TEST REPORT

Report Number: 103615308MPK-010
Project Number: G103615308
October 29, 2018

Testing performed on the
Vocera V5000 Smartbadge
Model: V5000

FCC ID: QGZV5000
IC: 4362A-V5000

To

FCC Part 15 Subpart C (15.247)
Industry Canada RSS-247 Issue 2

For

Vocera Communications

Test Performed by:	Test Authorized by:
Intertek	Vocera Communications
1365 Adams Court	525 Race St, Ste 150
Menlo Park, CA 94025 USA	San Jose, CA 95126 USA

Prepared by: _____ **Date:** October 29, 2018
Minh Ly

Reviewed by: _____ **Date:** October 29, 2018
Krishna K Vemuri

Report No. 103615308MPK-010

Equipment Under Test:	Vocera V5000 Smartbadge
Trade Name:	Vocera Communications
Model Number:	V5000
Applicant:	Vocera Communications
Contact:	Prakash Guda
Address:	Vocera Communications 525 Race St, Ste 150 San Jose, CA 95126 USA
Country	USA
Tel. Number:	(408) 882-5100
Email:	Pguda@vocera.com
Applicable Regulation:	FCC Part 15 Subpart C (15.247) Industry Canada RSS-247 Issue 2
Date of Test:	September 21 – October 26, 2018

We attest to the accuracy of this report:

Minh Ly
Project Engineer

Krishna K Vemuri
Engineering Team Lead

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1.0 Introduction

This report is designed to show compliance of the 2.4 GHz transceiver with the requirements of FCC Part 15 Subpart C (15.247) and RSS-247. This test report covers only the FHSS radio.

1.1 Summary of Tests

TEST	REFERENCE FCC Part 15 Subpart C (15.247)	REFERENCE Industry Canada	RESULTS
RF Output Power	15.247(b)	RSS-247, 5.4.2	Complies
20-dB Bandwidth	15.247(a)(1)	RSS-247, 5.1.1	Complies
Channel Separation	15.247(a)(1)	RSS-247, 5.1.2	Complies
Number of Hopping Channels	15.247(a)(1)	RSS-247, 5.14	Complies
Average Channel Occupancy Time	15.247(a)(1)	RSS-247, 5.14	Complies
Out-of-Band Antenna Conducted Emission	15.247(d)	RSS-247, 5.5	Complies
Transmitter Radiated Emissions	15.247(d), 15.209, 15.205	RSS-GEN	Complies
AC Line Conducted Emission	15.207	RSS-GEN	Complies
Antenna Requirement	15.203	RSS-GEN	Complies (Internal Antenna)

2.0 General Description

2.1 Product Description

Vocera Communications supplied the following description of the EUT:

The V5000 Smartbadge is a wearable communication device powered by a removable, rechargeable Lithium Ion battery. The badge contains a 2.4" color, capacitive touch screen, with an array of microphones, a hands free speaker and an audio receiver.

For more information, see user's manual provided by the manufacturer.

Information about the Bluetooth FHSS radio is presented below:

For more information, refer to the following product specification, declared by the manufacturer.

Information about the 2.4 GHz radio is presented below:

Applicant	Vocera Communications
Model No.	V5000
FCC Identifier	QGZ V5000
IC Identifier	4362A- V5000
Type of Transmission	Frequency Hopping Spread Spectrum
Rated RF Output	2.99 dBm
Antenna(s) & Gain	Internal Antenna, Gain: 4.9 dBi
Frequency Range	2402 – 2480 MHz
Number of Channel(s)	79, (Channels 0-78)
Modulation Type	GFSK, π/4-DQPSK, 8DPSK
Data Rate	Up to 3Mbps
Applicant Name & Address	Vocera Communications 525 Race St, Ste 150 San Jose, CA 95126 USA USA

EUT receive date: September 17, 2018

EUT receive condition: The pre-production version of the EUT was received in good condition with no apparent damage. As declared by the Applicant, it is identical to the production units.

Test start date: September 21, 2018

Test completion date: October 26, 2018

The test results in this report pertain only to the item tested.

2.2 Related Submittal(s) Grants

None.

2.3 Test Methodology

Antenna conducted measurements were performed according to the FCC documents “Guidance for Performing Compliance Measurement on Digital Transmission Systems, Frequency Hopping Spread Spectrum System, and Hybrid System devices Operating under §15.247” (KDB 558074 D01 Meas Guidance v05), RSS-247 Issue 2, ANSI C63.10: 2013 and RSS-GEN Issue 4.

Radiated emissions measurements were performed according to the procedures in ANSI C63.10: 2013. Radiated tests were performed at an antenna to EUT distance of 3 meters, unless stated otherwise in the **"Data Sheet"** of this Application.

All other measurements were made in accordance with the procedures in part 2 of CFR 47.

Following is the channel test plan:

Channels in 2.4 GHz band			
Test Channel		Frequency, MHz	Tested
Low	0	2402	√
Middle	39	2441	√
High	78	2480	√

2.4 Test Facility

The test site used to collect the radiated data is site 1 (10-m semi-anechoic chamber). This test facility and site measurement data have been fully placed on file with the FCC, IC and A2LA accredited.

3.0 System Test Configuration

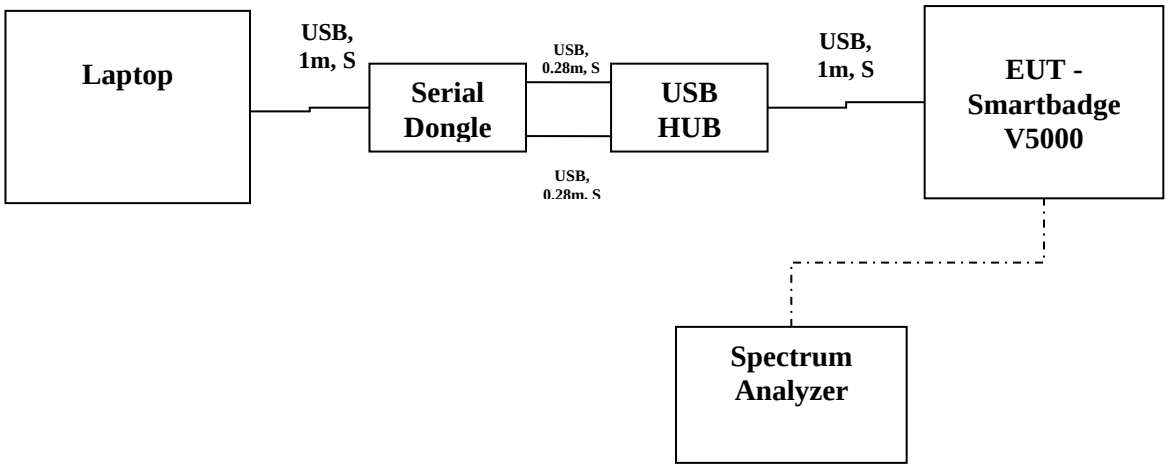
3.1 Support Equipment

Description	Manufacturer	Model Number
Laptop	Lenovo	T440P
USB Hub	Tendak	CP-029-BK
Serial Dongle	Vocera	210-01516-B04

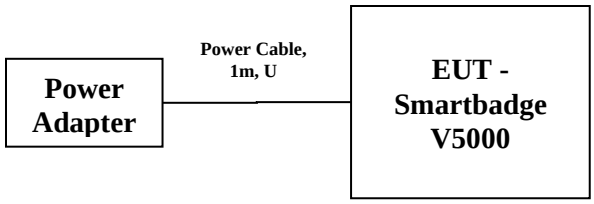
3.2 Block Diagram of Test Setup

Equipment Under Test			
Description	**Manufacturer**	**Model Number**	**Serial Number**
Smartbadge – Conducted Unit	Vocera	V5000	SA3308HF5002D1
Smartbadge – Radiated Unit	Vocera	V5000	SA3308HR50031F
Power Adapter	Asian Power Devices Inc.	WB-10E05R	S8827999000015
Earphone	Kingstate Electronics Corp.	KJFGKS172JJB-01	Not listed

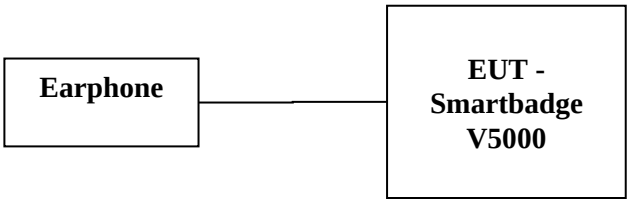
Antenna was removed and co-axial connector was installed for Conducted Measurements.



Radiated Measurements
Charging Mode



Radiated Measurements
Normal Mode



S = Shielded **U** = Unshielded	**F** = With Ferrite **m** = Length in Meters

3.3 Justification

For radiated emission measurements the EUT is placed on a non-conductive table. The EUT is attached to peripherals and they are connected and operational (as typical as possible). The EUT is wired to transmit full power. During testing, all cables are manipulated to produce worst-case emissions. Different orientation of the EUT were tested and only the worse-case emissions were reported.

The EUT was tested in 2 configurations:

A/ Charging mode: tested with power adapter
B/ Normal mode: tested in battery mode and earphone.

3.4 Software Exercise Program

The EUT exercise program used during radiated and conducted testing was provided by Vocera Communications

3.5 Mode of Operation During Test

During transmitter testing, the transmitter was setup to transmit continuously at maximum RF power on the low channel, middle channel, high channel and with hopping channels enabled.

3.6 Modifications Required for Compliance

Intertek installed no modifications during compliance testing in order to bring the product into compliance.

3.7 Additions, Deviations and Exclusions from Standards

No additions, deviations or exclusions from the standard were made.

4.0 Transmitter Emissions Measurement Results

4.1 20dB Bandwidth, and 99% Occupied Bandwidth
FCC Rule 15.247(a)(1)

4.1.1 Procedure

For FCC 20dB Channel Bandwidth the Procedure described in the FCC Publication 558074 D01 Meas Guidance v05 & Section 7.8.7 of ANSI C63.10:2013 for Frequency Hopping Spread Spectrum Systems was used to determine the 20dB bandwidth.

- Span = Approximately 2 to 3 times the 20dB bandwidth, centered on a hopping channel
- RBW = 1% of the 20dB bandwidth
- VBW = 3 x RBW
- Sweep = Auto
- Detector function = Peak
- Trace = Max hold

The EUT should be transmitting at its maximum data rate. Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. Use the marker delta function to measure 20 dB down one side of the emission. Reset the marker-delta function, and move the marker to the other side of the emission, until it is (as close as possible to) even with the reference marker level. The marker-delta reading at this point is the 20dB bandwidth of the emission. If this value varies with different modes of operation (e.g., data rate, modulation format, etc.), repeat this test for each variation. The limit is specified in one of the subparagraphs of this Section. Submit this plot(s).

For 99% power bandwidth measurement, the bandwidth was determined by using the built-in 99% occupied bandwidth function of the spectrum analyzer.

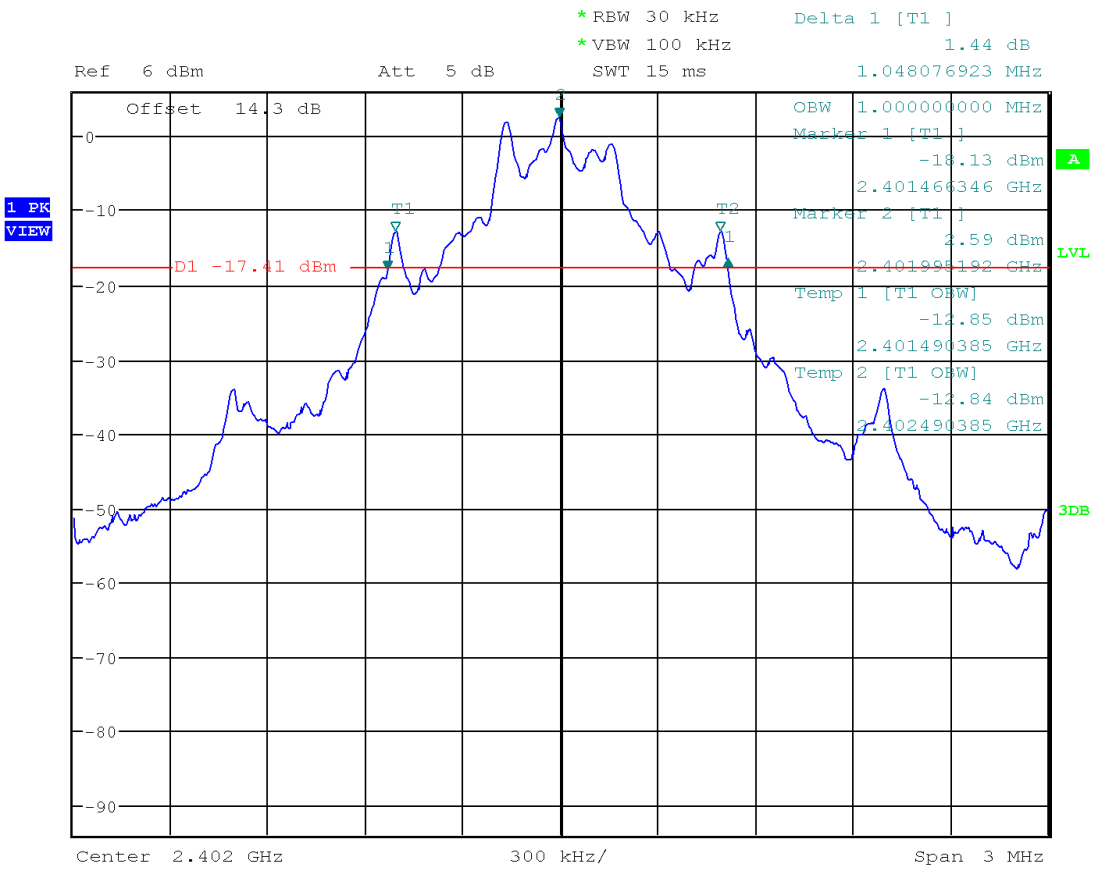
The antenna port of the EUT was connected to the input of a spectrum analyzer (SA). For each RF output channel investigated, the spectrum analyzer center frequency was set to the channel carrier. A Peak output reading was taken, a Display line was drawn for 20dB lower than Peak level. The 20dB bandwidth was determined from where the channel output spectrum intersected the display line.

