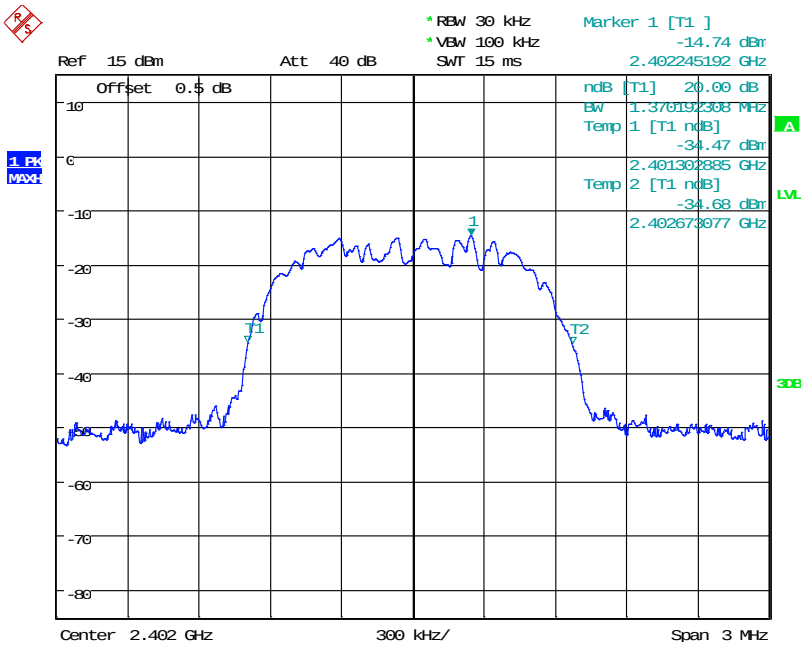
High Channel



Date: 19.JUN.2018 11:30:31

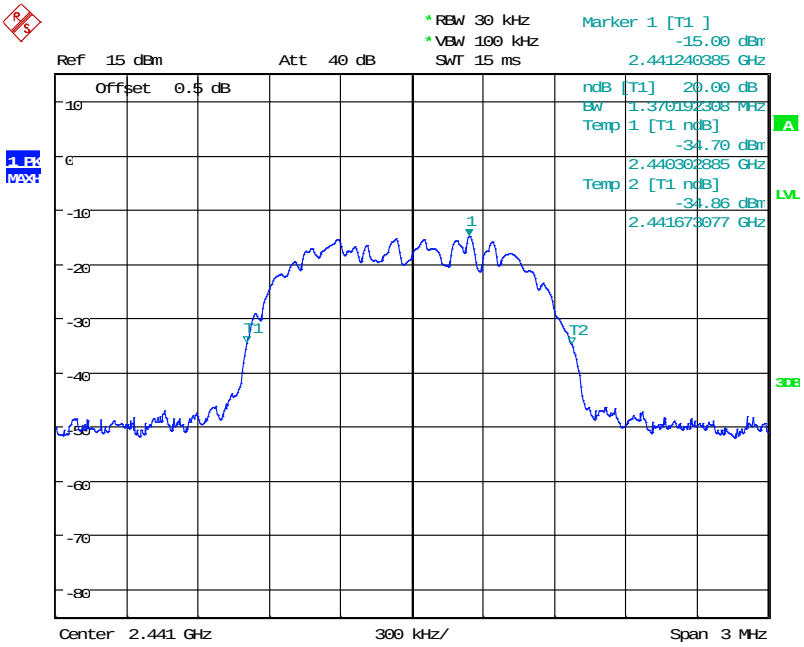
EDR Mode (π/4-DQPSK)

Low Channel



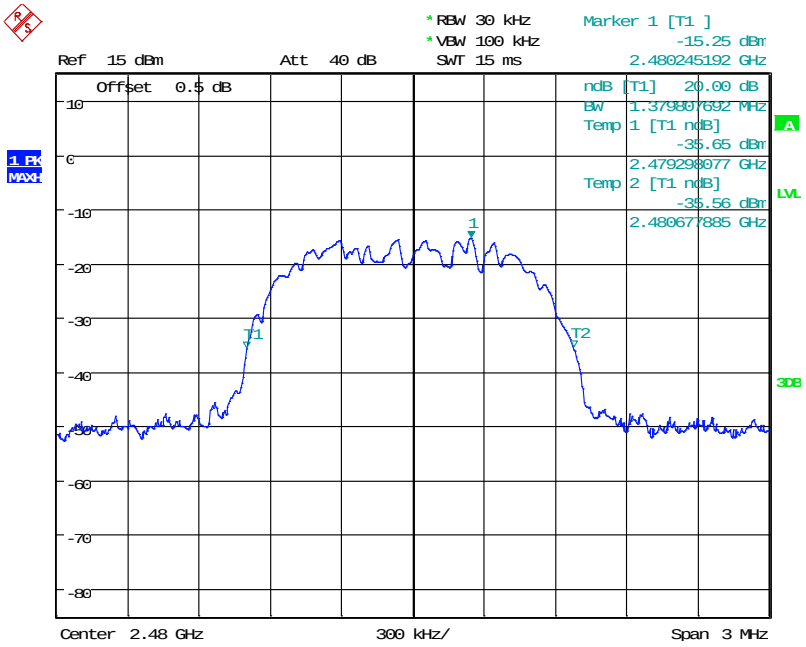
Date: 1.JUN.2018 13:50:43

Middle Channel



Date: 1.JUN.2018 13:52:50

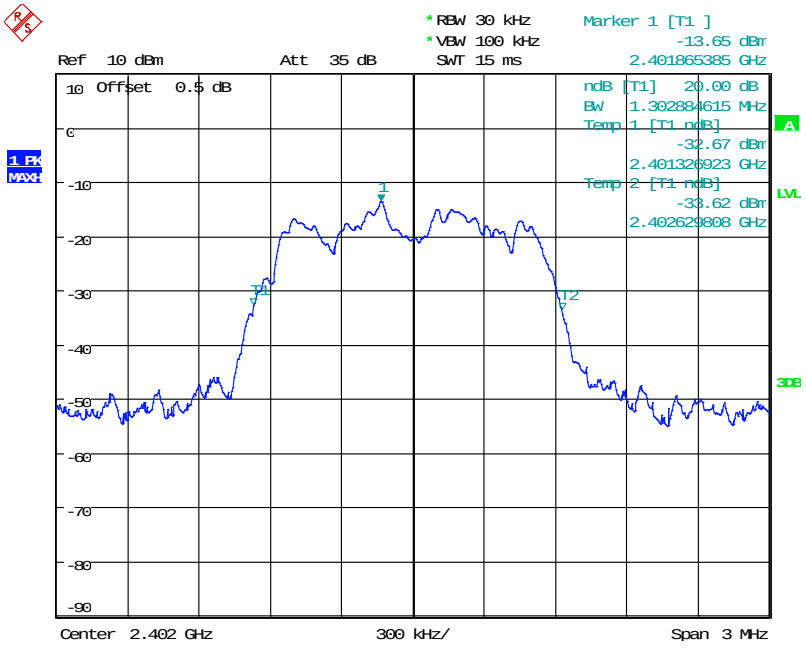
High Channel



Date: 1.JUN.2018 13:54:43

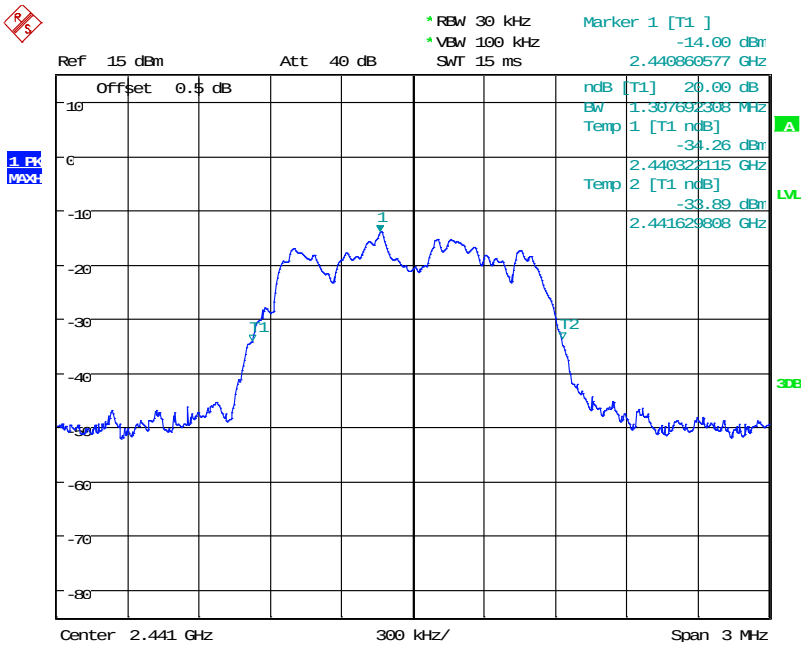
EDR Mode (8DPSK)

Low Channel



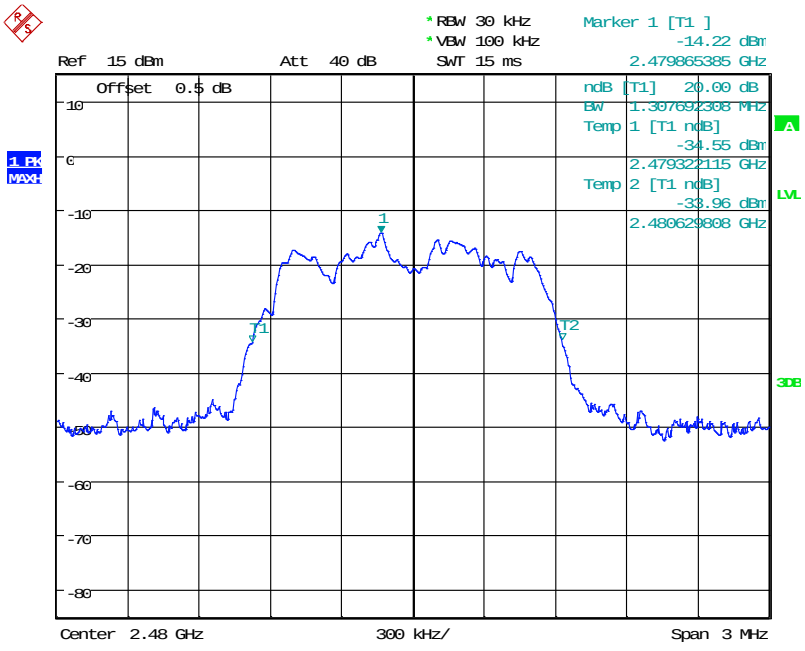
Date: 1.JUN.2018 14:02:43

Middle Channel



Date: 1.JUN.2018 14:04:56

High Channel



Date: 1.JUN.2018 14:06:54

10 FCC §15.247(a)(1) – Channel Separation Test

10.1 Applicable Standard

According to FCC §15.247(a) (1): Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

10.2 Test Procedure

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

10.3 Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	55 %
ATM Pressure:	1010 hPa

The testing was performed by Tom Hsu on 2018-06-01 ~ 2018-06-19.

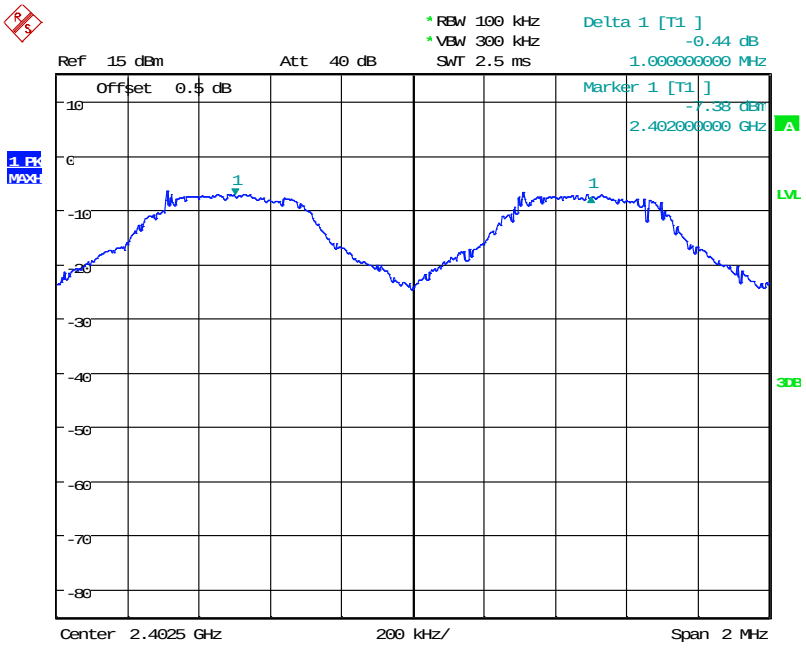
10.4 Test Results

Channel	Channel Separation (MHz)	20 dBc BW (MHz)	Two-thirds of the 20 dB bandwidth (MHz)	Channel Separation Limit	Result
BR Mode *(GFSK)*					
Low	1.00	1.03	0.69	>two-thirds of the 20 dB bandwidth	Compliance
Middle	1.00	1.04	0.69	>two-thirds of the 20 dB bandwidth	Compliance
High	1.00	1.02	0.68	>two-thirds of the 20 dB bandwidth	Compliance
EDR Mode *(π/4-DQPSK)*					
Low	1.00	1.37	0.91	>two-thirds of the 20 dB bandwidth	Compliance
Middle	1.01	1.37	0.91	>two-thirds of the 20 dB bandwidth	Compliance
High	0.99	1.38	0.92	>two-thirds of the 20 dB bandwidth	Compliance
EDR Mode *(8DPSK)*					
Low	1.00	1.30	0.87	>two-thirds of the 20 dB bandwidth	Compliance
Middle	1.00	1.31	0.87	>two-thirds of the 20 dB bandwidth	Compliance
High	1.00	1.31	0.87	>two-thirds of the 20 dB bandwidth	Compliance

