TEST REPORT

Report No.:	**E201609264085-5**	**Application No.:**	**E201609264085**
Client:	Harman Automotive Electronic Systems (Suzhou) Co., Ltd.		
Address:	No.125 Fangzhou Road, SIP, Su Zhou, Jiangsu Province		
Sample Description:	Infotainment headunit		
Model:	MKC AU		
Adding Model:	Y015,Y028		
FCC ID:	2ACRLMKCAU		
Test Specification:	FCC Part 15.247,Subpart C:2014		
Test Date:	2017-04-11 to 2017-05-19		
Issue Date:	2017-05-19		
Test Result:	*Pass.*		

Prepared By:	**Reviewed By:**	**Approved By:**
Brian Xiao/ Test Engineer	Lynn Xiao / Technical Manager	Yong Dai / Manager
Brian Xiao	Lynn Xiao	Yong Dai
Date:2017-05-19	Date:2017-05-19	Date:2017-05-19

Other Aspects:

/

Abbreviations: *ok / P = passed; fail / F = failed; n.a. / N = not applicable*

The test result in this test report refers exclusively to the presented test sample. This report shall not be reproduced except in full, without the written approval of GRGT.

DIRECTIONS OF TEST

1. This station carries out test task according to the national regulation of verifications which can be traced to National Primary Standards and BIPM.

2. The test report merely corresponds to the test sample. It is not permitted to copy extracts of these test result without the written permission of the test laboratory.

3. If there is any objection concerning the test, the client should inform the laboratory within 15 days from the date of receiving the test report.

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1. TEST RESULT SUMMARY

FCC Part 15.247:2014			
Standard	**Item**	**Limit / Severity**	**Result**
FCC Part 15,Subpart C (15.247)	Antenna Requirement	Section 15.247 (c)	PASS
	Occupied Bandwidth	Section 15.247 (a1)	PASS
	Carrier Frequencies Separated	Section 15.247(a)(1)	PASS
	Hopping Channel Number	Section 15.247(a)(1)(iii)	PASS
	Dwell Time	Section 15.247(a)(1)(iii)	PASS
	Maximum Peak Output Power	Section 15.247(b)(1)	PASS
	Conducted Emission	Section 15.207	PASS
	Conducted Spurious Emission (30MHz to 25GHz)	Section 15.209 &15.247(d)	PASS
	Radiated Spurious Emission (30MHz to 25GHz)	Section 15.209 &15.247(d)	PASS
	Band Edges Measurement	Section 15.247 (d) &15.205	PASS

2. GENERAL DESCRIPTION OF EUT

2.1 APPLICANT

Name:	Harman Automotive Electronic Systems (Suzhou) Co., Ltd.
Address:	No.125 Fangzhou Road, SIP, Su Zhou, Jiangsu Province

2.2 MANUFACTURER

Name:	Harman Automotive Electronic Systems (Suzhou) Co., Ltd.
Address:	No.125 Fangzhou Road, SIP, Su Zhou, Jiangsu Province

2.3 BASIC DESCRIPTION OF EQUIPMENT UNDER TEST

Equipment:	Infotainment headunit
Model No.:	MKC AU
Adding Model:	Y015,Y028
Trade Name:	/
Power supply	DC 12V
Frequency Range	2402MHz~2480MHz
Type of Modulation	BT1:GFSK, 8DPSK, Pi/4 QPSK BT2:GFSK, 8DPSK, Pi/4 QPSK BT3:GFSK, 8DPSK, Pi/4 QPSK
Channels:	Channels with 1MHz step
Antenna Gain:	BT1:1.1dBi BT2:1.7dBi BT3:3.6dBi
Antenna Type:	BT1:External antenna BT2:External antenna BT3:External antenna
EUT connection description(Broadcom chip):	1. EUT connect with broadcom chip controller board to work in a fixed frequency and FHSS mode. 2. The broadcom chip controller board connects with computer from a USB port. The computer has installed Taraterm test software to control the board.
EUT connection description（CSR chip）:	1. EUT connect with CSR chip controller board to work in a fixed frequency and FHSS mode. The Bluetooth chip of EUT has six pins (VCC, SPI_CSB, SPI_CLK, SPI_MOSI, SPI_MISO and GND) to connect with same pins in controller board. 2. The CSR chip controller board connects with computer from a USB port. The computer has installed CSR test software (Blue suite) to control the board.
Note:	1. The EUT has three modular, the BT1 modular is Broadcom chip, the BT2 and BT3 modular are CSR chip. 2. For all of the test item are perform by the Y015 model.

2.4 LOCAL SUPPORTIVE INSTRUMENTS

Name of Equipment	Manufacturer	Model	Serial Number	Note
Display	Nihon Seiki	X047	285560085	/
Amplifier	Panasonic	EAZ16126	/	/
CAN BOX	Harman	NEW CAN-BOX HS	/	/
LVDS cable for display	SMK	/	/	/
BT1 antenna	Harada Industries	/	/	/
BT2 antenna	Harada Industries	/	/	/
BT3 antenna	Harada Industries	/	/	/
GPS antenna	Harada Industries	/	/	
FM/AM antenna	Harada Industries	/	/	
Headphone	SENA	/	/	/
Cable				
Main cable	Match	/	/	No shielded
USB 1 cable	SMK	/	/	No shielded
USB 2 cable	SMK	/	/	No shielded
LVDS cable	SMK	/	/	No shielded
Amplifier power cable	Panasonic	/	/	No shielded
Amplifier input cable	Panasonic	/	/	No shielded
Amplifier output cable	Panasonic	/	/	No shielded

3. LABORATORY AND ACCREDITATIONS

3.1 LABORATORY

The tests and measurements refer to this report were performed by Guangzhou GRG Metrology and Test CO., LTD.

Add. : 163 Pingyun Rd, West of Huangpu Ave, Guangzhou, 510656, P. R. China
Telephone: +86-20-38699959, 38699960, 38699961
Fax : +86-20-38695185

3.2 ACCREDITATIONS

Our laboratories are accredited and approved by the following approval agencies.

USA	FCC Listed Lab (No. 688188)
Canada	Registration No.:8355A-1

3.3 MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:

Measurement		Frequency	Uncertainty
Radiated Emission	Horizontal	30MHz～1000MHz	4.2dB
		1GHz～26.5GHz	4.2dB
	Vertical	30MHz～1000MHz	4.4dB
		1GHz～26.5GHz	4.4dB
Conducted Emission		9kHz～30MHz	3.1 dB

This uncertainty represents an expanded uncertainty factor of *k*=2.

3.4 LIST OF USED TEST EQUIPMENT AT GRGT

Name of Equipment	Manufacturer	Model	Serial Number	Calibration Due
Conducted Emissions				
EMI Receiver	R&S	ESCI	EMC2007-G049	2018-04-01
Single-phase LISN	SCHWARZBECK	NSLK8127	8127450	2017-06-22
Spurious Emissions/Restricted Bands				
Receiver	R&S	ESU26	EMC2014-G260	2017-12-27
Biconical Log-periodic Antenna	ETS.LINDGREN	3142C	EMC2007-JT56	2018-03-02
Horn antenna	SCHWARZBECK	BBHA9120 D	EMC2009-G070(1)	2018-01-06
Horn antenna	ETS.LINDGREN	3117C	EMC2007-JT54	2018-03-31
Pre-Amplifier	lunar	LNA1G18G-40	EMC2016-G763	2017-06-21
Semi-anechoic chamber	ETS	966(RFD-F/A-100)	EMC2007-JT47	2017-12-05
Occupied Bandwidth/ Dwell Time/ Carrier Frequency/ Hopping Channel Number/Maximum Peak Output Power/100kHz Bandwidth of Frequency Band Edge				
Signal Analyzer	R&S	FSV30	EMC2015-G089	2018-02-05

4. TEST RESULTS

4.1 E.U.T. TEST CONDITIONS

Type of antenna: **BT1:External antenna**
BT2:External antenna
BT3:External antenna

Temperature: **23.1 °C**

Humidity: **59% RH**

Atmospheric Pressure: **1011 mbar**

Test frequencies: **According to the 15.31(m) Measurements on intentional radiators or receivers, other than TV broadcast receivers, shall be performed and. if required. reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table:**

Frequency range over which device operates	Number of frequencies	Location in the range of operation
1 MHz or less	1	Middle
1 to 10 MHz	2	1 near top and 1 near bottom
More than 10 MHz	3	1 near top. 1 near middle and 1 near bottom

EUT for BT1,BT2 and BT3 channels and frequencies list:

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2402	14	2416	28	2430
1	2403	15	2417	29	2431
2	2404	16	2418	30	2432
3	2405	17	2419	31	2433
4	2406	18	2420	32	2434
5	2407	19	2421	33	2435
6	2408	20	2422	34	2436
7	2409	21	2423	35	2437
8	2410	22	2424	36	2438
9	2411	23	2425	37	2439
10	2412	24	2426	38	2440
11	2413	25	2427	39	2441
12	2414	26	2428	40	2442
13	2415	27	2429	41	2443

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
42	2444	55	2457	68	2470
43	2445	56	2458	69	2471
44	2446	57	2459	70	2472
45	2447	58	2460	71	2473
46	2448	59	2461	72	2474
47	2449	60	2462	73	2475
48	2450	61	2463	74	2476
49	2451	62	2464	75	2477
50	2452	63	2465	76	2478
51	2453	64	2466	77	2479
52	2454	65	2467	78	2480
53	2455	66	2468		
54	2456	67	2469		

Test frequency is the lowest channel: 0 channel(2402MHz), middle channel: 39 channel(2441MHz) and highest channel: 78 channel(2480MHz)

Frequency Hopping System Requirement

Test Requirement: Section 15.247 (a)(1), (g), (h) requirement:

The system shall hop to channel frequencies that are selected at the system hopping rate from a Pseudorandom 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.

Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hop sets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

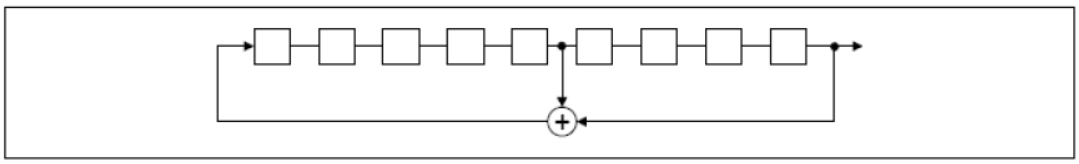
Compliance for section 15.247(a) (1)

According to Bluetooth Core Specification, the pseudorandom sequence may be generated in a ninestage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first ONE of 9 consecutive ONEs; i.e. the shift register is initialized with nine ones.

• Number of shift registers stages: 9

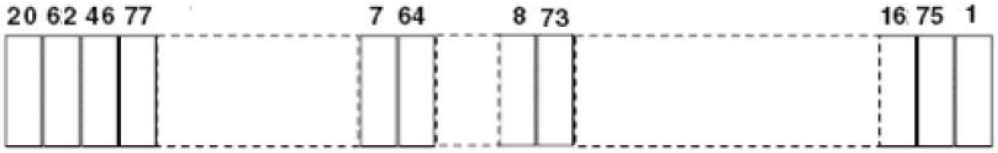
• Length of pseudo-random sequence: 2**9** -1 = 511 bits

• Longest sequence of zeros: 8 (non-inverted signal)



Linear Feedback Shift Register for Generation of the PRBS sequence

An example of Pseudorandom Frequency Hopping Sequence as follow:



Each frequency used equally on the average by each transmitter.

According to Bluetooth Core Specification, Bluetooth receivers are designed to have input and IF bandwidths that match the hopping channel bandwidths of any Bluetooth transmitters and shift frequencies in synchronization with the transmitted signals.

Compliance for section 15.247(g)

According to Bluetooth Core Specification, the Bluetooth system transmits the packet with the pseudorandom hopping frequency with a continuous data and the short burst transmission from the Bluetooth system is also transmitted under the frequency hopping system with the pseudorandom hopping frequency system.

Compliance for section 15.247(h)

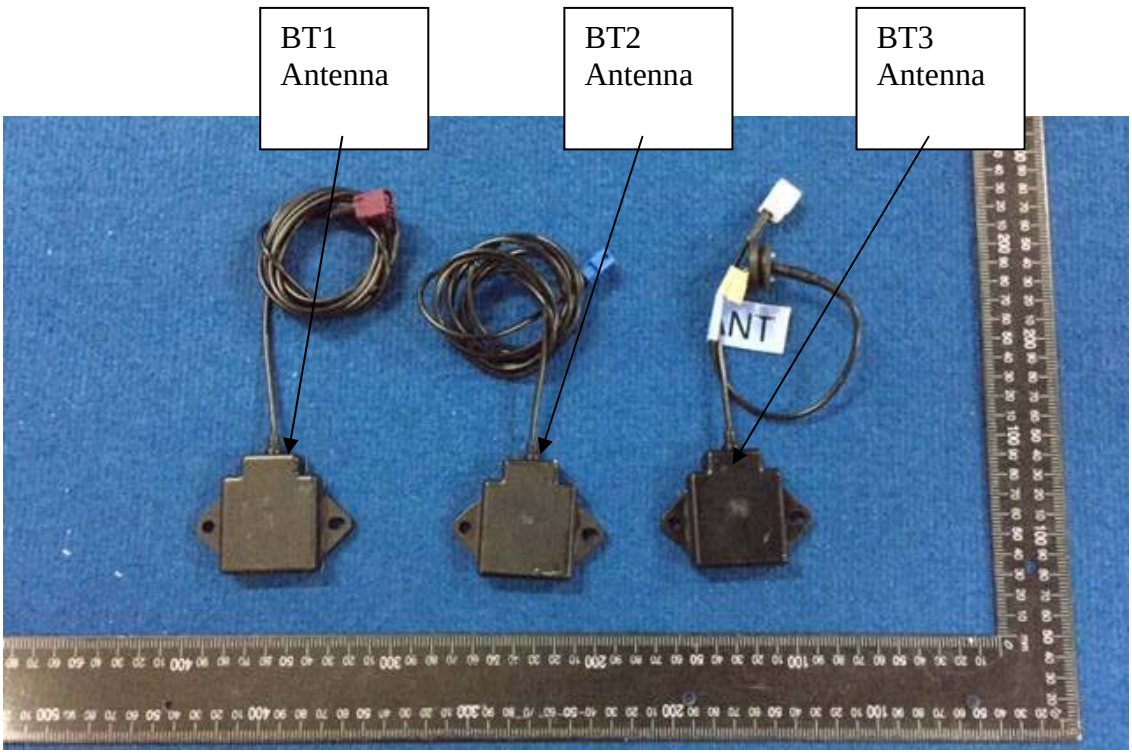
According to Bluetooth Core specification, the Bluetooth system incorporates with an adaptive system to detect other user within the spectrum band so that it individually and independently to avoid hopping on the occupied channels.