Tested By:	Minh Ly
Test Date:	September 24, 2018

4.1.2 Test Result

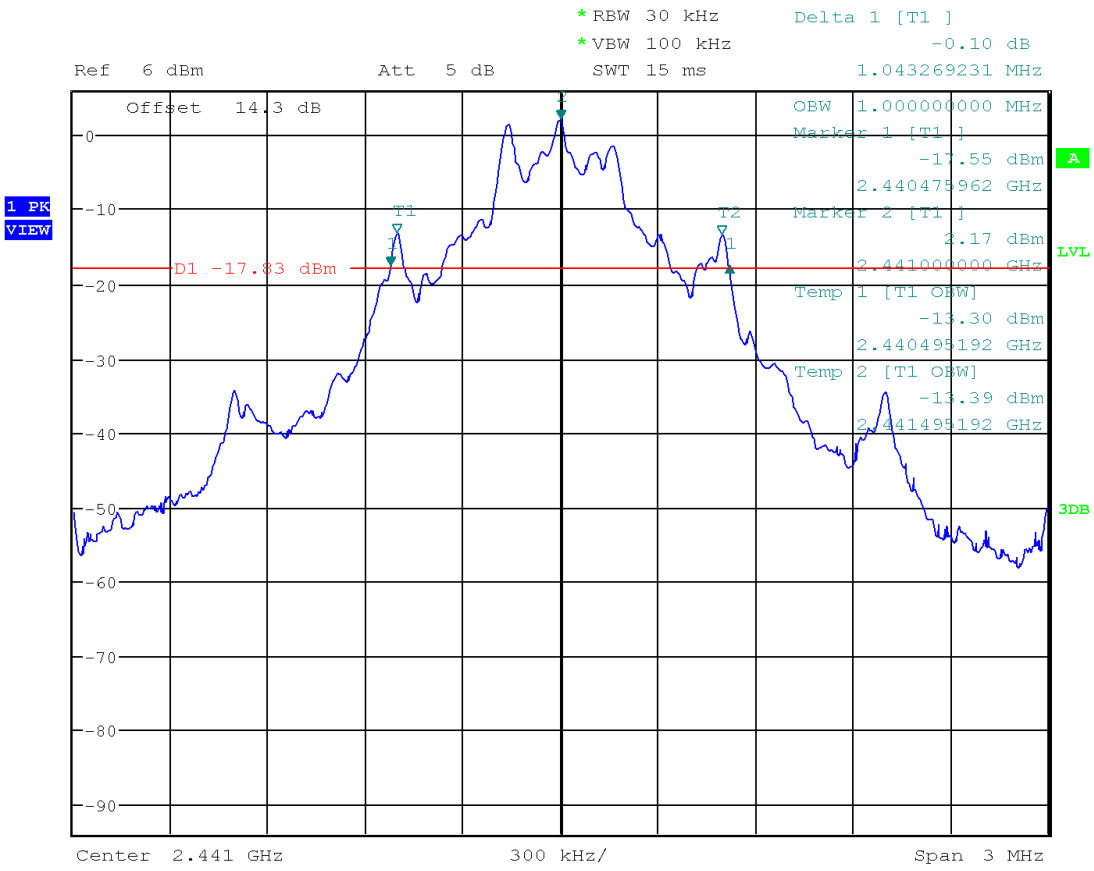
Modulation Type	Channel	Frequency MHz	20 dB FCC Bandwidth, MHz	99% Bandwidth, MHz	Plot #
GFSK	0	2402	1.048	1.000	1.1
	39	2441	1.043	1.000	1.2
	78	2480	1.048	1.004	1.3
π/4-DQPSK	0	2402	1.298	1.187	1.4
	39	2441	1.307	1.187	1.5
	78	2480	1.317	1.187	1.6
8DPSK	0	2402	1.177	1.302	1.7
	39	2441	1.312	1.182	1.8
	78	2480	1.312	1.182	1.9

Plot 1. 1 – 20dB Bandwidth Low Channel GFSK



Date: 24.SEP.2018 17:00:29

Plot 1. 2 – 20dB Bandwidth Middle Channel GFSK



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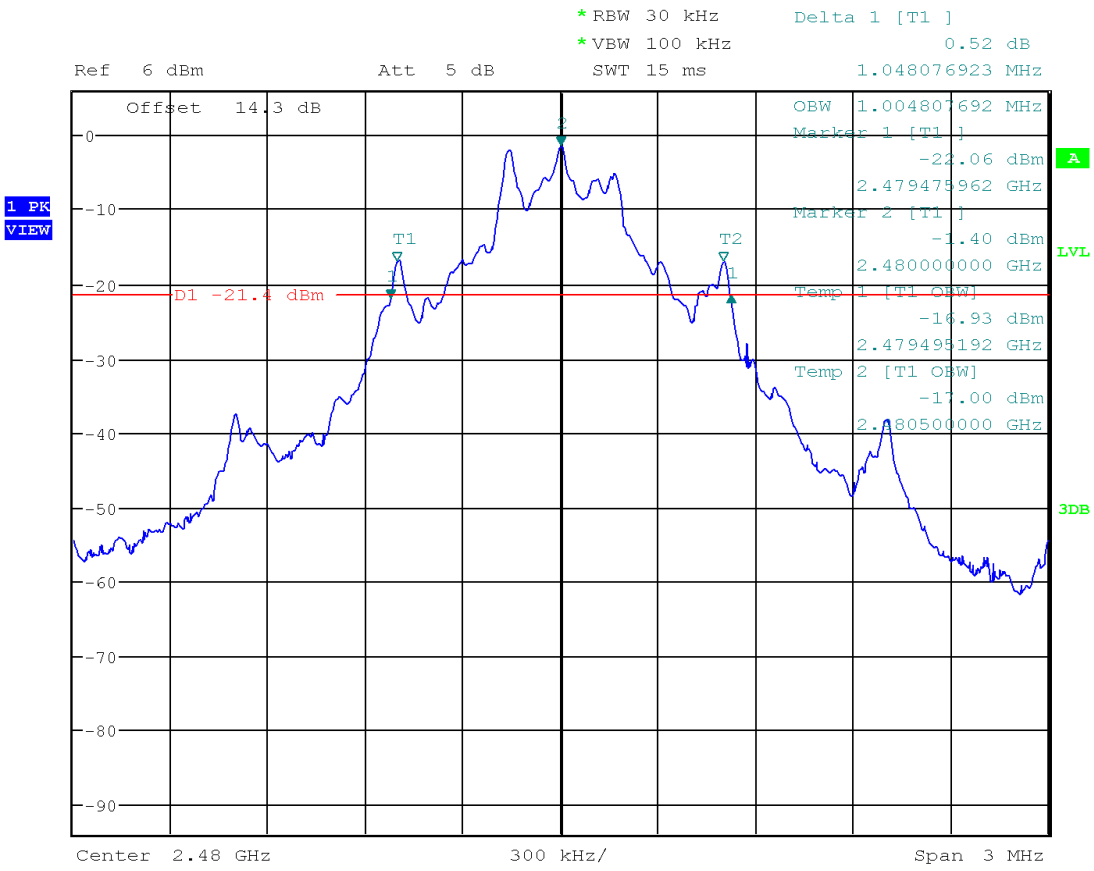
Plot 1. 3 – 20dB Bandwidth High Channel GFSK



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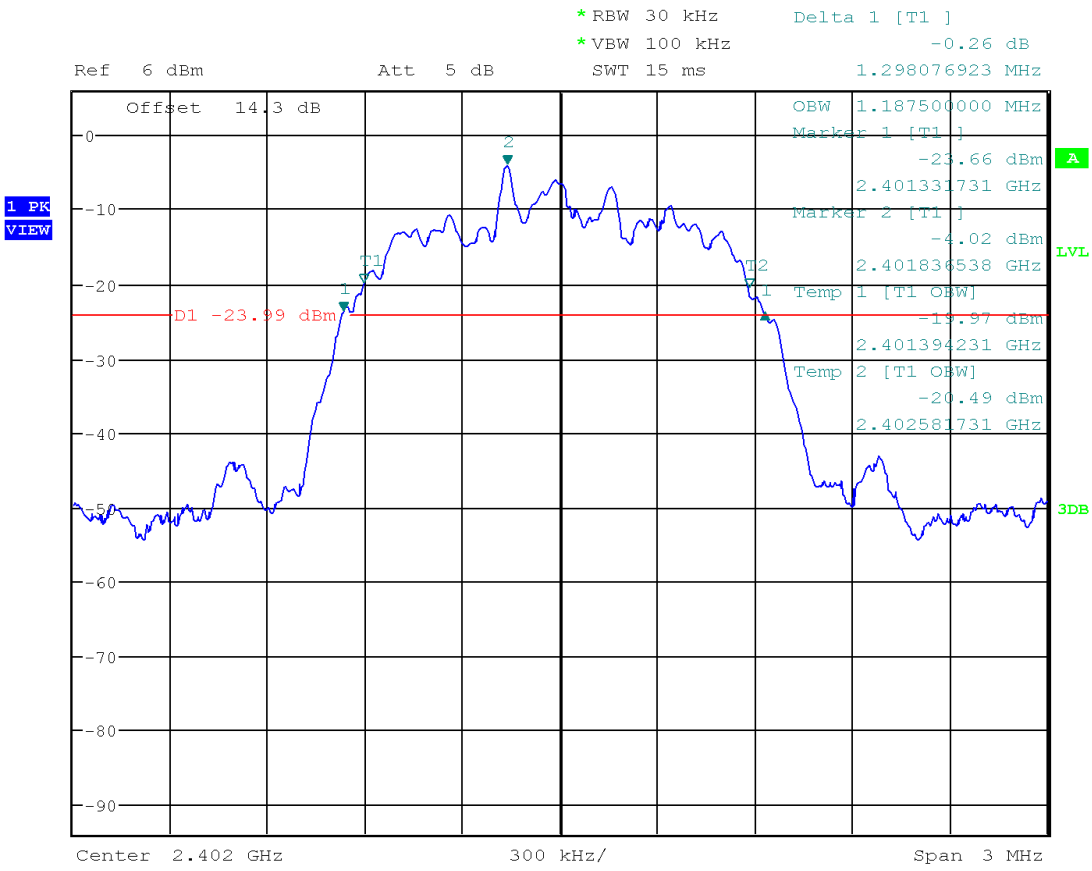
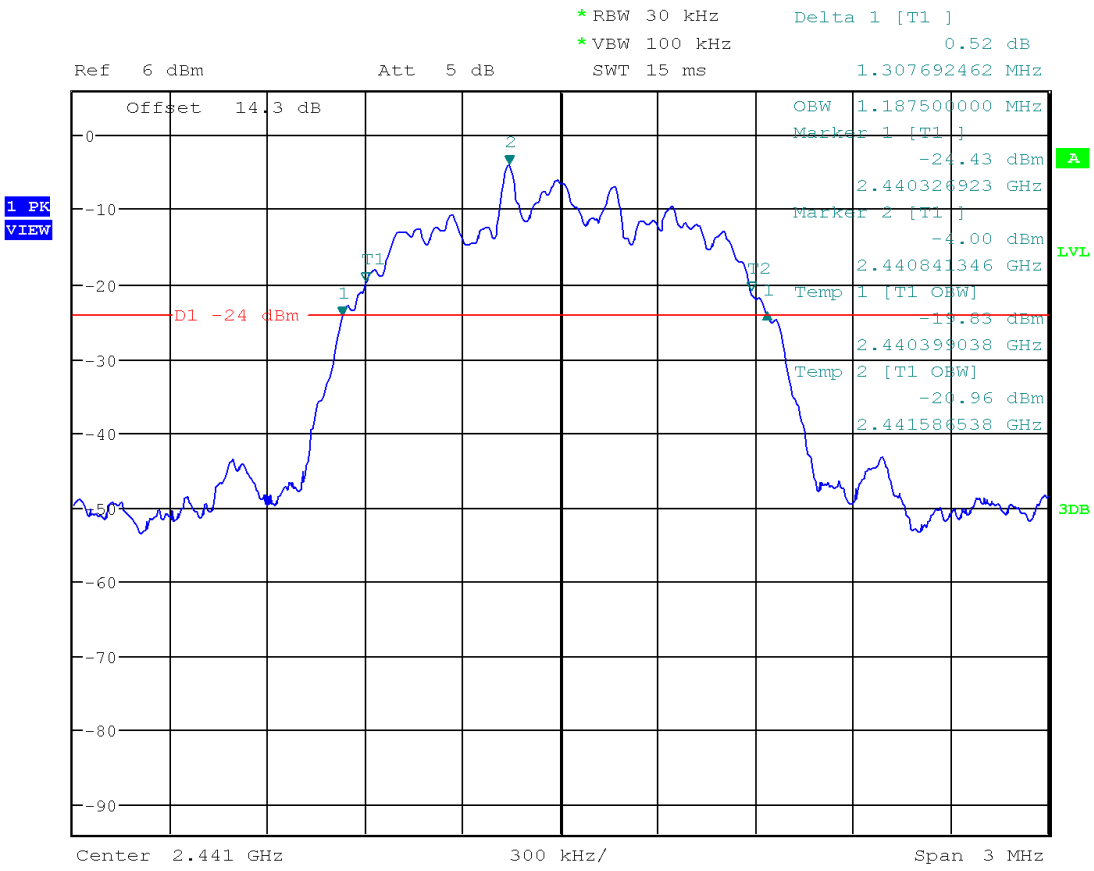
Plot 1. 4 – 20dB Bandwidth Low Channel π/4-DQPSK