Please refer to the following plots

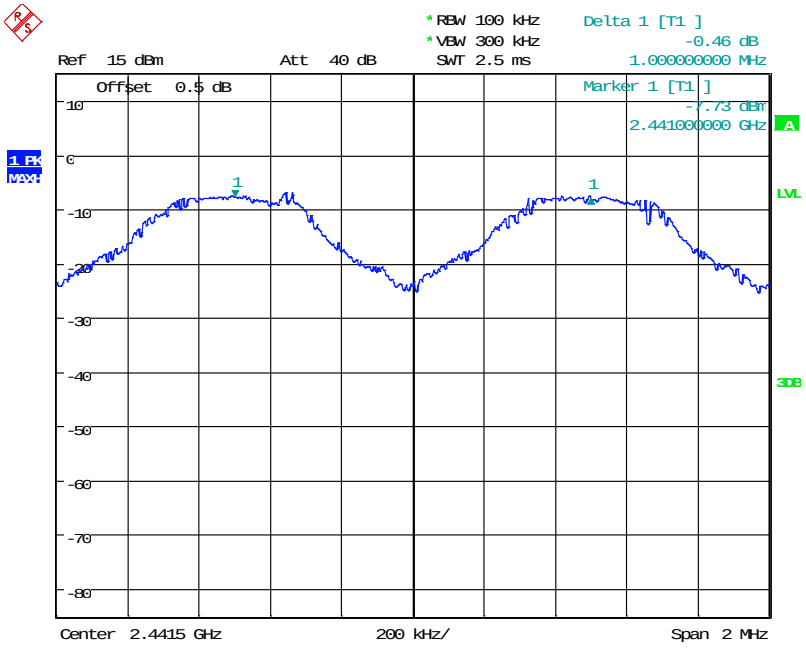
BR Mode (GFSK)

Low Channel



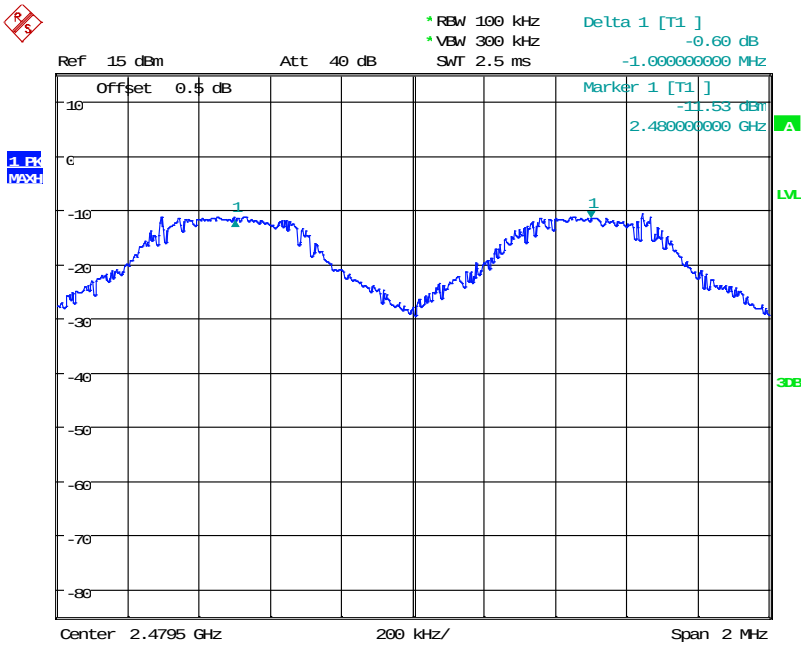
Date: 1.JUN.2018 13:45:30

Middle Channel



Date: 1.JUN.2018 13:46:27

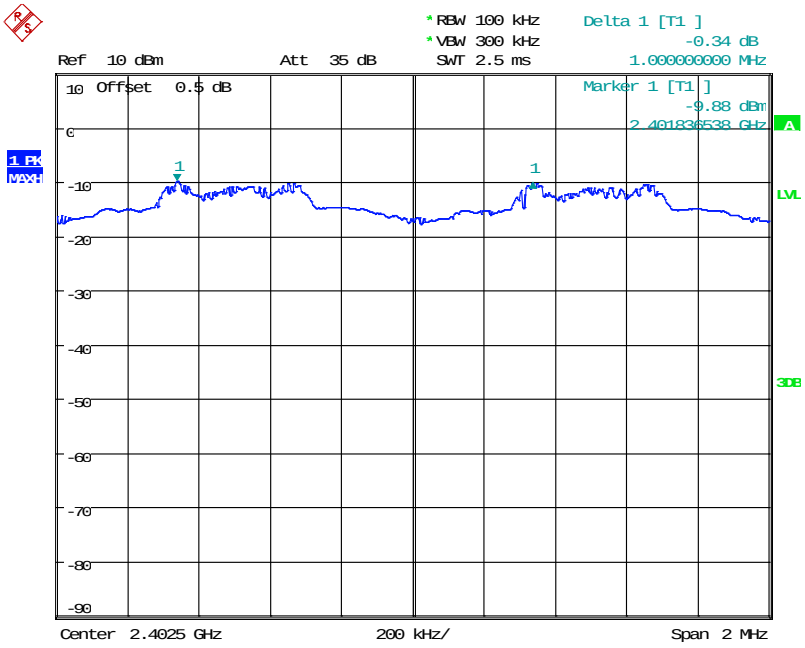
High Channel



Date: 5.JUN.2018 11:56:57

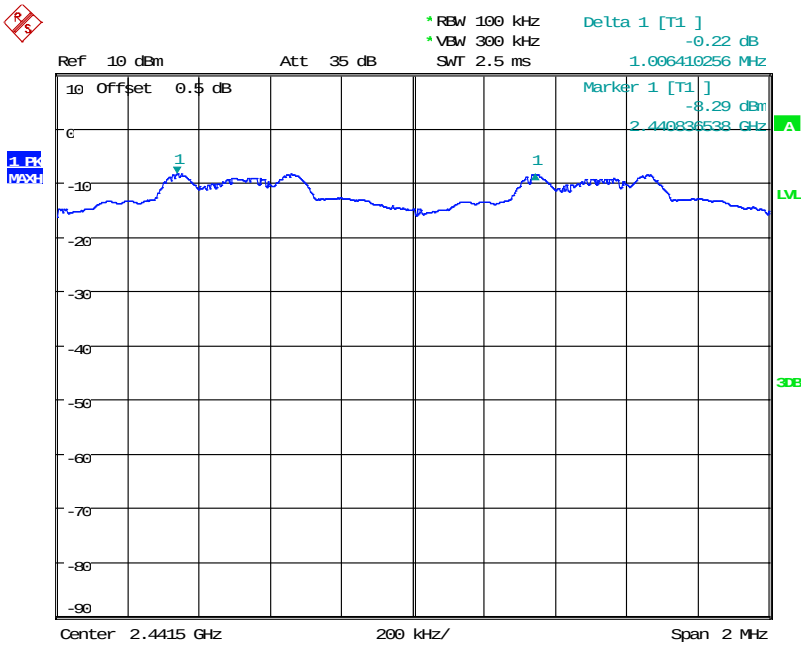
*EDR Mode (*π/4-DQPSK*)*

Low Channel



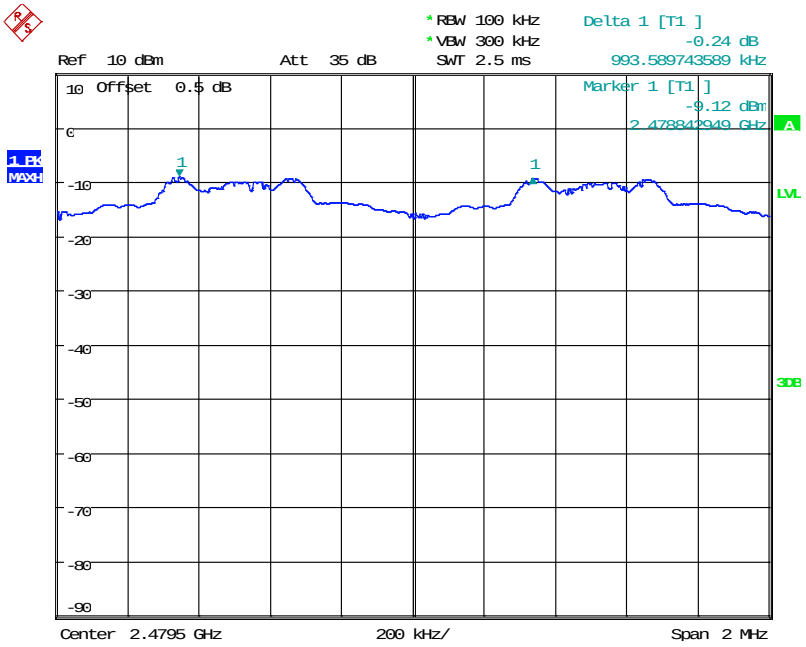
Date: 19.JUN.2018 11:43:29

Middle Channel



Date: 19.JUN.2018 11:46:13

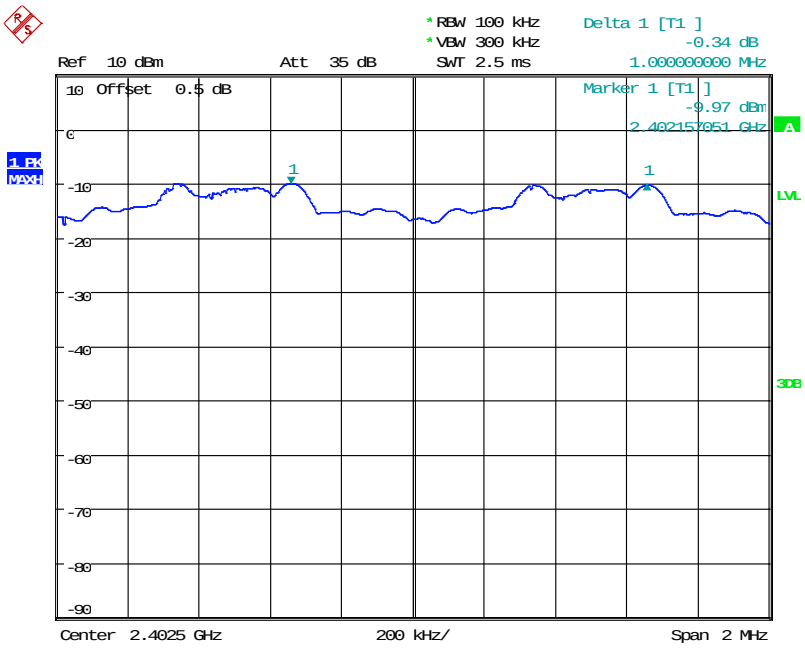
High Channel



Date: 19.JUN.2018 11:48:12

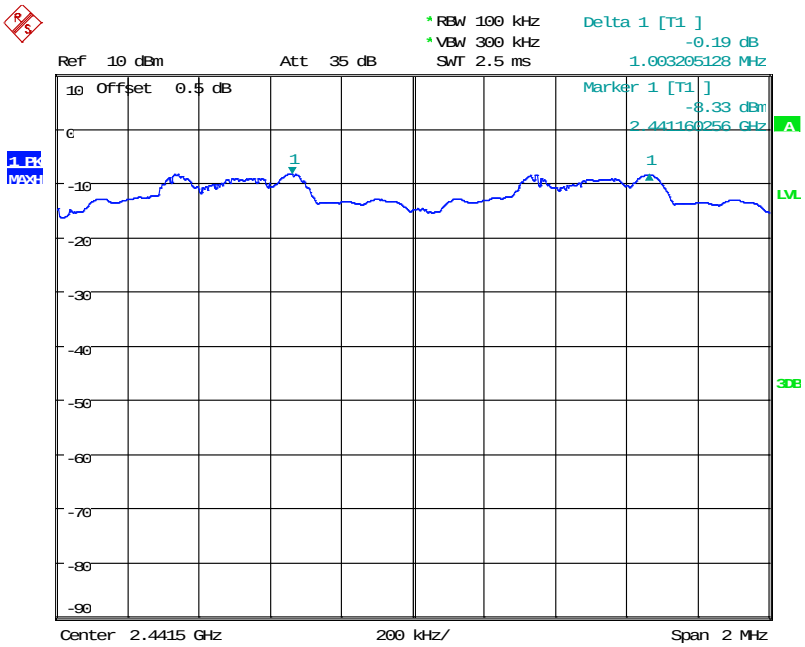
EDR Mode (8DPSK)

Low Channel



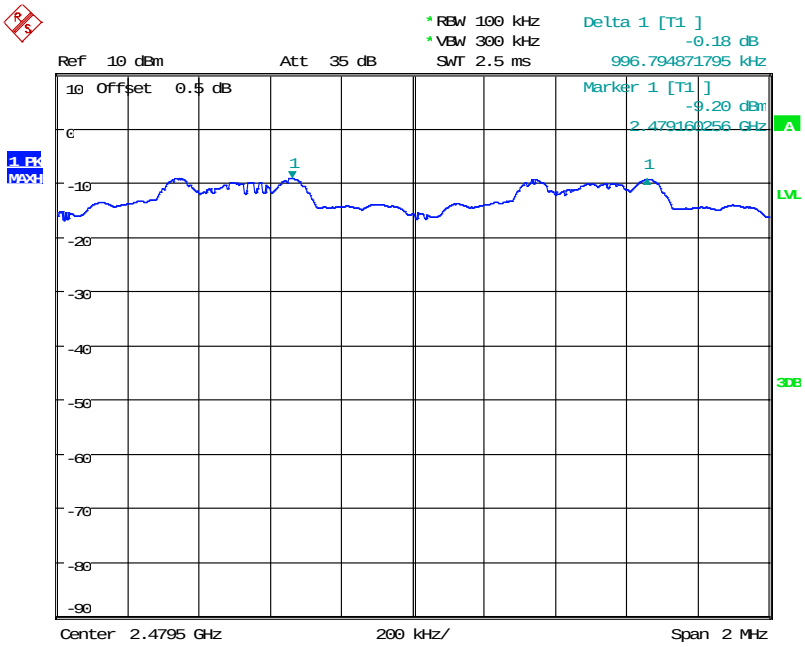
Date: 19.JUN.2018 11:56:37

Middle Channel



Date: 19.JUN.2018 11:53:53

High Channel



Date: 19.JUN.2018 11:50:00

11 FCC§15.247(a)(1)(iii) –Time of Occupancy (Dwell Time)

11.1 Applicable Standard

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

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

11.2 Test Procedure

The EUT must have its hopping function enabled. Use the following spectrum analyzer settings: Span = zero span, centered on a hopping channel

RBW ≤ channel spacing and where possible RBW should be set >> 1/T, where T is the expected dwell time per channel

Sweep = as necessary to capture the entire dwell time per hopping channel Detector function = peak

Trace = max hold

Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time.

Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements.

Determine the number of hops over the sweep time and calculate the total number of hops in the period specified in the requirements, using the following equation:

(Number of hops in the period specified in the requirements) = (number of hops on spectrum analyzer) x (period specified in the requirements / analyzer sweep time)

The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the period specified. If the number of hops in a specific time varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation.

11.3 Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	55 %
ATM Pressure:	1010 hPa

The testing was performed by Tom Hsu on 2018-06-01.

11.4 Test Results

Test mode: BR mode / 2402 ~ 2480MHz(*GFSK*)						
Mode	**Pulse Time (ms)**	**Hopping Number**	**Period Time (s)**	**Total of Dwell (ms)**	**Limit (ms)**	**Result**
DH1	0.39	320	31.6	124.80	<400	PASS
DH3	1.66	150	31.6	249.00	<400	PASS
DH5	2.90	90	31.6	261.00	<400	PASS
Test mode: EDR mode / 2402 ~ 2480MHz (*π/4-DQPSK*)						
Mode	**Pulse Time (ms)**	**Hopping Number**	**Period Time (s)**	**Total of Dwell (ms)**	**Limit (ms)**	**Result**
2DH1	0.40	320	31.6	128.00	<400	PASS
2DH3	1.66	150	31.6	249.00	<400	PASS
2DH5	2.91	70	31.6	203.70	<400	PASS
Test mode: EDR mode / 2402 ~ 2480MHz (*8DPSK*)						
Mode	**Pulse Time (ms)**	**Hopping Number**	**Period Time (s)**	**Total of Dwell (ms)**	**Limit (ms)**	**Result**
3DH1	0.40	320	31.6	128.00	<400	PASS
3DH3	1.66	140	31.6	232.40	<400	PASS
3DH5	2.90	80	31.6	232.00	<400	PASS

Note 1: A period time = 0.4*79 = 31.6 (s), Total of Dwell=Pulse Time * Hopping Number

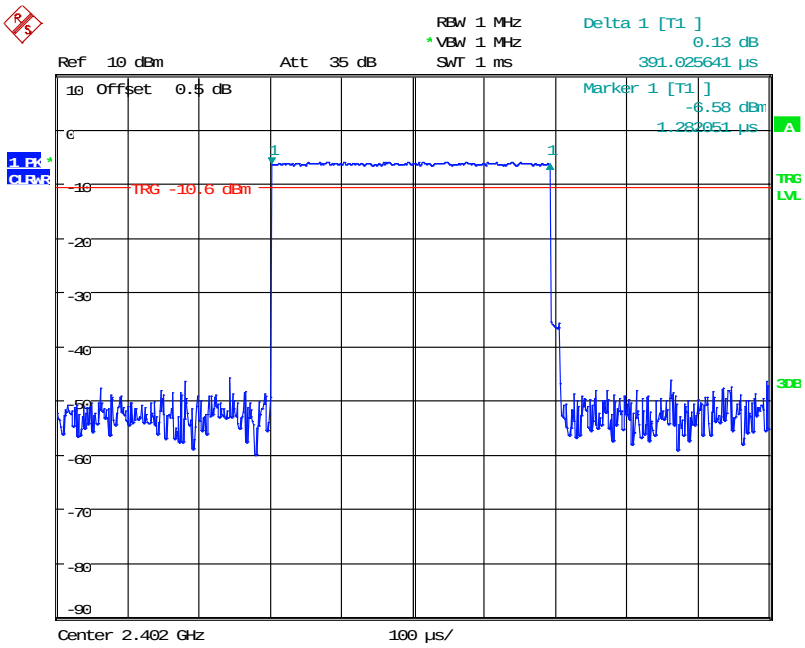
Note 2: Hopping Number = Hopping Number/10 * 10

Note 3: Hopping Number/10 = Total of highest signals in 3.16s. (Second high signals were other channel)

Please refer to the following plots

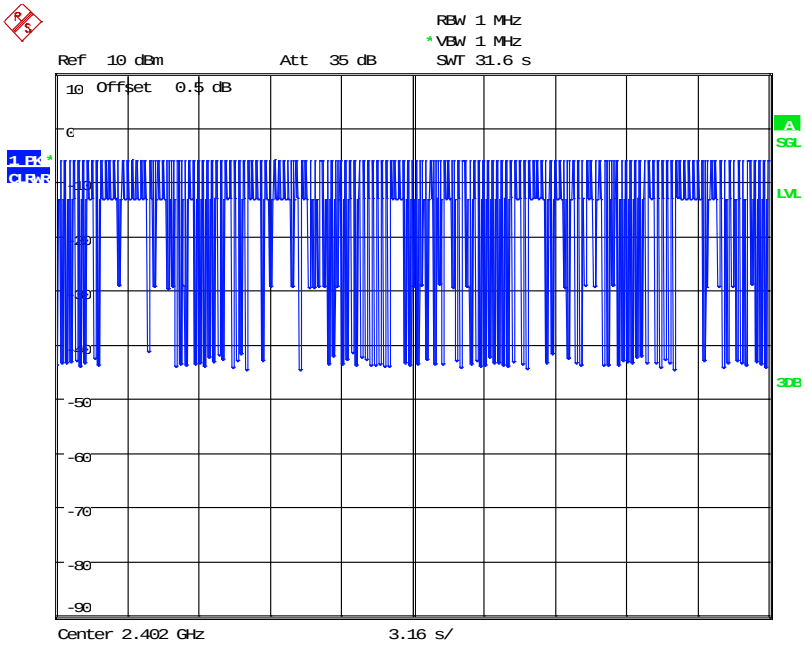
BR Mode (GFSK)

DH1: Pulse Width



Date: 1.JUN.2018 14:24:47

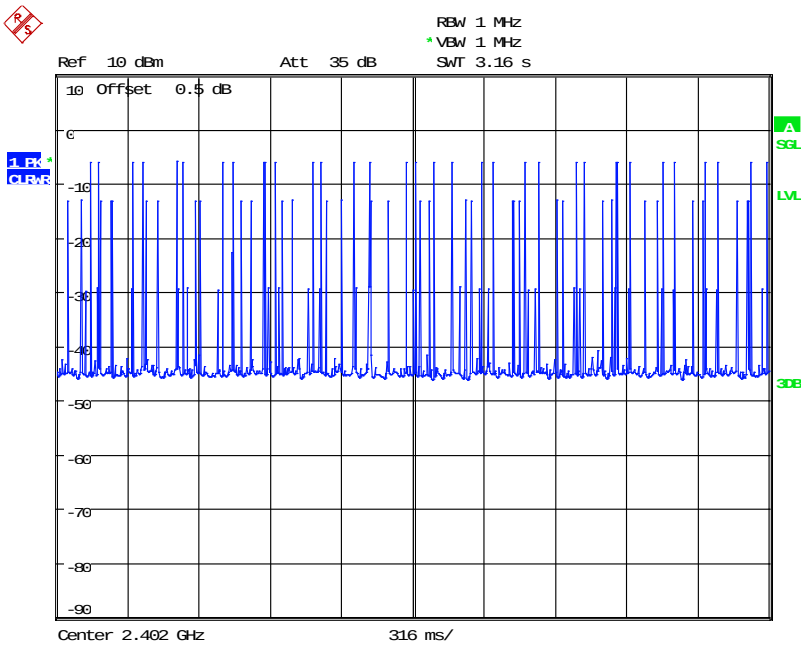
DH1: Hopping Number



Date: 1.JUN.2018 14:39:34

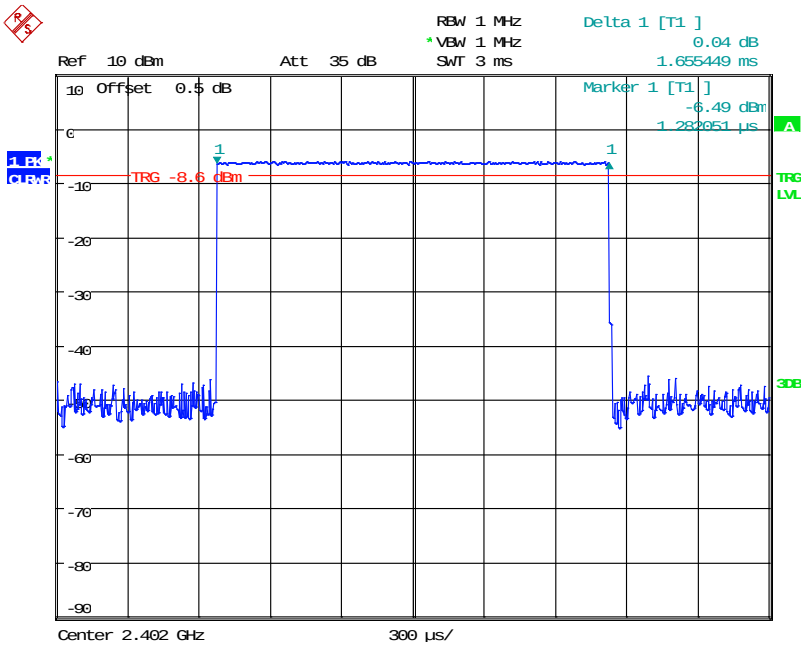
DH1: Hopping Number /10

(Hopping Number = 32 in 1/10 period of highest signals, Second High signals were other channel)



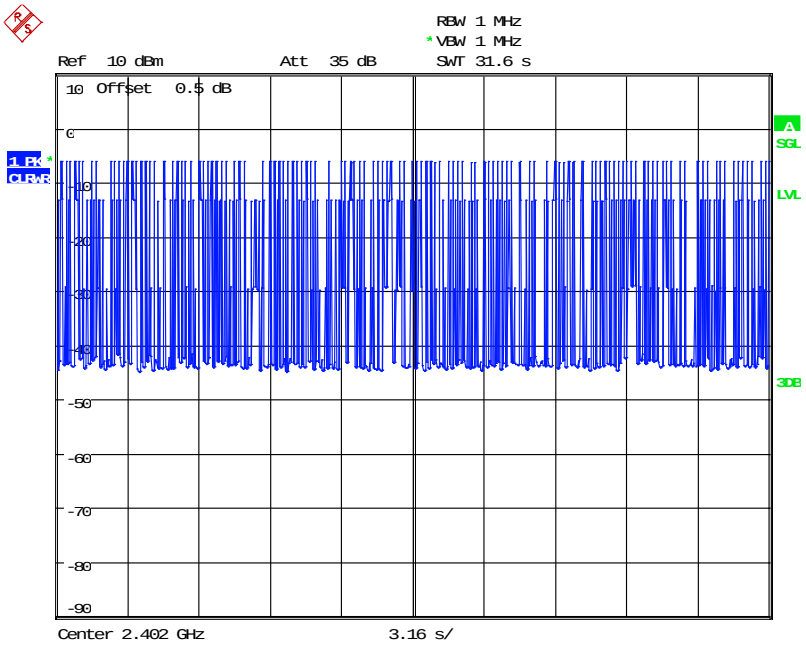
Date: 1.JUN.2018 14:40:24

DH3: Pulse Width



Date: 1.JUN.2018 14:26:56

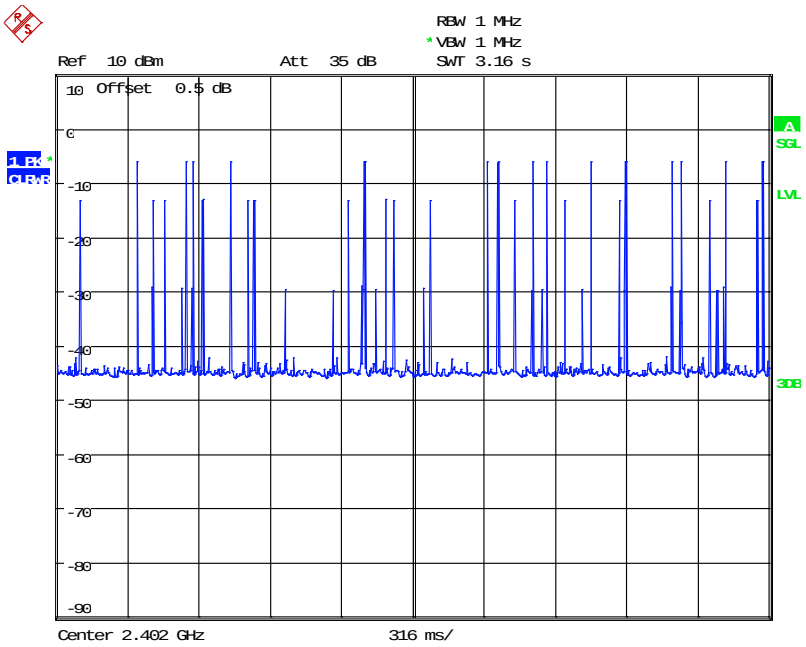
DH3: Hopping Number



Date: 1.JUN.2018 14:34:08

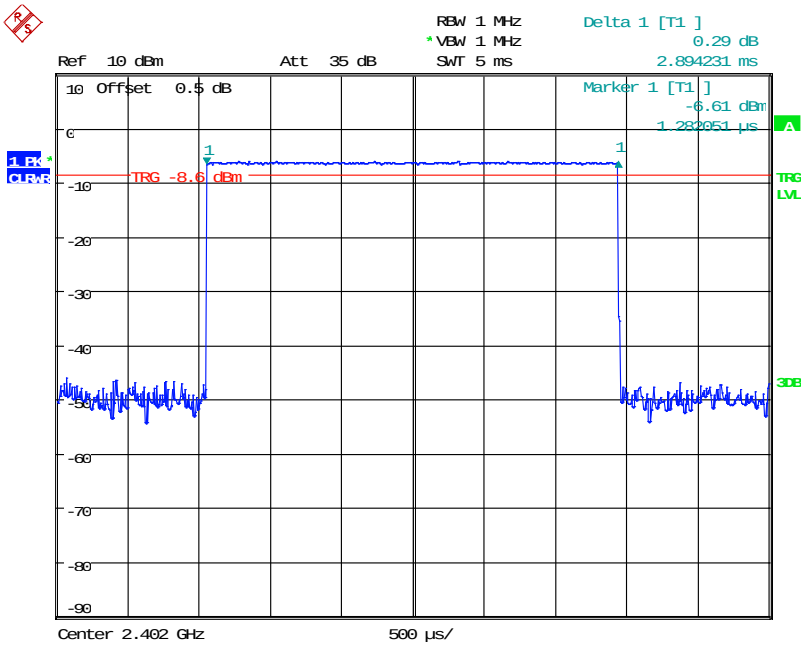
DH3: Hopping Number /10

(Hopping Number = 15 in 1/10 period of highest signals, Second High signals were other channel)