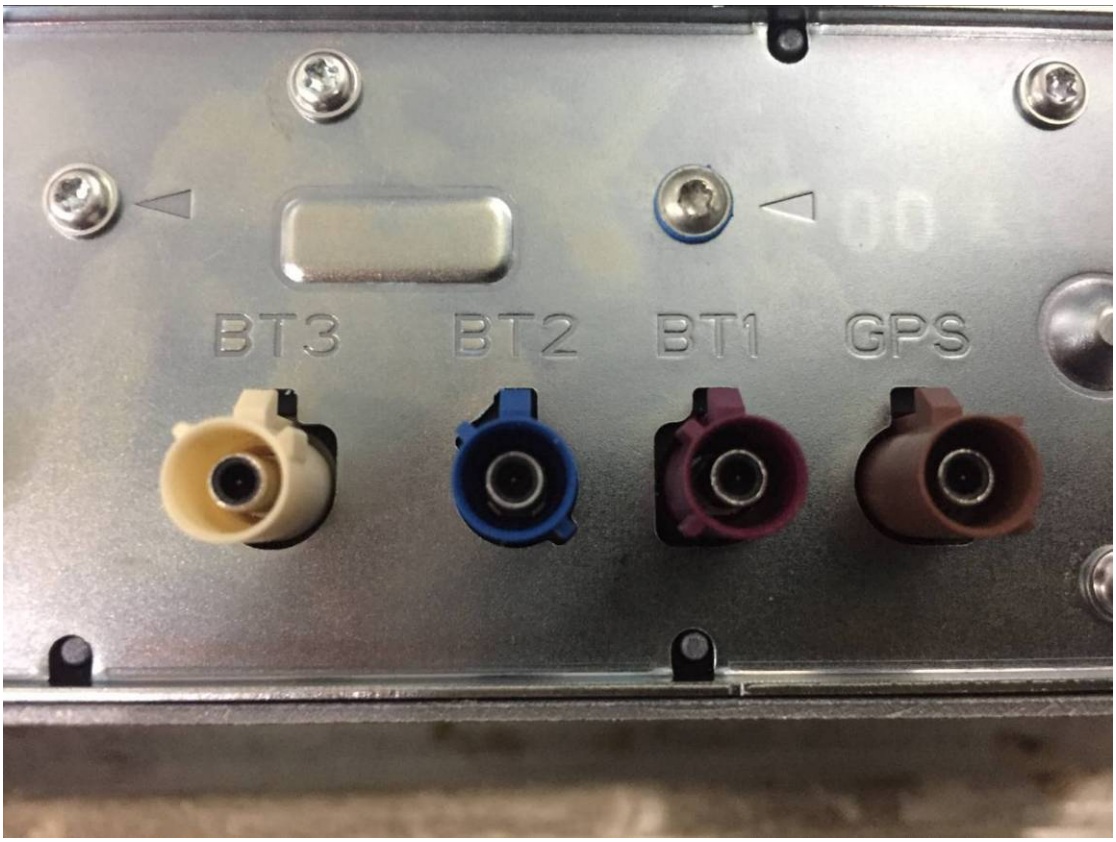
According to the Bluetooth Core specification, the Bluetooth system is designed not have the ability to coordinate with other FHSS System in an effort to avoid the simultaneous occupancy of individual hopping frequencies by multiple transmitter.

Reference document: BlueMod+B20-The Official Bluetooth SIG Member Website and The Official Bluetooth SIG Member Website BCM89335.

4.2 ANTENNA REQUIREMENT

The EUT antenna is External antenna(The antenna connector type is Fakra). BT1 Antenna gain is 1.1dBi, BT2 Antenna gain is 1.7dBi, BT3 Antenna gain is 3.6dBi .which accordance 15.203.is considered sufficient to comply with the provisions of this section.




BT3
BT2
BT1
GPS

4.3 OCCUPIED BANDWIDTH

4.3.1 LIMITS

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.

4.3.2 TEST PROCEDURES

1. Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum;
2. Set the spectrum analyzer: Span = approximately 2 to 3 times the 20dB bandwidth, centre on a hopping channel;
3. Set the spectrum analyzer: RBW >= 1% of the 20dB bandwidth (set 10 kHz). VBW >= RBW. Sweep = auto; Detector Function = Peak. Trace = Max Hold.
4. Mark the peak frequency and -20dB bandwidth.
5. Bandwidth value is OBW value.

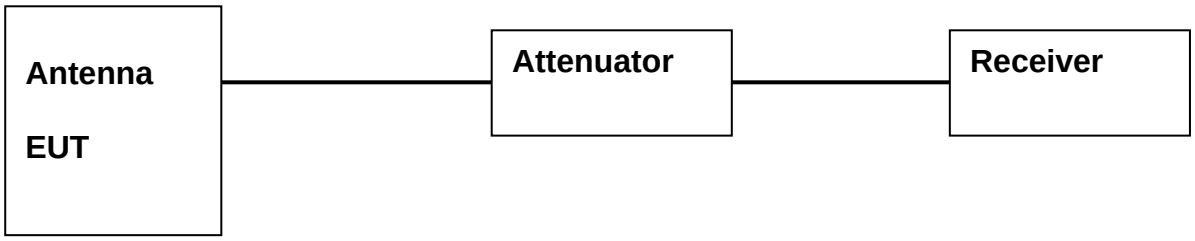
Remark:

BT1:Pre-test the 3 modulation to find GFSK and 8DPSK is worse case, so only record GFSK and 8DPSK test data.

BT2:Pre-test the 3 modulation to find GFSK and 8DPSK is worse case, so only record GFSK and 8DPSK test data.

BT3:Pre-test the 3 modulation to find GFSK and 8DPSK is worse case, so only record GFSK and 8DPSK test data.

4.3.3 TEST SETUP



4.3.4 TEST RESULTS

BT1:

For GFSK

Frequency (GHz)	Test Channel	bandwidth
2.402	Lowest	0.923MHz
2.441	Middle	0.923MHz
2.480	Highest	0.924MHz

For 8DPSK

Frequency (GHz)	Test Channel	bandwidth
2.402	Lowest	1.324MHz
2.441	Middle	1.322MHz
2.480	Highest	1.324MHz

BT2:

For GFSK

Frequency (GHz)	Test Channel	bandwidth
2.402	Lowest	0.923MHz
2.441	Middle	0.922MHz
2.480	Highest	0.922MHz

For 8DPSK

Frequency (GHz)	Test Channel	bandwidth
2.402	Lowest	1.293MHz
2.441	Middle	1.264MHz
2.480	Highest	1.260MHz

BT3:

For GFSK

Frequency (GHz)	Test Channel	bandwidth
2.402	Lowest	0.923MHz
2.441	Middle	0.923MHz
2.480	Highest	0.923MHz

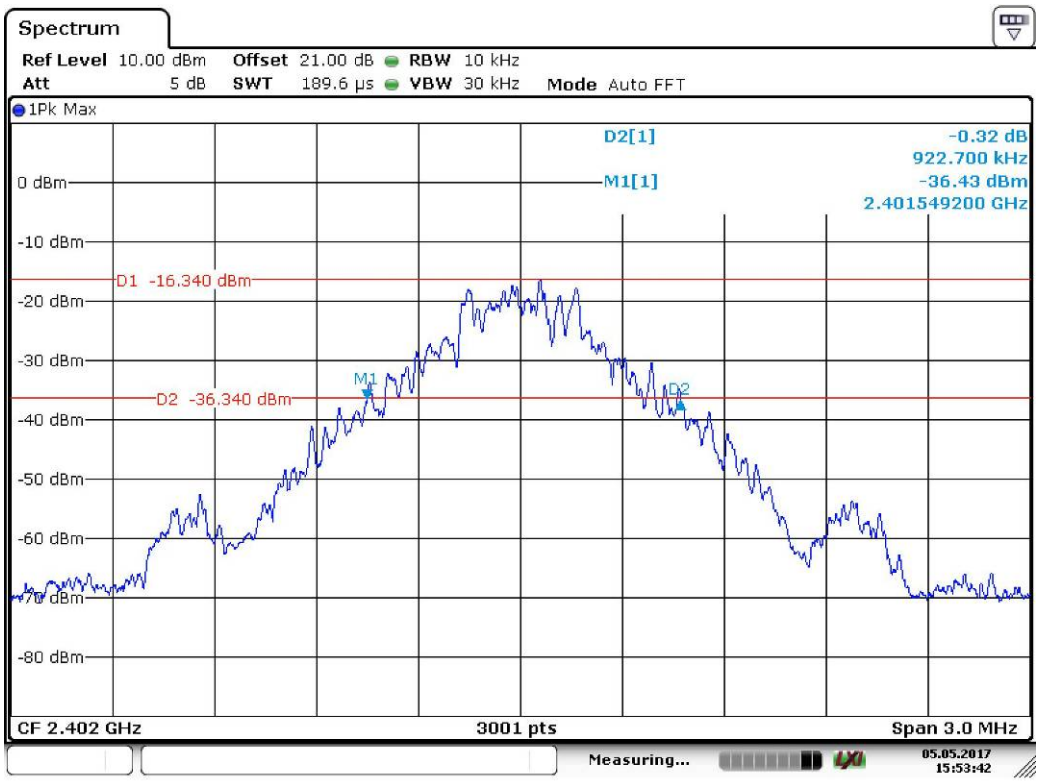
For 8DPSK

Frequency (GHz)	Test Channel	bandwidth
2.402	Lowest	1.283MHz
2.441	Middle	1.261MHz
2.480	Highest	1.259MHz

Result plot as follows:

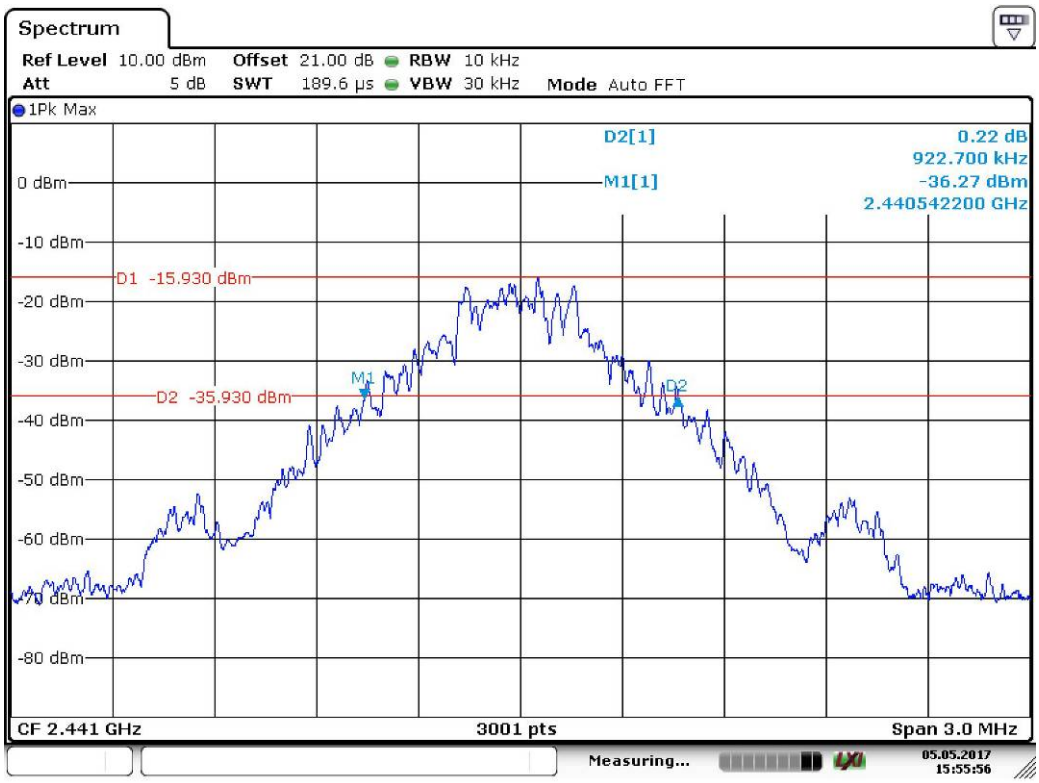
BT1:

GFSK Lowest Channel:



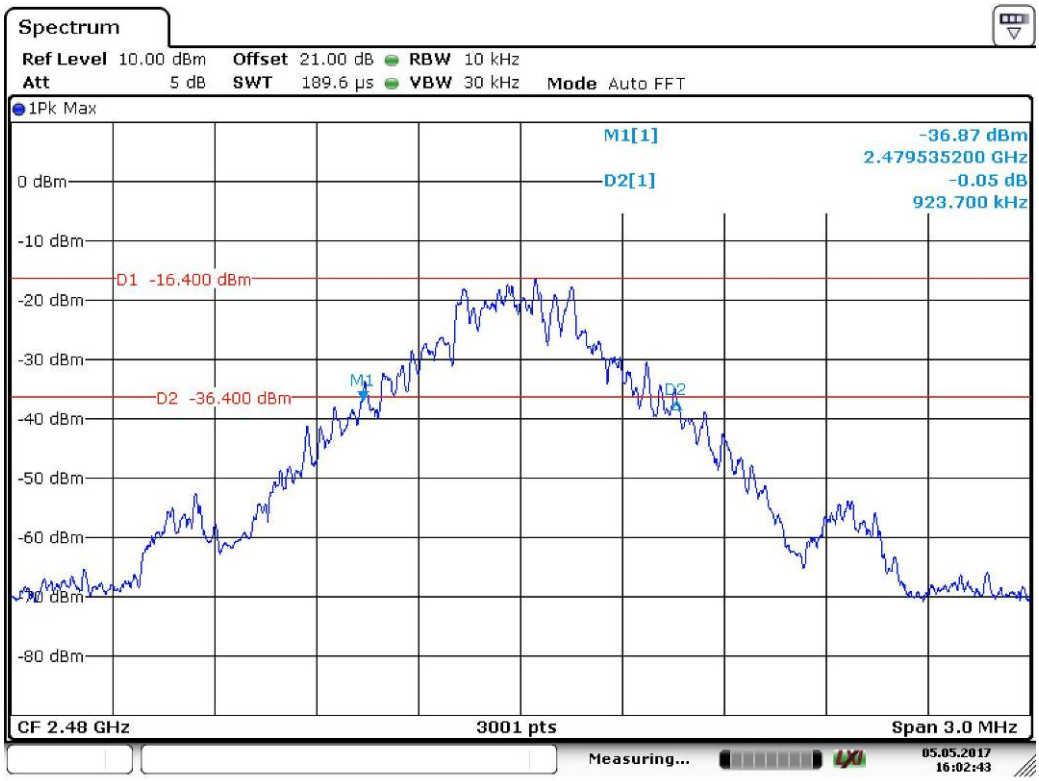
Date: 5.MAY.2017 15:53:42

GFSK Middle Channel:



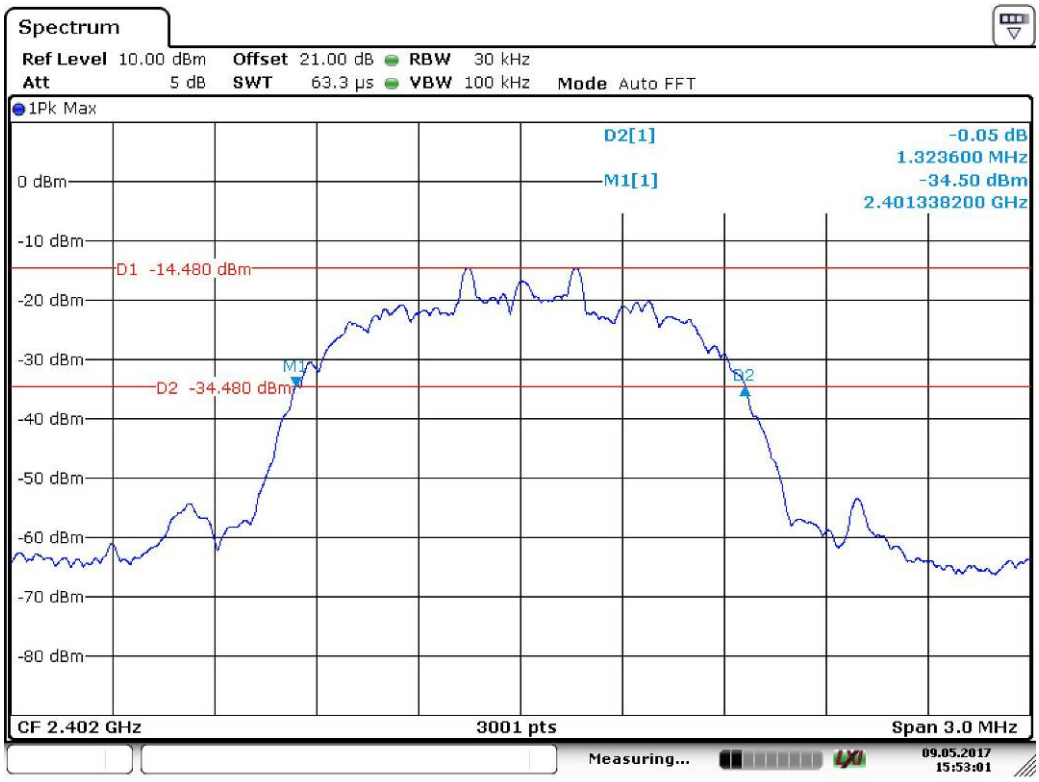
Date: 5.MAY.2017 15:55:57

GFSK Highest Channel:



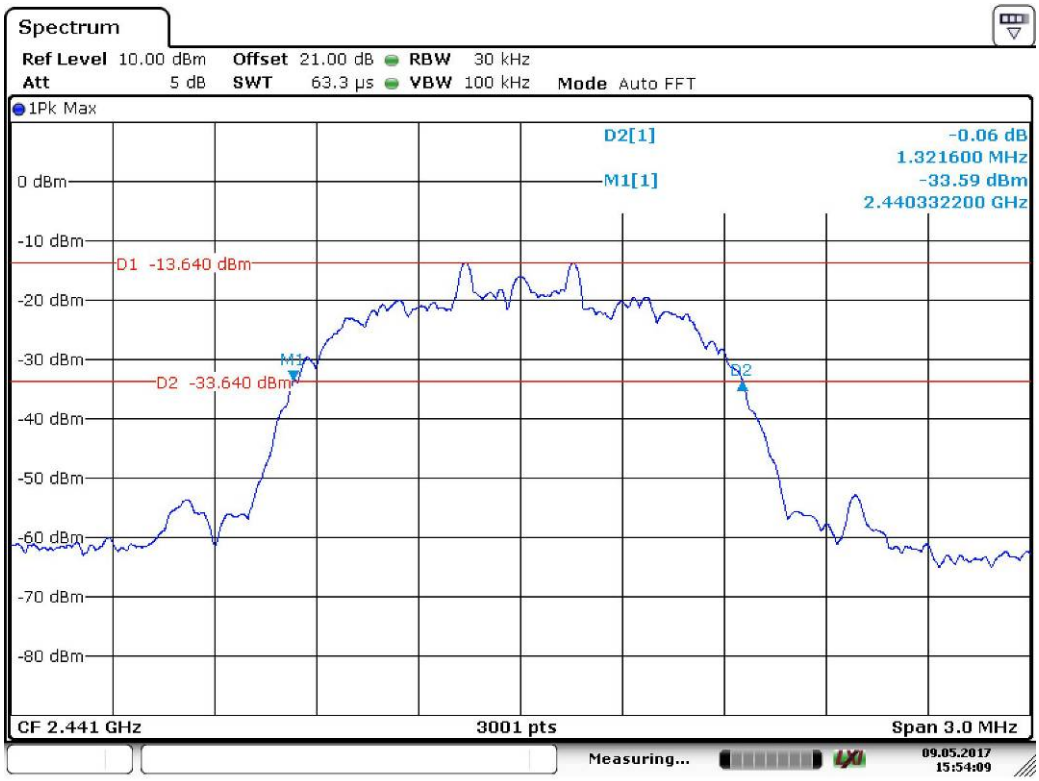
Date: 5.MAY.2017 16:02:43

8DPSK Lowest Channel:



Date: 9.MAY.2017 15:53:01

8DPSK Middle Channel:



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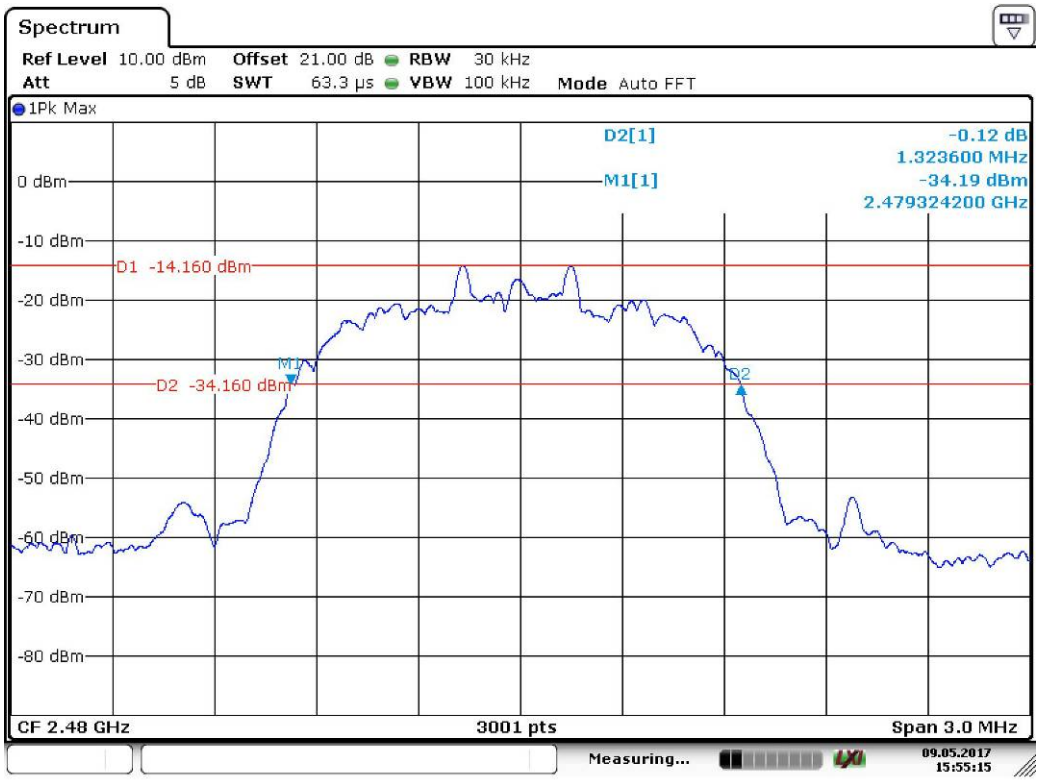
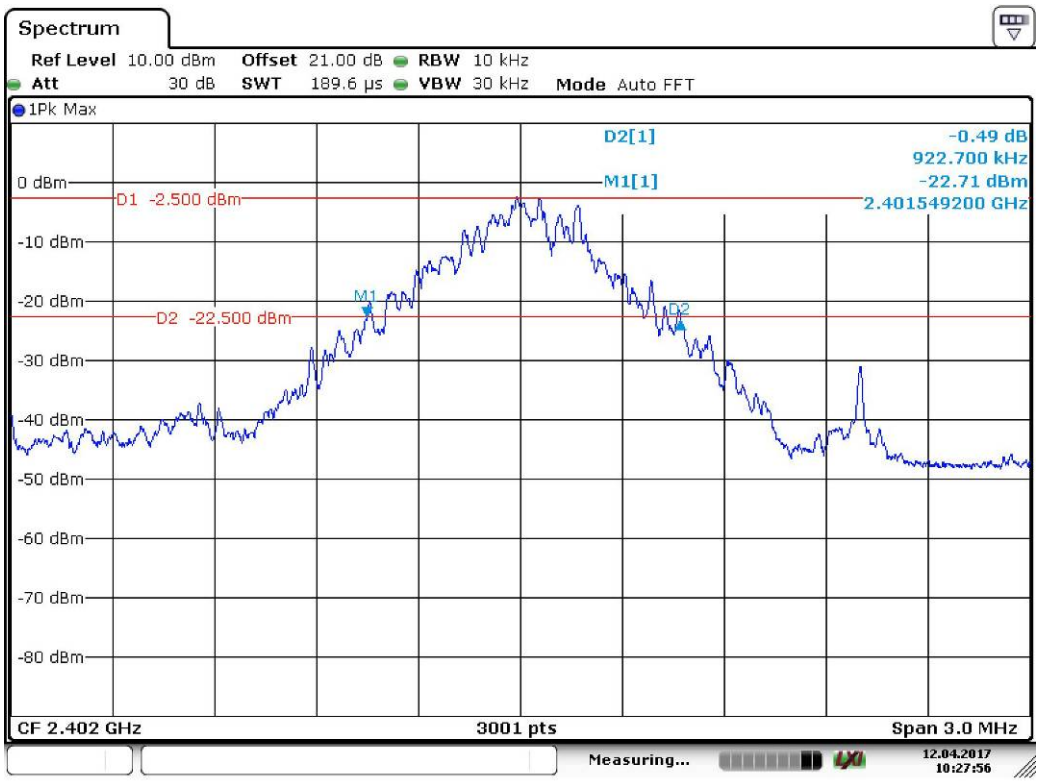
8DPSK Highest Channel:



Date: 9.MAY.2017 15:55:15

BT2:

GFSK Lowest Channel:



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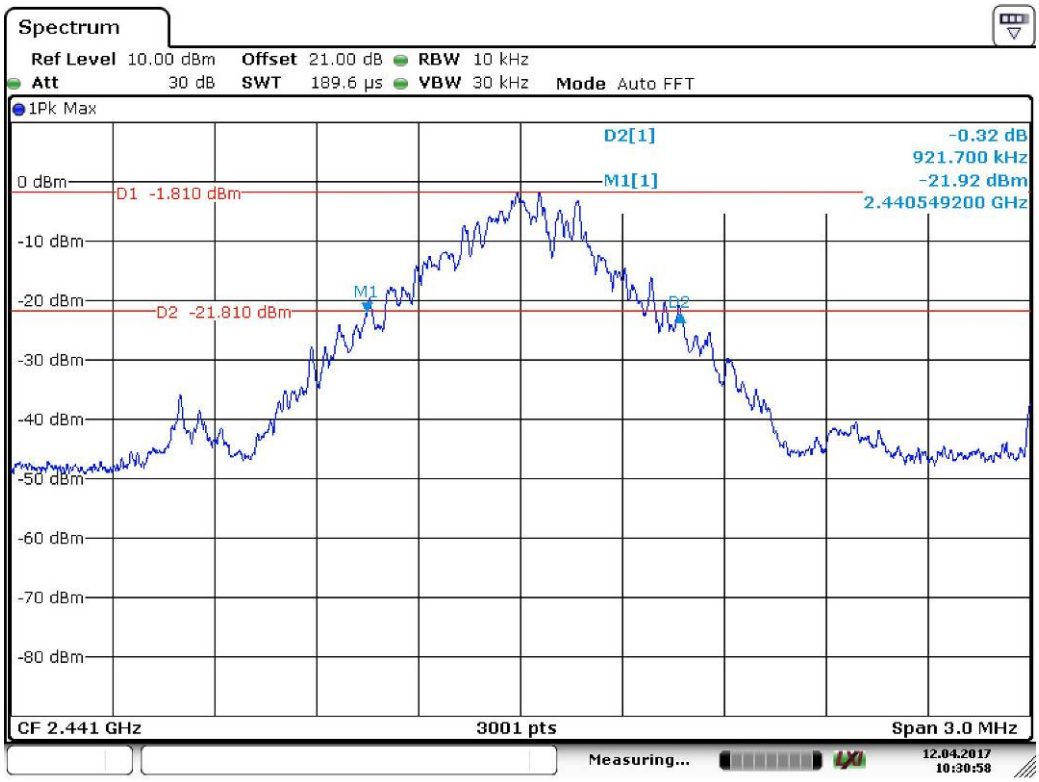
GFSK Middle Channel:



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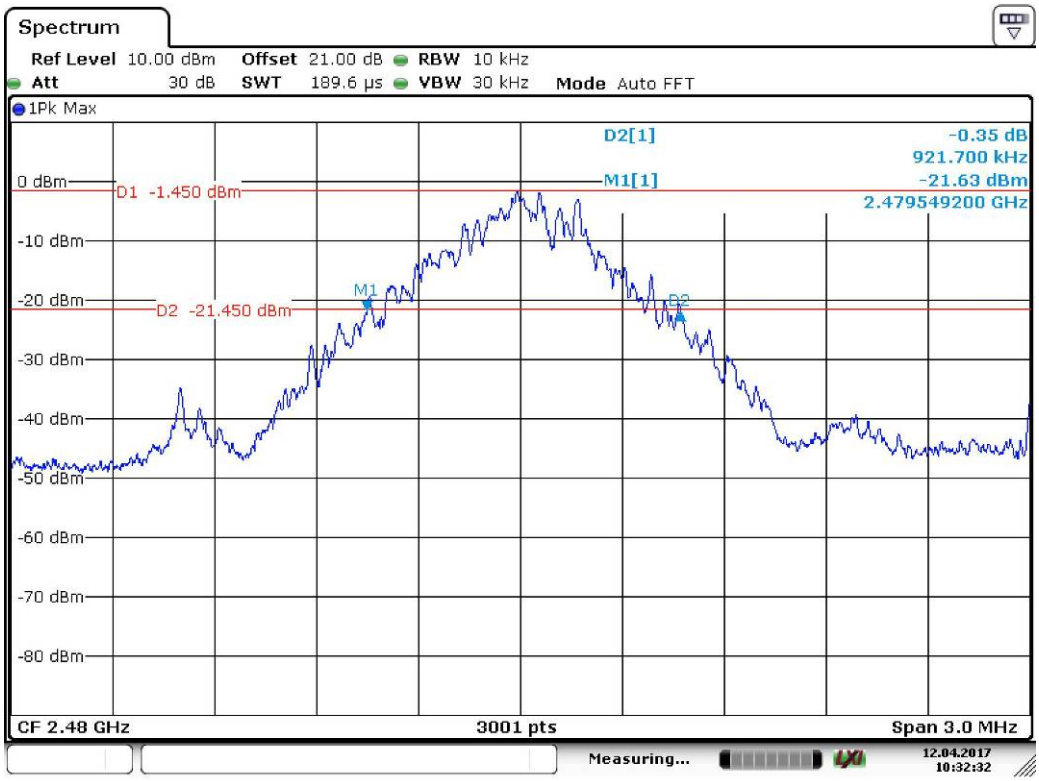
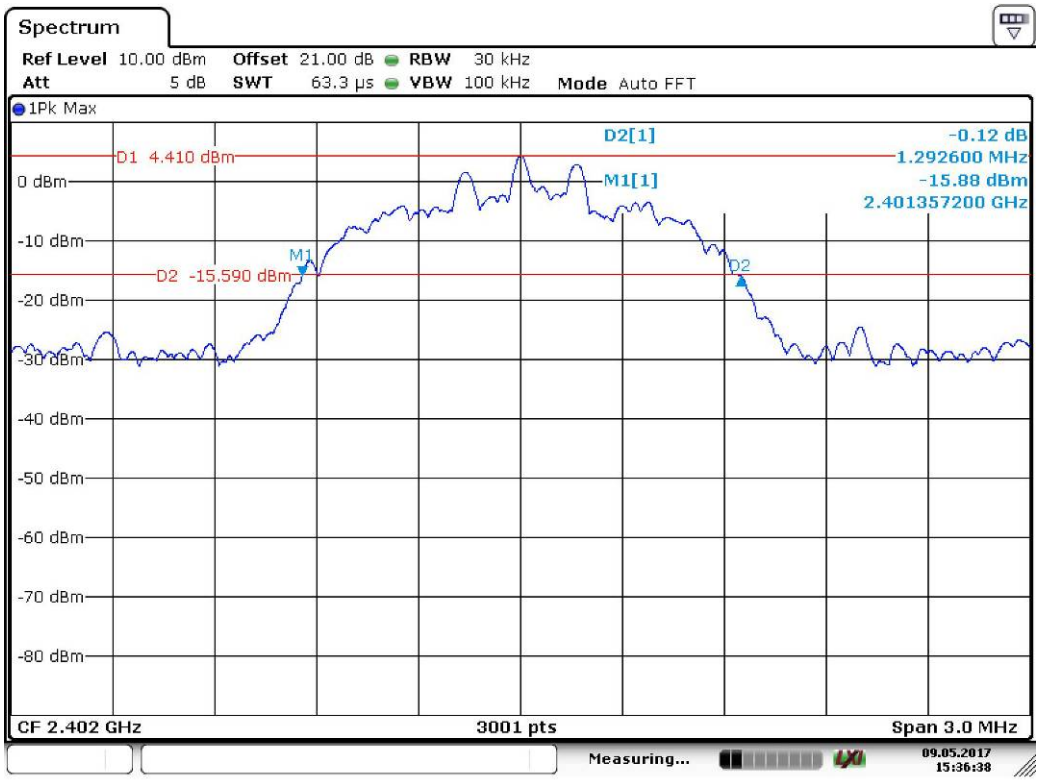


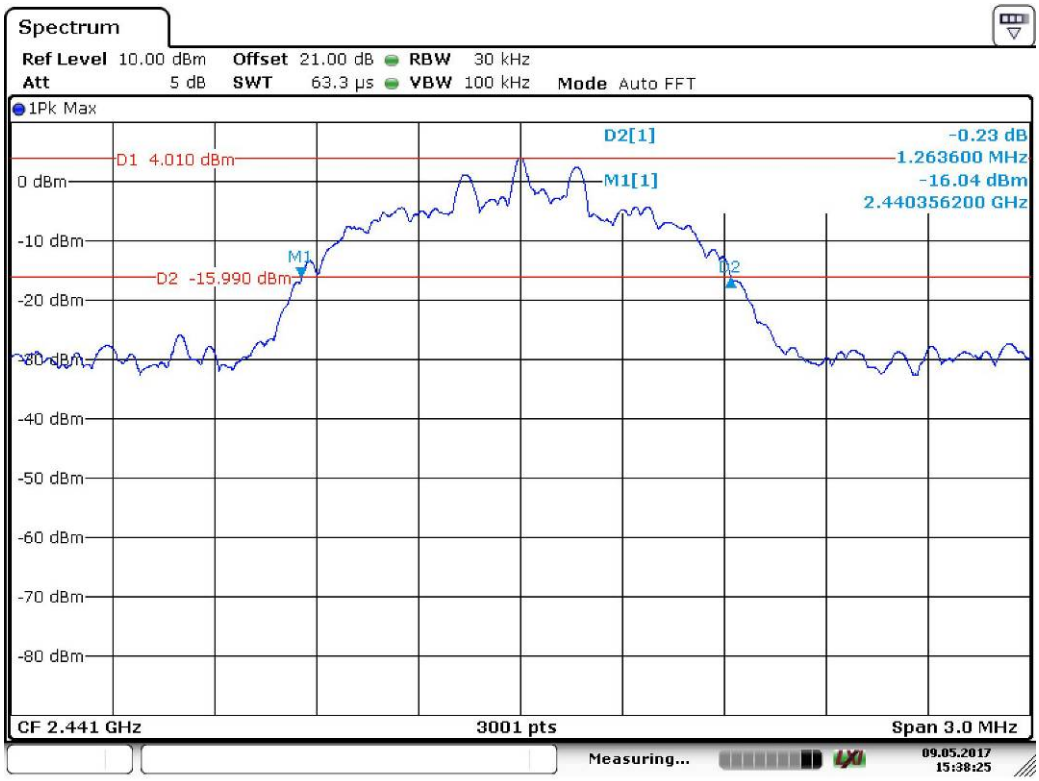
Date: 12.APR.2017 10:32:32

8DPSK Lowest Channel:



Date: 9.MAY.2017 15:36:38

8DPSK Middle Channel:



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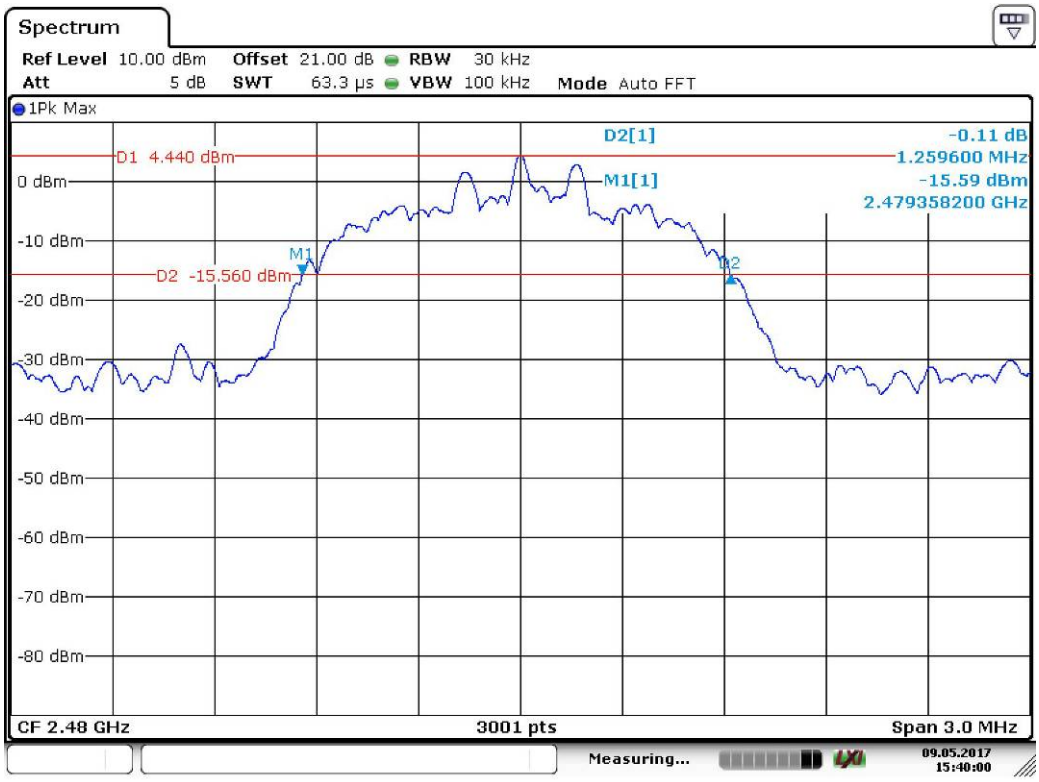
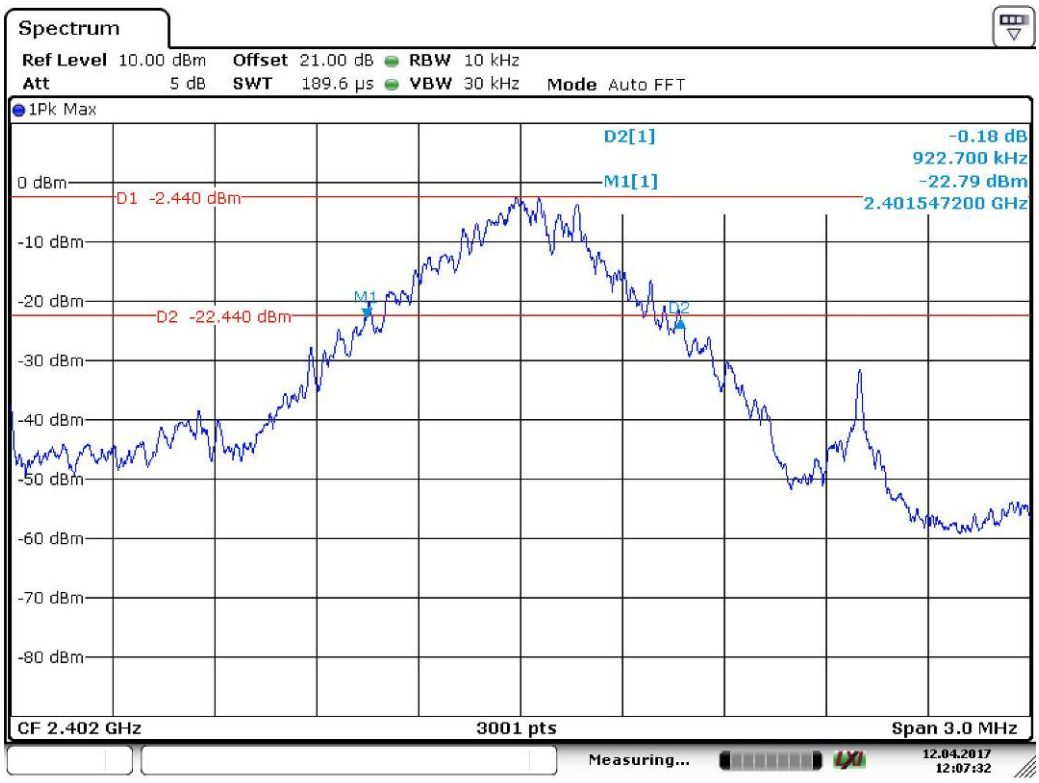
8DPSK Highest Channel:



Date: 9.MAY.2017 15:40:01

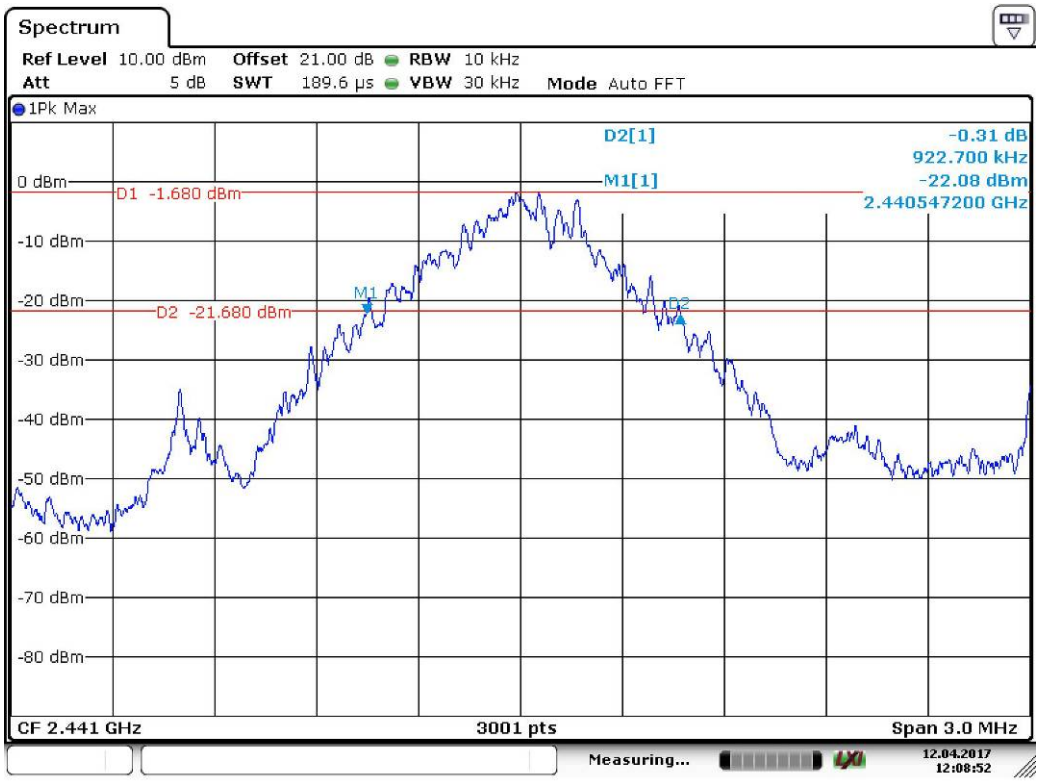
BT3:

GFSK Lowest Channel:



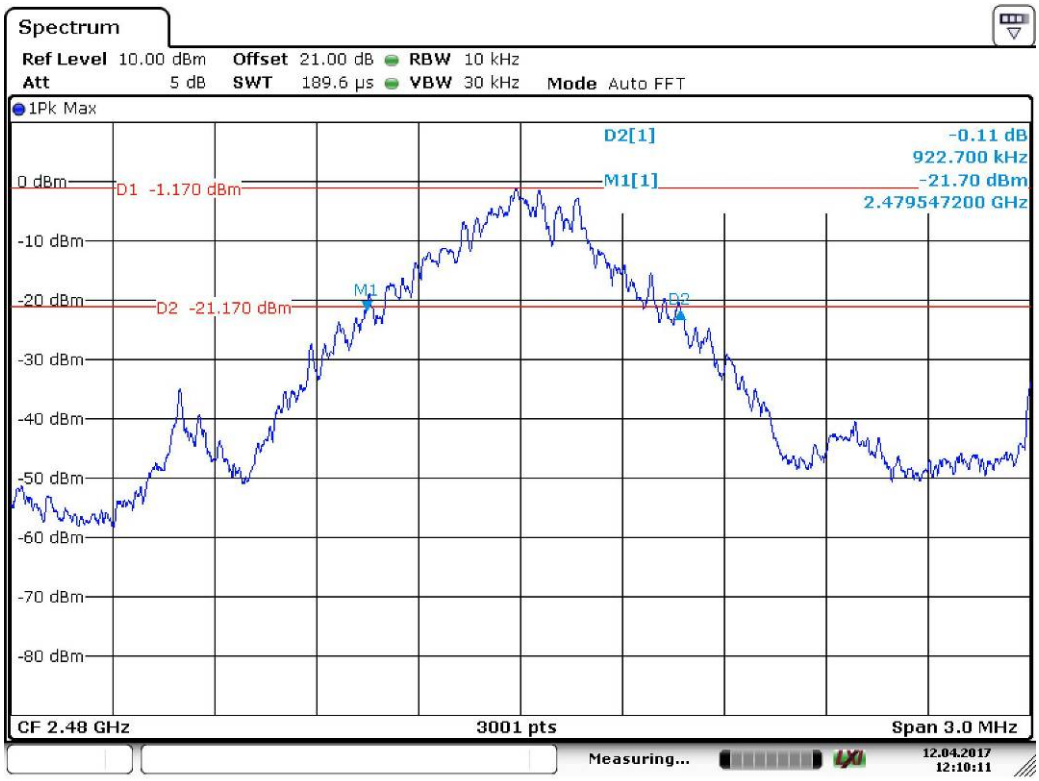
Date: 12.APR.2017 12:07:32

GFSK Middle Channel:



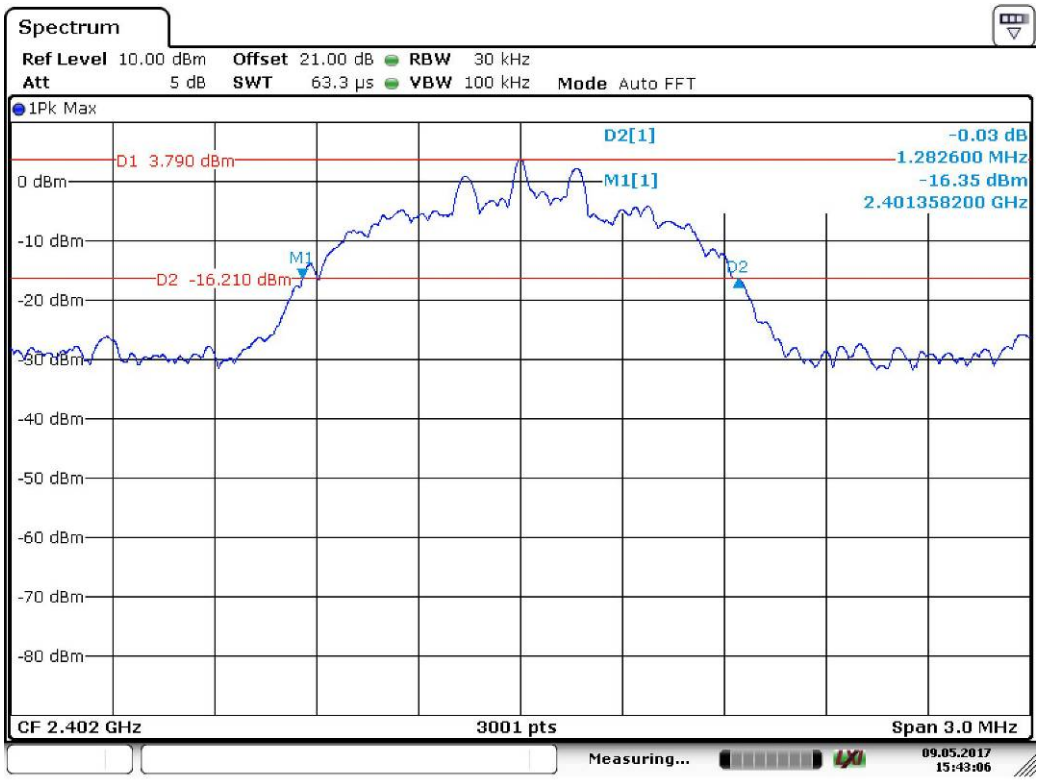
Date: 12.APR.2017 12:08:52

GFSK Highest Channel:



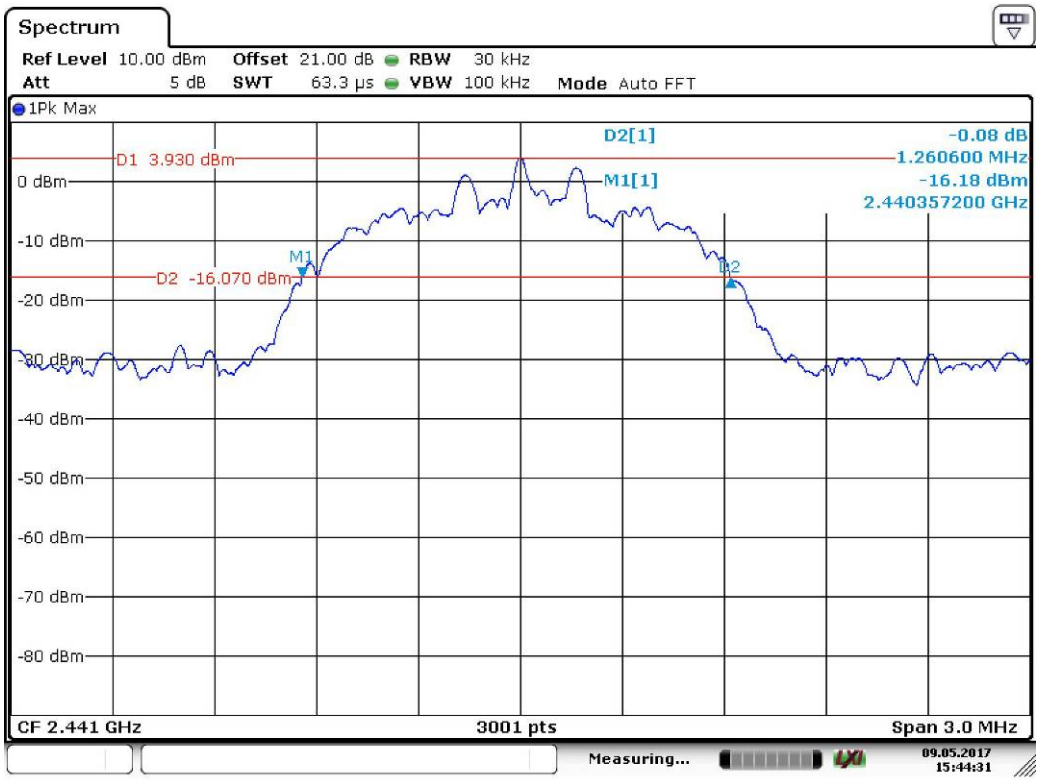
Date: 12.APR.2017 12:10:11

8DPSK Lowest Channel:



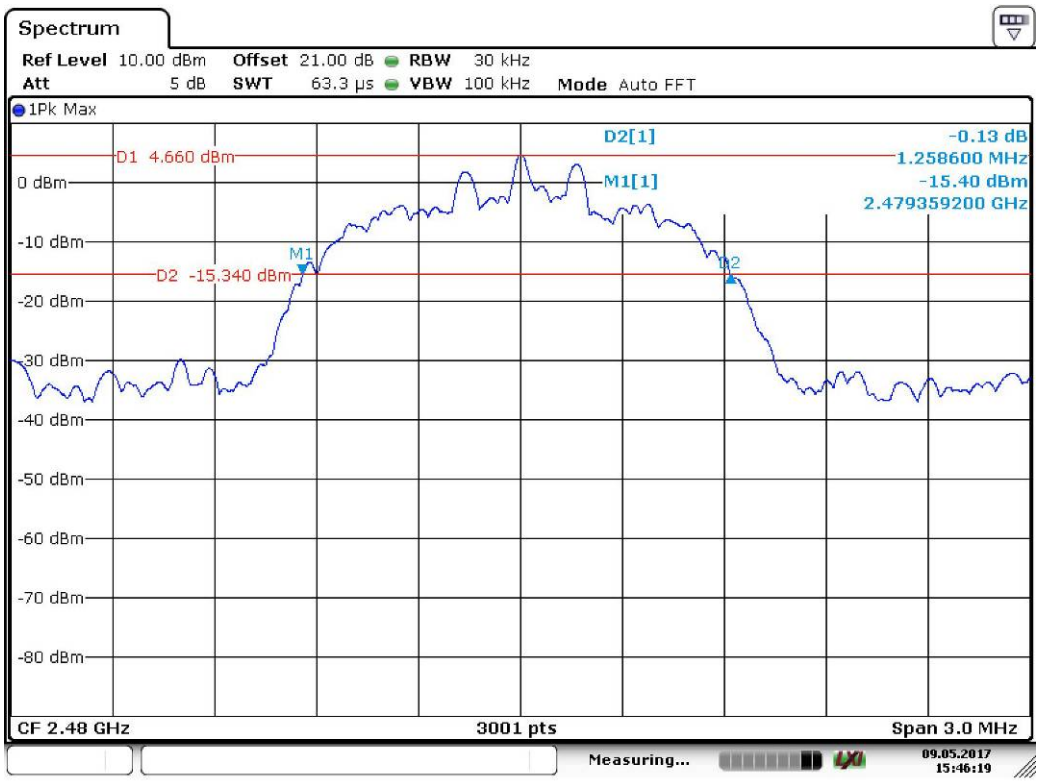
Date: 9.MAY.2017 15:43:06

8DPSK Middle Channel:



Date: 9.MAY.2017 15:44:31

8DPSK Highest Channel:



Date: 9.MAY.2017 15:46:19

4.4 CARRIER FREQUENCIES SEPARATED

4.4.1 LIMITS

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.