Date: 27.SEP.2018 15:56:15

Plot 1. 5 – 20dB Bandwidth Middle Channel π/4-DQPSK



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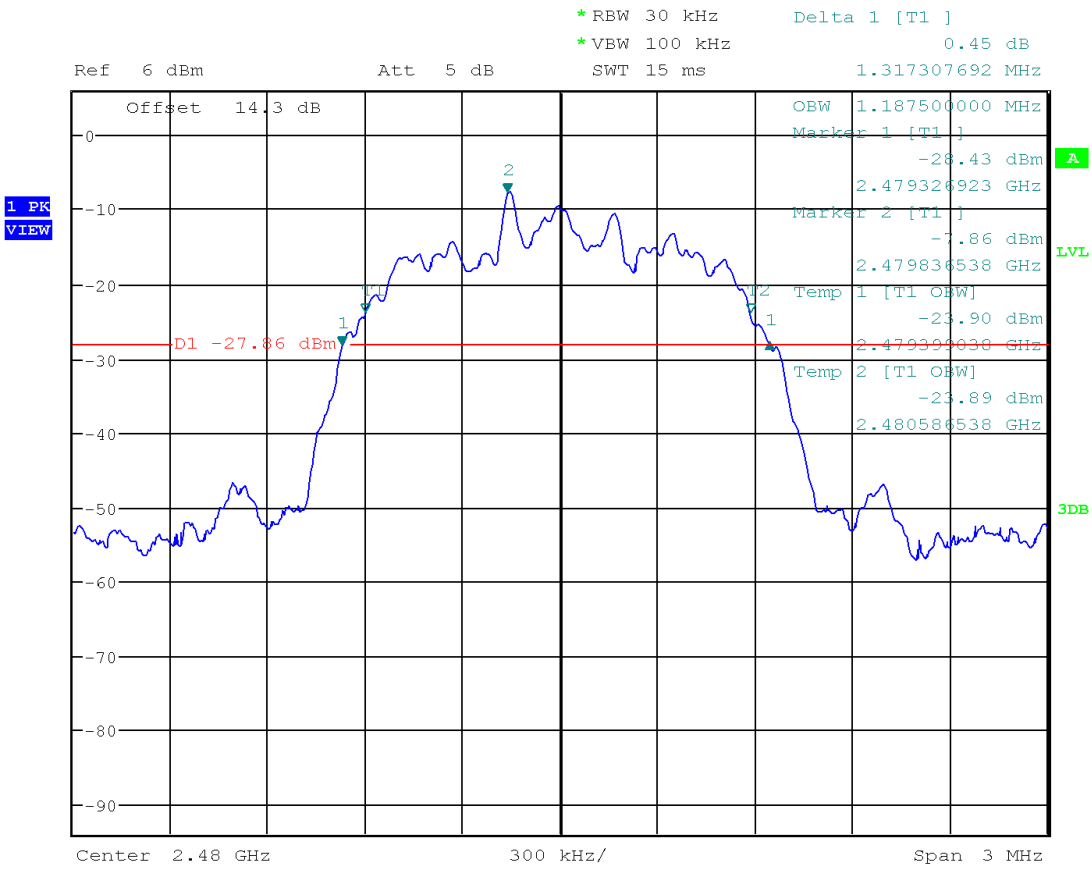
Plot 1. 6 – 20dB Bandwidth High Channel π/4-DQPSK



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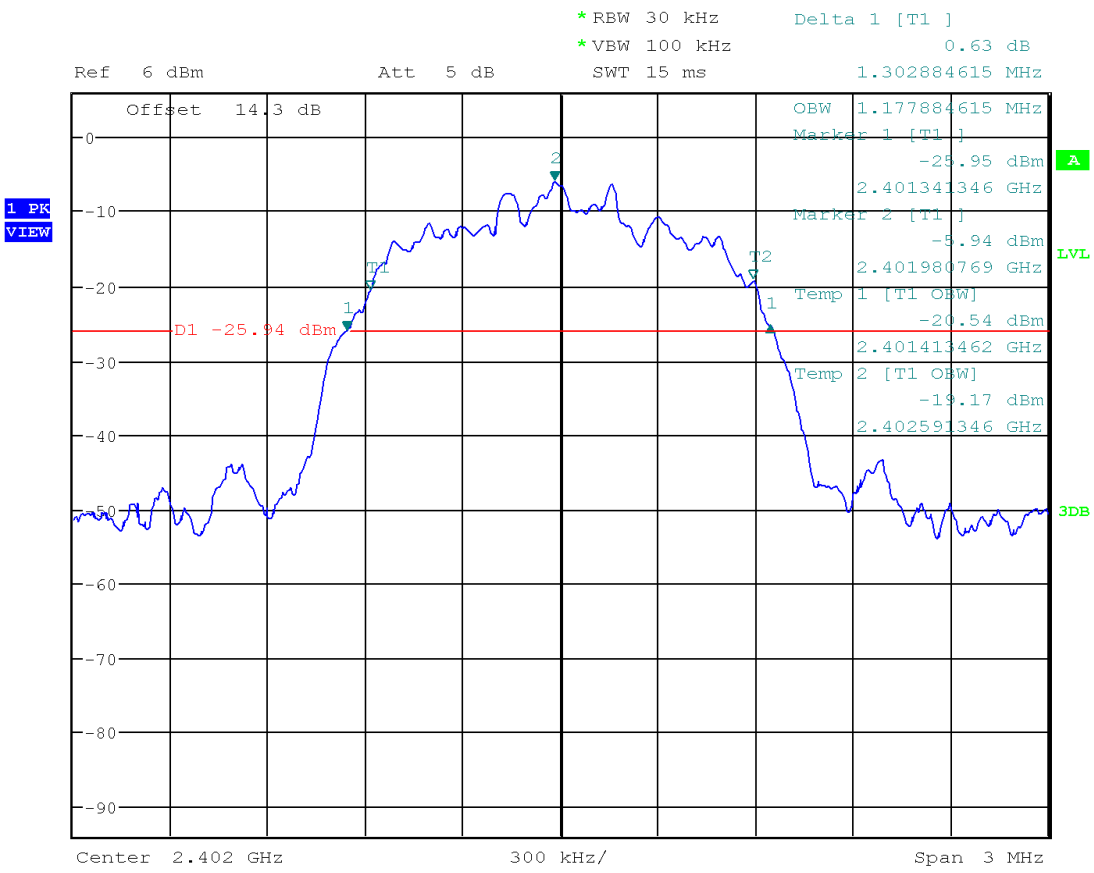
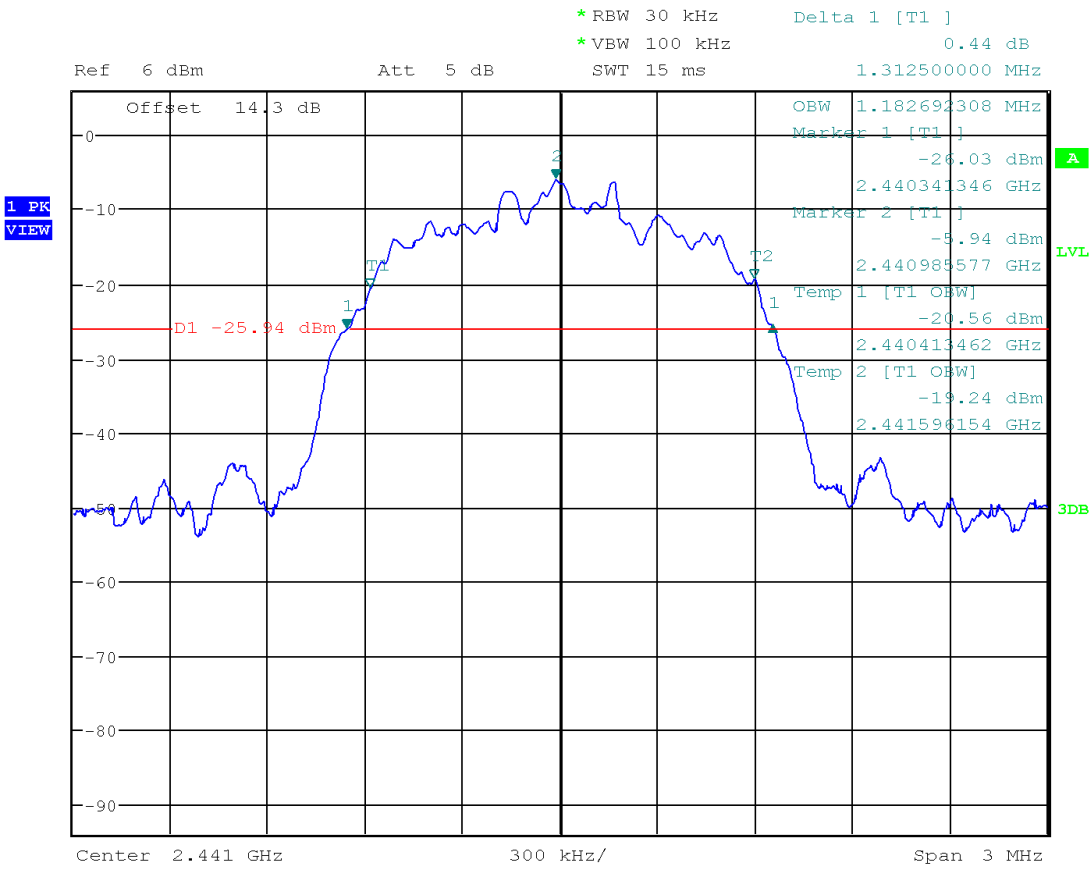
Plot 1. 7 – 20dB Bandwidth Low Channel 8DPSK



Date: 27.SEP.2018 16:00:47

Plot 1. 8 – 20dB Bandwidth Middle Channel 8DPSK



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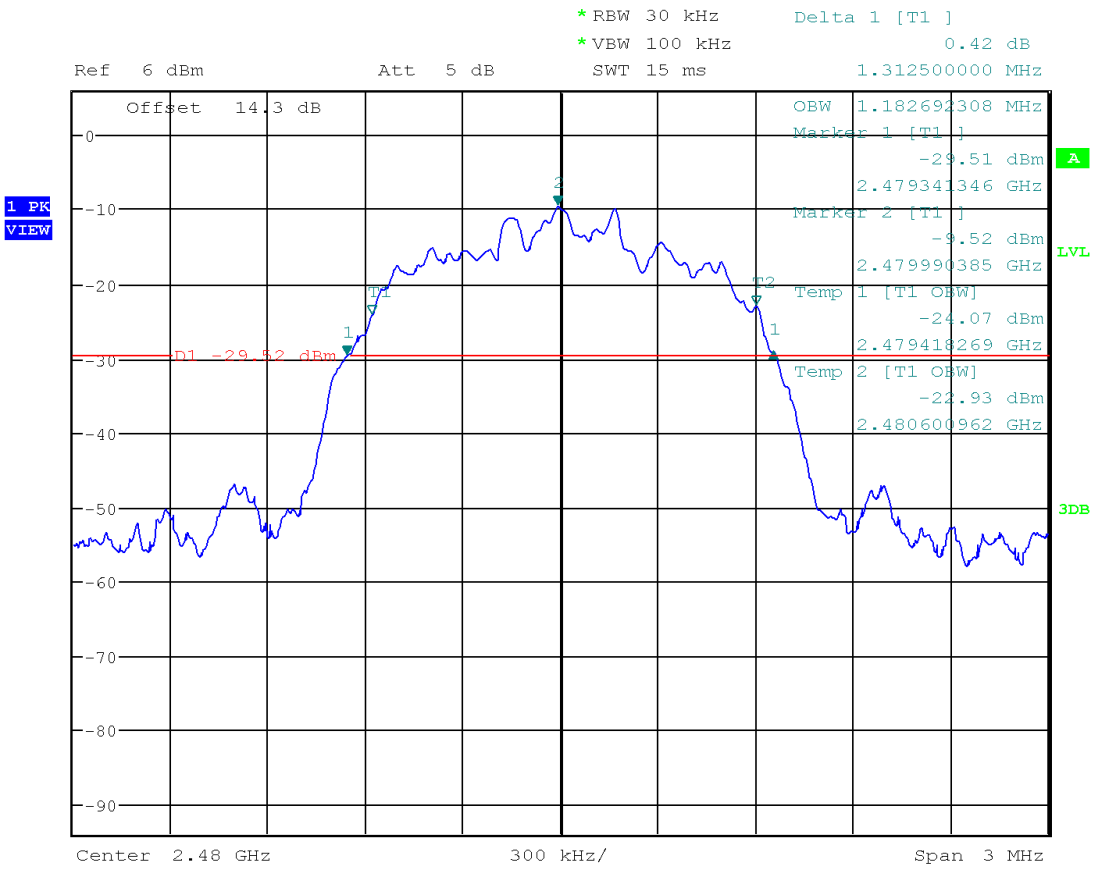
Plot 1. 9 – 20dB Bandwidth High Channel 8DPSK



Date: 27.SEP.2018 16:04:58

4.2 Conducted Output Power at Antenna Terminals
FCC Rule 15.247(b)(1)

4.2.1 Requirement

For systems operating in the 2400-2483.5 MHz band employing at least 75 hopping channels, the maximum peak output power is 1 watt (30 dBm), for all other systems 0.125 W (21 dBm).

4.2.2 Procedure

The procedure described in FCC Publication 558074 D01 Meas Guidance v05 was used. Specifically, Section 7.8.5 of ANSI C63.10:2013 for Frequency Hopping Spread Spectrum Systems was used to determine the RF Output Power.