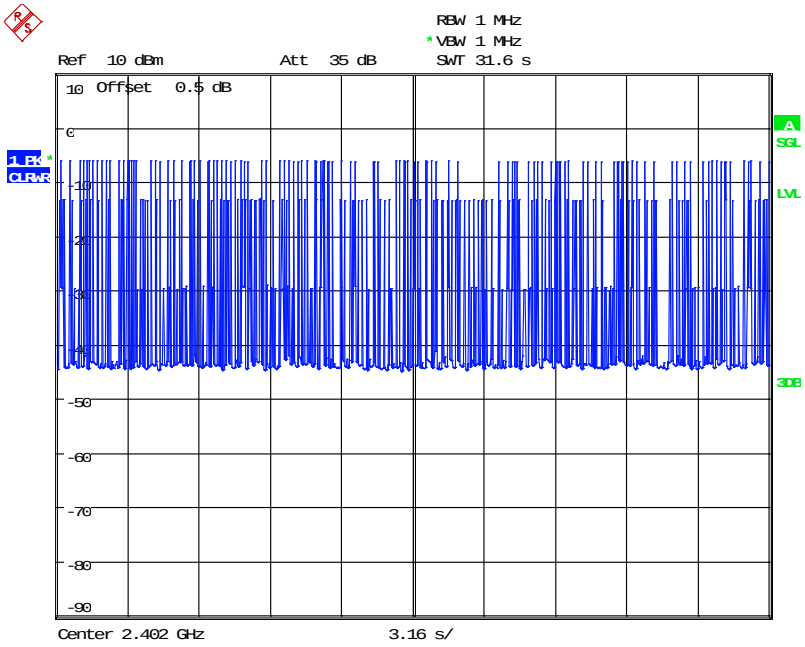
Date: 1.JUN.2018 14:40:57

DH5: Pulse Width



Date: 1.JUN.2018 14:28:21

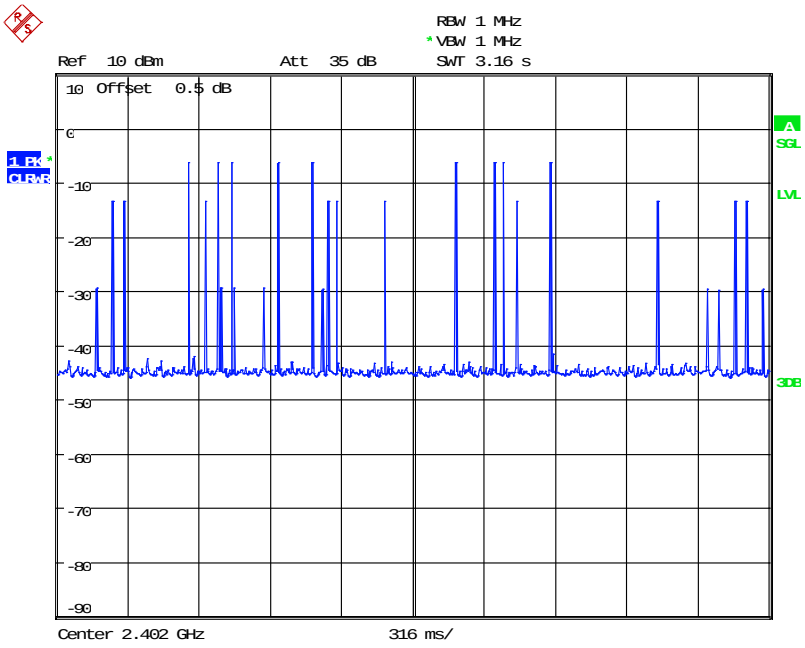
DH5: Hopping Number



Date: 1.JUN.2018 14:33:18

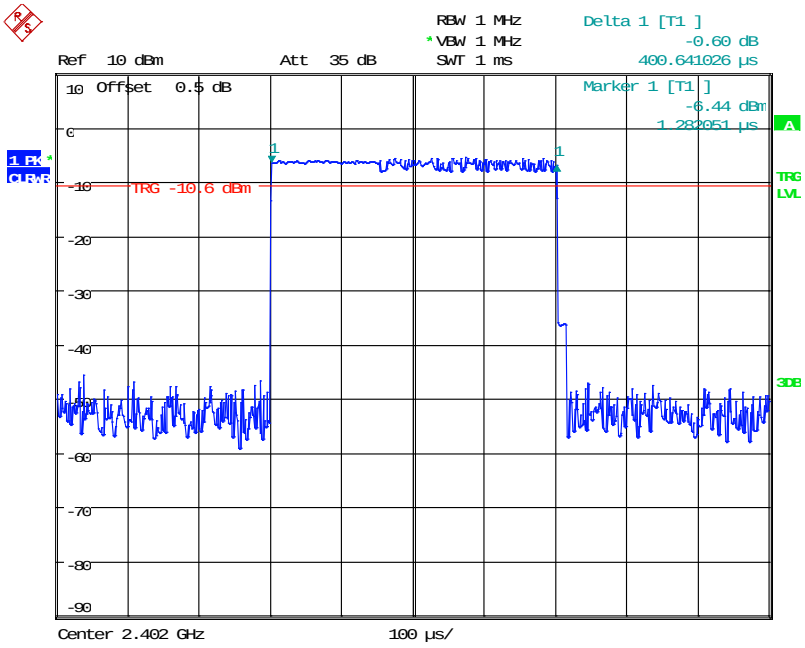
DH5: Hopping Number /10

(Hopping Number = 9 in 1/10 period of highest signals, Second High signals were other channel)

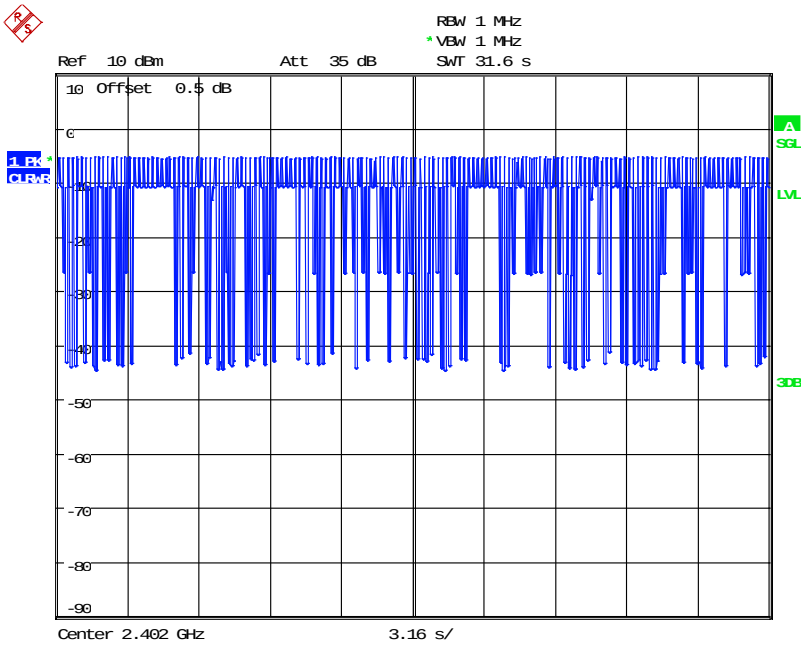


EDR Mode (π/4-DQPSK)

2DH1: Pulse Width



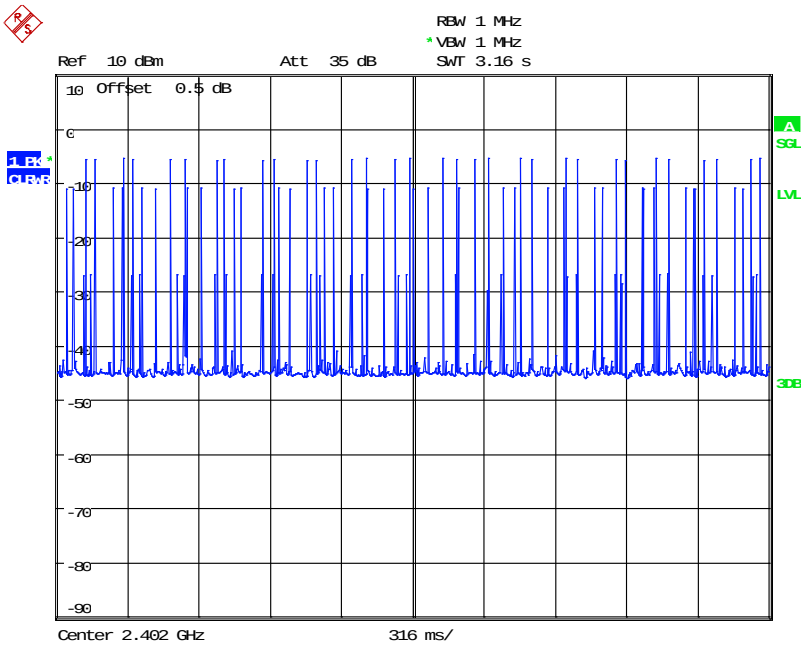
2DH1: Hopping Number



Date: 1.JUN.2018 14:37:53

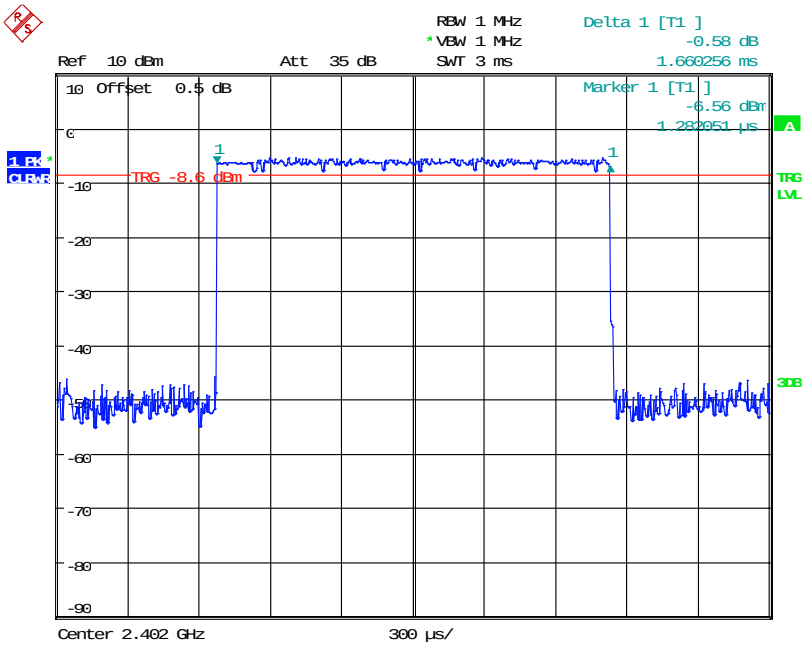
2DH1: Hopping Number /10

(Hopping Number = 32 in 1/10 period of highest signals, Second High signals were other channel)



