

# TEST REPORT

FCC ID: SXV-CR5

Product: Bluetooth Earphones

Model No.: COWON CR5

Additional Model No.: N/A

Trade Mark: **COWON**

Report No.: TCT190820E902

Issued Date: Aug. 23, 2019

Issued for:

**COWON SYSTEMS, Inc.**

6th Fl. COWON TOWER, 689-3, Yeoksam-Dong, Gangnam-Gu, Seoul 135-080,  
South Korea

Issued By:

**Shenzhen Tongce Testing Lab.**

1B/F., Building 1, Yibaolai Industrial Park, Qiaotou, Fuyong, Baoan District,  
Shenzhen, Guangdong, China

TEL: +86-755-27673339

FAX: +86-755-27673332

This test report was based on TCT190107E025; Change model No., trade mark, external photos, applicant, manufacturer and address.

**Note:** This report shall not be reproduced except in full, without the written approval of Shenzhen Tongce Testing Lab.

This document may be altered or revised by Shenzhen Tongce Testing Lab. personnel only, and shall be noted in the revision section of the document. The test results in the report only apply to the tested sample.

**TABLE OF CONTENTS**

<b>1. Test Certification .....</b>	<b>3</b>
<b>2. Test Result Summary .....</b>	<b>4</b>
<b>3. EUT Description.....</b>	<b>5</b>
<b>4. General Information.....</b>	<b>6</b>
4.1. Test environment and mode.....	6
4.2. Description of Support Units.....	6
<b>5. Facilities and Accreditations .....</b>	<b>7</b>
5.1. Facilities .....	7
5.2. Location .....	7
5.3. Measurement Uncertainty.....	7
<b>6. Test Results and Measurement Data .....</b>	<b>8</b>
6.1. Antenna requirement .....	8
6.2. Conducted Emission.....	9
6.3. Conducted Output Power .....	13
6.4. 20dB Occupy Bandwidth .....	18
6.5. Carrier Frequencies Separation .....	23
6.6. Hopping Channel Number .....	28
6.7. Dwell Time.....	31
6.8. Pseudorandom Frequency Hopping Sequence.....	36
6.9. Conducted Band Edge Measurement.....	37
6.10. Conducted Spurious Emission Measurement.....	41
6.11. Radiated Spurious Emission Measurement .....	45
<b>Appendix A: Photographs of Test Setup</b>	
<b>Appendix B: Photographs of EUT</b>	

## 1. Test Certification

<b>Product:</b>	Bluetooth Earphones
<b>Model No.:</b>	COWON CR5
<b>Additional Model No.:</b>	N/A
<b>Trade Mark:</b>	<b>COWON</b>
<b>Applicant:</b>	COWON SYSTEMS, Inc.
<b>Address:</b>	6th Fl. COWON TOWER, 689-3, Yeoksam-Dong, Gangnam-Gu, Seoul 135-080, South Korea
<b>Manufacturer:</b>	COWON SYSTEMS, Inc.
<b>Address:</b>	6th Fl. COWON TOWER, 689-3, Yeoksam-Dong, Gangnam-Gu, Seoul 135-080, South Korea
<b>Date of Test:</b>	Jan. 08, 2019 – Jan. 16, 2019
<b>Applicable Standards:</b>	FCC CFR Title 47 Part 15 Subpart C Section 15.247 FCC KDB 558074 D01 15.247 Meas Guidance v05r02 ANSI C63.10:2013

The above equipment has been tested by Shenzhen Tongce Testing Lab. and found compliance with the requirements set forth in the technical standards mentioned above. The results of testing in this report apply only to the product/system, which was tested. Other similar equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

**Tested By:** Jerry Xie  
Jerry Xie

**Date:** Jan. 16, 2019

**Reviewed By:** Beryl Zhao  
Beryl Zhao

**Date:** Aug. 23, 2019

**Approved By:** Tomsin  
Tomsin

**Date:** Aug. 23, 2019


## 2. Test Result Summary

Requirement	CFR 47 Section	Result
Antenna Requirement	§15.203/§15.247 (c)	PASS
AC Power Line Conducted Emission	§15.207	PASS
Conducted Peak Output Power	§15.247 (b)(1) §2.1046	PASS
20dB Occupied Bandwidth	§15.247 (a)(1) §2.1049	PASS
Carrier Frequencies Separation	§15.247 (a)(1)	PASS
Hopping Channel Number	§15.247 (a)(1)	PASS
Dwell Time	§15.247 (a)(1)	PASS
Radiated Emission	§15.205/§15.209 §2.1053, §2.1057	PASS
Band Edge	§15.247(d) §2.1051, §2.1057	PASS

**Note:**

1. PASS: Test item meets the requirement.
2. Fail: Test item does not meet the requirement.
3. N/A: Test case does not apply to the test object.
4. The test result judgment is decided by the limit of test standard.

### 3. EUT Description

<b>Product:</b>	Bluetooth Earphones
<b>Model No.:</b>	COWON CR5
<b>Additional Model No.:</b>	N/A
<b>Trade Mark:</b>	
<b>Hardware Version:</b>	V2.0
<b>Software Version:</b>	V1.0
<b>Bluetooth version:</b>	V5.0 (This report is for BDR+EDR)
<b>Operation Frequency:</b>	2402MHz~2480MHz
<b>Transfer Rate:</b>	1/2/3 Mbits/s
<b>Number of Channel:</b>	79
<b>Modulation Type:</b>	GFSK, $\pi/4$ -DQPSK, 8DPSK
<b>Modulation Technology:</b>	FHSS
<b>Antenna Type:</b>	Ceramic Antenna
<b>Antenna Gain:</b>	4.9dBi
<b>Power Supply:</b>	Rechargeable Li-ion Battery DC 3.7V

#### Operation Frequency each of channel for GFSK, $\pi/4$ -DQPSK, 8DPSK

Channel	Frequency	Channel	Frequency	Channel	Frequency	Channel	Frequency
0	2402MHz	20	2422MHz	40	2442MHz	60	2462MHz
1	2403MHz	21	2423MHz	41	2443MHz	61	2463MHz
...	...	...	...	...	...	...	...
10	2412MHz	30	2432MHz	50	2452MHz	70	2472MHz
11	2413MHz	31	2433MHz	51	2453MHz	71	2473MHz
...	...	...	...	...	...	...	...
18	2420MHz	38	2440MHz	58	2460MHz	78	2480MHz
19	2421MHz	39	2441MHz	59	2461MHz	-	-

Remark: Channel 0, 39 & 78 have been tested for GFSK,  $\pi/4$ -DQPSK, 8DPSK modulation mode.

## 4. General Information

### 4.1. Test environment and mode

Operating Environment:	
Temperature:	25.0 °C
Humidity:	56 % RH
Atmospheric Pressure:	1010 mbar
Test Mode:	
Engineering mode:	Keep the EUT in continuous transmitting by select channel and modulations with Fully-charged battery
<p>The sample was placed 0.8m &amp; 1.5m for the measurement below &amp; above 1GHz above the ground plane of 3m chamber. Measurements in both horizontal and vertical polarities were performed. During the test, each emission was maximized by: having the EUT continuously working, investigated all operating modes, rotated about all 3 axis (X, Y &amp; Z) and considered typical configuration to obtain worst position, manipulating interconnecting cables, rotating the turntable, varying antenna height from 1m to 4m in both horizontal and vertical polarizations. The emissions worst-case are shown in Test Results of the following pages.</p>	

### 4.2. Description of Support Units

The EUT has been tested as an independent unit together with other necessary accessories or support units. The following support units or accessories were used to form a representative test configuration during the tests.

Equipment	Model No.	Serial No.	FCC ID	Trade Name
Adapter	XC-0501000-06-B	/	/	ADAPTER

**Note:**

1. All the equipment/cables were placed in the worst-case configuration to maximize the emission during the test.
2. Grounding was established in accordance with the manufacturer's requirements and conditions for the intended use.
3. For conducted measurements (Output Power, 20dB Occupied Bandwidth, Carrier Frequencies Separation, Hopping Channel Number, Dwell Time, Spurious Emissions), the antenna of EUT is connected to the test equipment via temporary antenna connector, the antenna connector is soldered on the antenna port of EUT, and the temporary antenna connector is listed in the Test Instruments.

## 5. Facilities and Accreditations

### 5.1. Facilities

The test facility is recognized, certified, or accredited by the following organizations:

- FCC - Registration No.: 645098

Shenzhen Tongce Testing Lab

The 3m Semi-anechoic chamber has been registered and fully described in a report with the (FCC) Federal Communications Commission. The acceptance letter from the FCC is maintained in our files.

- IC - Registration No.: 10668A-1

The 3m Semi-anechoic chamber of Shenzhen TCT Testing Technology Co., Ltd. has been registered by Certification and Engineering Bureau of Industry Canada for radio equipment testing

### 5.2. Location

Shenzhen Tongce Testing Lab

Address: 1B/F., Building 1, Yibaolai Industrial Park, Qiaotou, Fuyong, Baoan District, Shenzhen, Guangdong, China

Tel: 86-755-27673339

### 5.3. Measurement Uncertainty

The reported uncertainty of measurement  $y \pm U$ , where expanded uncertainty  $U$  is based on a standard uncertainty multiplied by a coverage factor of  $k=2$ , providing a level of confidence of approximately 95 %.

No.	Item	MU
1	Conducted Emission	$\pm 2.56\text{dB}$
2	RF power, conducted	$\pm 0.12\text{dB}$
3	Spurious emissions, conducted	$\pm 0.11\text{dB}$
4	All emissions, radiated(<1G)	$\pm 3.92\text{dB}$
5	All emissions, radiated(>1G)	$\pm 4.28\text{dB}$
6	Temperature	$\pm 0.1^\circ\text{C}$
7	Humidity	$\pm 1.0\%$

## 6. Test Results and Measurement Data

### 6.1. Antenna requirement

**Standard requirement:**

FCC Part15 C Section 15.203 /247(c)

15.203 requirement:

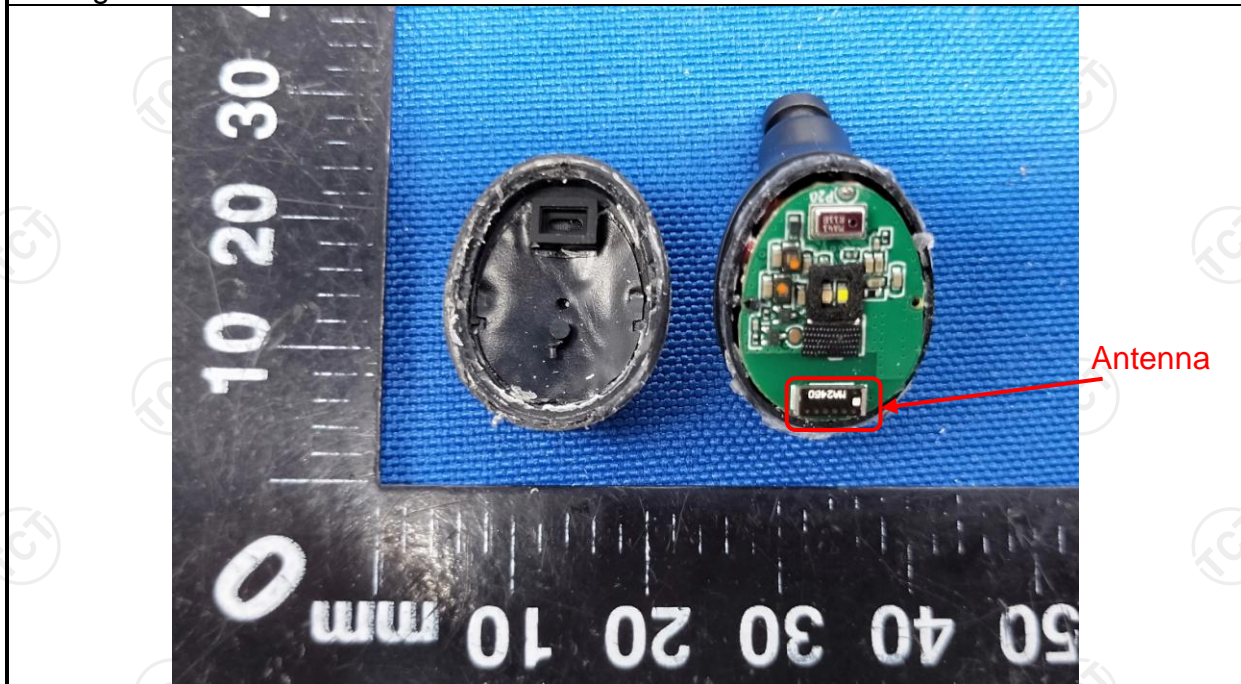
An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator, the manufacturer may design the unit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

15.247(c) (1)(i) requirement:

(i) Systems operating in the 2400-2483.5 MHz band that is used exclusively for fixed. Point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6dBi.