- Span = approximately 5 times the 20dB bandwidth, centered on a hopping channel
- RBW > the 20dB bandwidth of the emission being measured
- VBW = 3 x 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. The indicated level is the peak output power (see the NOTE above regarding external attenuation and cable loss). The limit is specified in one of the subparagraphs of this Section. Submit this plot.

The antenna port of the EUT was connected to the input of a spectrum analyzer. Power was read directly from the spectrum analyzer and cable loss correction was added to the reading to obtain the power at the antenna terminals.

Tested By:	Minh Ly
Test Date:	September 24, 2018

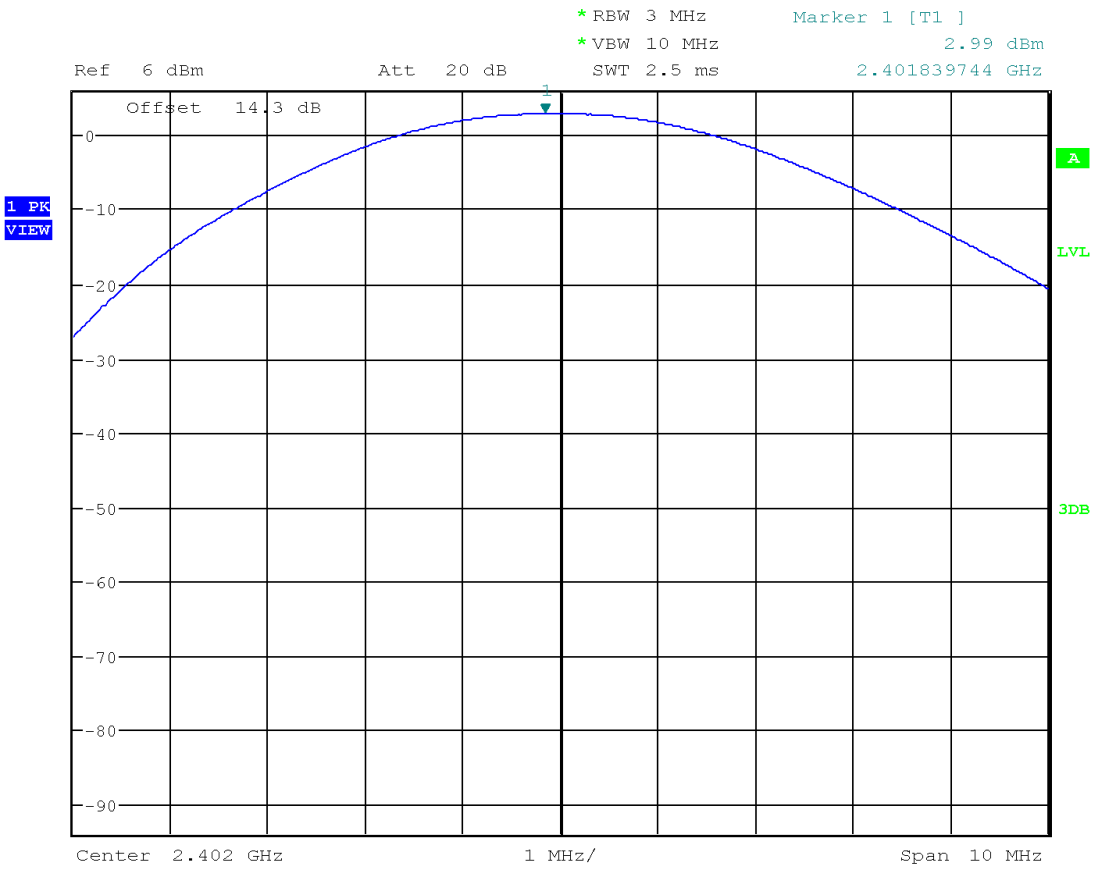
4.3.3 Test Result

Refer to the following plots for the test result:

Modulation Type	Channel	Frequency MHz	Conducted Peak Power dBm	Conducted Peak Power mW	Plot #
GFSK	0	2402	2.99	1.99	2.1
	39	2441	2.49	1.78	2.2
	78	2480	-0.94	0.80	2.3
π/4-DQPSK	0	2402	-1.19	0.76	2.4
	39	2441	-1.13	0.77	2.5
	78	2480	-4.84	0.33	2.6
8DPSK	0	2402	-0.81	0.83	2.7
	39	2441	-0.78	0.84	2.7
	78	2480	-4.58	0.35	2.9

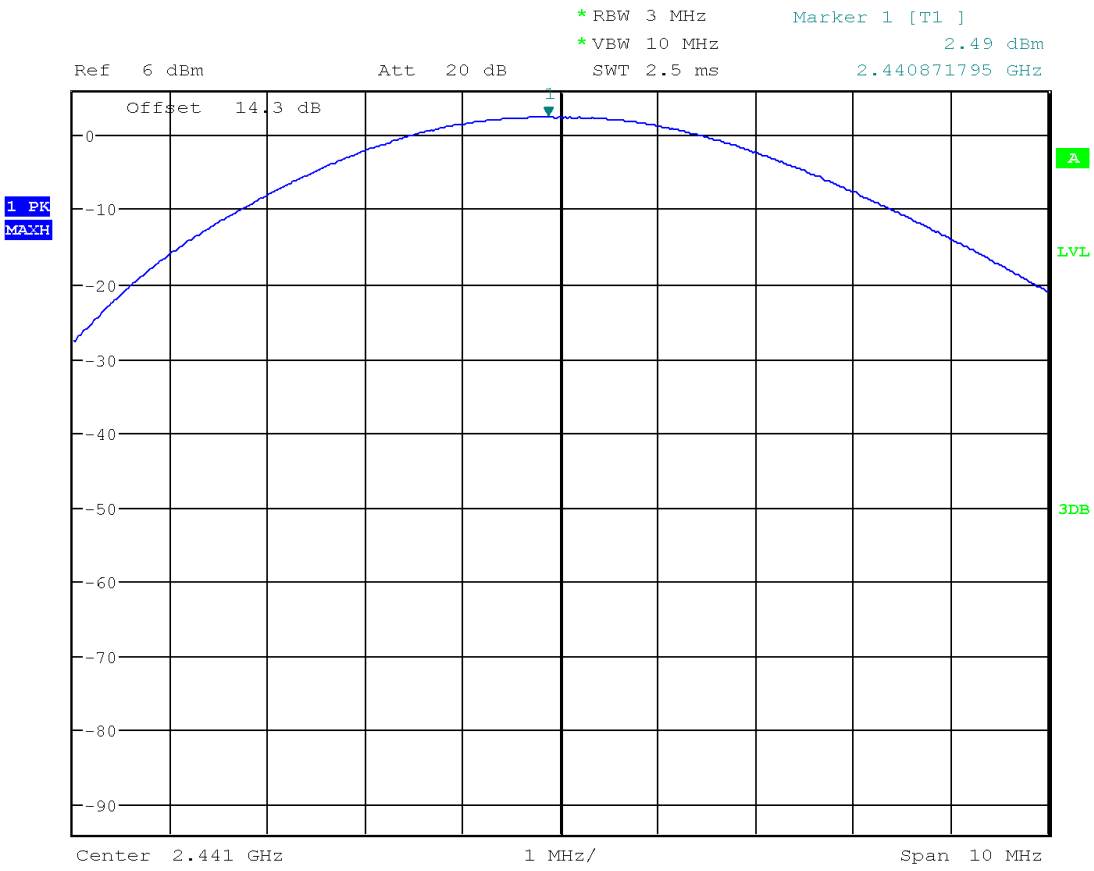
Results	Complies

Plot 2. 2 – Output Power Low Channel GFSK



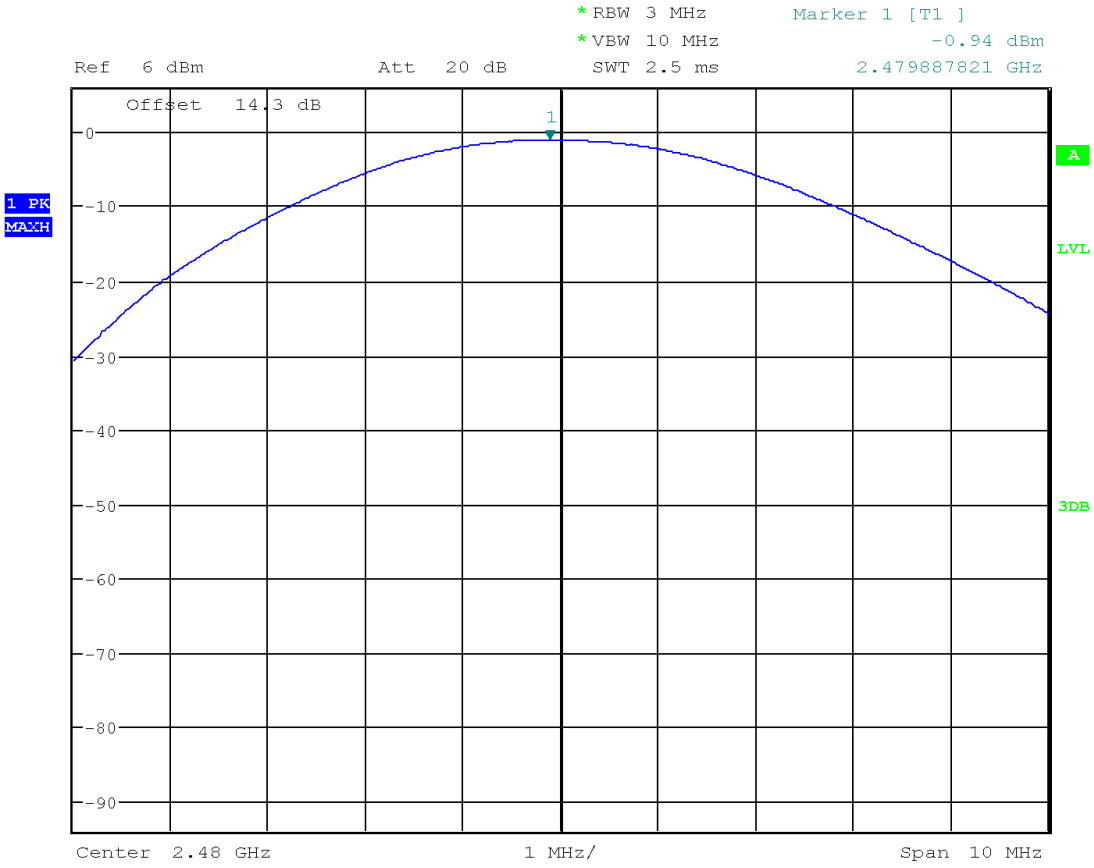
Date: 24.SEP.2018 16:38:50

Plot 2. 2 – Output Power Middle Channel GFSK



Date: 24.SEP.2018 16:39:53

Plot 2. 3 – Output Power High Channel GFSK



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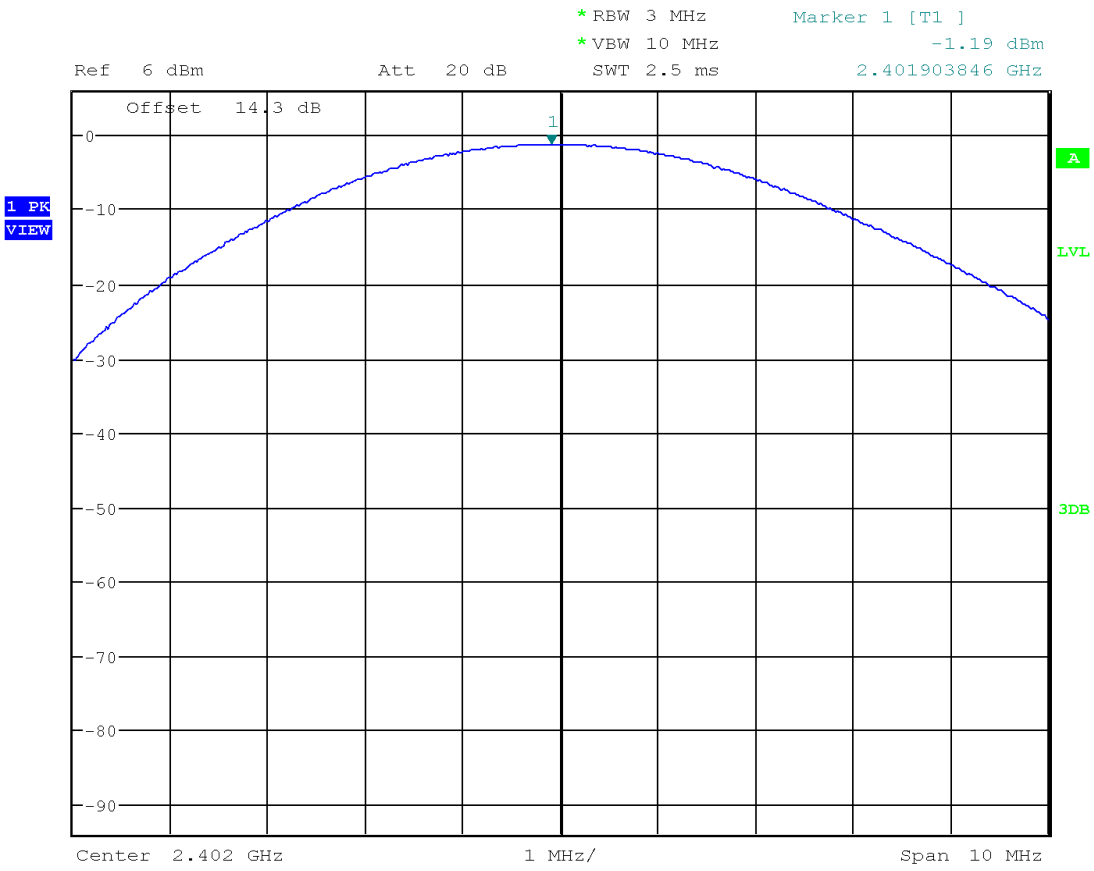
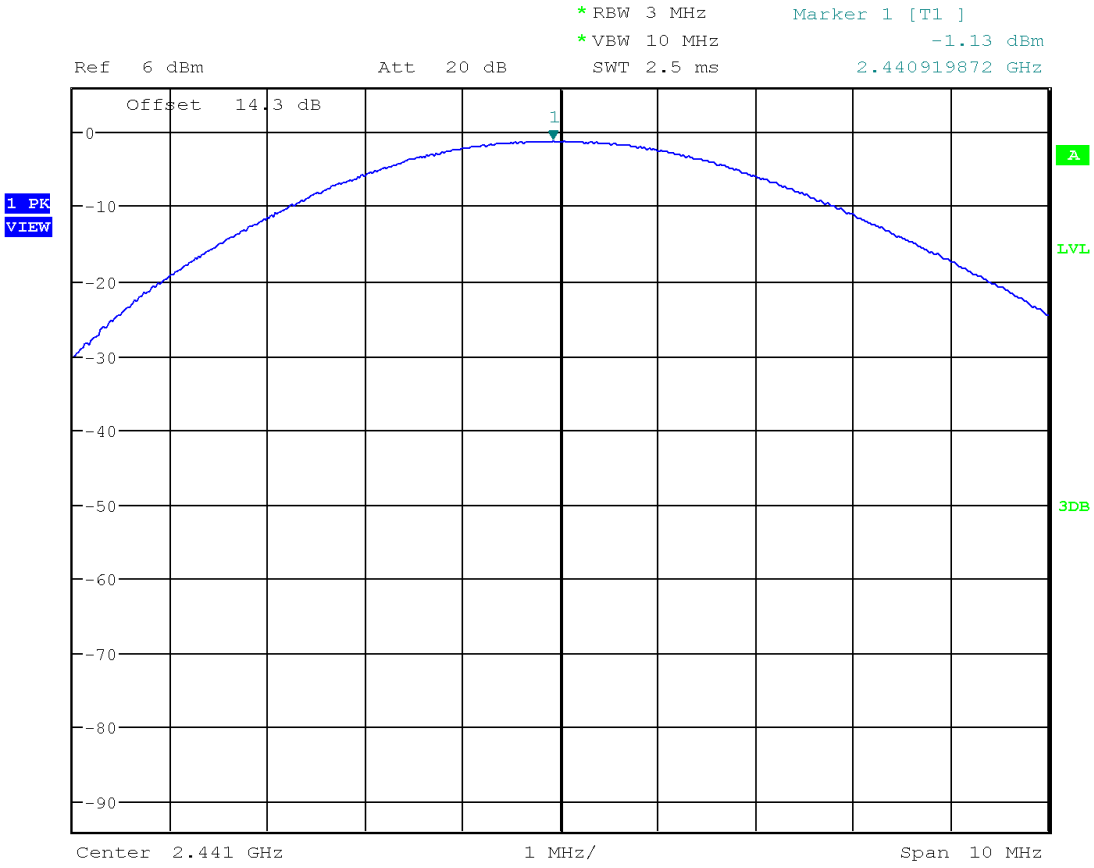
Plot 2. 4 – Output Power Low Channel π/4-DQPSK