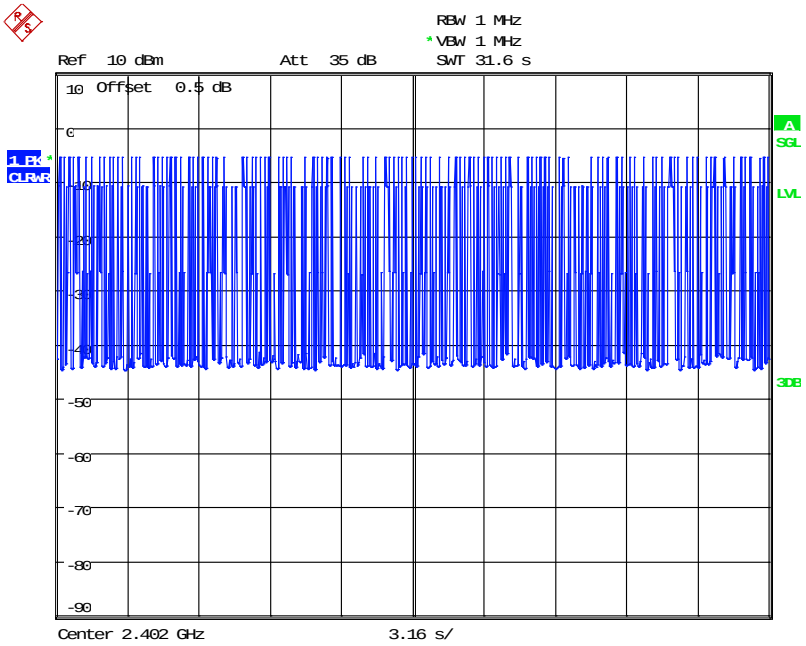
Date: 1.JUN.2018 14:42:25

2DH3: Pulse Width



Date: 1.JUN.2018 14:27:19

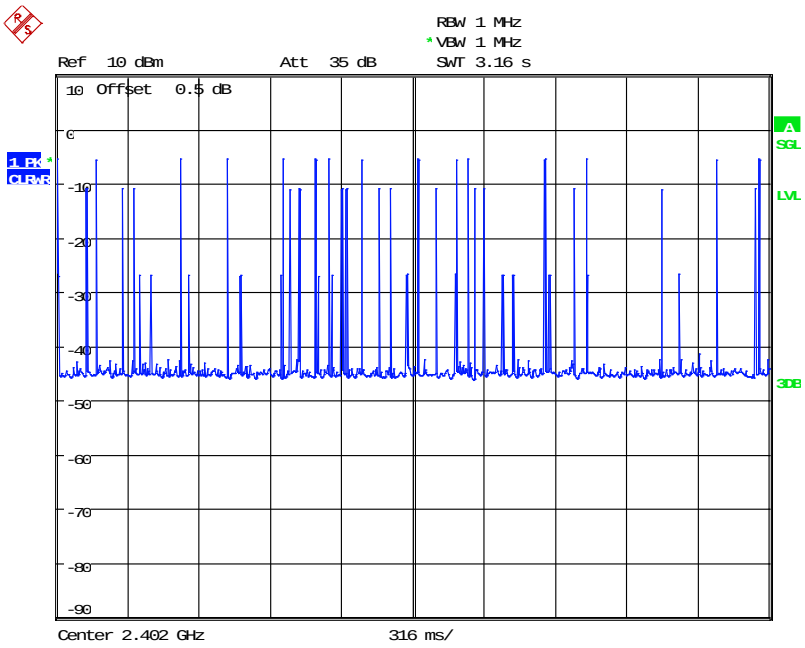
2DH3: Hopping Number



Date: 1.JUN.2018 14:35:21

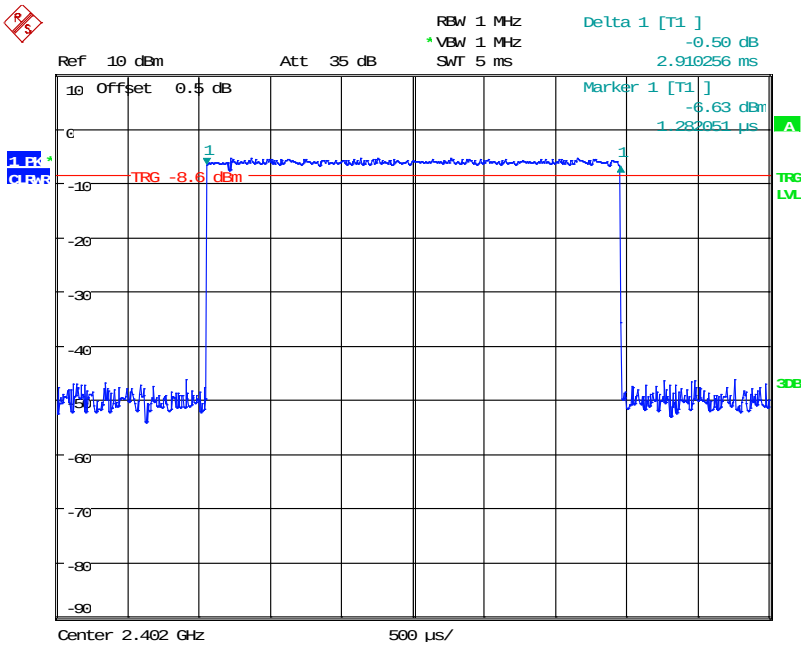
2DH3: Hopping Number /10

(Hopping Number = 15 in 1/10 period of highest signals, Second High signals were other channel)



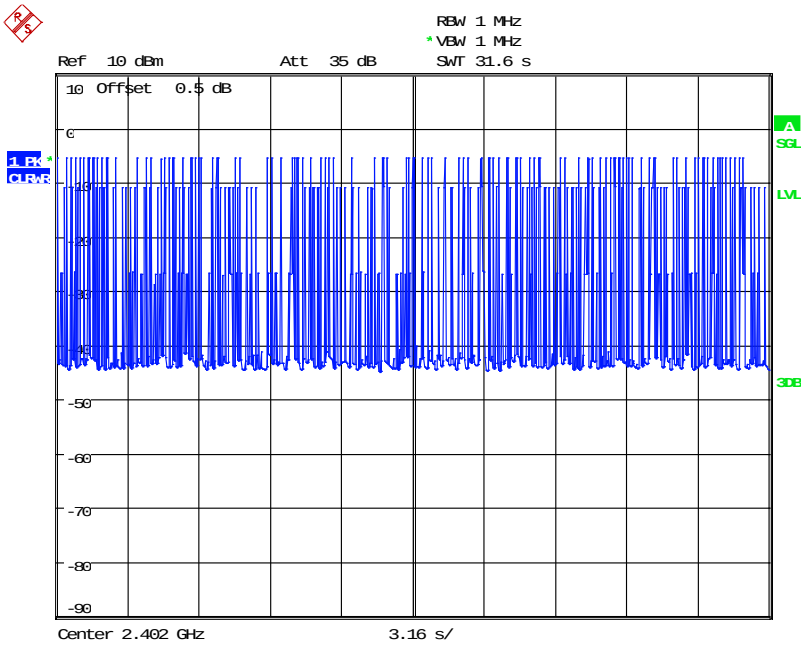
Date: 1.JUN.2018 14:43:01

2DH5: Pulse Width



Date: 1.JUN.2018 14:28:44

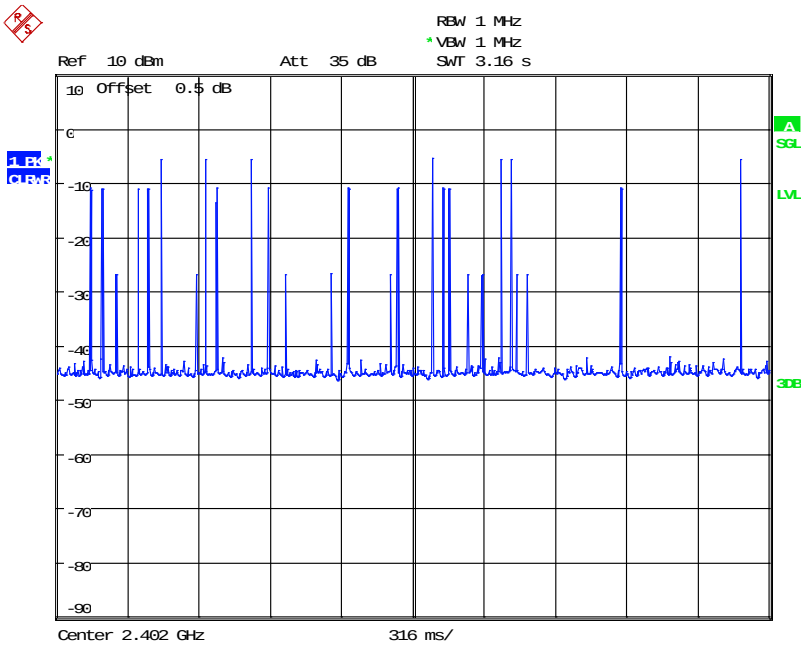
2DH5: Hopping Number



Date: 1.JUN.2018 14:32:27

2DH5: Hopping Number /10

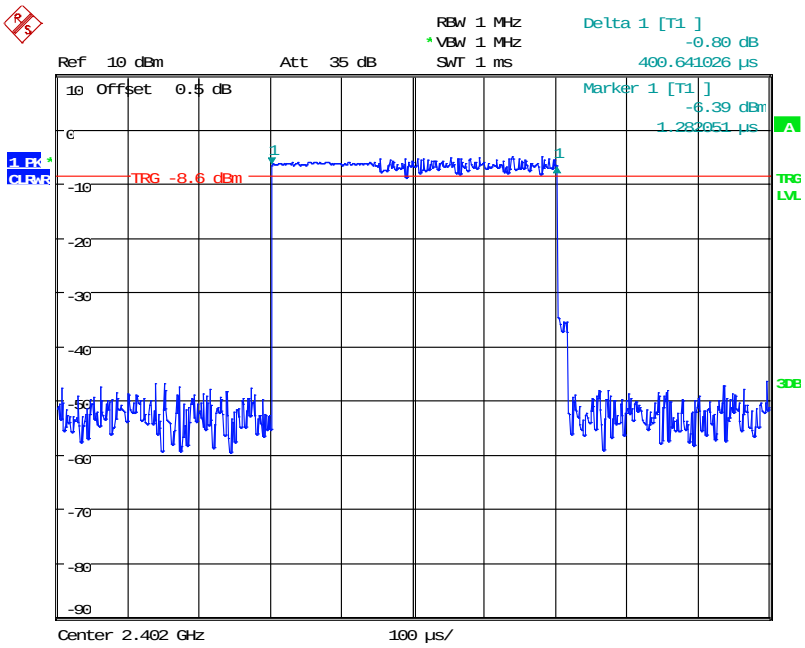
(Hopping Number = 7 in 1/10 period of highest signals, Second High signals were other channel)



Date: 1.JUN.2018 14:44:00

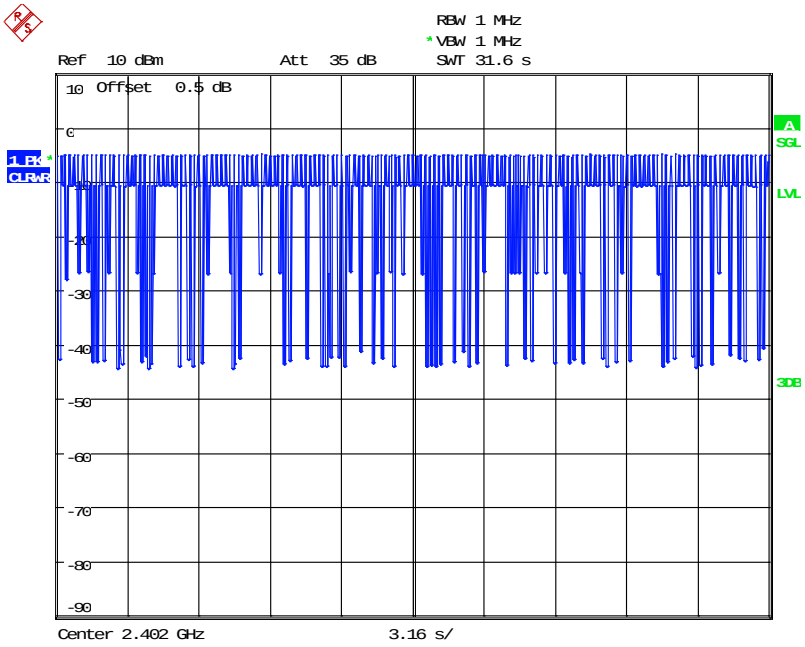
EDR Mode (8DPSK)

3DH1: Pulse Width



Date: 1.JUN.2018 14:26:11

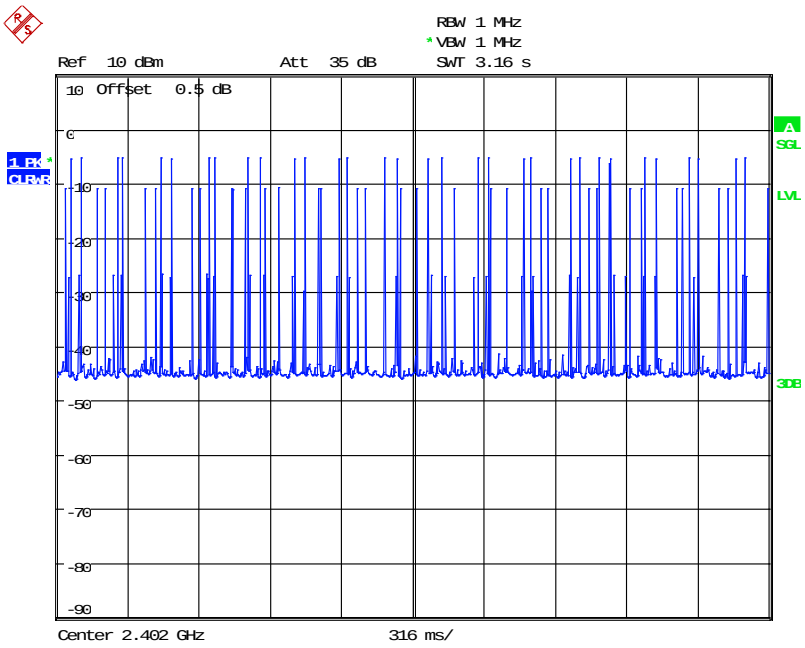
3DH1: Hopping Number



Date: 1.JUN.2018 14:37:05

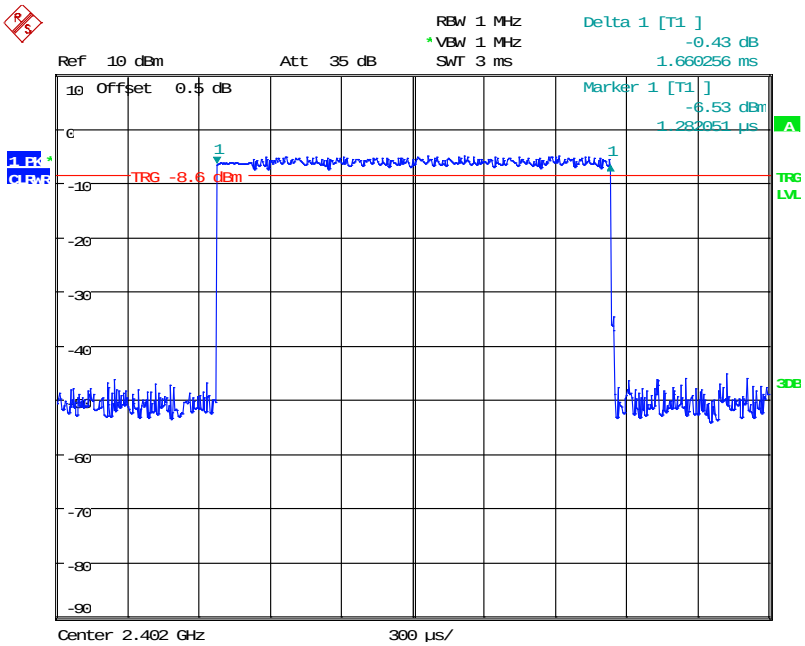
3DH1: Hopping Number /10

(Hopping Number = 32 in 1/10 period of highest signals, Second High signals were other channel)