**E.U.T Antenna:**

The Bluetooth antenna is ceramic antenna which permanently attached, and the best case gain of the antenna is 4.9dBi.





## 6.2. Conducted Emission

### 6.2.1. Test Specification

<b>Test Requirement:</b>	FCC Part15 C Section 15.207														
<b>Test Method:</b>	ANSI C63.10:2013														
<b>Frequency Range:</b>	150 kHz to 30 MHz														
<b>Receiver setup:</b>	RBW=9 kHz, VBW=30 kHz, Sweep time=auto														
<b>Limits:</b>	<table border="1"> <thead> <tr> <th rowspan="2">Frequency range (MHz)</th> <th colspan="2">Limit (dBuV)</th> </tr> <tr> <th>Quasi-peak</th> <th>Average</th> </tr> </thead> <tbody> <tr> <td>0.15-0.5</td> <td>66 to 56*</td> <td>56 to 46*</td> </tr> <tr> <td>0.5-5</td> <td>56</td> <td>46</td> </tr> <tr> <td>5-30</td> <td>60</td> <td>50</td> </tr> </tbody> </table>	Frequency range (MHz)	Limit (dBuV)		Quasi-peak	Average	0.15-0.5	66 to 56*	56 to 46*	0.5-5	56	46	5-30	60	50
Frequency range (MHz)	Limit (dBuV)														
	Quasi-peak	Average													
0.15-0.5	66 to 56*	56 to 46*													
0.5-5	56	46													
5-30	60	50													
<b>Test Setup:</b>	<p><i>Remark</i> E.U.T: Equipment Under Test LISN: Line Impedance Stabilization Network Test table height=0.8m</p>														
<b>Test Mode:</b>	Refer to item 4.1														
<b>Test Procedure:</b>	<ol style="list-style-type: none"> <li>1. The E.U.T is connected to an adapter through a line impedance stabilization network (L.I.S.N.). This provides a 50ohm/50uH coupling impedance for the measuring equipment.</li> <li>2. The peripheral devices are also connected to the main power through a LISN that provides a 50ohm/50uH coupling impedance with 50ohm termination. (Please refer to the block diagram of the test setup and photographs).</li> <li>3. Both sides of A.C. line are checked for maximum conducted interference. In order to find the maximum emission, the relative positions of equipment and all of the interface cables must be changed according to ANSI C63.10:2013 on conducted measurement.</li> </ol>														
<b>Test Result:</b>	PASS														

**6.2.2. Test Instruments**

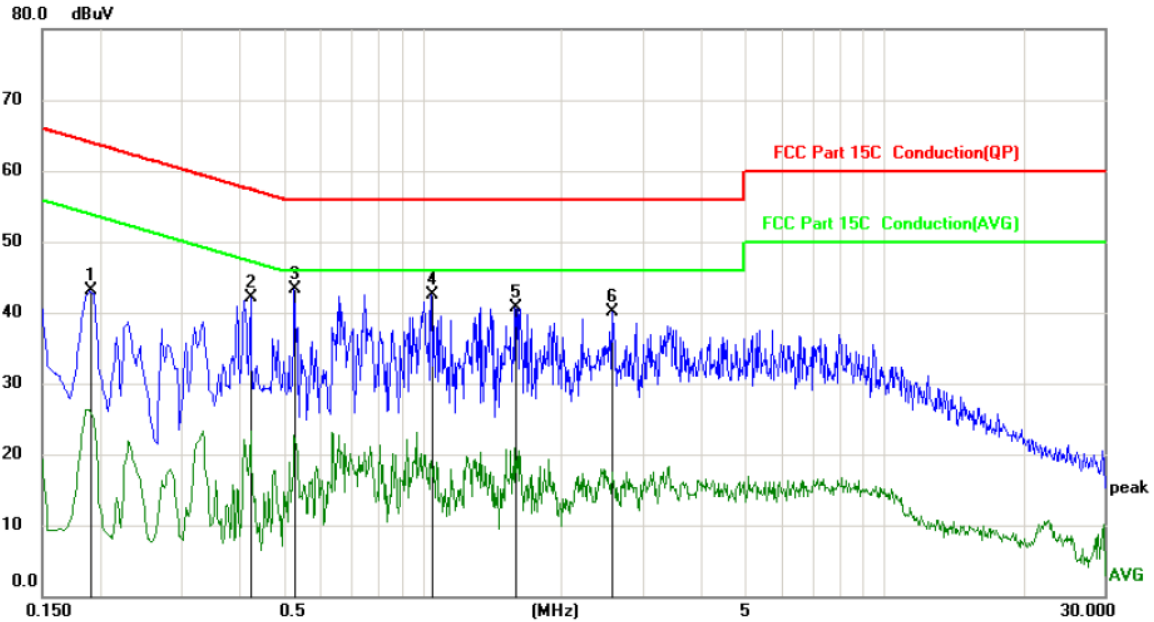
Conducted Emission Shielding Room Test Site (843)				
Equipment	Manufacturer	Model	Serial Number	Calibration Due
Test Receiver	R&S	ESPI	101402	Jul. 17, 2019
LISN	Schwarzbeck	NSLK 8126	8126453	Sep. 20, 2019
Coax cable (9KHz-30MHz)	TCT	CE-05	N/A	Sep. 16, 2019
EMI Test Software	Shurple Technology	EZ-EMC	N/A	N/A

**Note:** The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).

6.2.3. Test data

Please refer to following diagram for individual

Conducted Emission on Line Terminal of the power line (150 kHz to 30MHz)



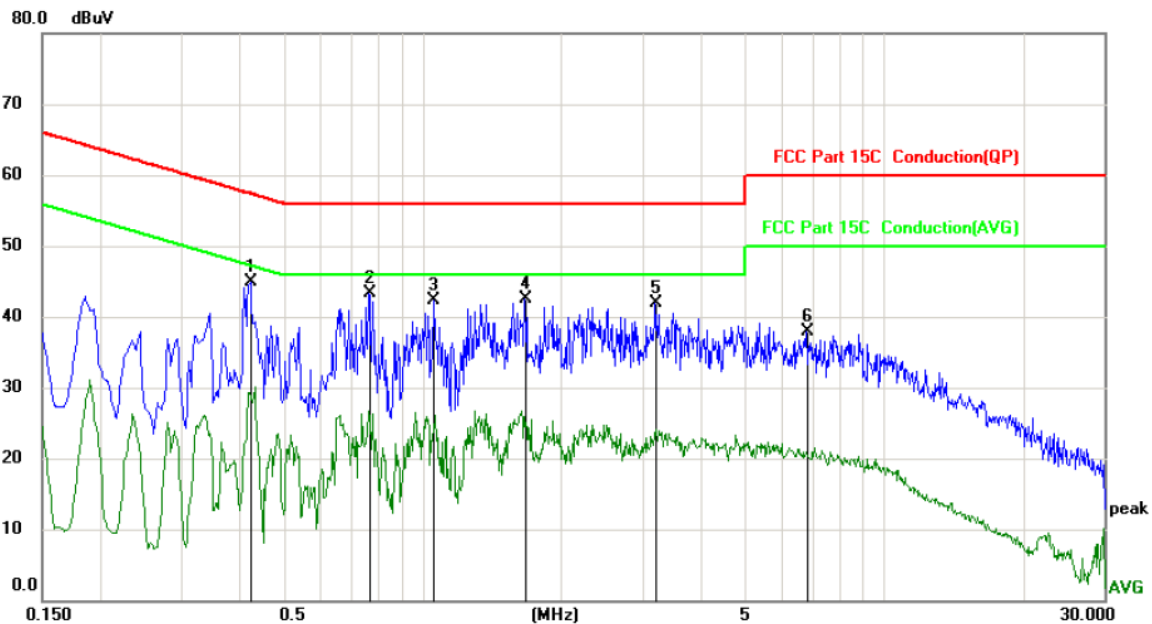
Site: \_\_\_\_\_ Phase: **L1** Temperature: 25  
Limit: FCC Part 15C Conduction(QP) Power: \_\_\_\_\_ Humidity: 55 %

No.	Mk.	Freq. MHz	Reading Level dBµV	Correct Factor dB	Measure- ment dBµV	Limit dBµV	Over dB	Detector	Comment
1		0.1905	32.90	10.12	43.02	64.01	-20.99	peak	
2		0.4245	32.02	10.13	42.15	57.36	-15.21	peak	
3	*	0.5280	33.15	10.13	43.28	56.00	-12.72	peak	
4		1.0455	32.32	10.12	42.44	56.00	-13.56	peak	
5		1.5900	30.60	10.12	40.72	56.00	-15.28	peak	
6		2.5755	29.95	10.12	40.07	56.00	-15.93	peak	

**Note:**

- Freq. = Emission frequency in MHz
- Reading level (dBµV) = Receiver reading
- Corr. Factor (dB) = LISN factor + Cable loss
- Measurement (dBµV) = Reading level (dBµV) + Corr. Factor (dB)
- Limit (dBµV) = Limit stated in standard
- Margin (dB) = Measurement (dBµV) – Limits (dBµV)
- Q.P. =Quasi-Peak
- AVG =average
- Any value more than 10dB below limit have not been specifically reported.
- \* is meaning the worst frequency has been tested in the frequency range 150 kHz to 30MHz.

**Conducted Emission on Neutral Terminal of the power line (150 kHz to 30MHz)**



Site: Phase: **N** Temperature: 25  
 Limit: FCC Part 15C Conduction(QP) Power: Humidity: 55 %

No.	Mk.	Freq. MHz	Reading Level dBuV	Correct Factor dB	Measure- ment dBuV	Limit dBuV	Over dB	Detector	Comment
1	*	0.4245	34.84	10.13	44.97	57.36	-12.39	peak	
2		0.7665	33.14	10.12	43.26	56.00	-12.74	peak	
3		1.0545	32.24	10.12	42.36	56.00	-13.64	peak	
4		1.6710	32.30	10.12	42.42	56.00	-13.58	peak	
5		3.1965	31.75	10.13	41.88	56.00	-14.12	peak	
6		6.7920	27.85	10.14	37.99	60.00	-22.01	peak	

**Note1:**

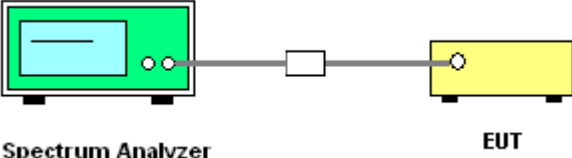
*Freq. = Emission frequency in MHz*  
*Reading level (dBuV) = Receiver reading*  
*Corr. Factor (dB) = LISN factor + Cable loss*  
*Measurement (dBuV) = Reading level (dBuV) + Corr. Factor (dB)*  
*Limit (dBuV) = Limit stated in standard*  
*Margin (dB) = Measurement (dBuV) – Limits (dBuV)*  
*Q.P. =Quasi-Peak    AVG =average*  
*Any value more than 10dB below limit have not been specifically reported.*  
*\* is meaning the worst frequency has been tested in the frequency range 150 kHz to 30MHz.*

**Note2:**

*Measurements were conducted in all three channels (high, middle, low) and three modulation (GFSK, Pi/4DQPSK, 8DPSK), and the worst case Mode (Lowest channel and 8DPSK) was submitted only.*

### 6.3. Conducted Output Power

#### 6.3.1. Test Specification

<b>Test Requirement:</b>	FCC Part15 C Section 15.247 (b)(3)
<b>Test Method:</b>	ANSI C63.10:2013
<b>Limit:</b>	Section 15.247 (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following: (1) For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band 0.125 watts.
<b>Test Setup:</b>	 <p style="text-align: center;">Spectrum Analyzer                      EUT</p>
<b>Test Mode:</b>	Transmitting mode with modulation
<b>Test Procedure:</b>	<p>Use the following spectrum analyzer settings:            Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel            RBW &gt; the 20 dB bandwidth of the emission being measured            VBW ≥ RBW            Sweep = auto            Detector function = peak            Trace = max hold            Allow the trace to stabilize.            Use the marker-to-peak function to set the marker to the peak of the emission.</p>
<b>Test Result:</b>	PASS

#### 6.3.2. Test Instruments

Equipment	Manufacturer	Model	Serial Number	Calibration Due
Spectrum Analyzer	R&S	FSU	200054	Sep. 20, 2019
RF Cable (9KHz-26.5GHz)	TCT	RE-06	N/A	Sep. 20, 2019
Antenna Connector	TCT	RFC-01	N/A	Sep. 20, 2019