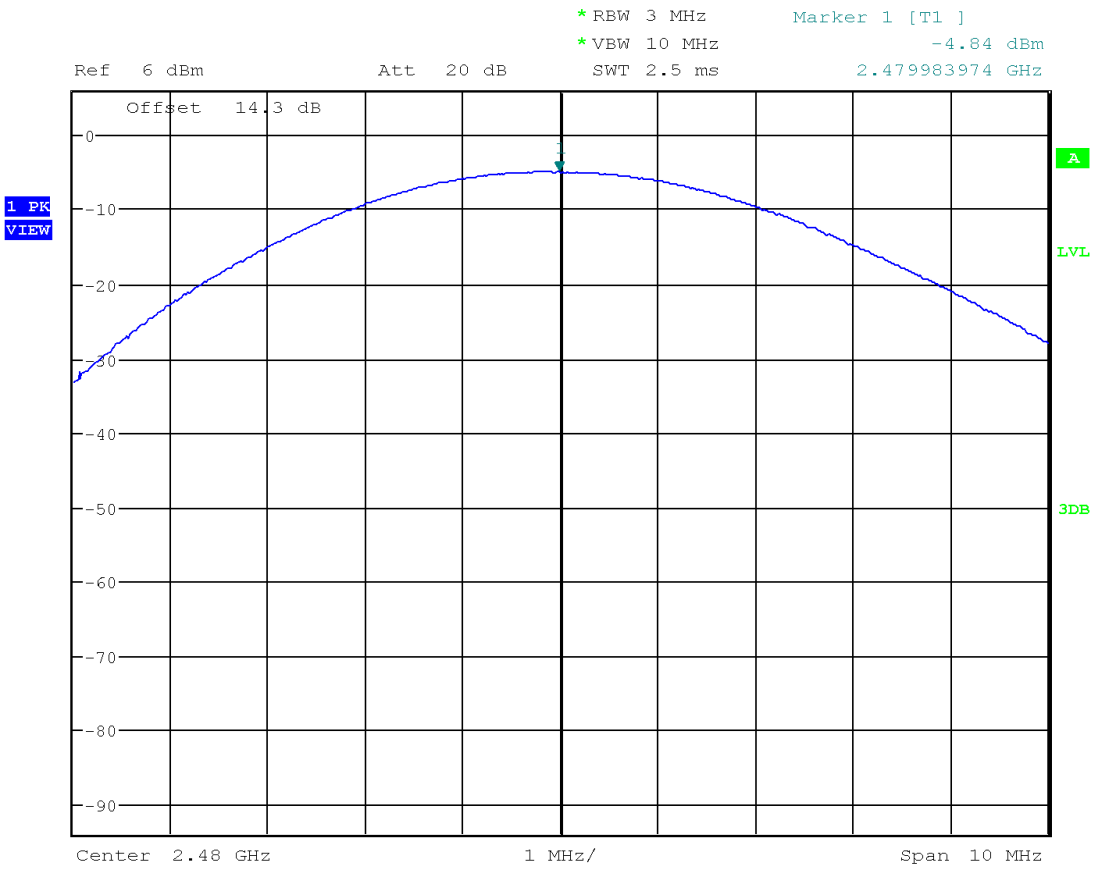
Date: 24.SEP.2018 16:42:23

Plot 2. 5 – Output Power Middle Channel π/4-DQPSK



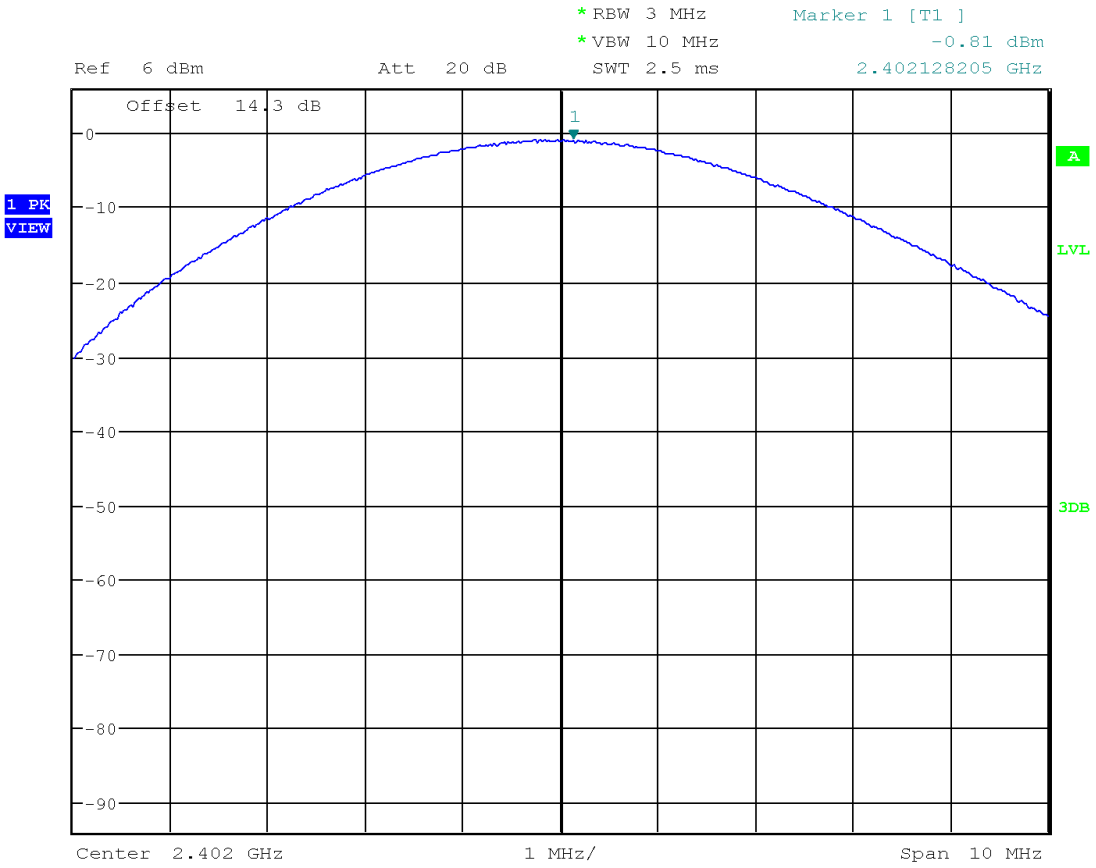
Date: 24.SEP.2018 16:43:19

Plot 2. 6 – Output Power High Channel π/4-DQPSK



Date: 24.SEP.2018 16:44:17

Plot 2. 7 – Output Power Low Channel 8DPSK



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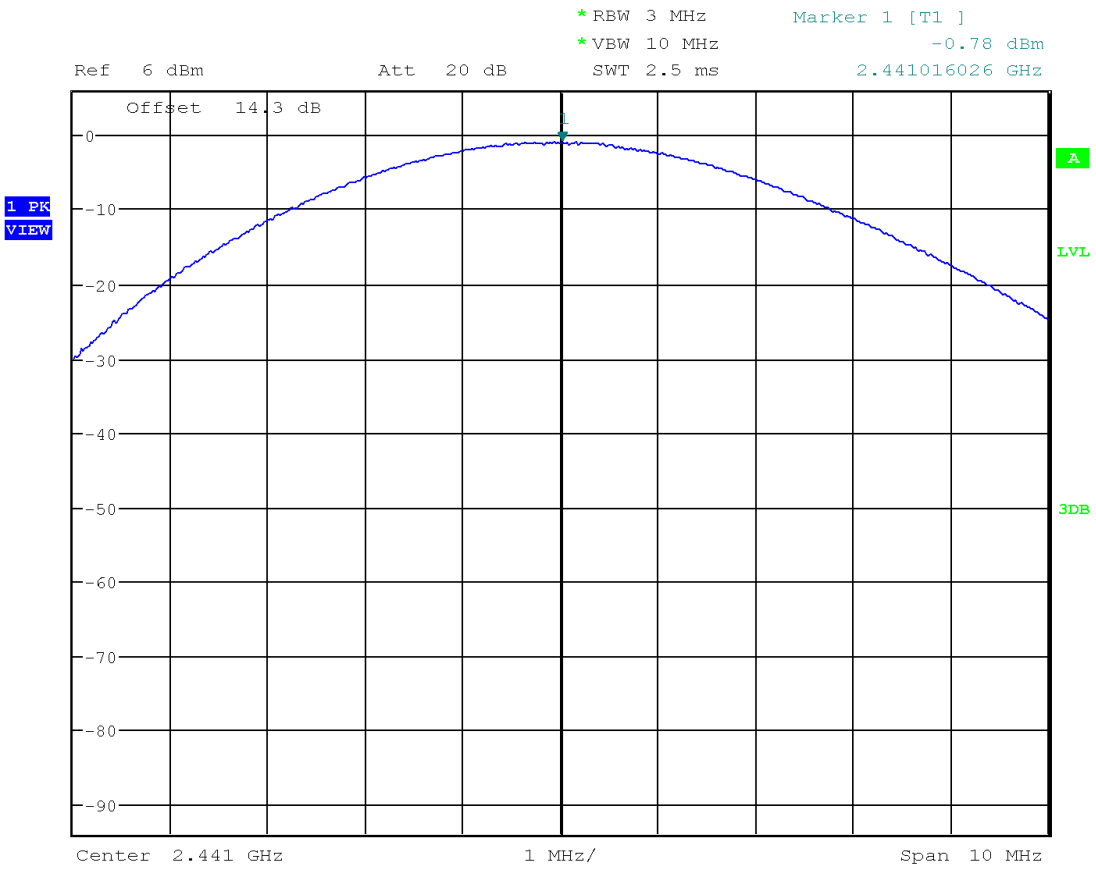
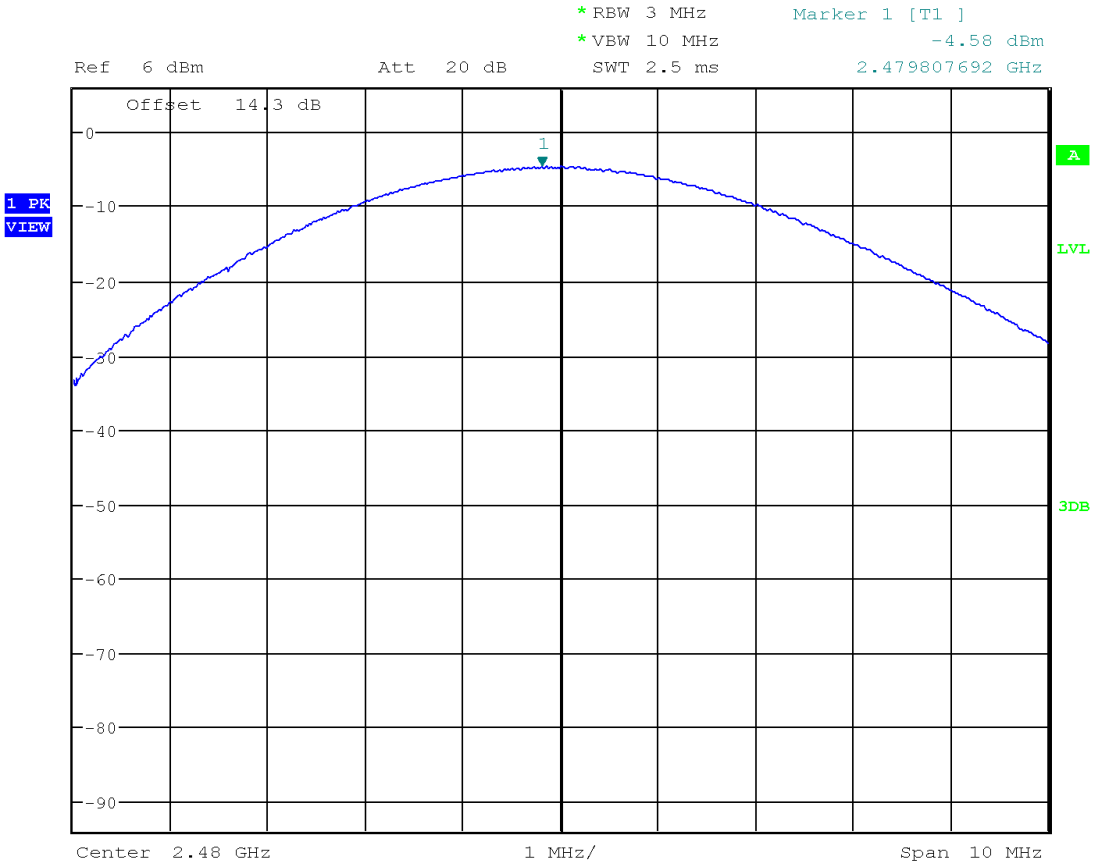
Plot 2. 8 – Output Power Middle Channel 8DPSK