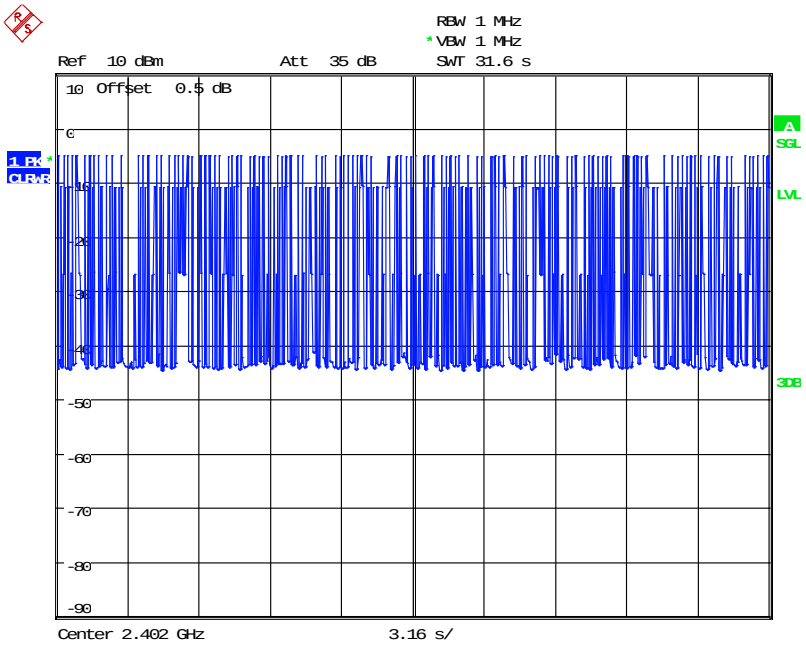
Date: 1.JUN.2018 14:44:18

3DH3: Pulse Width



Date: 1.JUN.2018 14:27:43

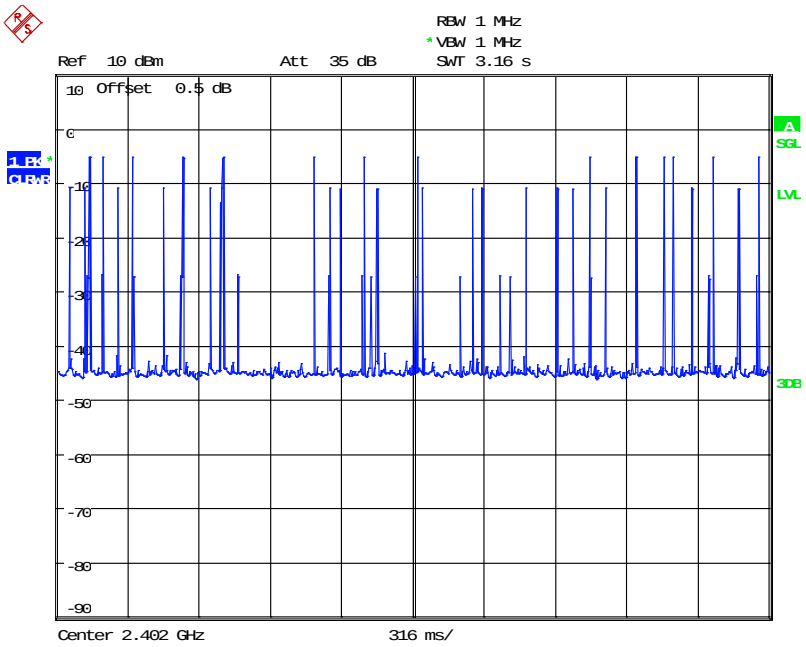
3DH3: Hopping Number



Date: 1.JUN.2018 14:36:10

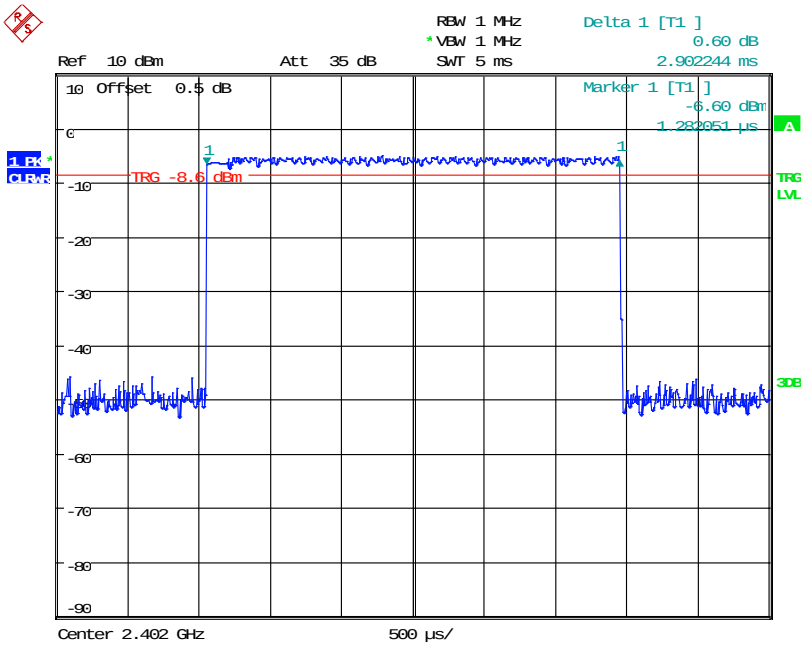
3DH3: Hopping Number /10

(Hopping Number = 14 in 1/10 period of highest signals, Second High signals were other channel)



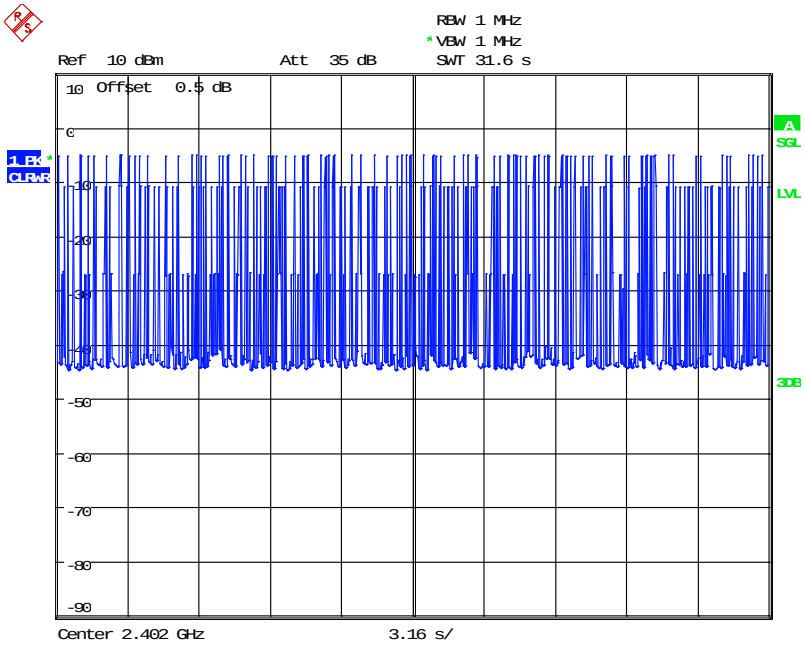
Date: 1.JUN.2018 14:45:09

3DH5: Pulse Width



Date: 1.JUN.2018 14:29:03

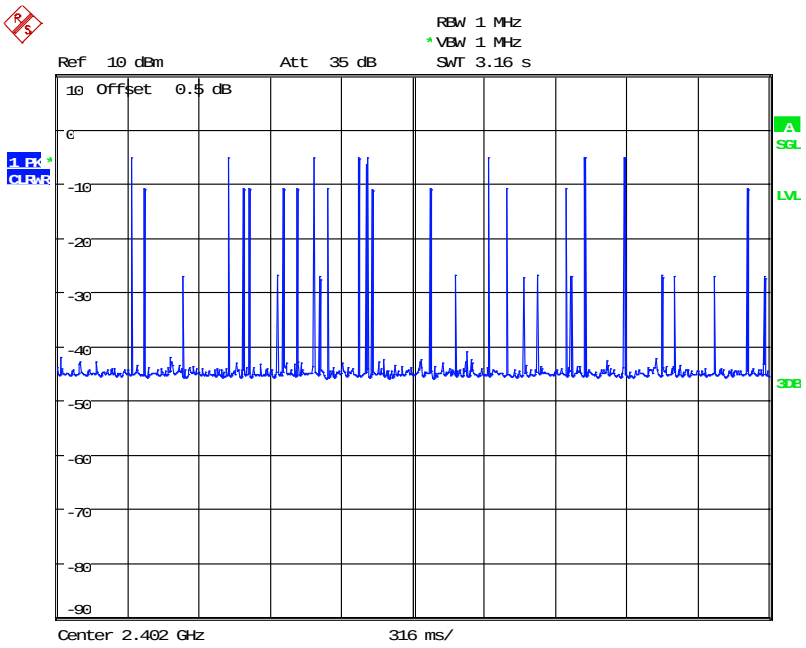
3DH5: Hopping Number



Date: 1.JUN.2018 14:30:36

3DH5: Hopping Number /10

(Hopping Number = 8 in 1/10 period of highest signals, Second High signals were other channel)



Date: 1.JUN.2018 14:45:29

12 FCC §15.247(a)(1)(iii) –Quantity of hopping channel Test

12.1 Applicable Standard

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

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

12.2 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.

12.3 Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	55 %
ATM Pressure:	1010 hPa

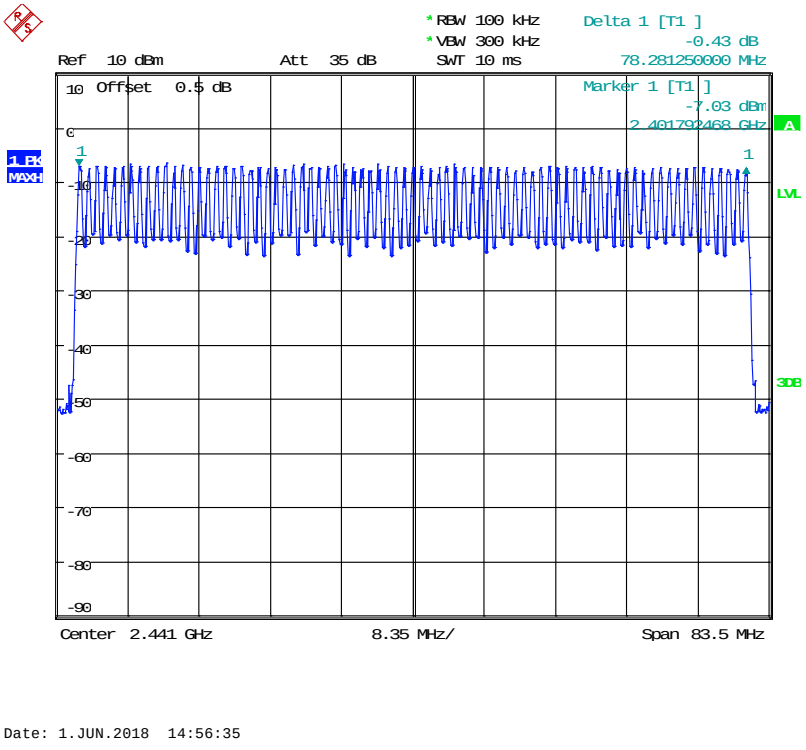
The testing was performed by Tom Hsu on 2018-06-01.