**Note:** The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).

**6.3.3. Test Data**

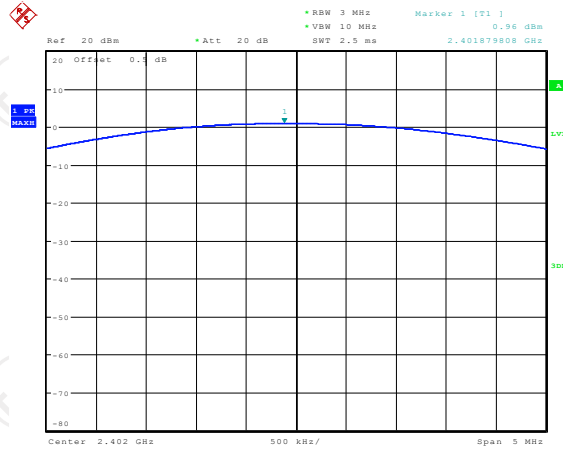
GFSK mode			
Test channel	Peak Output Power (dBm)	Limit (dBm)	Result
Lowest	0.96	21.00	PASS
Middle	0.81	21.00	PASS
Highest	0.15	21.00	PASS

Pi/4DQPSK mode			
Test channel	Peak Output Power (dBm)	Limit (dBm)	Result
Lowest	3.30	21.00	PASS
Middle	3.30	21.00	PASS
Highest	2.60	21.00	PASS

8DPSK mode			
Test channel	Peak Output Power (dBm)	Limit (dBm)	Result
Lowest	3.95	21.00	PASS
Middle	3.76	21.00	PASS
Highest	3.13	21.00	PASS

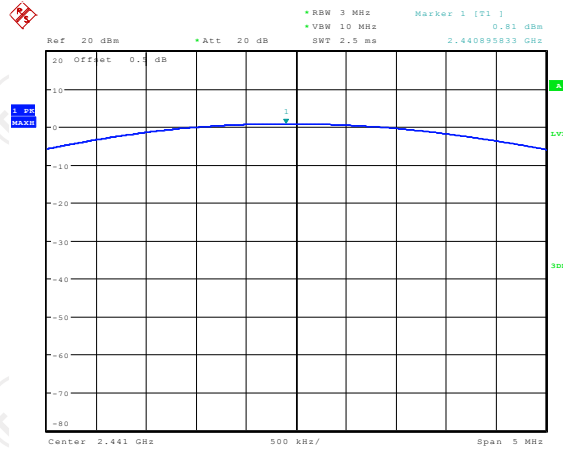
Test plots as follows:

Lowest channel



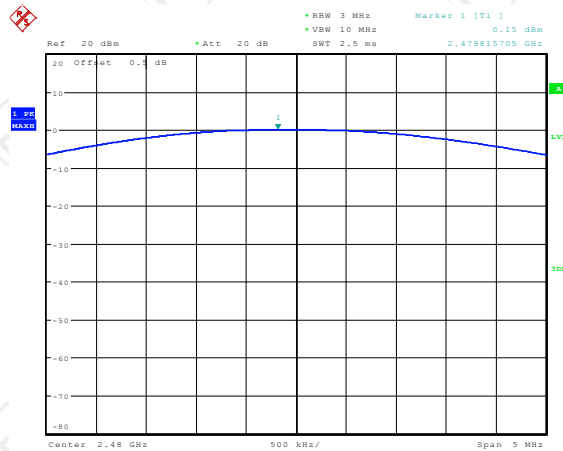
Date: 16.JAN.2019 10:04:08

Middle channel



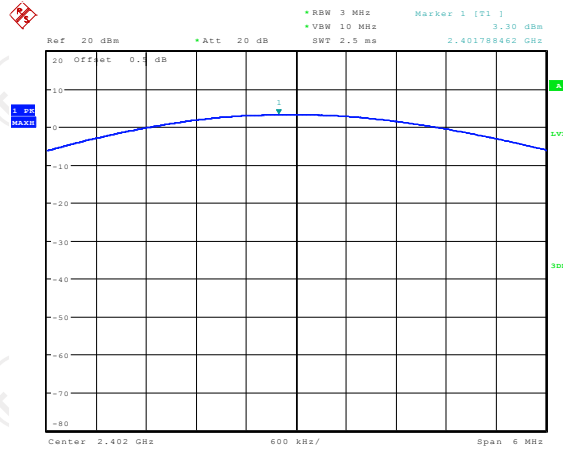
Date: 16.JAN.2019 10:05:00

Highest channel



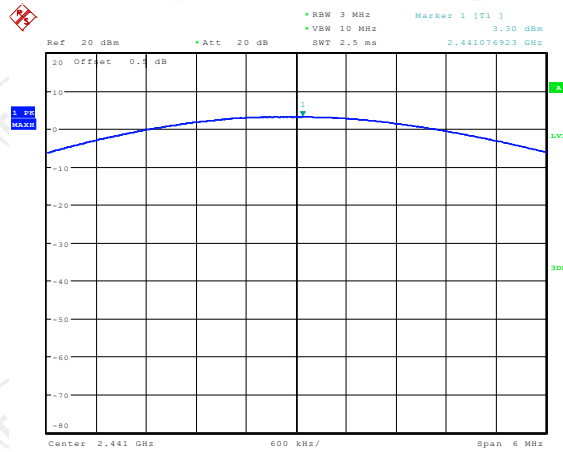
Date: 16.JAN.2019 10:05:29

Lowest channel



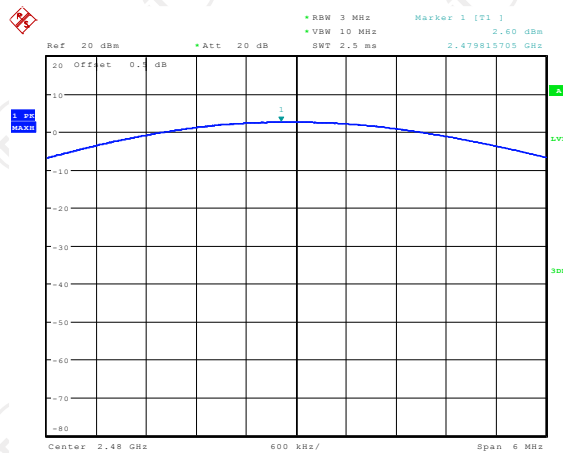
Date: 16.JAN.2019 10:35:49

Middle channel



Date: 16.JAN.2019 10:17:57

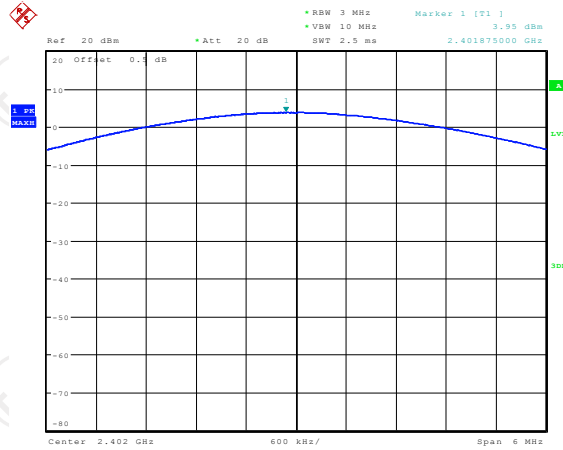
Highest channel



Date: 16.JAN.2019 10:16:53

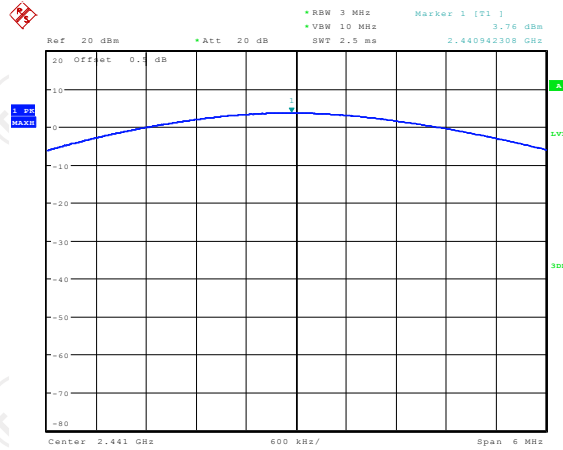


Lowest channel



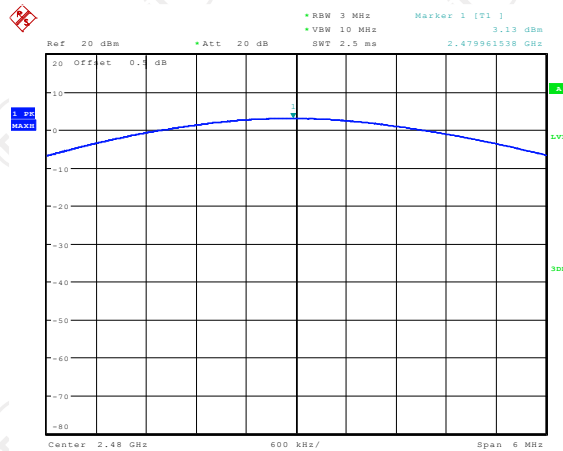
Date: 16.JAN.2019 10:33:46

Middle channel



Date: 16.JAN.2019 10:34:32

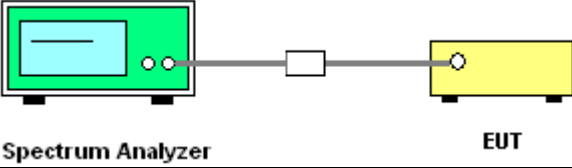
Highest channel



Date: 16.JAN.2019 10:35:09

## 6.4. 20dB Occupy Bandwidth

### 6.4.1. Test Specification

<b>Test Requirement:</b>	FCC Part15 C Section 15.247 (a)(1)
<b>Test Method:</b>	ANSI C63.10:2013
<b>Limit:</b>	N/A
<b>Test Setup:</b>	 <p style="text-align: center;">Spectrum Analyzer                      EUT</p>
<b>Test Mode:</b>	Transmitting mode with modulation
<b>Test Procedure:</b>	<ol style="list-style-type: none"> <li>1. The testing follows ANSI C63.10:2013 Measurement Guidelines.</li> <li>2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.</li> <li>3. Set to the maximum power setting and enable the EUT transmit continuously.</li> <li>4. Use the following spectrum analyzer settings for 20dB Bandwidth measurement. Span = approximately 2 to 5 times the 20 dB bandwidth, centered on a hopping channel; <math>1\% \leq RBW \leq 5\%</math> of the 20 dB bandwidth; <math>VBW \geq 3RBW</math>; Sweep = auto; Detector function = peak; Trace = max hold.</li> <li>5. Measure and record the results in the test report.</li> </ol>
<b>Test Result:</b>	PASS

### 6.4.2. Test Instruments

Equipment	Manufacturer	Model	Serial Number	Calibration Due
Spectrum Analyzer	R&S	FSU	200054	Sep. 20, 2019
RF Cable (9KHz-26.5GHz)	TCT	RE-06	N/A	Sep. 20, 2019
Antenna Connector	TCT	RFC-01	N/A	Sep. 20, 2019

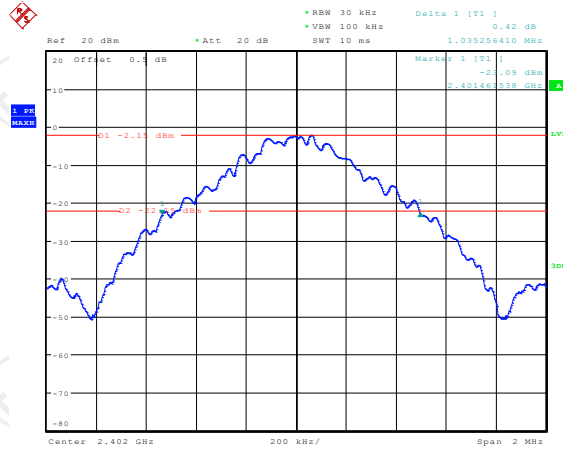
**Note:** The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).