Date: 24.SEP.2018 16:46:43

Plot 2. 9 – Output Power High Channel 8DPSK



Date: 24.SEP.2018 16:47:18

4.3 Carrier Frequency Separation
FCC 15.247 (a)(1)

4.3.1 Requirement

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

4.3.2 Procedure

The procedure described in FCC Publication 558074 D01 Meas Guidance v05 was used. Specifically, Section 7.8.2 of ANSI C63.10:2013 for Frequency Hopping Spread Spectrum Systems was used to determine the Carrier Frequency Separation.

- The EUT must have its hopping function enabled
- Span = wide enough to capture the peaks of two adjacent channels
- Resolution (or IF) Bandwidth (RBW) = Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
- Video (or Average) Bandwidth (VBW) ≥ RBW
- Sweep = auto
- Detector function = peak
- Trace = max hold

Allow the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels. The limit is specified in one of the subparagraphs of this Section. Submit this plot.

Tested By:	Minh Ly
Test Date:	September 27, 2018

4.3.3 Test Result

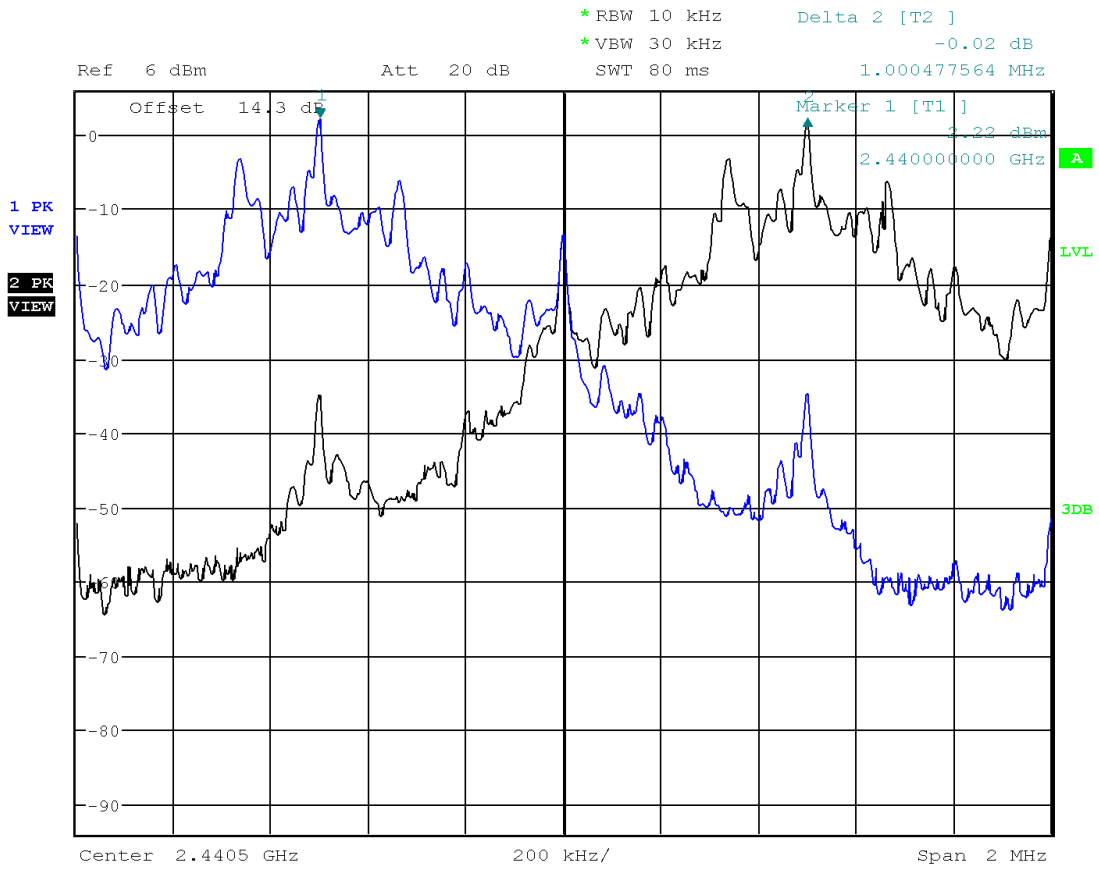
The worst case 20dB Bandwidth is 1.317 MHz, therefor this bandwidth was used to calculate the minimum limit for Carrier Frequency Separation below.

(2/3) * 1.317 MHz = 0.878 MHz (minimum requirement)

The Carrier Frequency Separation is **1.00 MHz**, therefore meets the minimum requirement. Please refer to spectrum analyzer plot 3.1 below for the test result.

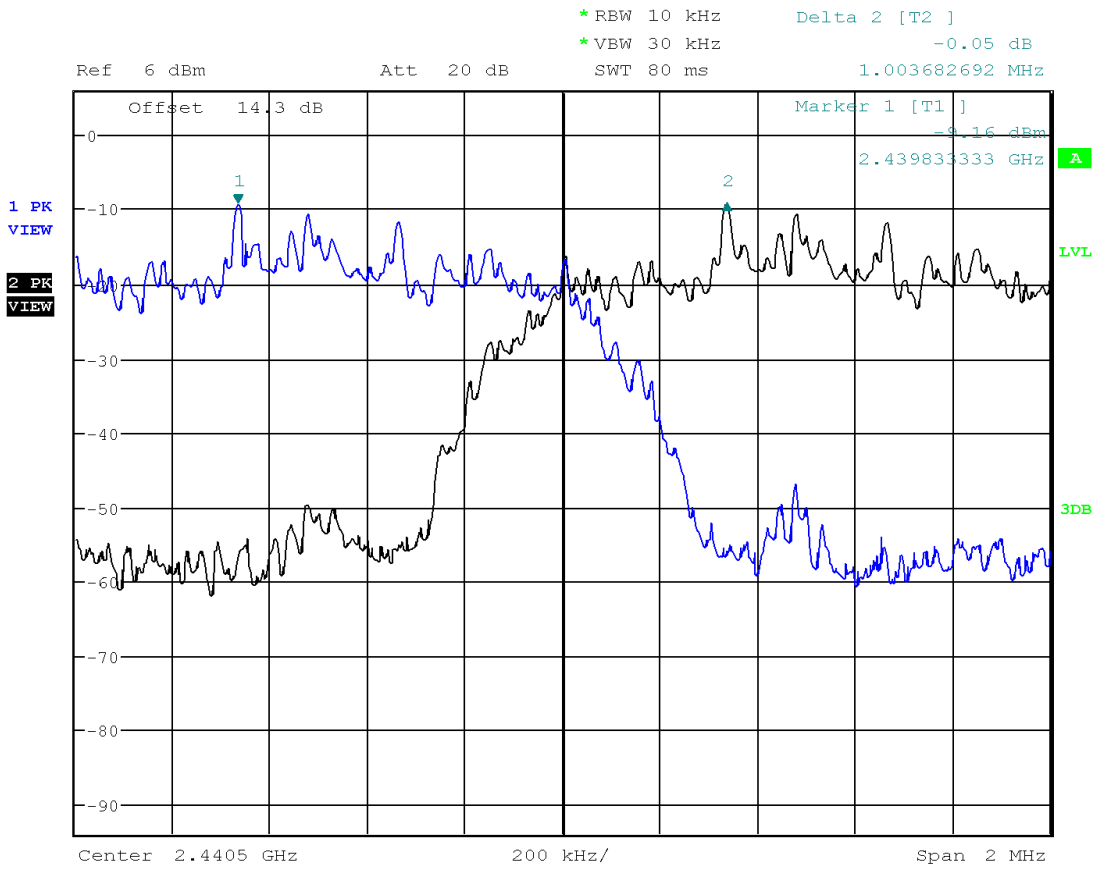
Results	**Complies**

Plot 3.3– Channel Separation GFSK

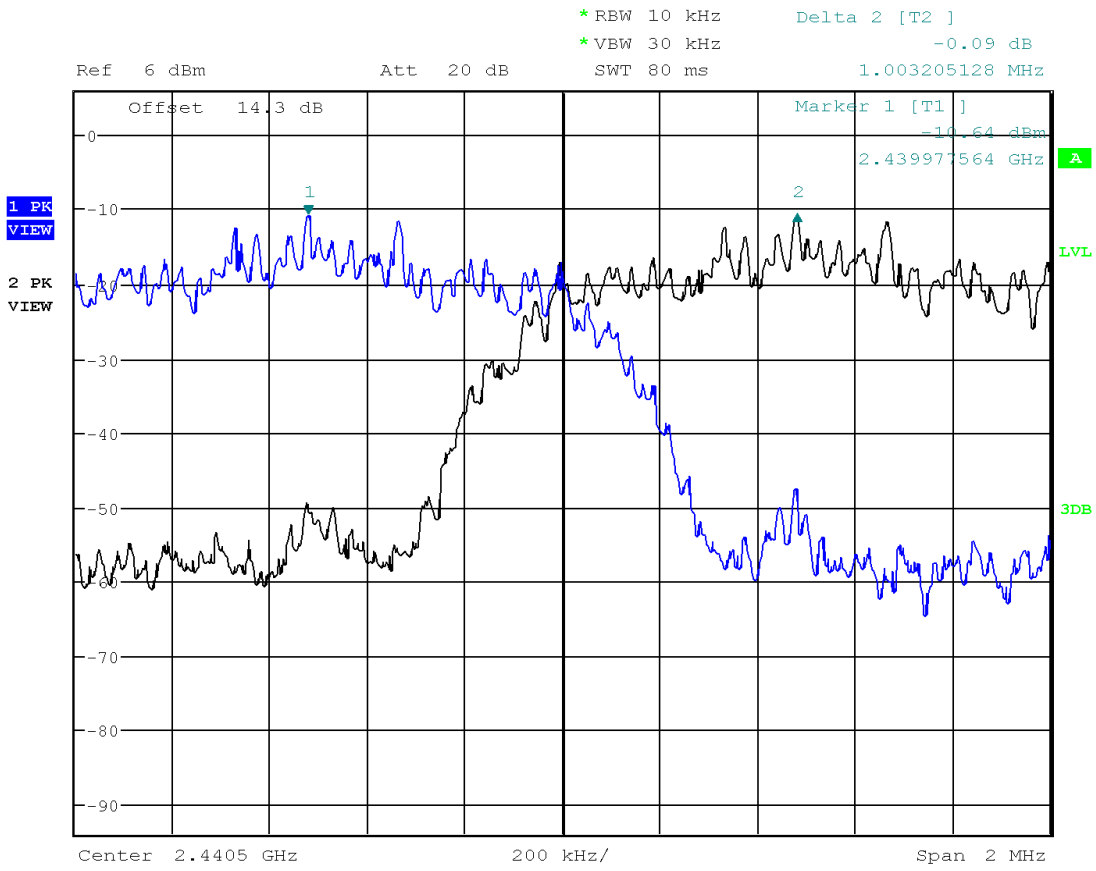


Date: 27.SEP.2018 17:57:10

Plot 3.2– Channel Separation π/4-DQPSK



Plot 3.2– Channel Separation DPQSK



Date: 27.SEP.2018 17:59:38

4.4 Number of Channels
FCC 15.247 (a)(1)(iii)

4.4.1 Requirement

Systems operating in the 2400-2483.5 MHz band shall use at least 15 hopping channels.

4.4.2 Procedure

The procedure described in FCC Publication 558074 D01 Meas Guidance v05 was used. Specifically, Section 7.8.3 of ANSI C63.10:2013 for Frequency Hopping Spread Spectrum Systems was used to determine the Number of Channels.

- The EUT must have its hopping function enabled.
- Span = the frequency band of operation
- RBW = To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20dB bandwidth, whichever is smaller
- VBW ≥ RBW
- Sweep = auto
- Detector function = peak
- Trace = max hold

Allow the trace to stabilize. It may prove necessary to break the span up to sections, in order to clearly show all of the hopping frequencies.