12.4 Test Results

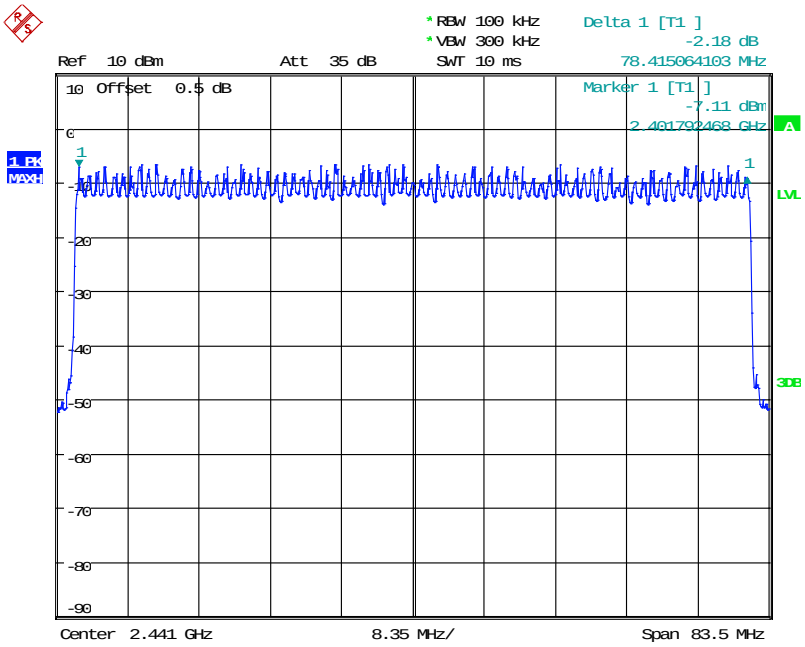
Mode	Frequency Range (MHz)	Number of Hopping Channel (CH)	Limit (CH)	Result
GFSK	2402-2480	79	>15	Compliance
π/4-DQPSK	2402-2480	79	>15	Compliance
8DPSK	2402-2480	79	>15	Compliance

Please refer to the following plots

BR Mode (GFSK)

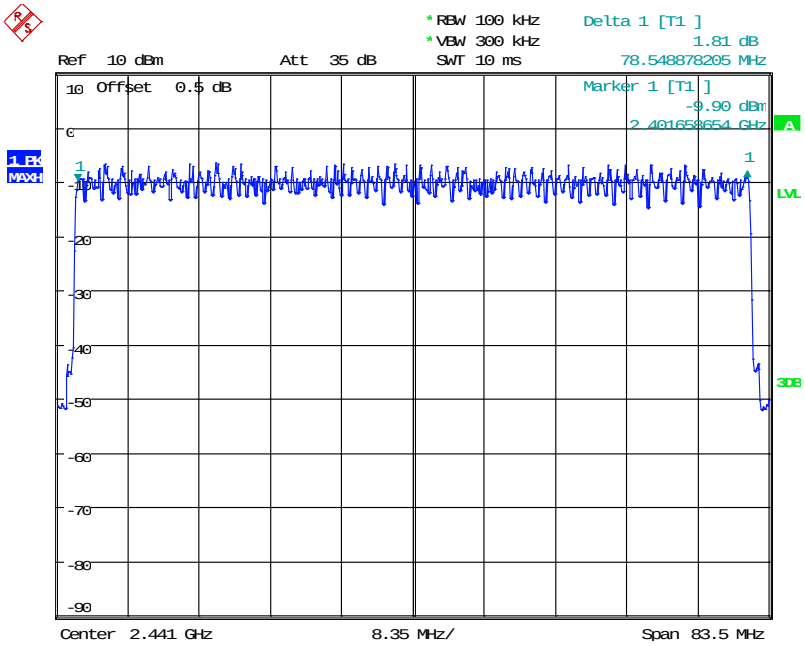


EDR Mode (π/4-DQPSK)



Date: 1.JUN.2018 14:55:20

EDR Mode (8DPSK)



Date: 1.JUN.2018 14:51:31

13 FCC §15.247(b)(1) – Maximum Output Power

13.1 Applicable Standard

According to FCC §15.247(b) (1).

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. For all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

13.2 Test Procedure

1. Place the EUT on a bench and set it in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to measuring equipment.

13.3 Test Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	55 %
ATM Pressure:	101.0 kPa

The testing was performed by Tom Hsu on 2018-06-01.

13.4 Test Results

Channel	Frequency (MHz)	Peak Conducted Output Power		Limit (W)	Result
		(dBm)	(W)		
BR Mode (GFSK)					
Low	2402	-6.20	0.00024	0.125	Compliance
Middle	2441	-6.13	0.00024	0.125	Compliance
High	2480	-6.82	0.00021	0.125	Compliance
EDR Mode (π/4-DQPSK)					
Low	2402	-5.17	0.00030	0.125	Compliance
Middle	2441	-5.07	0.00031	0.125	Compliance
High	2480	-5.39	0.00029	0.125	Compliance
EDR Mode (8DPSK)					
Low	2402	-4.91	0.00032	0.125	Compliance
Middle	2441	-4.59	0.00035	0.125	Compliance
High	2480	-5.11	0.00031	0.125	Compliance

14 FCC §15.247(d) – 100 kHz Bandwidth of Frequency Band Edge

14.1 Applicable Standard

According to FCC §15.247(d), in any 100 kHz bandwidth outside the frequency bands in which the spread spectrum 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. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emissions limits specified in §15.209(a) see §15.205(c)

14.2 Test Procedure

Span = wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation
RBW = 100 kHz VBW = 300 kHz
Sweep = coupled
Detector function = peak Trace = max hold

14.3 Test Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	55 %
ATM Pressure:	101.0 kPa

The testing was performed by Tom Hsu on 2018-06-01.

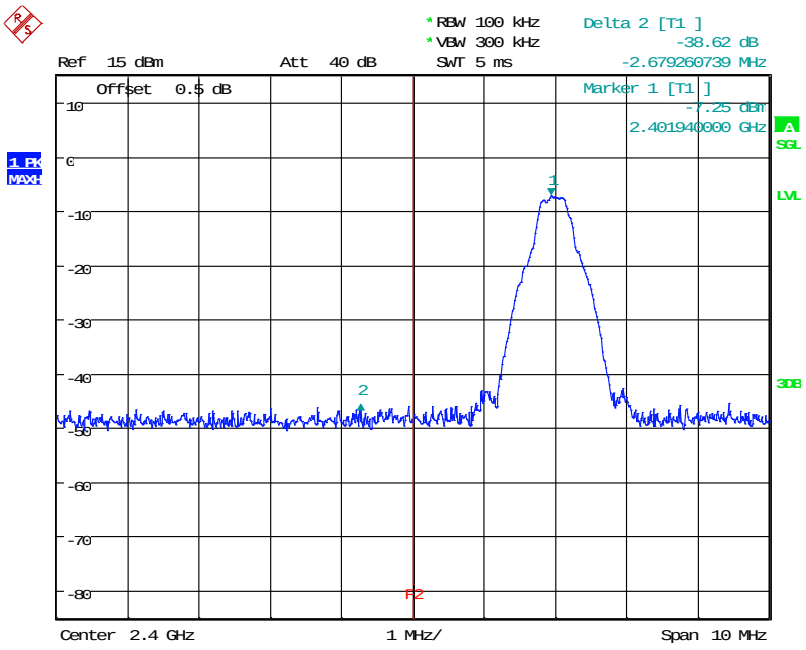
14.4 Test Results

Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	RESULT
BR Mode (GFSK)				
Low	2402	38.62	≥ 20	PASS
High	2480	37.83	≥ 20	PASS
BR Hopping Mode (GFSK)				
Low	2402-2480	38.17	≥ 20	PASS
High	2402-2480	37.50	≥ 20	PASS
EDR Mode (π/4-DQPSK)				
Low	2402	36.44	≥ 20	PASS
High	2480	35.58	≥ 20	PASS
EDR Hopping Mode (π/4-DQPSK)				
Low	2402-2480	36.53	≥ 20	PASS
High	2402-2480	37.70	≥ 20	PASS
EDR Mode (8DPSK)				
Low	2402	35.53	≥ 20	PASS
High	2480	35.48	≥ 20	PASS
EDR Hopping Mode (8DPSK)				
Low	2402-2480	38.29	≥ 20	PASS
High	2402-2480	38.12	≥ 20	PASS

Please refer to the following plots

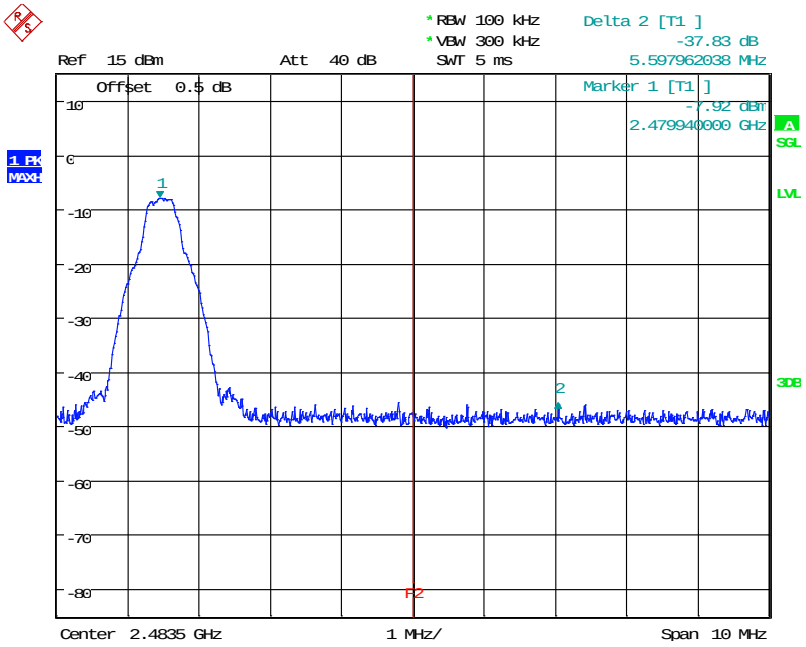
BR Mode (GFSK)

Band Edge, CH Low



Date: 1.JUN.2018 13:38:26

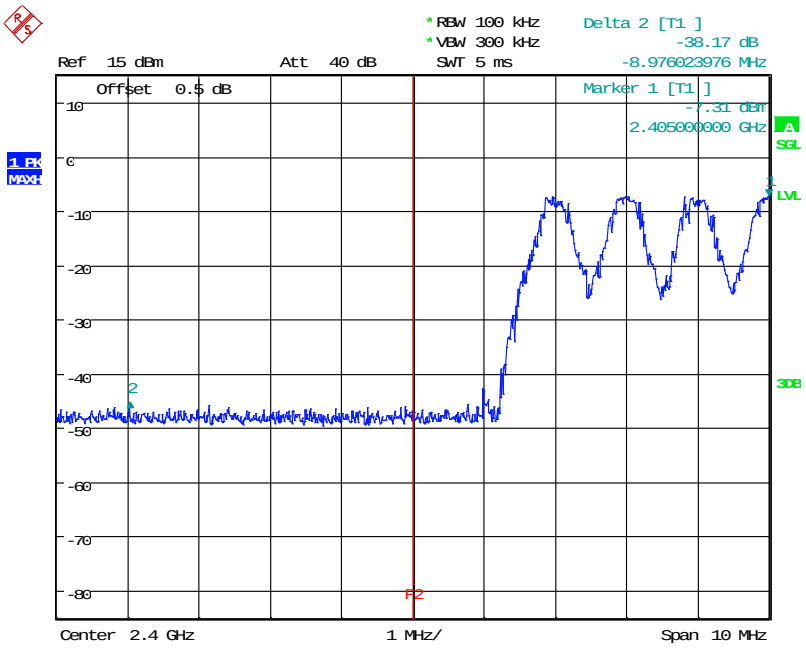
Band Edge, CH High



Date: 1.JUN.2018 13:42:59

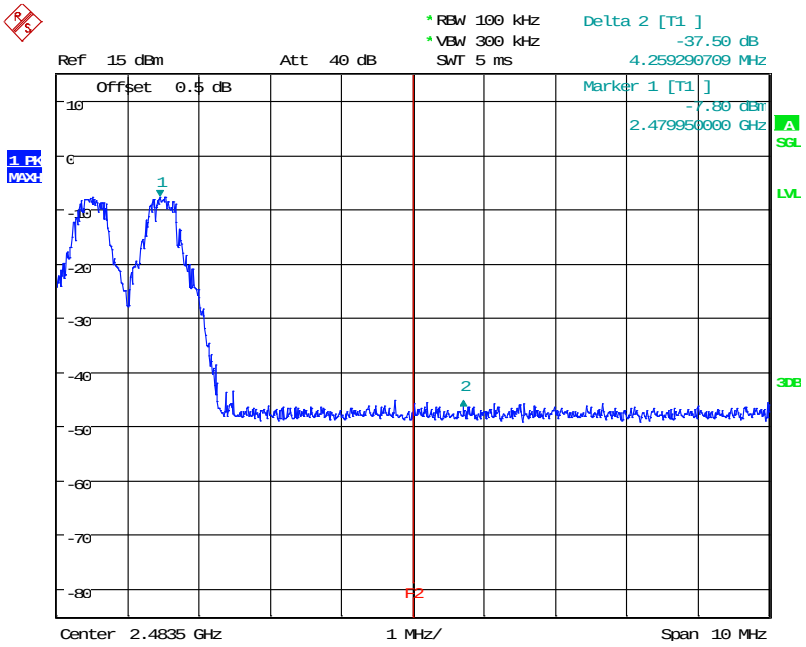
BR Hopping Mode (GFSK)