**6.4.3. Test data**

Test channel	20dB Occupy Bandwidth (kHz)			
	GFSK	$\pi/4$ -DQPSK	8DPSK	Conclusion
Lowest	1035.26	1371.79	1355.77	PASS
Middle	1028.85	1375.00	1355.77	PASS
Highest	1035.26	1375.00	1355.77	PASS

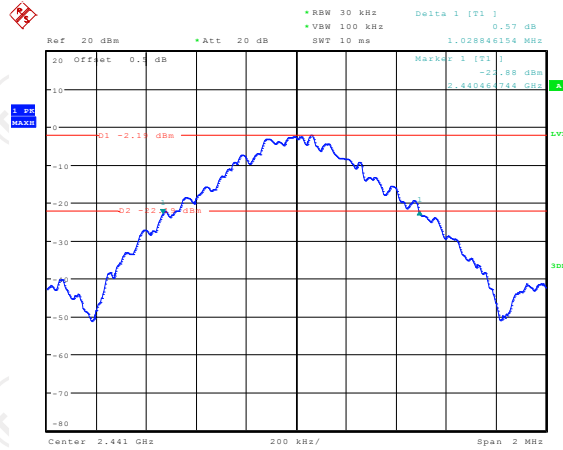
Test plots as follows:

Lowest channel



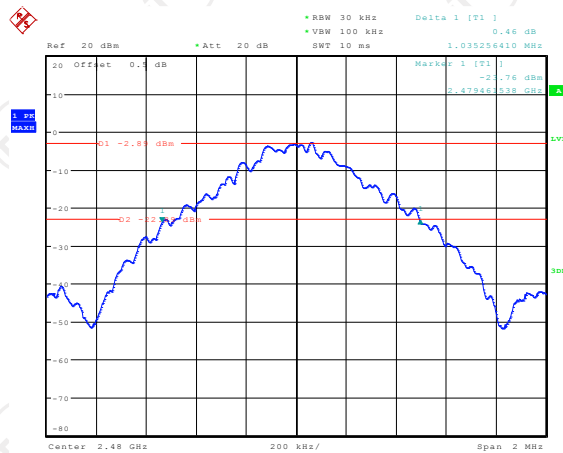
Date: 16.JAN.2019 09:52:10

Middle channel



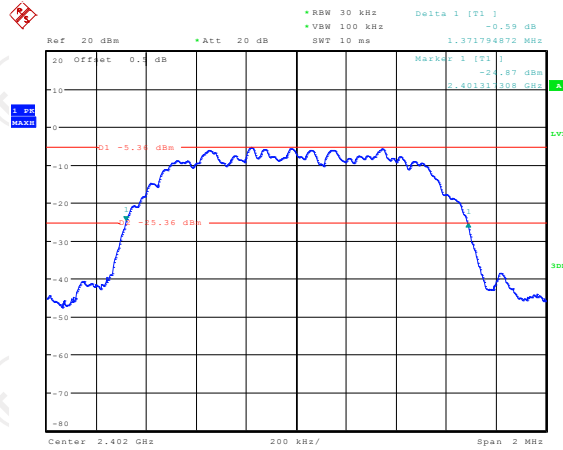
Date: 16.JAN.2019 09:53:49

Highest channel



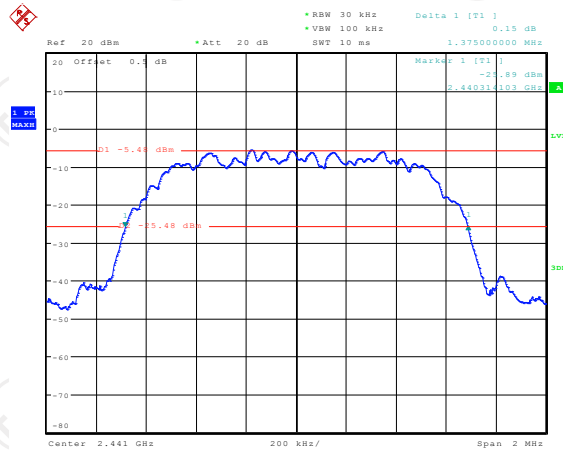
Date: 16.JAN.2019 09:54:44

Lowest channel



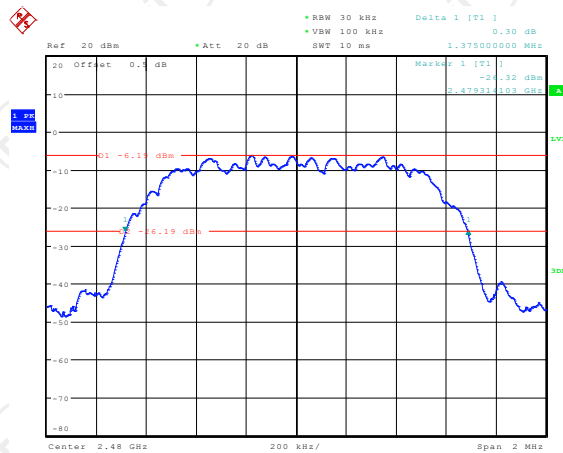
Date: 16.JAN.2019 09:57:44

Middle channel



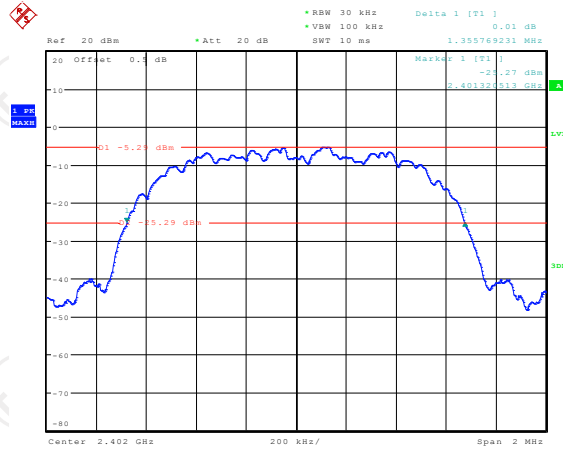
Date: 16.JAN.2019 09:58:45

Highest channel



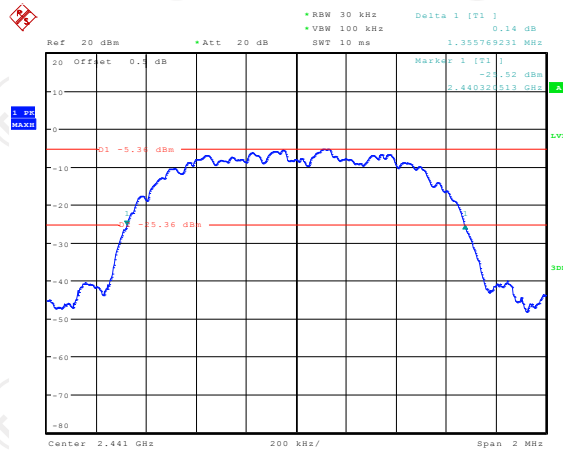
Date: 16.JAN.2019 09:59:39

Lowest channel



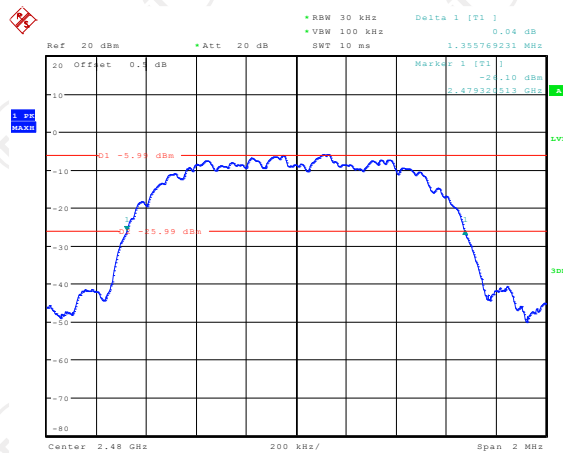
Date: 16.JAN.2019 10:02:43

Middle channel



Date: 16.JAN.2019 10:01:38

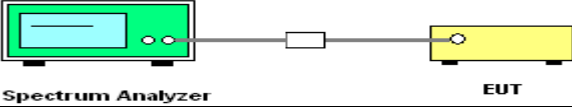
Highest channel



Date: 16.JAN.2019 10:00:40

## 6.5. Carrier Frequencies Separation

### 6.5.1. Test Specification

<b>Test Requirement:</b>	FCC Part15 C Section 15.247 (a)(1)
<b>Test Method:</b>	ANSI C63.10:2013
<b>Limit:</b>	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.
<b>Test Setup:</b>	 <p style="text-align: center;">Spectrum Analyzer                      EUT</p>
<b>Test Mode:</b>	Hopping mode
<b>Test Procedure:</b>	<ol style="list-style-type: none"> <li>1. The testing follows ANSI C63.10:2013 Measurement Guidelines.</li> <li>2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.</li> <li>3. Set to the maximum power setting and enable the EUT transmit continuously.</li> <li>4. Enable the EUT hopping function.</li> <li>5. Use the following spectrum analyzer settings: Span = wide enough to capture the peaks of two adjacent channels; RBW is set to approximately 30% of the channel spacing, adjust as necessary to best identify the center of each individual channel; VBW ≥ RBW; Sweep = auto; Detector function = peak; Trace = max hold.</li> <li>6. Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Record the value in report.</li> </ol>
<b>Test Result:</b>	PASS

### 6.5.2. Test Instruments

Equipment	Manufacturer	Model	Serial Number	Calibration Due
Spectrum Analyzer	R&S	FSU	200054	Sep. 20, 2019
RF Cable (9KHz-26.5GHz)	TCT	RE-06	N/A	Sep. 20, 2019
Antenna Connector	TCT	RFC-01	N/A	Sep. 20, 2019

**Note:** The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).

**6.5.3. Test data**

GFSK mode			
Test channel	Carrier Frequencies Separation (kHz)	Limit (kHz)	Result
Lowest	1003.21	690.17	PASS
Middle	1000.00	690.17	PASS
Highest	1000.00	690.17	PASS

Pi/4 DQPSK mode			
Test channel	Carrier Frequencies Separation (kHz)	Limit (kHz)	Result
Lowest	1003.21	916.67	PASS
Middle	1000.00	916.67	PASS
Highest	1000.00	916.67	PASS

8DPSK mode			
Test channel	Carrier Frequencies Separation (kHz)	Limit (kHz)	Result
Lowest	1003.21	903.85	PASS
Middle	1000.00	903.85	PASS
Highest	1006.41	903.85	PASS

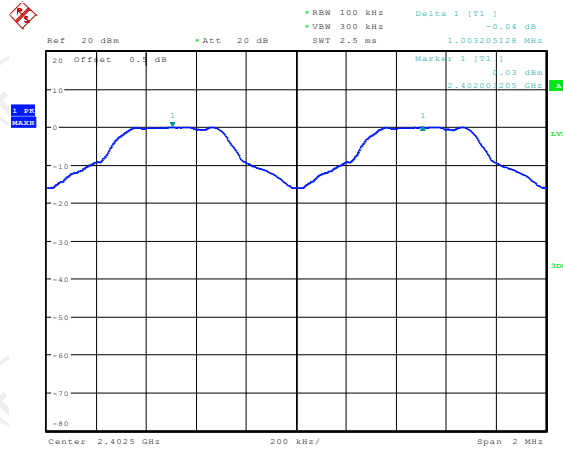
**Note: According to section 6.4**

Mode	20dB bandwidth (kHz) (worse case)	Limit (kHz) (Carrier Frequencies Separation)
GFSK	1035.26	690.17
$\pi/4$ -DQPSK	1375.00	916.67
8DPSK	1355.77	903.85

Test plots as follows:

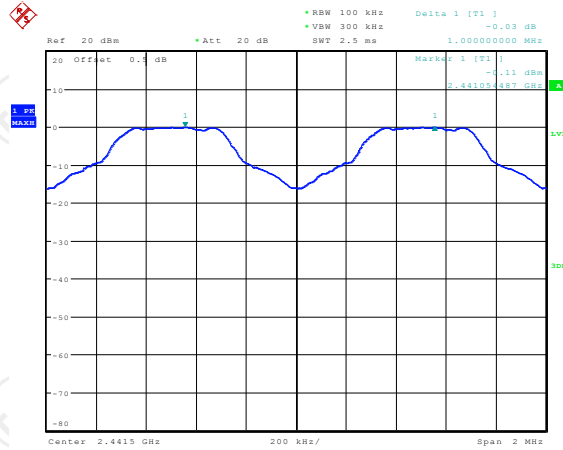


Lowest channel



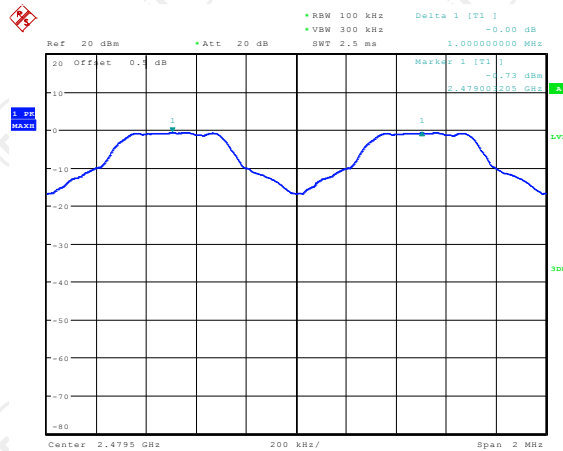
Date: 16.JAN.2019 10:37:33

Middle channel



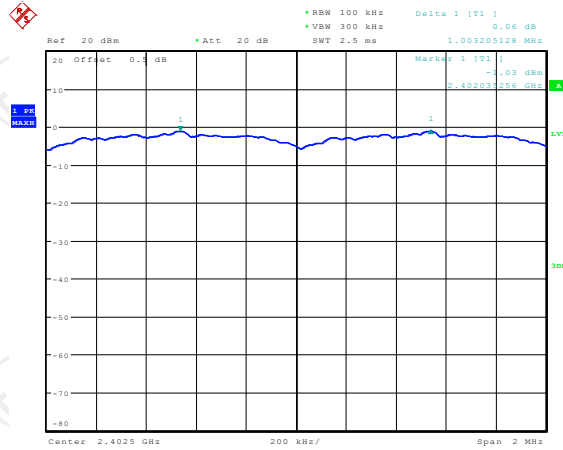
Date: 16.JAN.2019 10:38:45

Highest channel



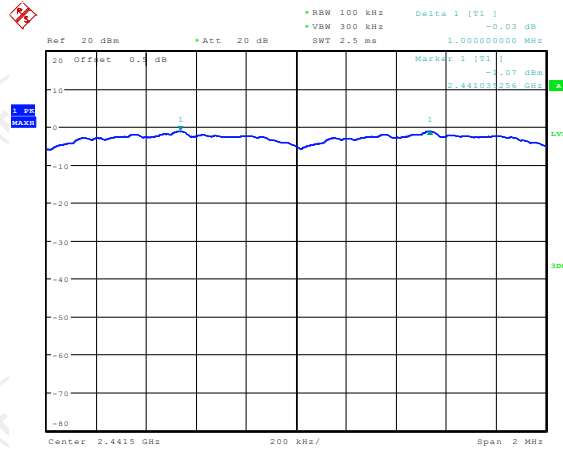
Date: 16.JAN.2019 10:40:25

Lowest channel



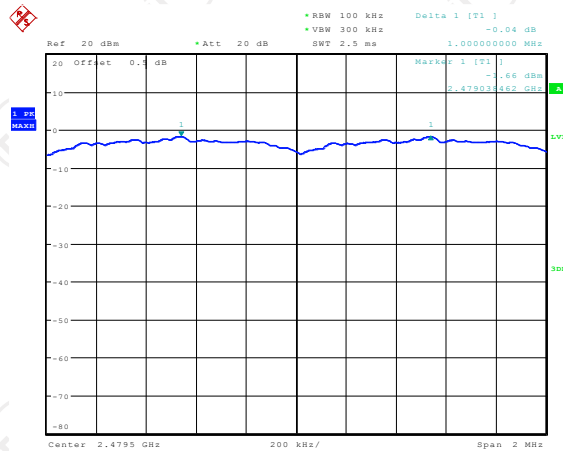
Date: 16.JAN.2019 10:43:41

Middle channel



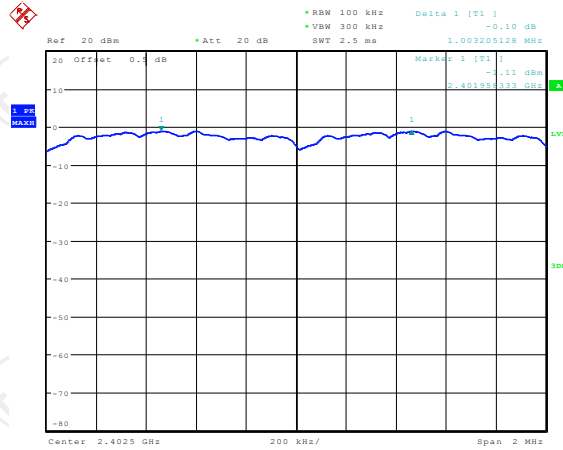
Date: 16.JAN.2019 10:42:57

Highest channel



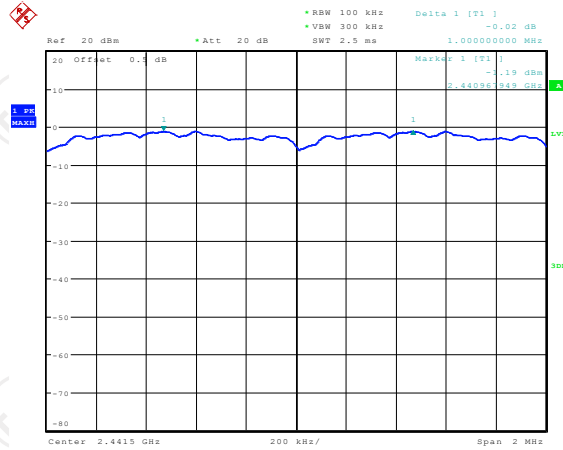
Date: 16.JAN.2019 10:41:48

Lowest channel



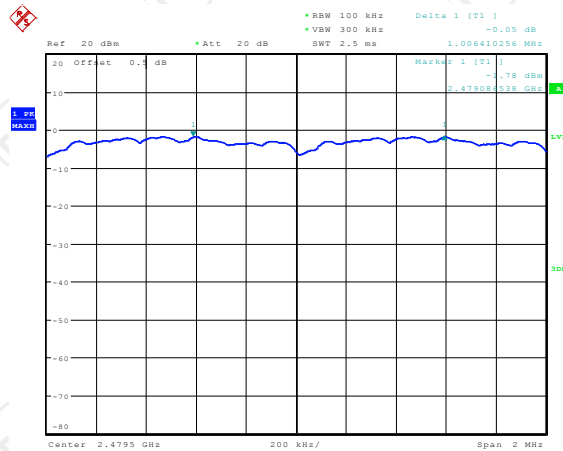
Date: 16.JAN.2019 10:44:40

Middle channel



Date: 16.JAN.2019 10:45:39


Highest channel



Date: 16.JAN.2019 10:46:37

## 6.6. Hopping Channel Number

### 6.6.1. Test Specification

<b>Test Requirement:</b>	FCC Part15 C Section 15.247 (a)(1)
<b>Test Method:</b>	ANSI C63.10:2013
<b>Limit:</b>	Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.
<b>Test Setup:</b>	 <p style="text-align: center;">Spectrum Analyzer                      EUT</p>
<b>Test Mode:</b>	Hopping mode
<b>Test Procedure:</b>	<ol style="list-style-type: none"> <li>1. The testing follows ANSI C63.10:2013 Measurement Guidelines.</li> <li>2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.</li> <li>3. Set to the maximum power setting and enable the EUT transmit continuously.</li> <li>4. Enable the EUT hopping function.</li> <li>5. Use the following spectrum analyzer settings: Span = the frequency band of operation; set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller; VBW<math>\geq</math>RBW; Sweep = auto; Detector function = peak; Trace = max hold.</li> <li>6. The number of hopping frequency used is defined as the number of total channel.</li> <li>7. Record the measurement data in report.</li> </ol>
<b>Test Result:</b>	PASS

### 6.6.2. Test Instruments

Equipment	Manufacturer	Model	Serial Number	Calibration Due
Spectrum Analyzer	R&S	FSU	200054	Sep. 20, 2019
RF Cable (9KHz-26.5GHz)	TCT	RE-06	N/A	Sep. 20, 2019
Antenna Connector	TCT	RFC-01	N/A	Sep. 20, 2019

**Note:** The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).

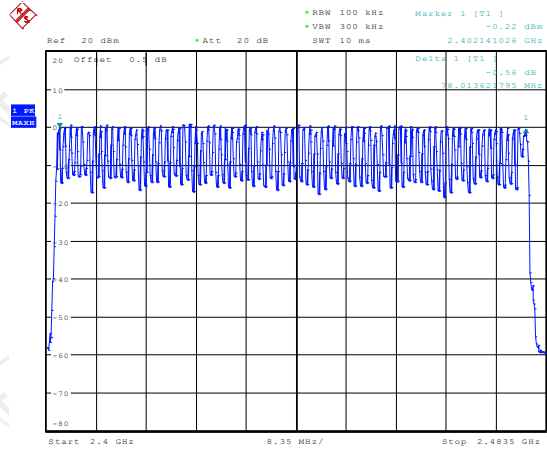
**6.6.3. Test data**

Mode	Hopping channel numbers	Limit	Result
GFSK, Pi/4DQPSK, 8DPSK	79	15	PASS

Test plots as follows:

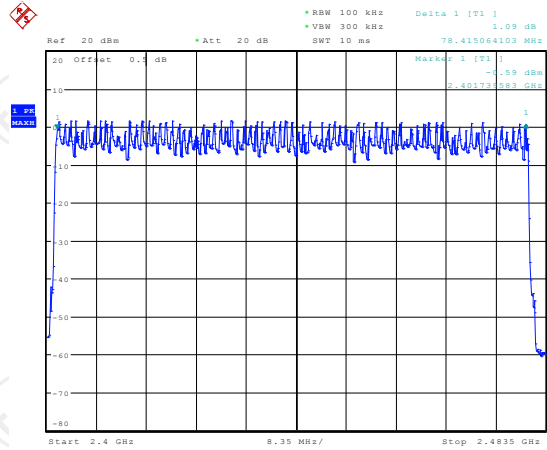


### GFSK



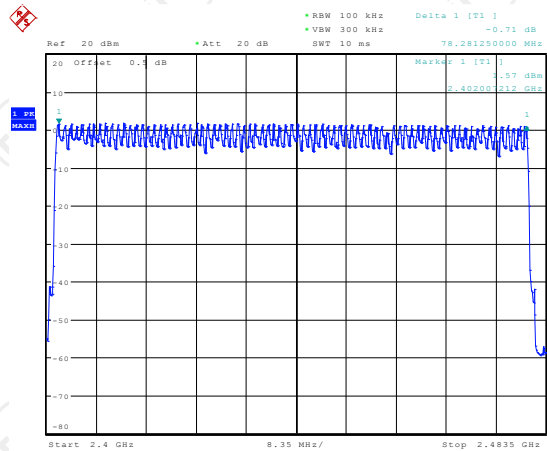
Date: 16.JAN.2019 10:48:28

### Pi/4DQPSK



Date: 16.JAN.2019 10:51:16

### 8DPSK



Date: 16.JAN.2019 10:55:01



**6.7.3. Test Data**

Mode	Packet	Hops Over Occupancy Time (hops)	Package Transfer Time (ms)	Dwell time (second)	Limit (second)	Result
GFSK	DH1	320	0.389	0.124	0.4	PASS
GFSK	DH3	160	1.663	0.266	0.4	PASS
GFSK	DH5	106.67	2.910	0.310	0.4	PASS
Pi/4 DQPSK	2-DH1	320	0.396	0.127	0.4	PASS
Pi/4 DQPSK	2-DH3	160	1.659	0.265	0.4	PASS
Pi/4 DQPSK	2-DH5	106.67	2.923	0.312	0.4	PASS
8DPSK	3-DH1	320	0.397	0.127	0.4	PASS
8DPSK	3-DH3	160	1.663	0.266	0.4	PASS
8DPSK	3-DH5	106.67	2.917	0.311	0.4	PASS

**Note:** 1. In normal mode, hopping rate is 1600 hops/s with 6 slots in 79 hopping channels.

For DH1, With channel hopping rate (1600 / 2 / 79) in Occupancy Time Limit (0.4 x 79) (s), Hops Over Occupancy Time comes to (1600 / 2 / 79) x (0.4 x 79) = 320 hops

For DH3, With channel hopping rate (1600 / 6 / 79) in Occupancy Time Limit (0.4 x 79) (s), Hops Over Occupancy Time comes to (1600 / 4 / 79) x (0.4 x 79) = 160 hops

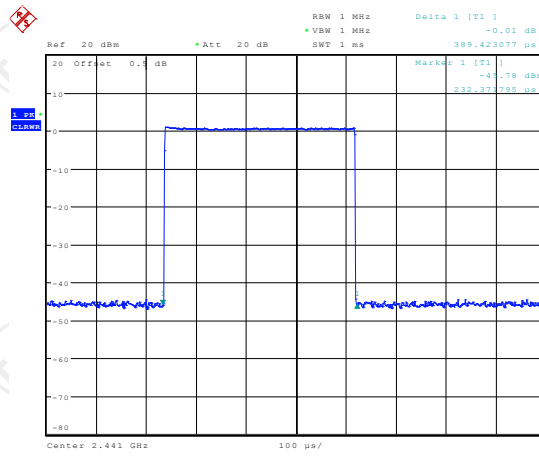
For DH5, With channel hopping rate (1600 / 6 / 79) in Occupancy Time Limit (0.4 x 79) (s), Hops Over Occupancy Time comes to (1600 / 6 / 79) x (0.4 x 79) = 106.67 hops