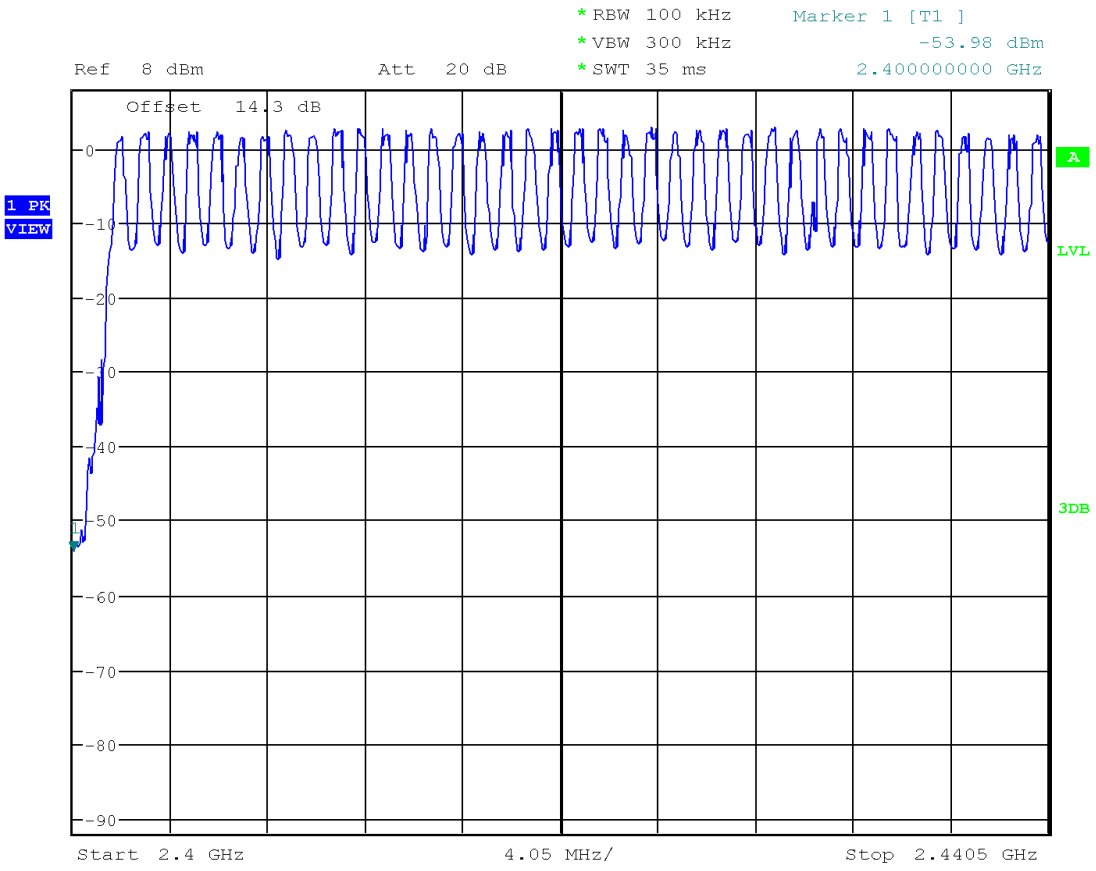
With the analyzer set to MAX HOLD, readings were taken once channels were filled in. The traces were broken down into 2 spans from 2400 to 2483.5MHz. The channel peaks were recorded and compared to the minimum number of channels required in the regulation.

Tested By:	Minh Ly
Test Date:	September 27, 2018

4.4.3 Test Result

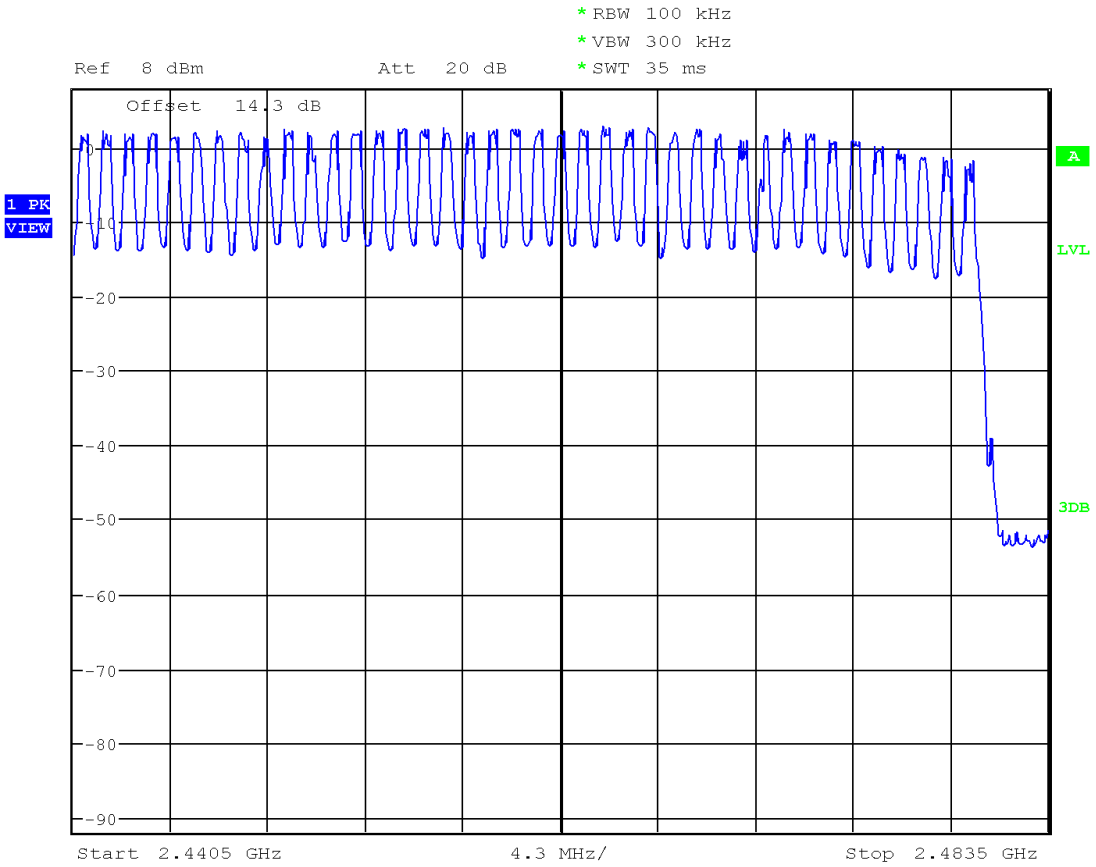
Results	79 Channels -Complies

Plot 4.1 - Number of hopping channels (2400 to 2440.5 MHz)



Date: 27.SEP.2018 18:06:00

Plot 4.2 - Number of hopping channels (GFSK - 2440.5 to 2483.5 MHz)



Date: 27.SEP.2018 18:10:54

4.5 Average Channel Occupancy Time
FCC 15.247(a)(1)

4.5.1 Requirement

For systems operating in the 2400-2483.5 MHz band, the average time of occupancy on any channel shall not be greater than 0.4 second within a period of 0.4 second multiplied by the number of hopping channels employed.

4.5.2 Procedure

The procedure described in FCC Publication 558074 D01 Meas Guidance v05 was used. Specifically, Section 7.8.4 of ANSI C63.10:2013 for Frequency Hopping Spread Spectrum Systems was used to determine the Average Channel Occupancy Time.

- The EUT must have its hopping function enabled.
- Span = zero span, centered on a hopping channel
- RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel
- VBW = 3 x RBW
- Sweep = as necessary to capture the entire dwell time per hopping channel
- Detector function = peak
- Trace = max hold

If possible, use the marker-delta function to determine the dwell time. If this value varies with different modes of operation (e.g., data rate, modulation format, etc.), repeat this test for each variation. The limit is specified in one of the subparagraphs of this Section. An oscilloscope may be used instead of a spectrum analyzer.

The spectrum analyzer center frequency was set to one of the known hopping channels, the SPAN was set to ZERO SPANS, and the TRIGGER was set to VIDEO. The time duration of the transmission so captured was measured with the MARKER DELTA function.

Since the radio is employed 79 hopping channels, the Occupancy Time was calculated for the period of 0.4 * 79 = 31.6 sec.

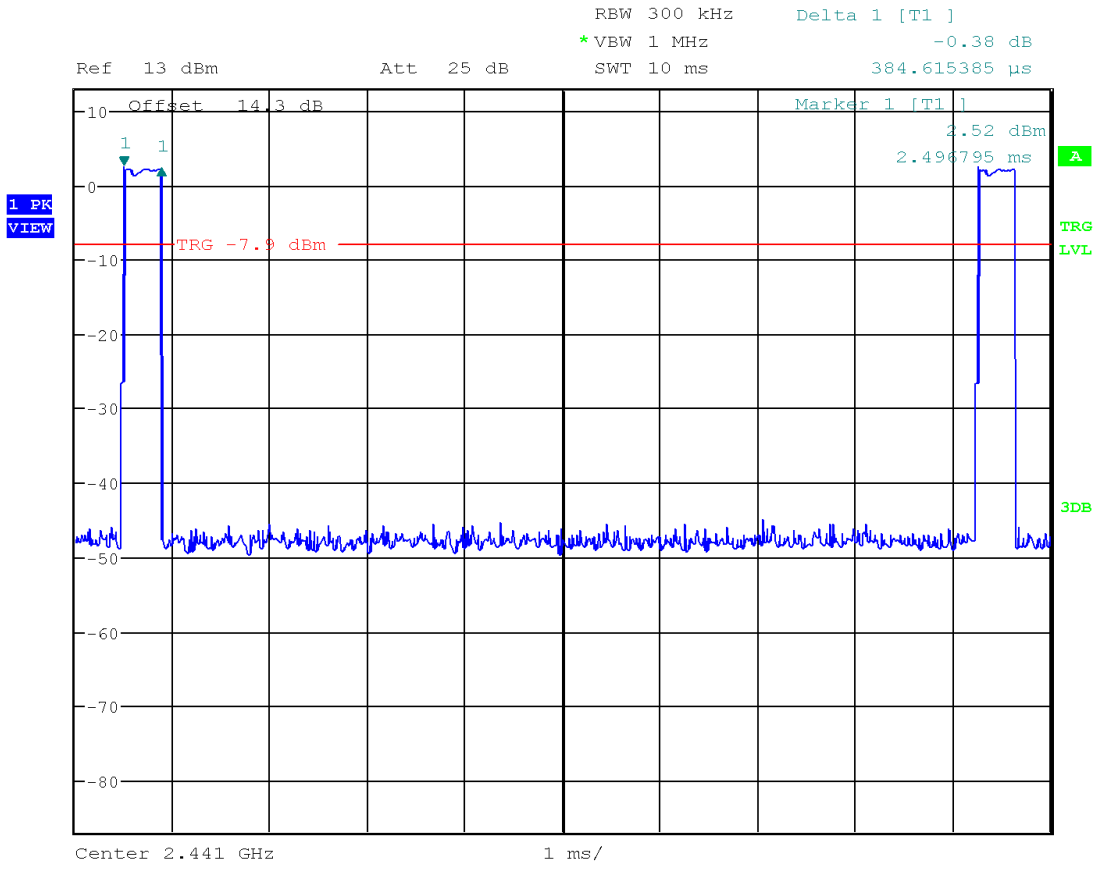
Tested By:	Minh Ly
Test Date:	September 27, 2018

4.5.3 Test Results

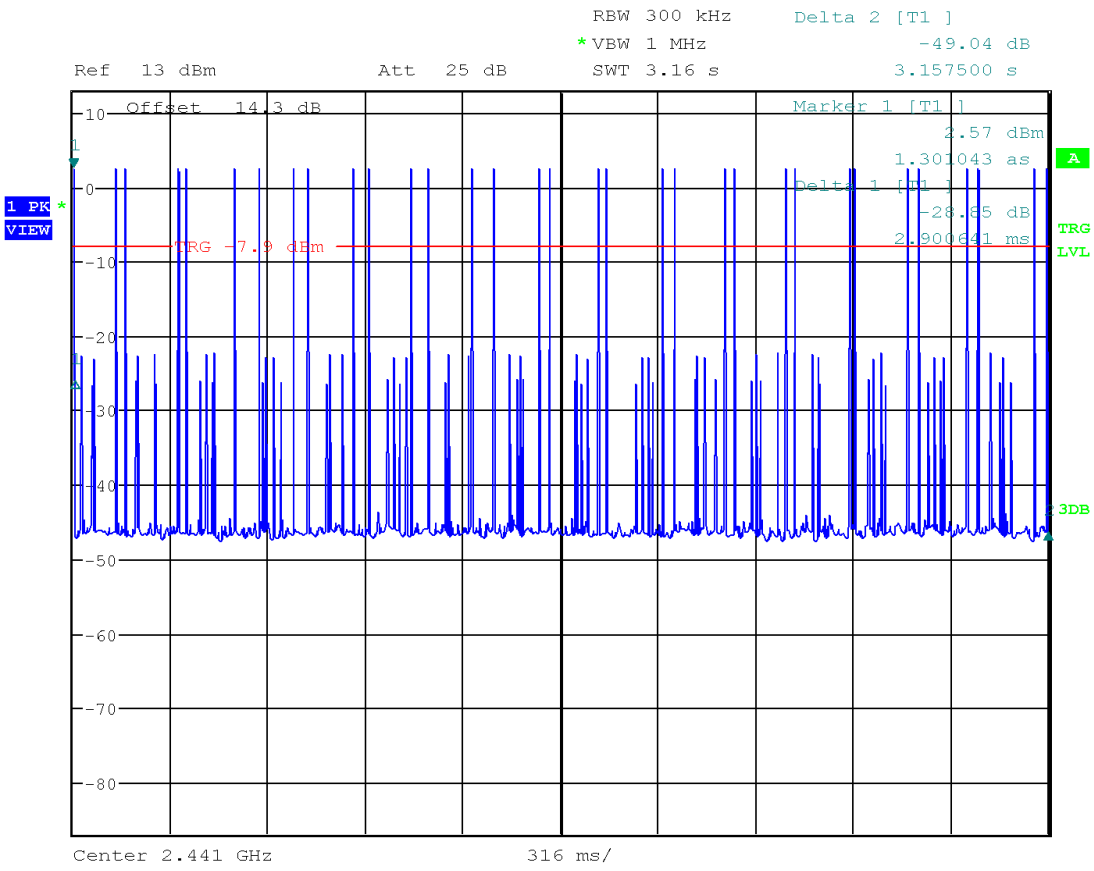
Results	Complies

GFSK, DH1

No. of Burst in 3.16s (31.6s Period)	Burst On Time (ms)	Dwell Time (ms)	Dwell Time limit (ms)
32*10	0.384	122.9	400