Band Edge, CH Low



Date: 1.JUN.2018 13:48:22

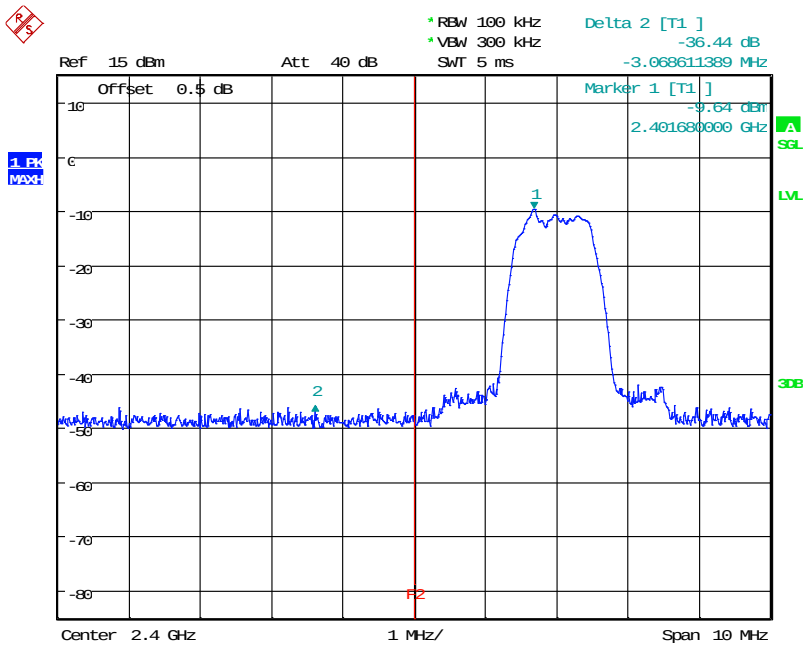
Band Edge, CH High



Date: 1.JUN.2018 13:49:17

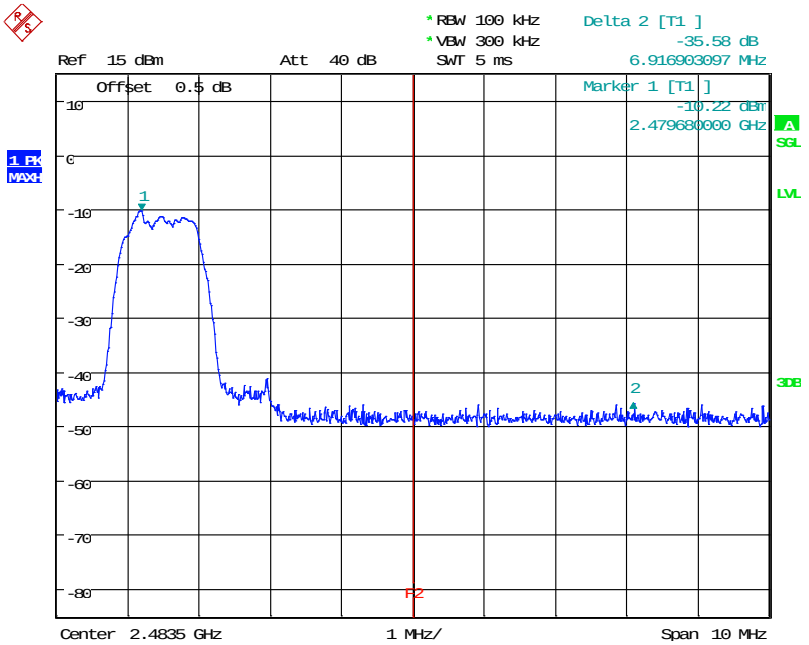
EDR Mode (π/4-DQPSK)

Band Edge, CH Low



Date: 1.JUN.2018 13:52:10

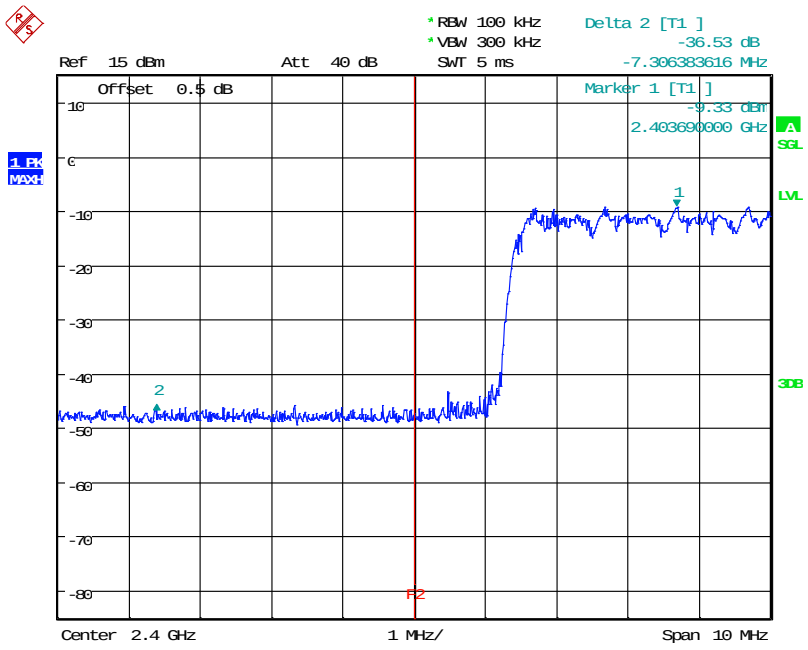
Band Edge, CH High



Date: 1.JUN.2018 13:56:32

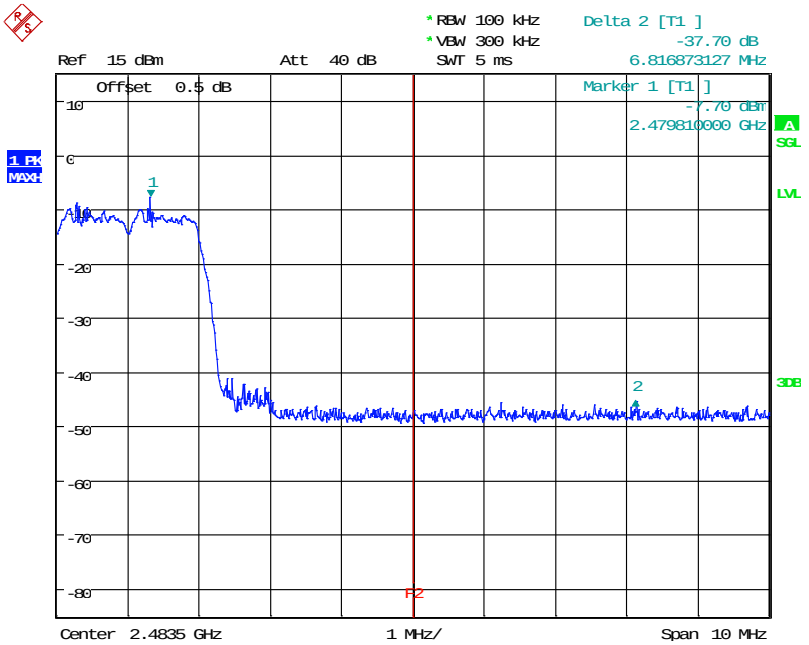
EDR Hopping Mode (π/4-DQPSK)

Band Edge, CH Low



Date: 1.JUN.2018 14:00:38

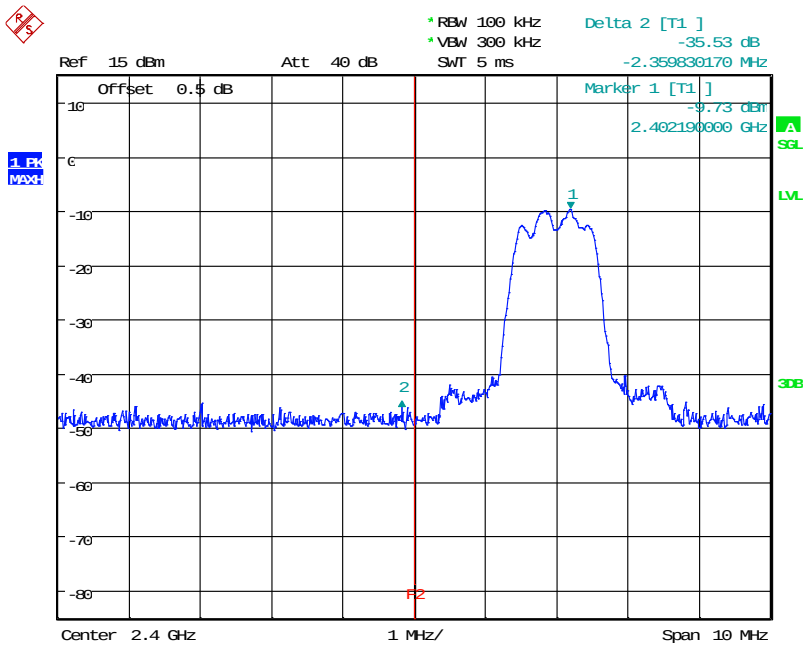
Band Edge, CH High



Date: 1.JUN.2018 14:01:20

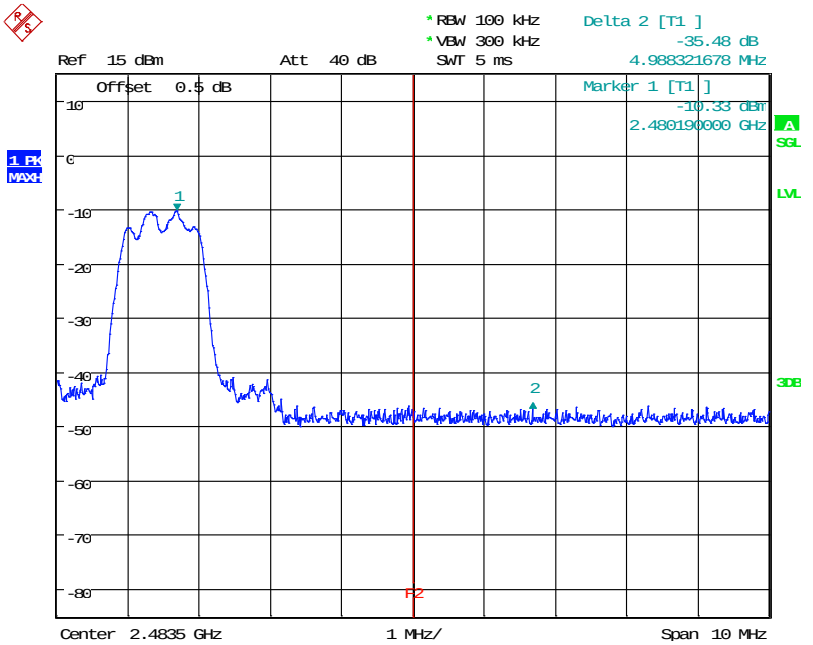
EDR Mode (8DPSK)

Band Edge, CH Low



Date: 1.JUN.2018 14:04:08

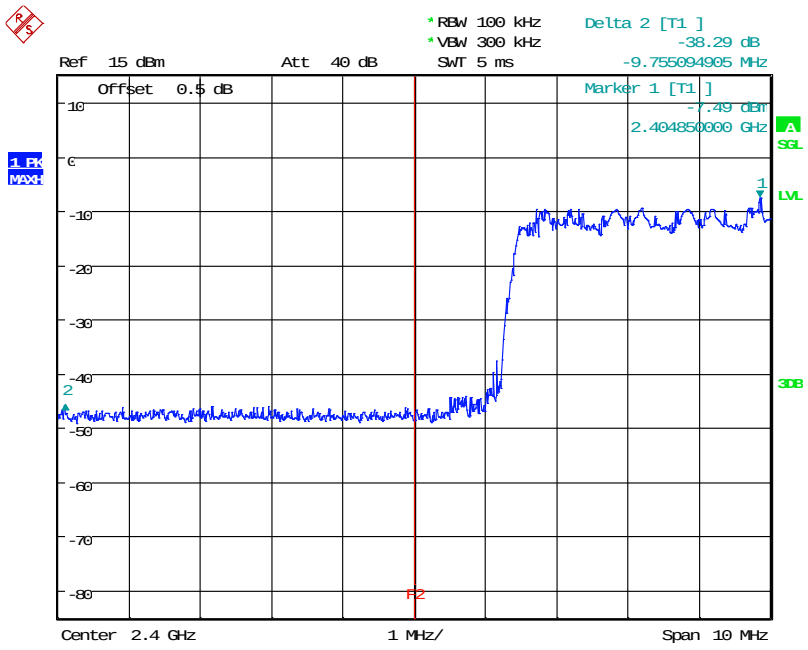
Band Edge, CH High



Date: 1.JUN.2018 14:08:42

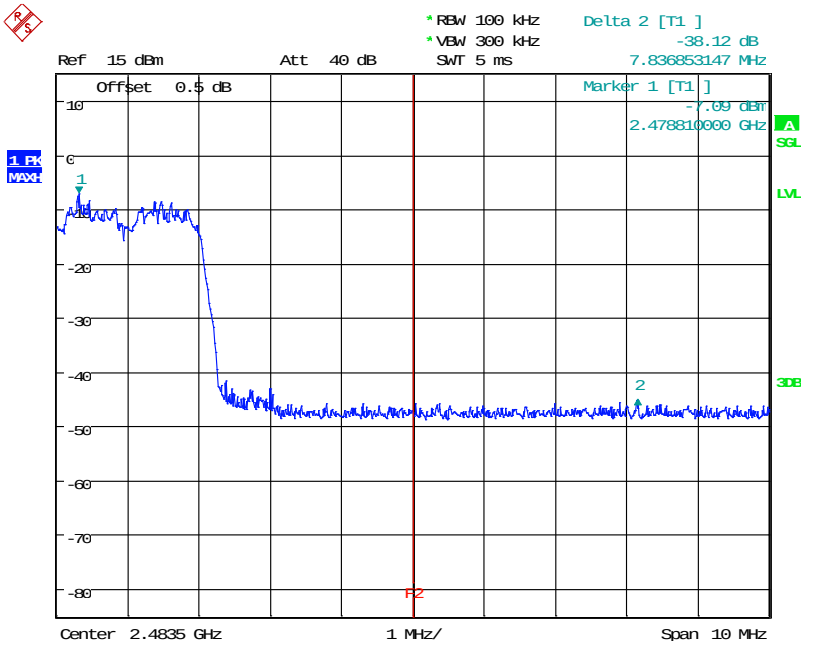
EDR Hopping Mode (8DPSK)

Band Edge, CH Low



Date: 1.JUN.2018 14:15:57

Band Edge, CH High



Date: 1.JUN.2018 14:17:08

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