2. Dwell Time(s) = Hops Over Occupancy Time (hops) x Package Transfer Time

**Test plots as follows:**

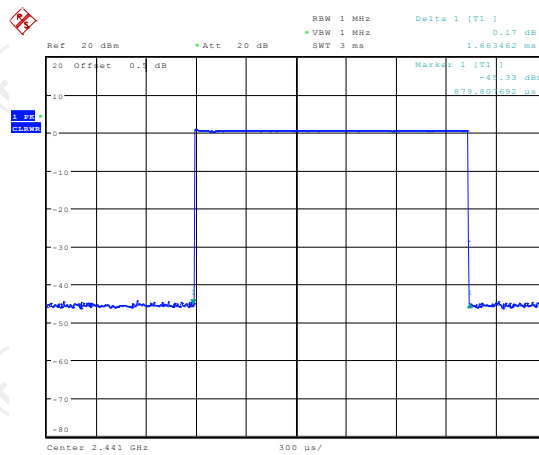


### GFSK DH1



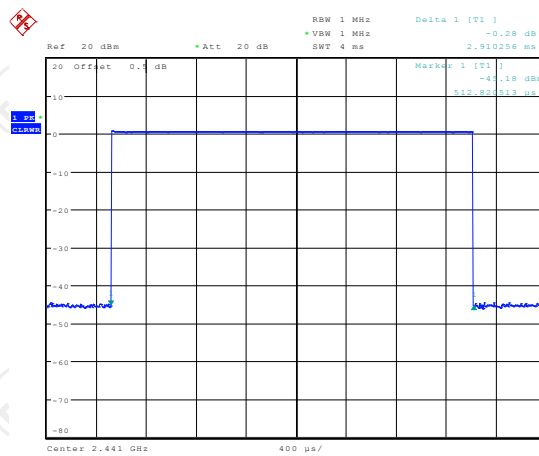
Date: 16.JAN.2019 10:59:11

### DH3



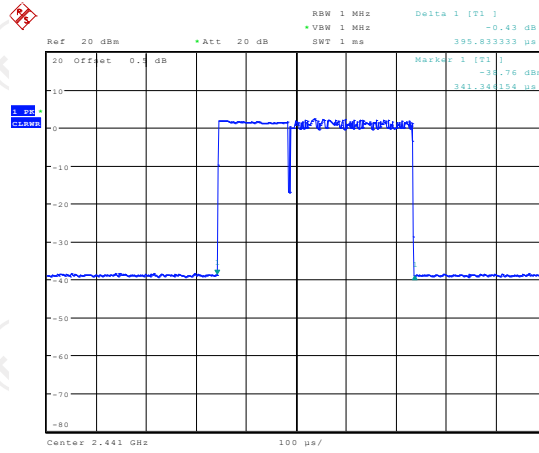
Date: 16.JAN.2019 10:59:55

### DH5



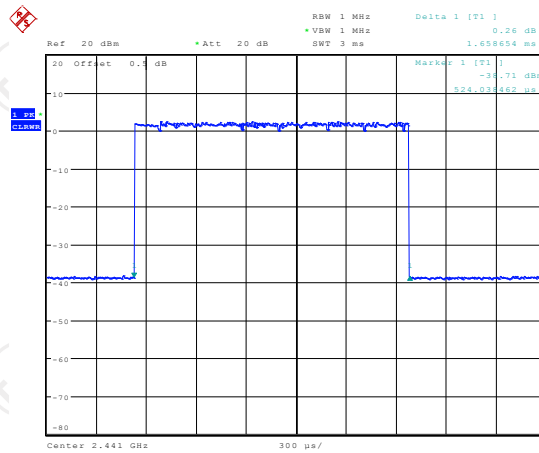
Date: 16.JAN.2019 11:00:37

### Pi/4DQPSK 2-DH1



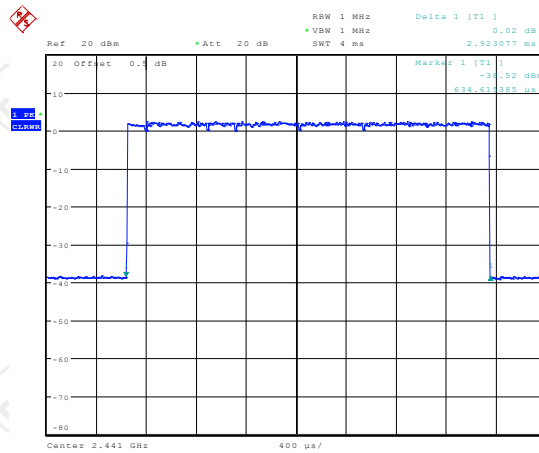
Date: 16.JAN.2019 11:01:26

### 2-DH3



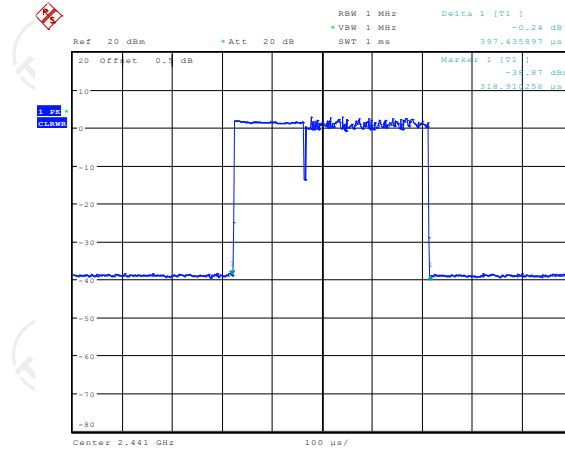
Date: 16.JAN.2019 11:02:23

### 2-DH5



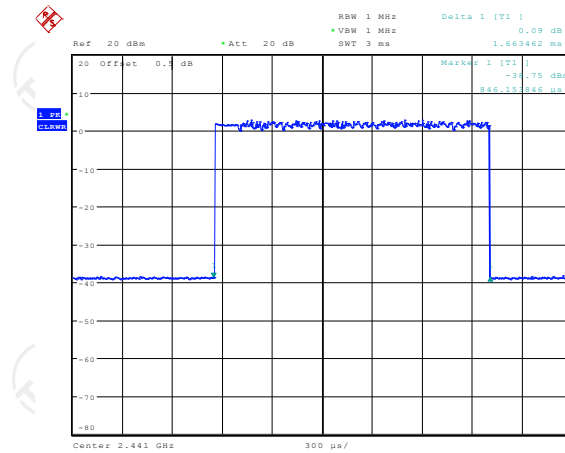
Date: 16.JAN.2019 11:03:11

### 8DPSK 3-DH1



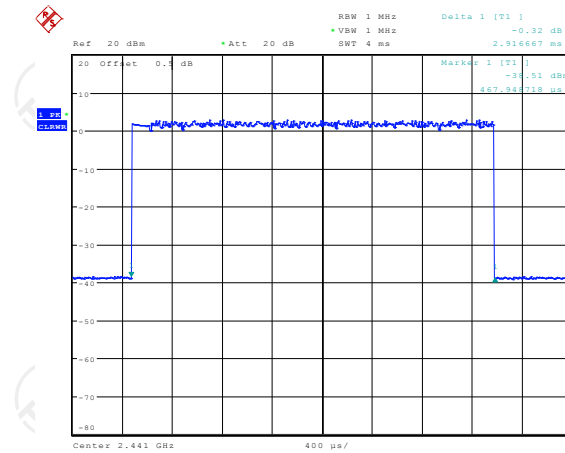
Date: 16.JAN.2019 11:03:45

### 3-DH3



Date: 16.JAN.2019 11:04:26

### 3-DH5



Date: 16.JAN.2019 11:06:00

### 6.8. Pseudorandom Frequency Hopping Sequence

<b>Test Requirement:</b>	<b>FCC Part15 C Section 15.247 (a)(1) requirement:</b>
--------------------------	--

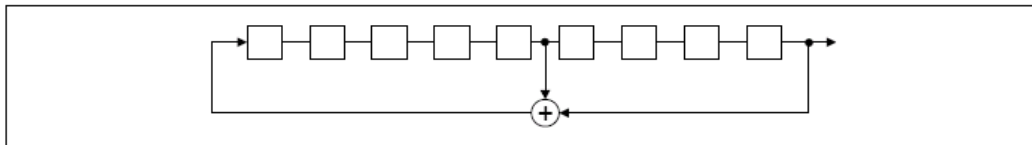
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

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 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.

#### EUT Pseudorandom Frequency Hopping Sequence

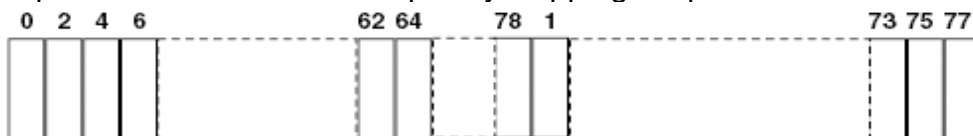
The pseudorandom sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first one of 9 consecutive ones; i.e. the shift register is initialized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

- Number of shift register 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*

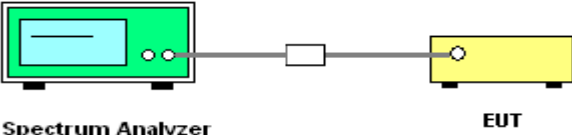
An example of Pseudorandom Frequency Hopping Sequence as follow:



Each frequency used equally on the average by each transmitter. The system receivers have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchronization with the transmitted signals.

## 6.9. Conducted Band Edge Measurement

### 6.9.1. Test Specification

<b>Test Requirement:</b>	FCC Part15 C Section 15.247 (d)
<b>Test Method:</b>	ANSI C63.10:2013
<b>Limit:</b>	In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.
<b>Test Setup:</b>	 <p style="text-align: center;">Spectrum Analyzer                      EUT</p>
<b>Test Mode:</b>	Transmitting mode with modulation
<b>Test Procedure:</b>	<ol style="list-style-type: none"> <li>1. The testing follows the guidelines in Band-edge Compliance of RF Conducted Emissions of ANSI C63.10:2013 Measurement Guidelines.</li> <li>2. Set to the maximum power setting and enable the EUT transmit continuously.</li> <li>3. Set RBW = 100 kHz (<math>\geq 1\%</math> span=10MHz), VBW = 300 kHz (<math>\geq</math>RBW). Band edge emissions must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100kHz RBW. The attenuation shall be 30 dB instead of 20 dB when RMS conducted output power procedure is used.</li> <li>4. Enable hopping function of the EUT and then repeat step 2 and 3.</li> <li>5. Measure and record the results in the test report.</li> </ol>
<b>Test Result:</b>	PASS