4.4.2 TEST PROCEDURES

1. Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum.
2. Set the spectrum analyzer: RBW >= 1% of the span (set 100 kHz). VBW >= RBW, Span = 3MHz. Sweep = auto; Detector Function = Peak. Trace = Max, hold.
3. Allow the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels. The limit is specified in one of the subparagraphs of this Section. Submit this plot.

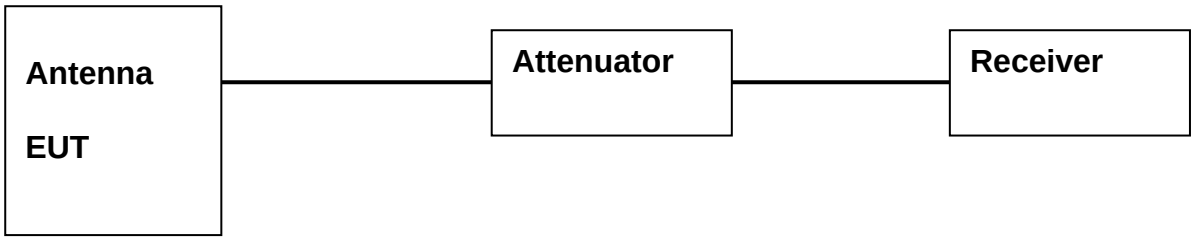
Remark：

BT1:Pre-test the 3 modulation to find GFSK and 8DPSK is worse case, so only record GFSK and 8DPSK test data.

BT2:Pre-test the 3 modulation to find GFSK and 8DPSK is worse case, so only record GFSK and 8DPSK test data.

BT3:Pre-test the 3 modulation to find GFSK and 8DPSK is worse case, so only record GFSK and 8DPSK test data.

4.4.3 TEST SETUP



4.4.4 TEST RESULTS

BT1：

Mode	Test Channel	Carrier Frequencies Separated	2/3 20 dB bandwidth	PASS/FAIL
GFSK	Lower Channels (channel 0 and channel 1)	1.002MHz	0.615 MHz	Pass
	Middle Channels (channel 39 and channel 40)	0.994MHz	0.615 MHz	Pass
	Upper Channels (channel 77 and channel 78)	0.992MHz	0.616 MHz	Pass
8DPSK	Lower Channels (channel 0 and channel 1)	0.999MHz	0.883 MHz	Pass
	Middle Channels (channel 39 and channel 40)	0.995MHz	0.881 MHz	Pass
	Upper Channels (channel 77 and channel 78)	0.999MHz	0.883 MHz	Pass

BT2：

Mode	Test Channel	Carrier Frequencies Separated	2/3 20 dB bandwidth	PASS/FAIL
GFSK	Lower Channels (channel 0 and channel 1)	1.001MHz	0.615 MHz	Pass
	Middle Channels (channel 39 and channel 40)	1.003MHz	0.615 MHz	Pass
	Upper Channels (channel 77 and channel 78)	1.002MHz	0.615 MHz	Pass
8DPSK	Lower Channels (channel 0 and channel 1)	1.006MHz	0.862 MHz	Pass
	Middle Channels (channel 39 and channel 40)	1.010MHz	0.843 MHz	Pass
	Upper Channels (channel 77 and channel 78)	1.006MHz	0.840 MHz	Pass

BT3：

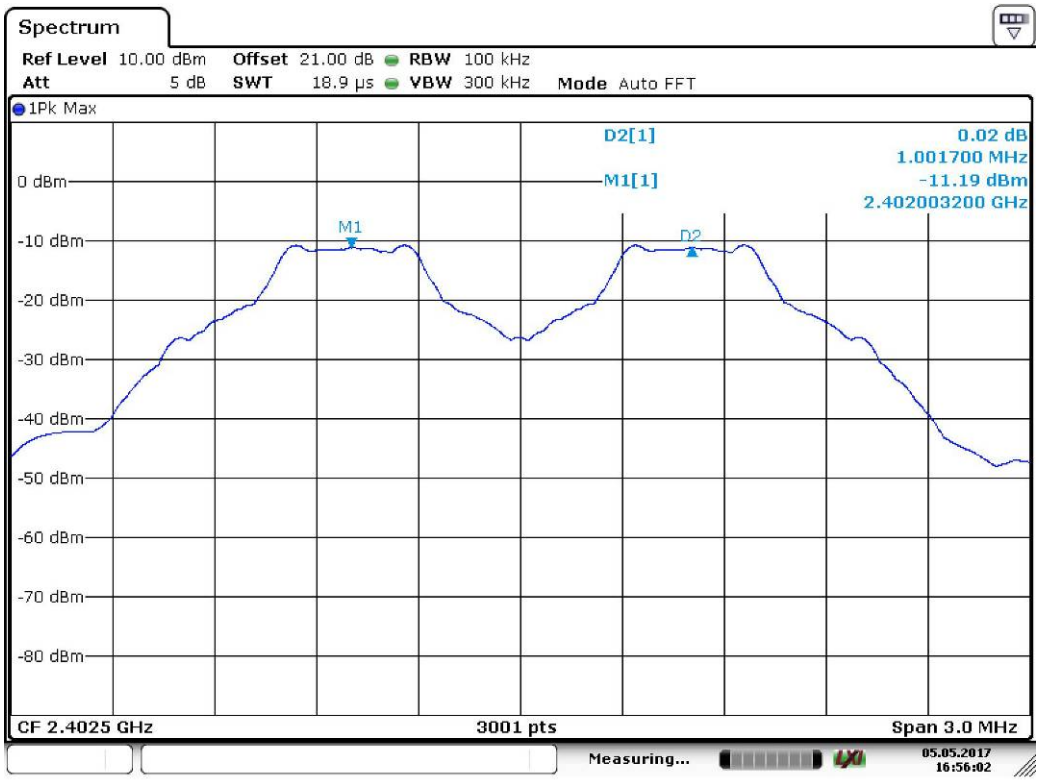
Mode	Test Channel	Carrier Frequencies Separated	2/3 20 dB bandwidth	PASS/FAIL
GFSK	Lower Channels (channel 0 and channel 1)	1.001MHz	0.615 MHz	Pass
	Middle Channels (channel 39 and channel 40)	1.003MHz	0.615 MHz	Pass
	Upper Channels (channel 77 and channel 78)	1.001MHz	0.615 MHz	Pass
8DPSK	Lower Channels (channel 0 and channel 1)	1.007MHz	0.855 MHz	Pass
	Middle Channels (channel 39 and channel 40)	1.005MHz	0.841 MHz	Pass
	Upper Channels (channel 77 and channel 78)	1.003MHz	0.839 MHz	Pass

Note: The two-thirds of the 20 dB bandwidth is greater than 25 kHz, so the limit for the two-thirds of the 20 dB bandwidth is applied.

Result plot as follows:

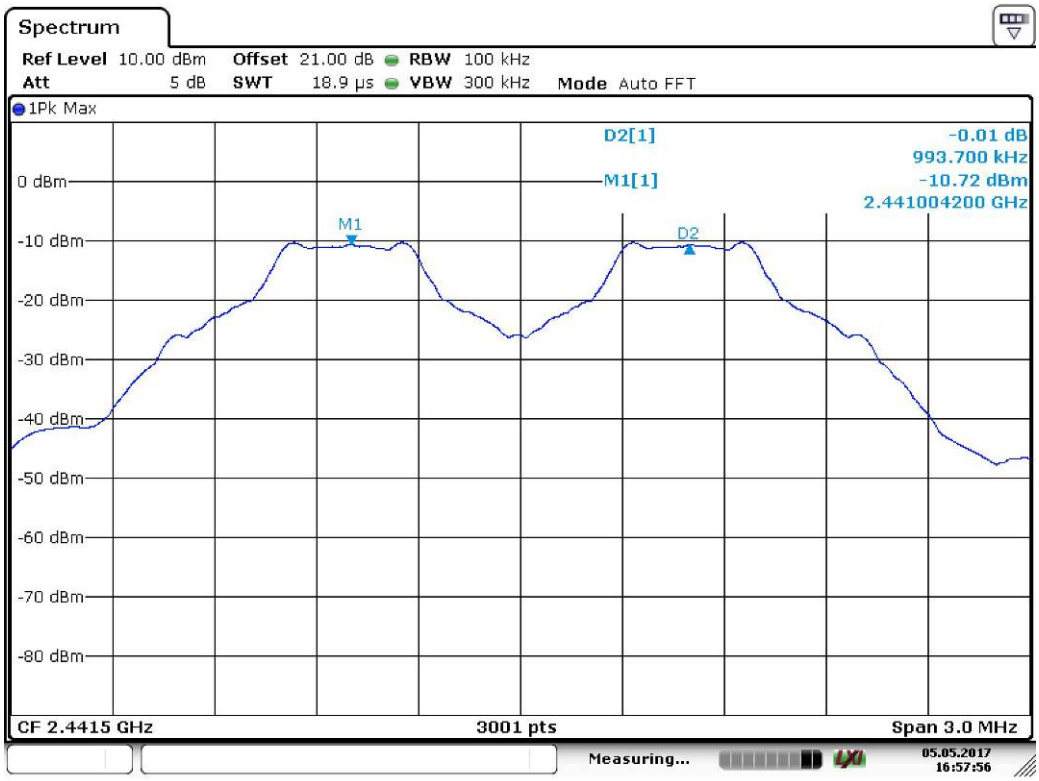
BT1:

GFSK Lowest Channels:



Date: 5.MAY.2017 16:56:02

GFSK Middle Channels:

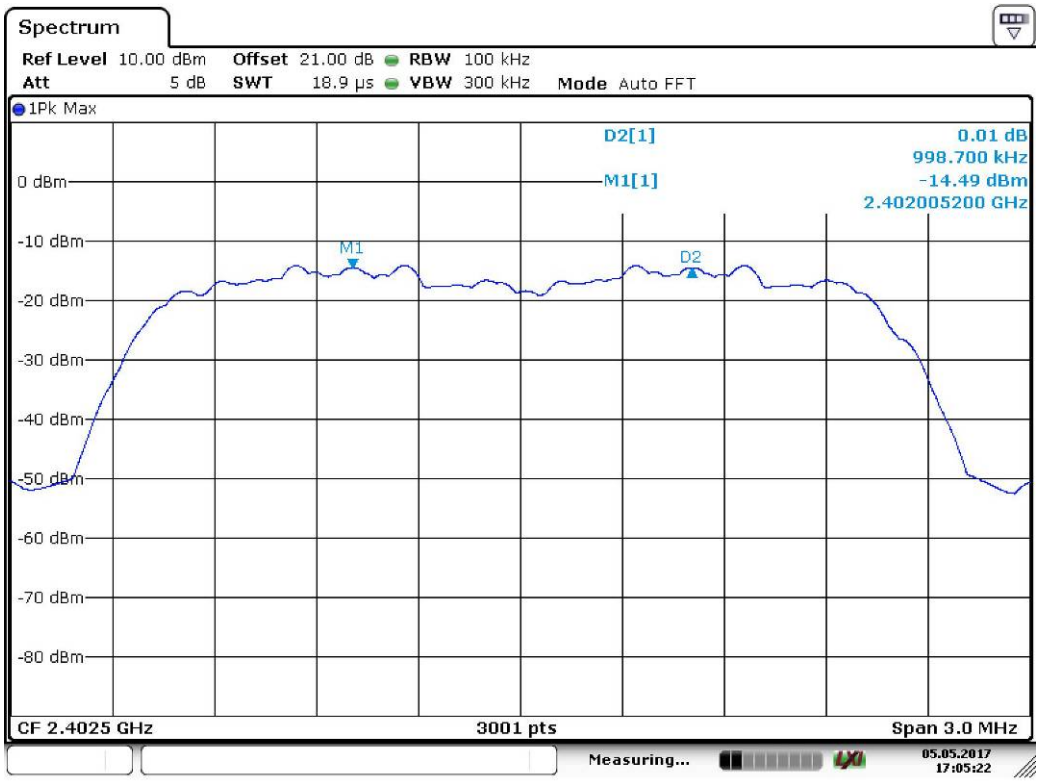


Date: 5.MAY.2017 16:57:56

GFSK Highest Channels:

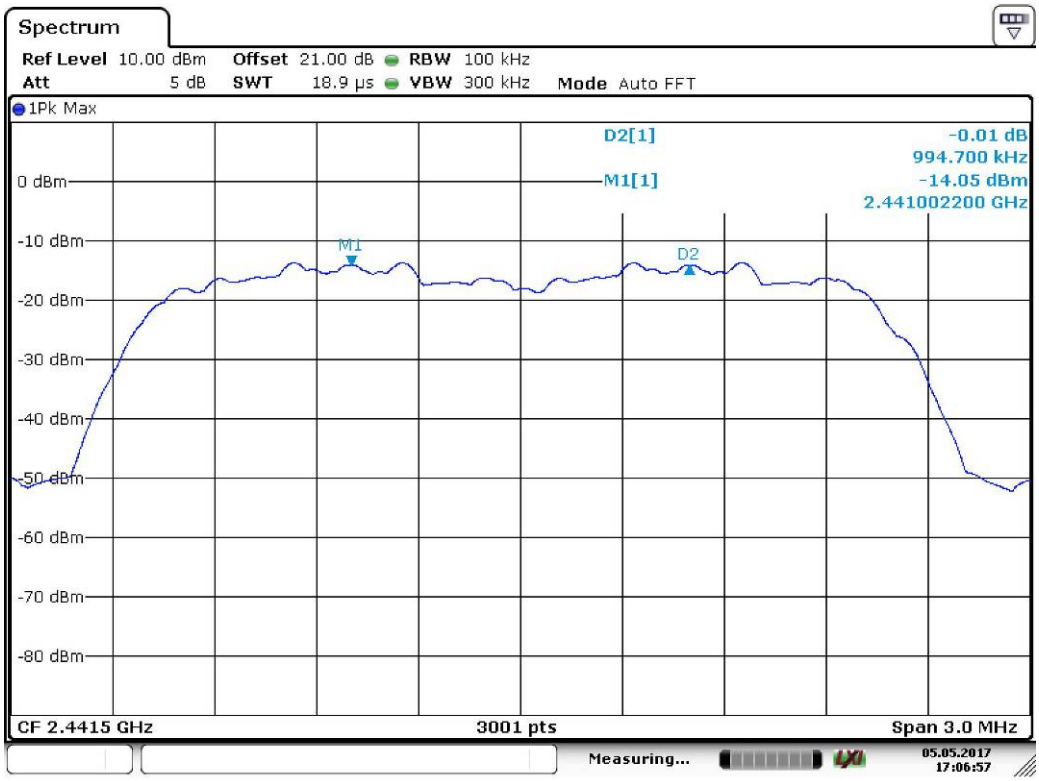
Date: 5.MAY.2017 16:59:50

8DPSK Lowest Channels:



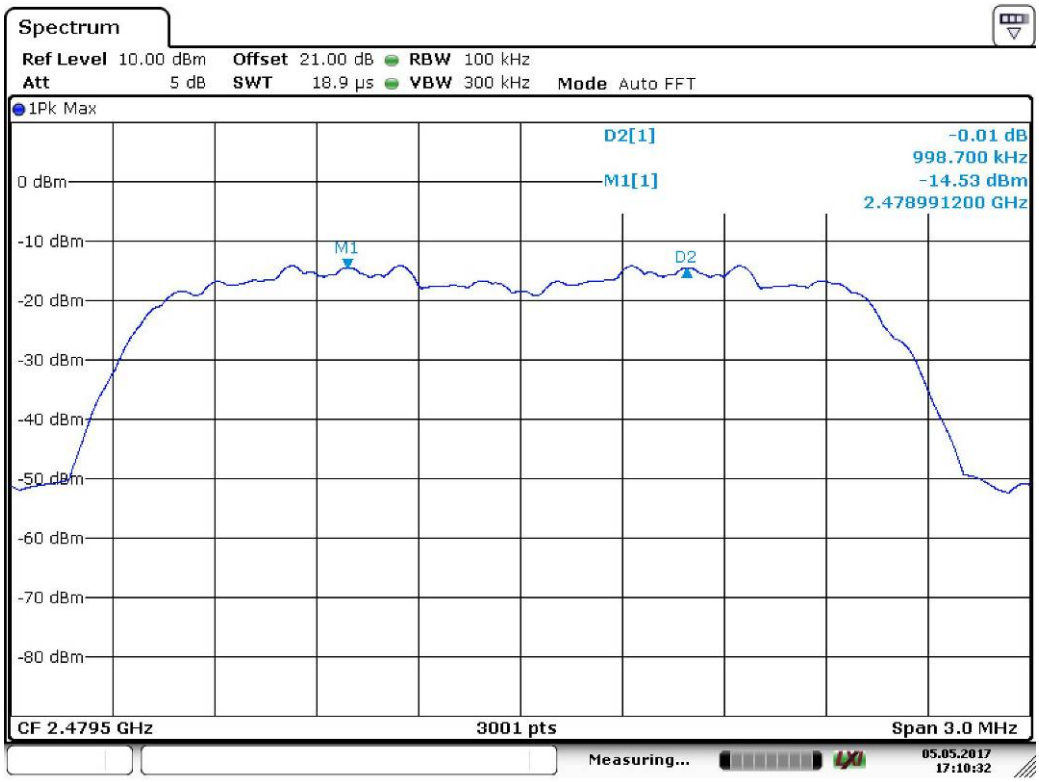
Date: 5.MAY.2017 17:05:22

8DPSK Middle Channels:



Date: 5.MAY.2017 17:06:57

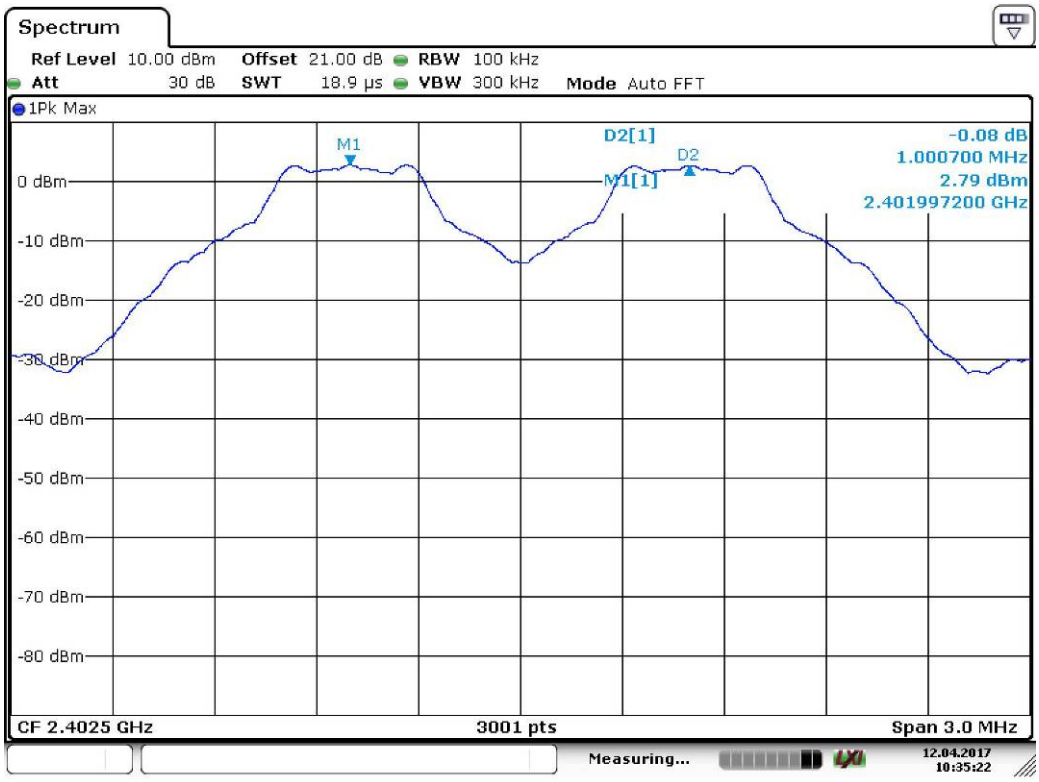
8DPSK Highest Channels:



Date: 5.MAY.2017 17:10:32

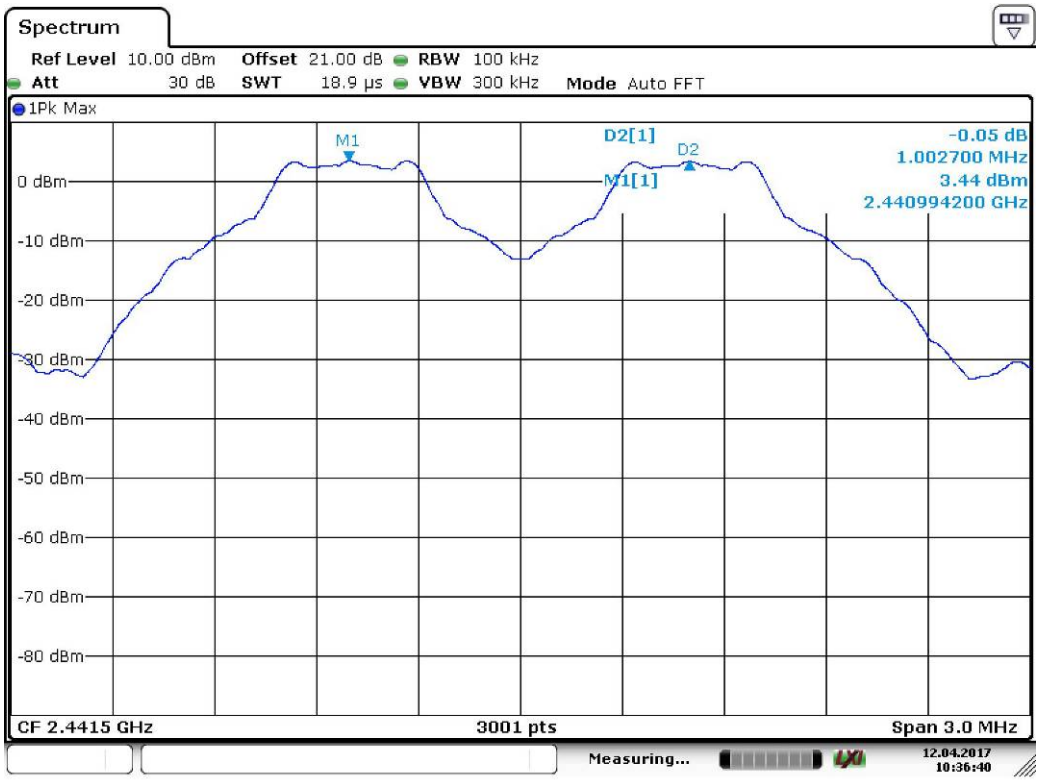
BT2:

GFSK Lowest Channels:



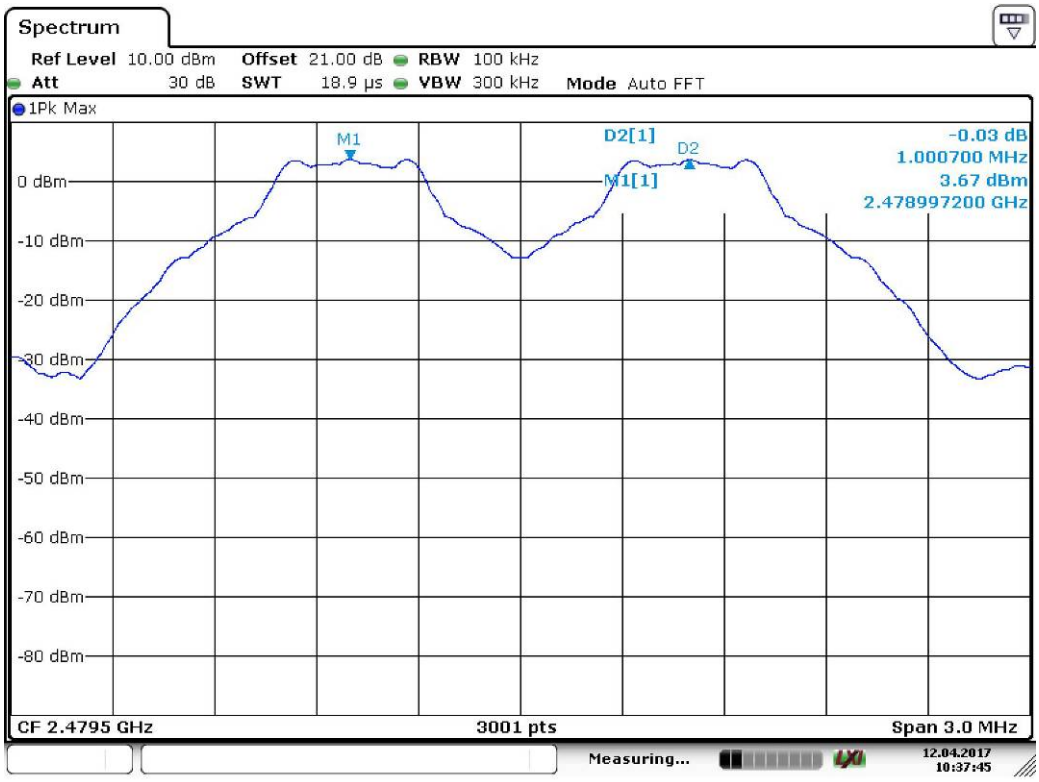
Date: 12.APR.2017 10:35:22

GFSK Middle Channels:



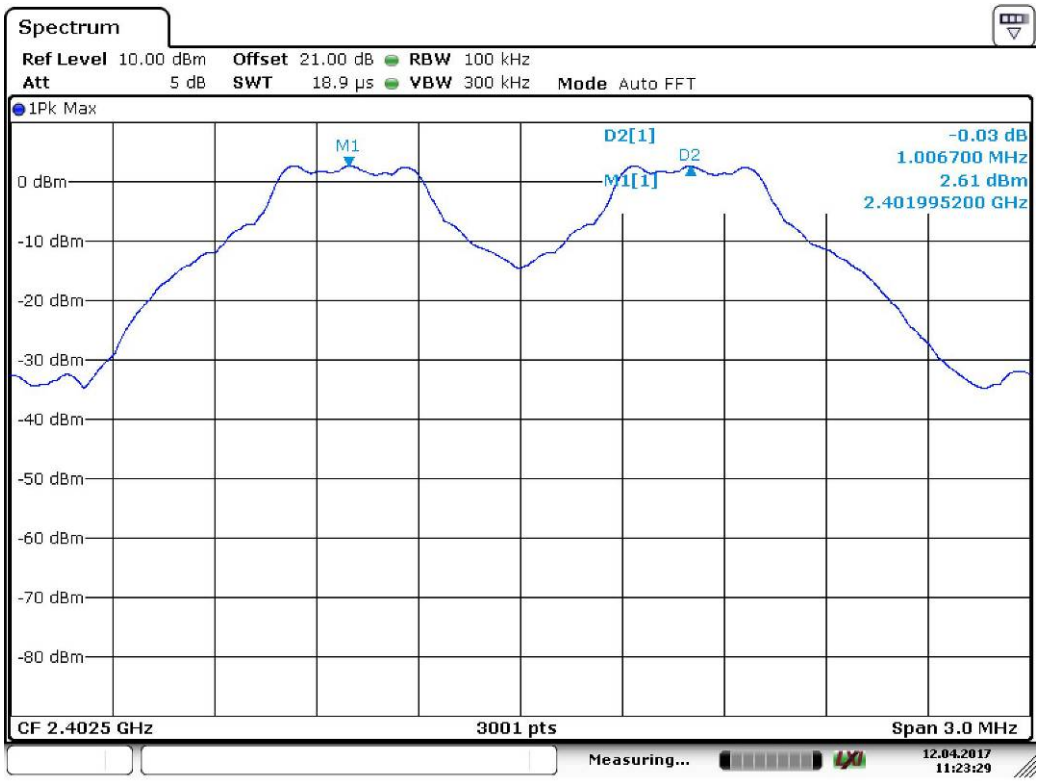
Date: 12.APR.2017 10:36:40

GFSK Highest Channels:



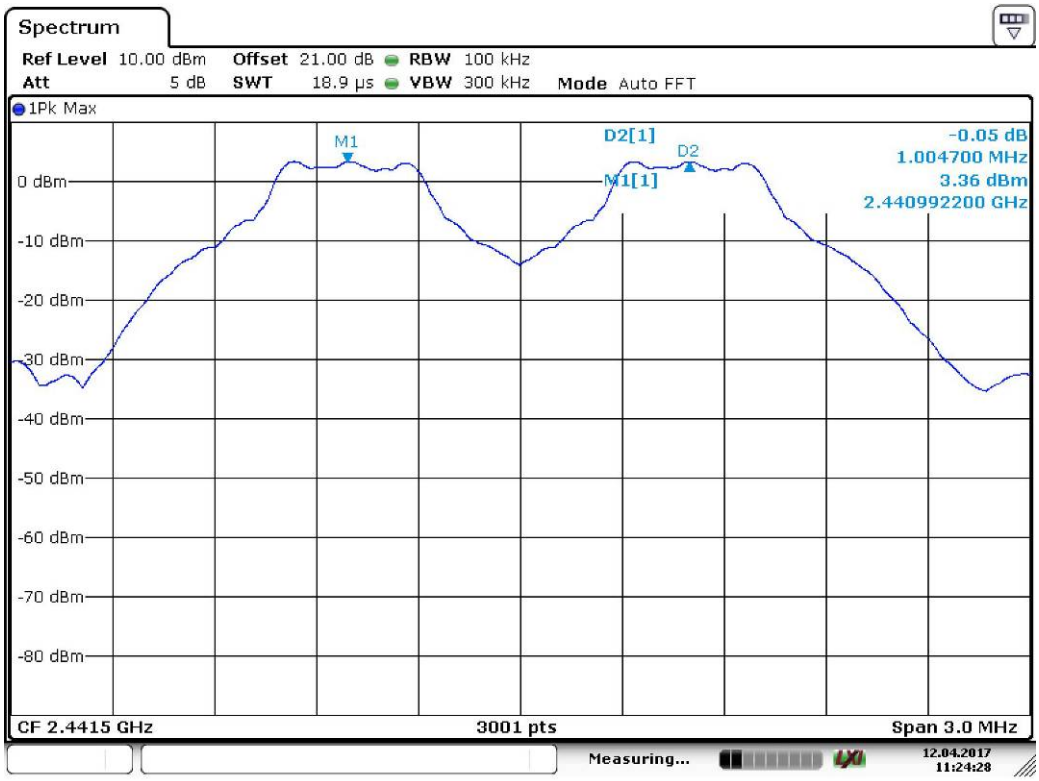
Date: 12.APR.2017 10:37:45

8DPSK Lowest Channels:



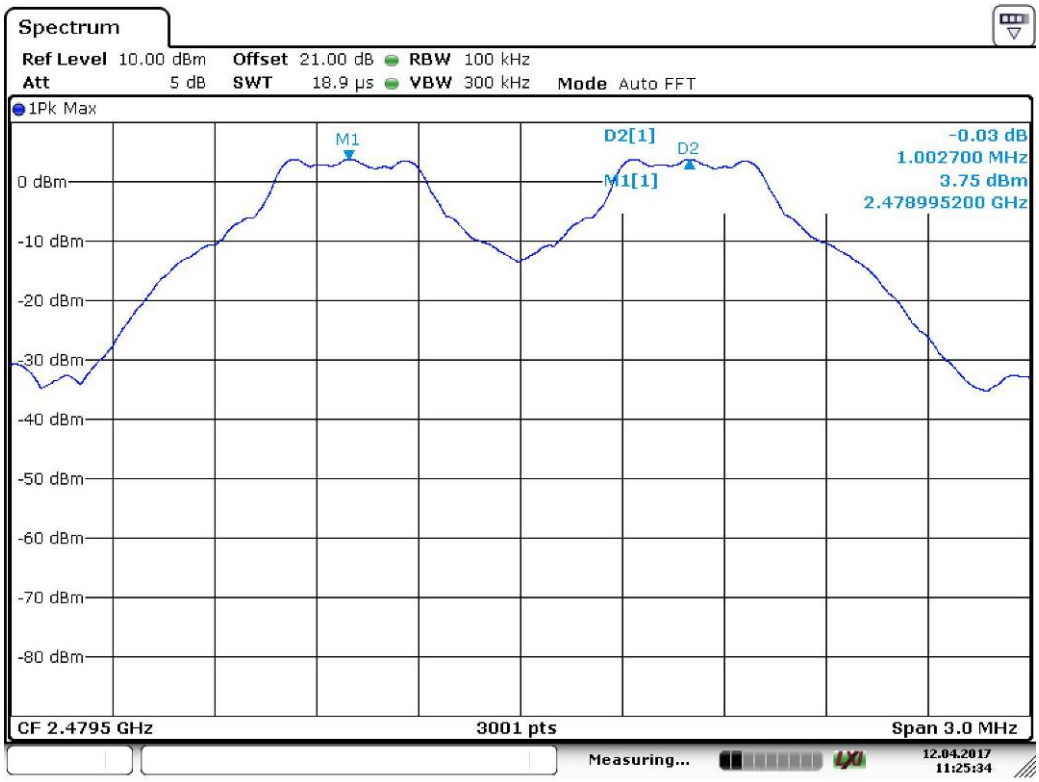
Date: 12.APR.2017 11:23:30

8DPSK Middle Channels:



Date: 12.APR.2017 11:24:28

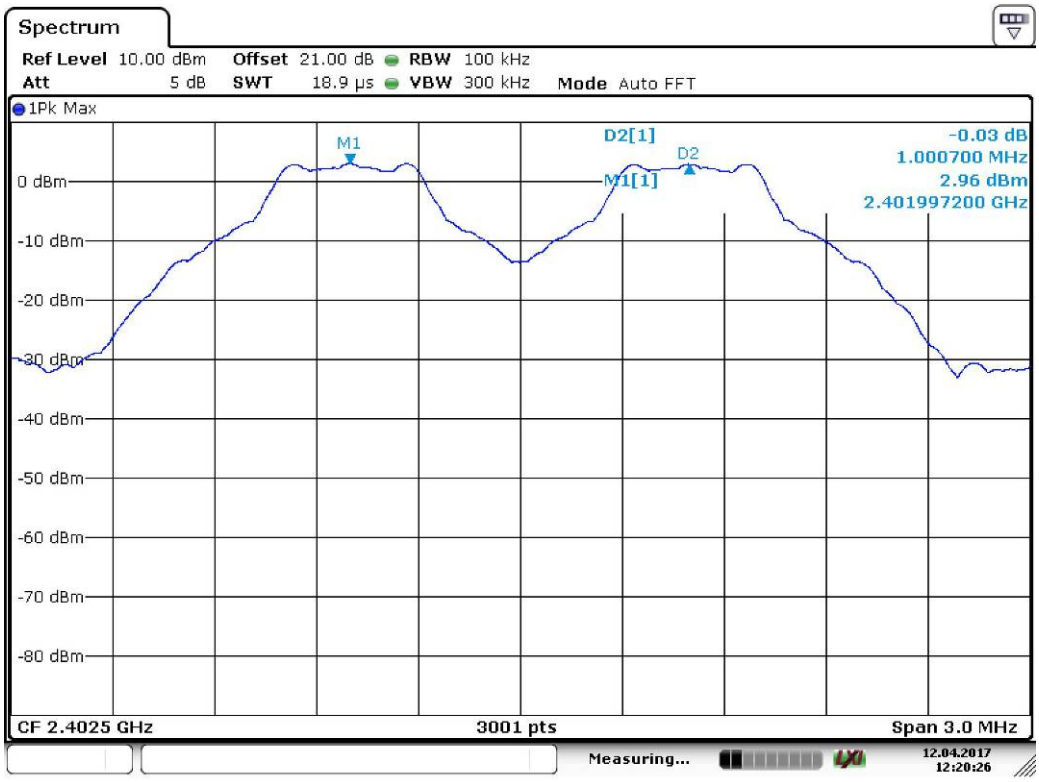
8DPSK Highest Channels:



Date: 12.APR.2017 11:25:34

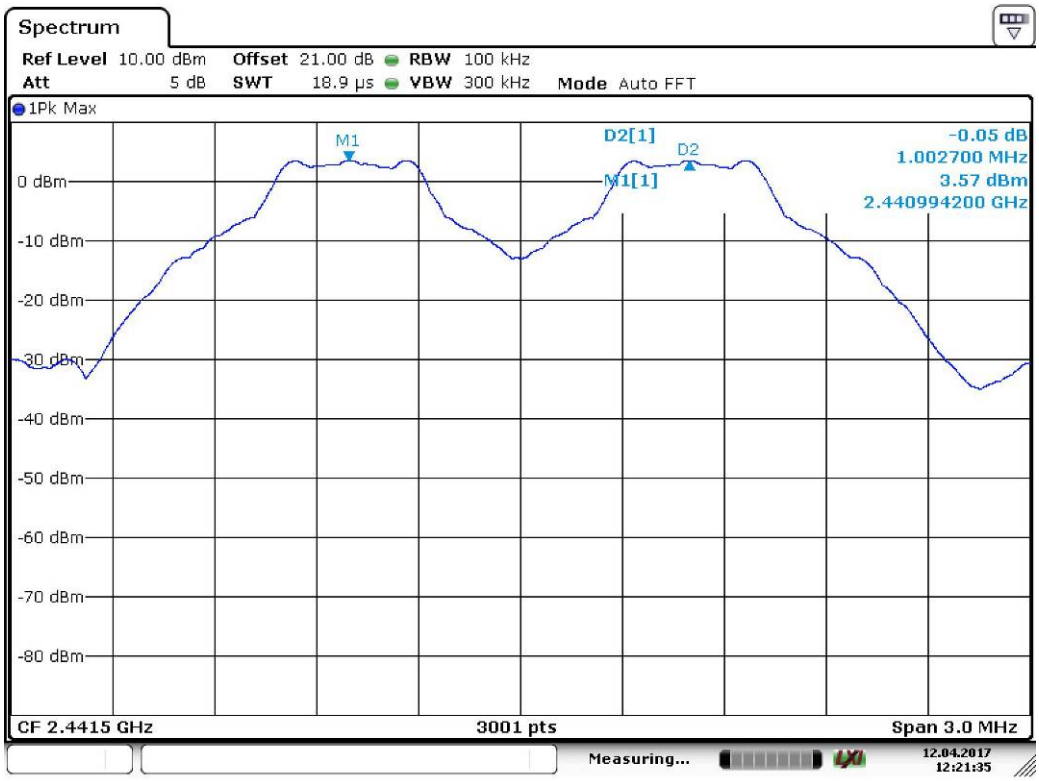
BT3:

GFSK Lowest Channels:



Date: 12.APR.2017 12:20:27

GFSK Middle Channels:



Date: 12.APR.2017 12:21:35