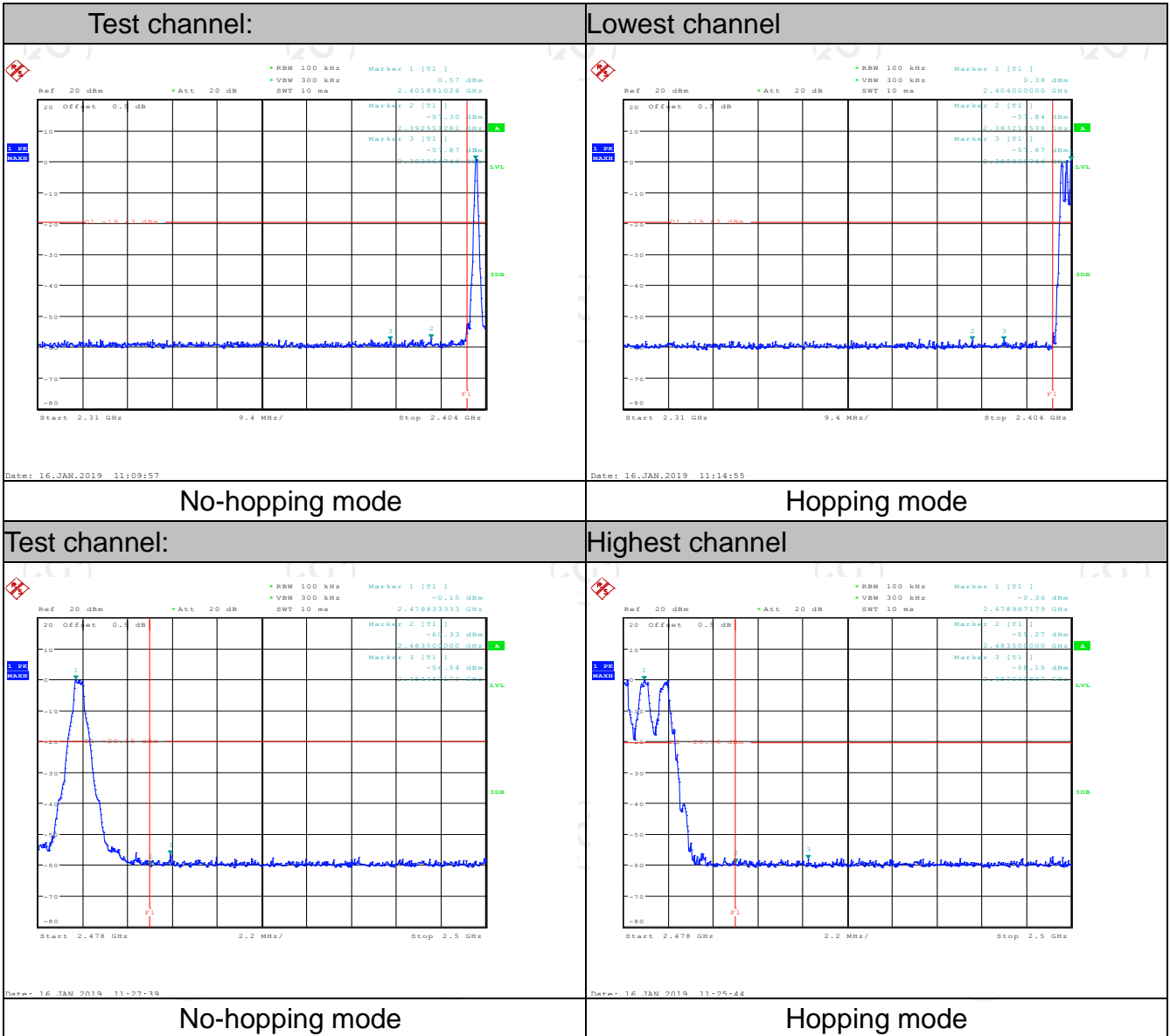
### 6.9.2. Test Instruments

Equipment	Manufacturer	Model	Serial Number	Calibration Due
Spectrum Analyzer	R&S	FSU	200054	Sep. 20, 2019
RF Cable (9KHz-26.5GHz)	TCT	RE-06	N/A	Sep. 20, 2019
Antenna Connector	TCT	RFC-01	N/A	Sep. 20, 2019

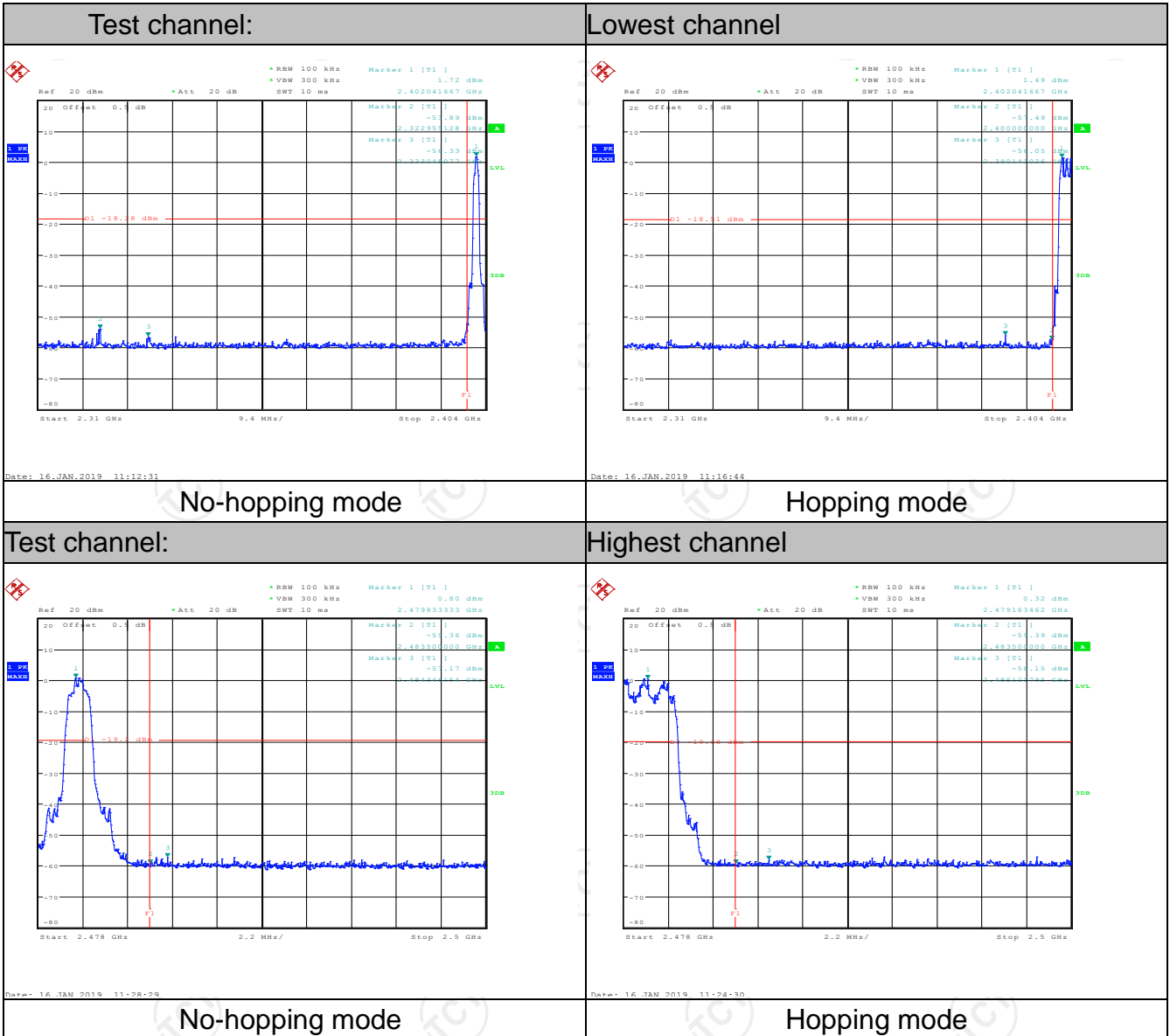
**Note:** The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).

6.9.3. Test Data

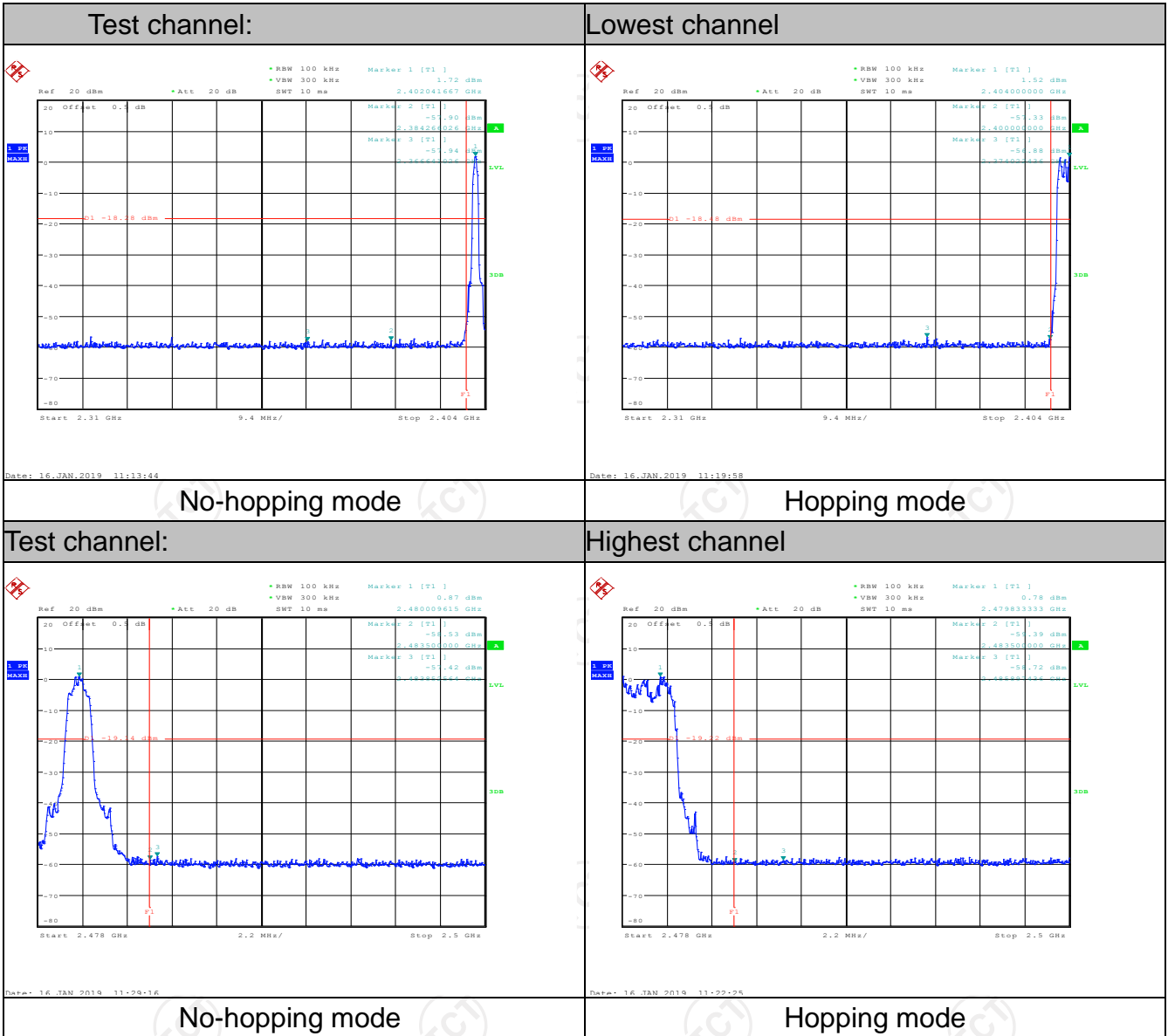
GFSK Modulation



**Pi/4DQPSK Modulation**



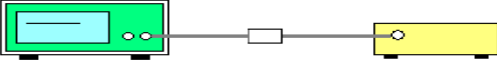
**8DPSK Modulation**





## 6.10. Conducted Spurious Emission Measurement

### 6.10.1. Test Specification

<b>Test Requirement:</b>	FCC Part15 C Section 15.247 (d)
<b>Test Method:</b>	ANSI C63.10:2013
<b>Limit:</b>	In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.
<b>Test Setup:</b>	 <p style="text-align: center;">Spectrum Analyzer                      EUT</p>
<b>Test Mode:</b>	Transmitting mode with modulation
<b>Test Procedure:</b>	<ol style="list-style-type: none"> <li>1. The testing follows the guidelines in Spurious RF Conducted Emissions of ANSI C63.10:2013 Measurement Guidelines</li> <li>2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.</li> <li>3. Set to the maximum power setting and enable the EUT transmit continuously.</li> <li>4. Set RBW = 100 kHz, VBW = 300kHz, scan up through 10th harmonic. All harmonics / spurs must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100 kHz RBW.</li> <li>5. Measure and record the results in the test report.</li> <li>6. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.</li> </ol>
<b>Test Result:</b>	PASS

### 6.10.2. Test Instruments

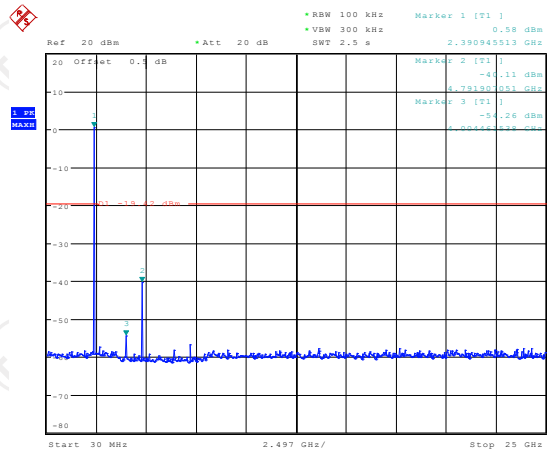
Equipment	Manufacturer	Model	Serial Number	Calibration Due
Spectrum Analyzer	R&S	FSU	200054	Sep. 20, 2019
Spectrum Analyzer	ROHDE&SCHWARZ	FSQ40	200061	Sep. 20, 2019
RF Cable (9KHz-26.5GHz)	TCT	RE-06	N/A	Sep. 20, 2019
Antenna Connector	TCT	RFC-01	N/A	Sep. 20, 2019

**Note:** The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).

6.10.3. Test Data

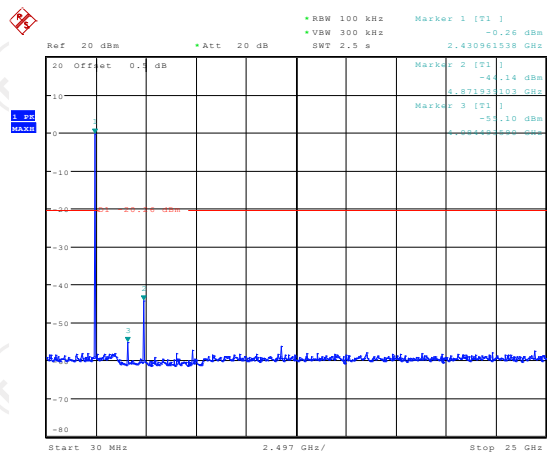
GFSK mode

Lowest Channel



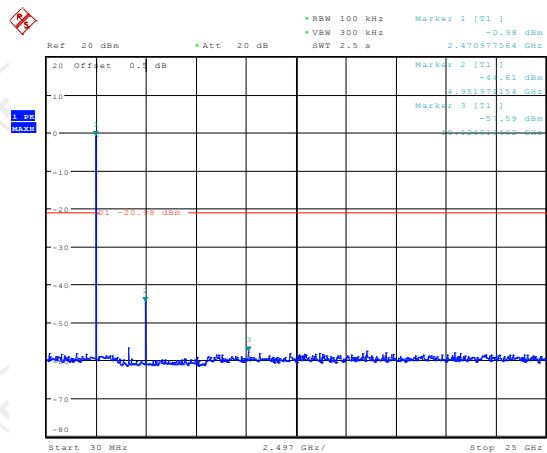
Date: 16.JAN.2019 11:30:45

Middle Channel



Date: 16.JAN.2019 11:32:08

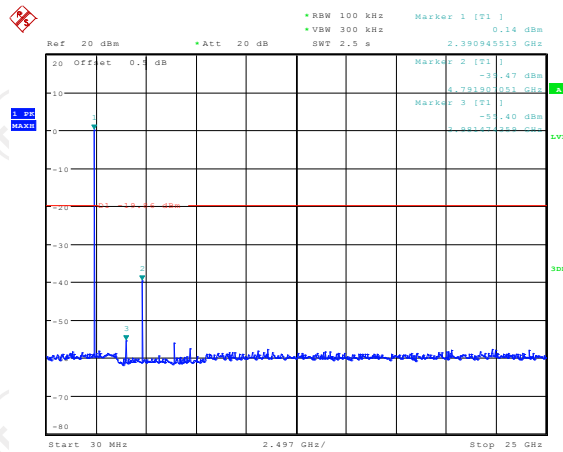
Highest Channel



Date: 16.JAN.2019 11:33:25

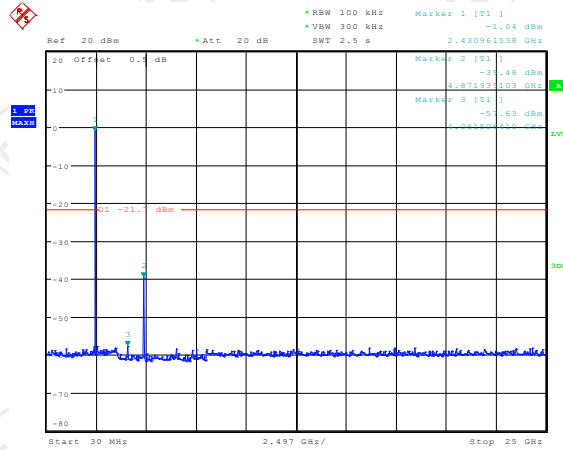
Pi/4DQPSK mode

Lowest Channel



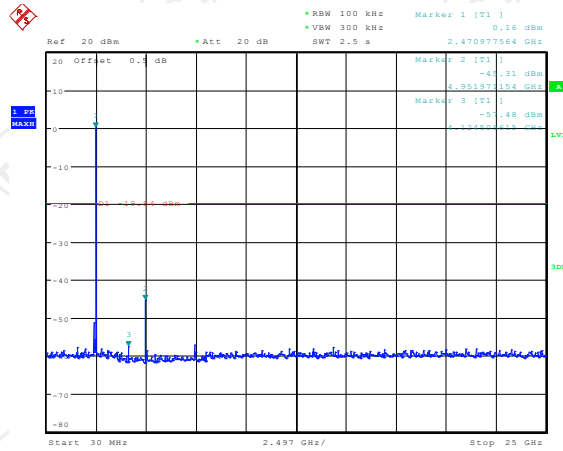
Date: 16.JAN.2019 11:36:44

Middle Channel



Date: 16.JAN.2019 11:35:41

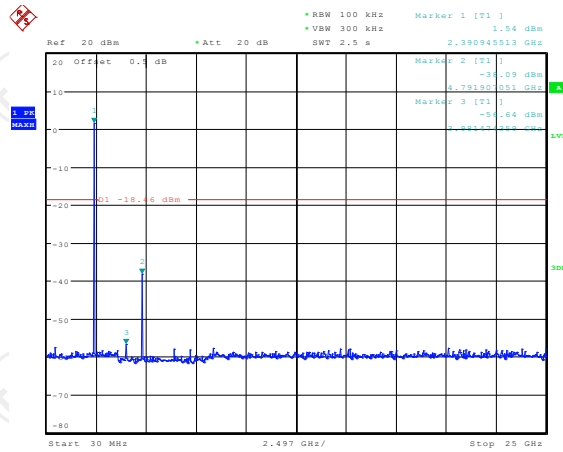
Highest Channel



Date: 16.JAN.2019 11:34:16

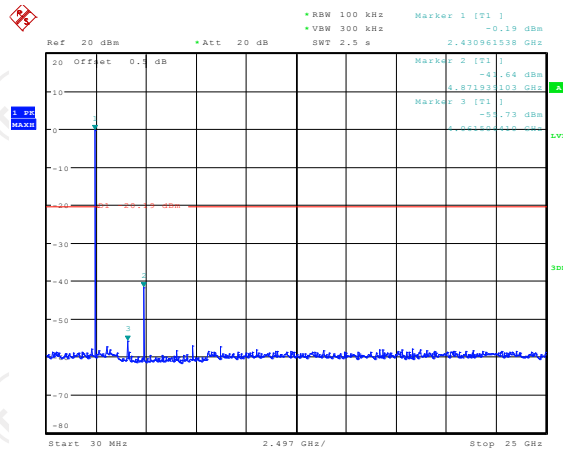
8DPSK mode

Lowest Channel



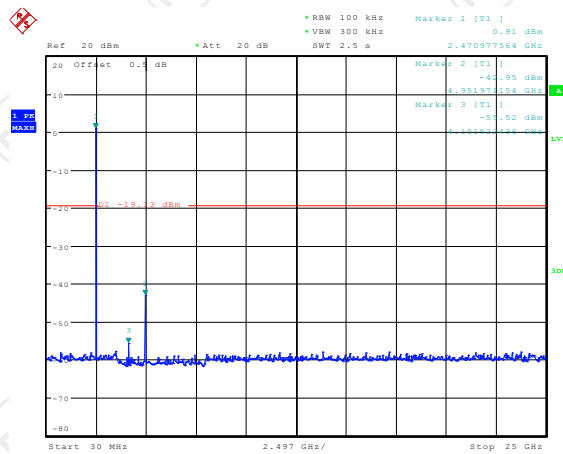
Date: 16.JAN.2019 11:37:48

Middle Channel



Date: 16.JAN.2019 11:38:58

Highest Channel



Date: 16.JAN.2019 11:40:13

## 6.11. Radiated Spurious Emission Measurement

### 6.11.1. Test Specification

<b>Test Requirement:</b>	FCC Part15 C Section 15.209																													
<b>Test Method:</b>	ANSI C63.10:2013																													
<b>Frequency Range:</b>	9 kHz to 25 GHz																													
<b>Measurement Distance:</b>	3 m																													
<b>Antenna Polarization:</b>	Horizontal & Vertical																													
<b>Receiver Setup:</b>	<table border="1"> <thead> <tr> <th>Frequency</th> <th>Detector</th> <th>RBW</th> <th>VBW</th> <th>Remark</th> </tr> </thead> <tbody> <tr> <td>9kHz- 150kHz</td> <td>Quasi-peak</td> <td>200Hz</td> <td>1kHz</td> <td>Quasi-peak Value</td> </tr> <tr> <td>150kHz- 30MHz</td> <td>Quasi-peak</td> <td>9kHz</td> <td>30kHz</td> <td>Quasi-peak Value</td> </tr> <tr> <td>30MHz-1GHz</td> <td>Quasi-peak</td> <td>100KHz</td> <td>300KHz</td> <td>Quasi-peak Value</td> </tr> <tr> <td rowspan="2">Above 1GHz</td> <td>Peak</td> <td>1MHz</td> <td>3MHz</td> <td>Peak Value</td> </tr> <tr> <td>Peak</td> <td>1MHz</td> <td>10Hz</td> <td>Average Value</td> </tr> </tbody> </table>	Frequency	Detector	RBW	VBW	Remark	9kHz- 150kHz	Quasi-peak	200Hz	1kHz	Quasi-peak Value	150kHz- 30MHz	Quasi-peak	9kHz	30kHz	Quasi-peak Value	30MHz-1GHz	Quasi-peak	100KHz	300KHz	Quasi-peak Value	Above 1GHz	Peak	1MHz	3MHz	Peak Value	Peak	1MHz	10Hz	Average Value
	Frequency	Detector	RBW	VBW	Remark																									
	9kHz- 150kHz	Quasi-peak	200Hz	1kHz	Quasi-peak Value																									
	150kHz- 30MHz	Quasi-peak	9kHz	30kHz	Quasi-peak Value																									
	30MHz-1GHz	Quasi-peak	100KHz	300KHz	Quasi-peak Value																									
Above 1GHz	Peak	1MHz	3MHz	Peak Value																										
	Peak	1MHz	10Hz	Average Value																										
<b>Limit:</b>	<table border="1"> <thead> <tr> <th>Frequency</th> <th>Field Strength (microvolts/meter)</th> <th>Measurement Distance (meters)</th> </tr> </thead> <tbody> <tr> <td>0.009-0.490</td> <td>2400/F(KHz)</td> <td>300</td> </tr> <tr> <td>0.490-1.705</td> <td>24000/F(KHz)</td> <td>30</td> </tr> <tr> <td>1.705-30</td> <td>30</td> <td>30</td> </tr> <tr> <td>30-88</td> <td>100</td> <td>3</td> </tr> <tr> <td>88-216</td> <td>150</td> <td>3</td> </tr> <tr> <td>216-960</td> <td>200</td> <td>3</td> </tr> <tr> <td>Above 960</td> <td>500</td> <td>3</td> </tr> </tbody> </table>	Frequency	Field Strength (microvolts/meter)	Measurement Distance (meters)	0.009-0.490	2400/F(KHz)	300	0.490-1.705	24000/F(KHz)	30	1.705-30	30	30	30-88	100	3	88-216	150	3	216-960	200	3	Above 960	500	3					
	Frequency	Field Strength (microvolts/meter)	Measurement Distance (meters)																											
	0.009-0.490	2400/F(KHz)	300																											
	0.490-1.705	24000/F(KHz)	30																											
	1.705-30	30	30																											
	30-88	100	3																											
	88-216	150	3																											
	216-960	200	3																											
	Above 960	500	3																											
	<table border="1"> <thead> <tr> <th>Frequency</th> <th>Field Strength (microvolts/meter)</th> <th>Measurement Distance (meters)</th> <th>Detector</th> </tr> </thead> <tbody> <tr> <td rowspan="2">Above 1GHz</td> <td>500</td> <td>3</td> <td>Average</td> </tr> <tr> <td>5000</td> <td>3</td> <td>Peak</td> </tr> </tbody> </table>	Frequency	Field Strength (microvolts/meter)	Measurement Distance (meters)	Detector	Above 1GHz	500	3	Average	5000	3	Peak																		
Frequency	Field Strength (microvolts/meter)	Measurement Distance (meters)	Detector																											
Above 1GHz	500	3	Average																											
	5000	3	Peak																											
<b>Test setup:</b>	For radiated emissions below 30MHz																													
	<p>Distance = 3m</p> <p>EUT</p> <p>Turn table</p> <p>Ground Plane</p> <p>Computer</p> <p>Pre - Amplifier</p> <p>Receiver</p>																													
	30MHz to 1GHz																													