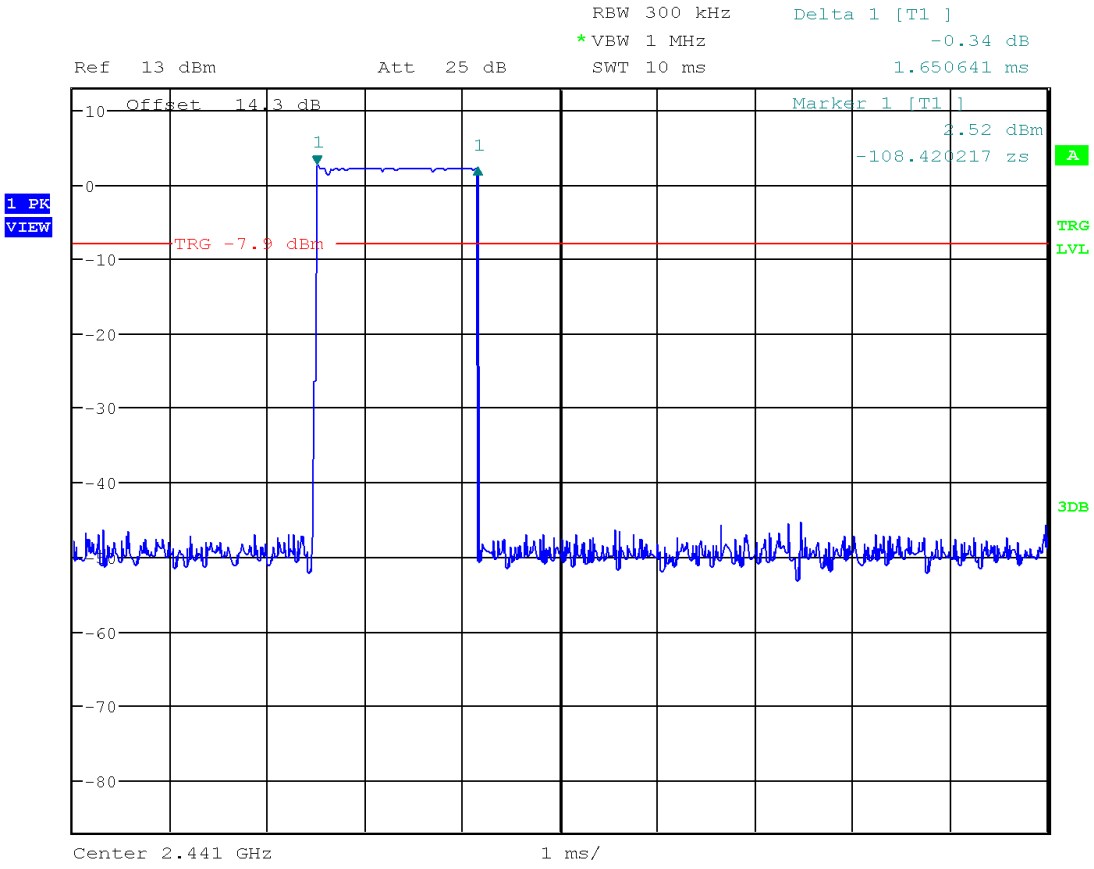
Date: 27.SEP.2018 18:55:33



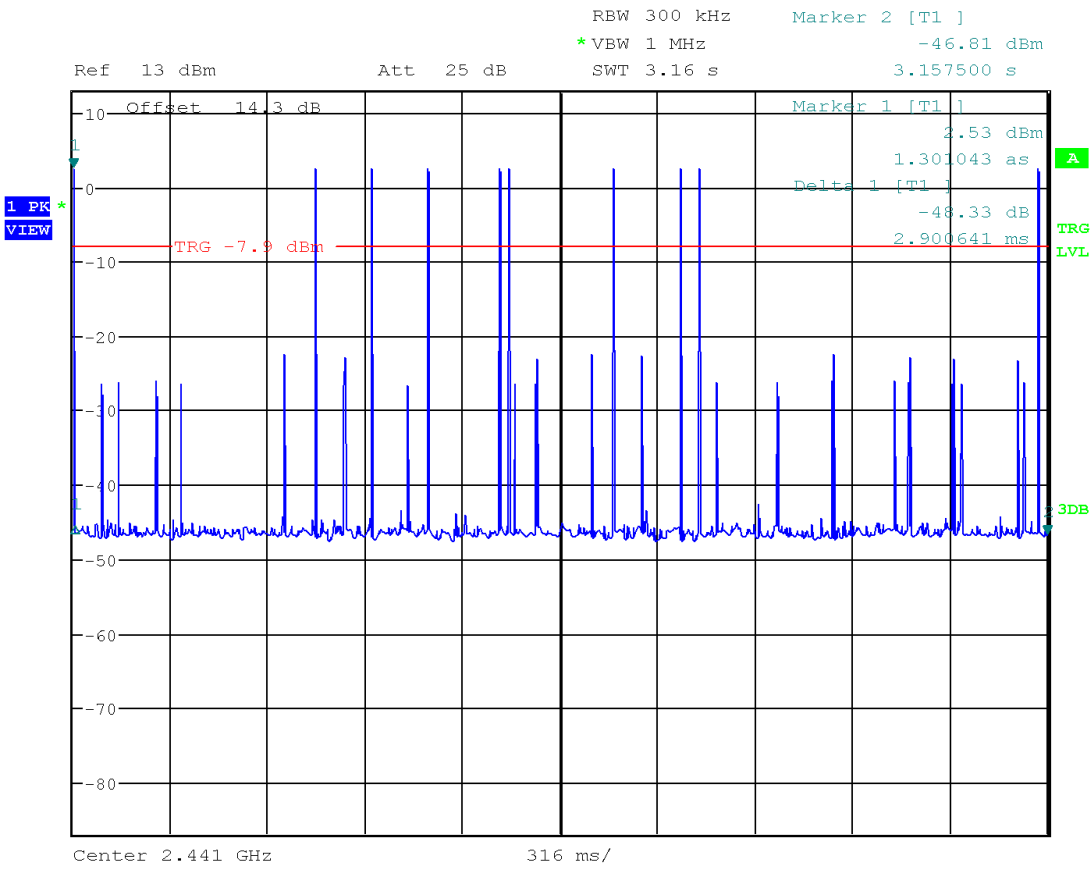
Date: 27.SEP.2018 19:17:40

GFSK, DH3

No. of Burst in 3.16s (31.6s Period)	Burst On Time (ms)	Dwell Time (ms)	Dwell Time limit (ms)
10*10	1.65	165	400



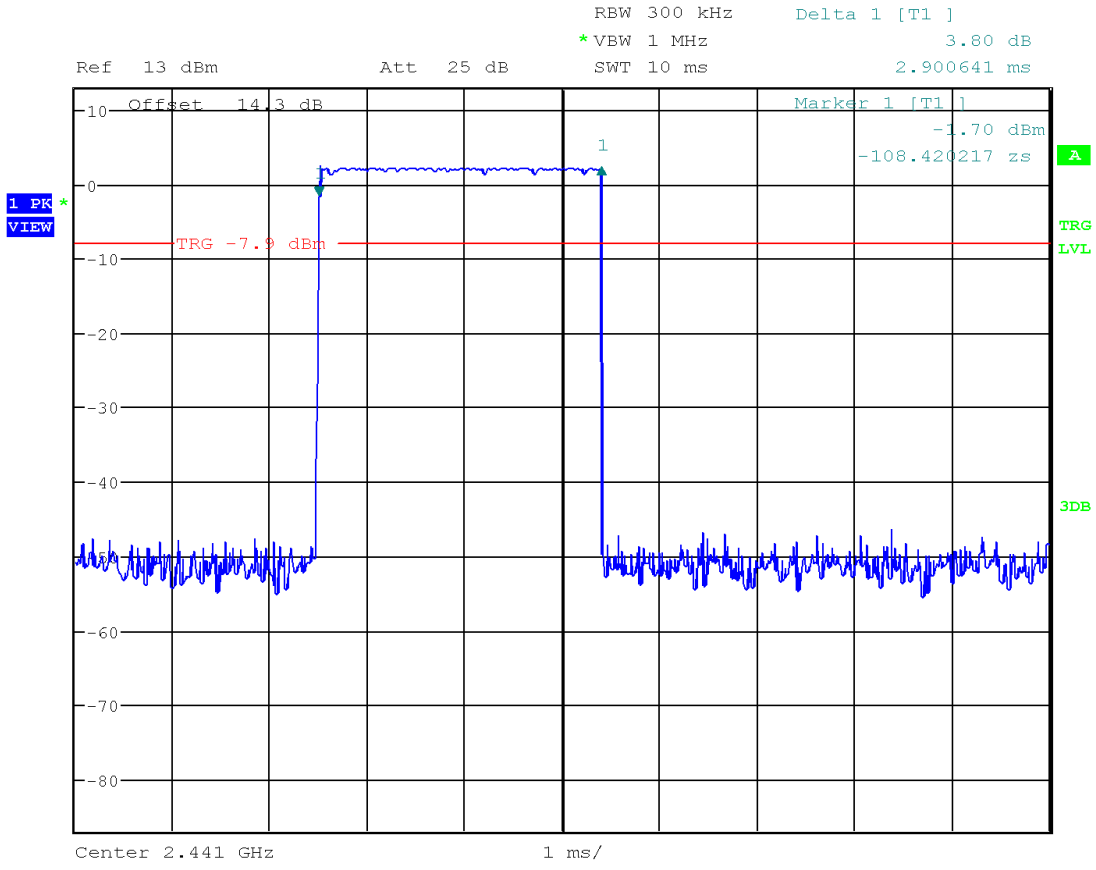
Date: 27.SEP.2018 18:59:21

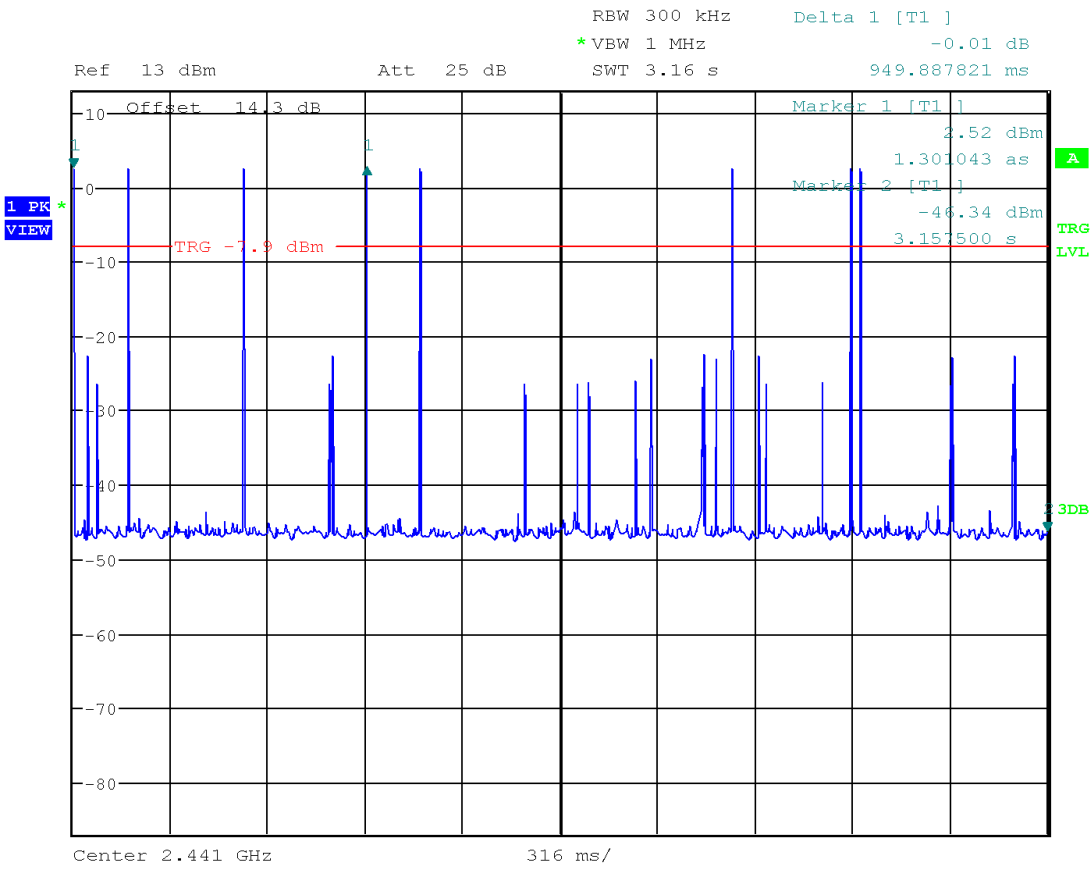


Date: 27.SEP.2018 19:19:24

GFSK, DH5

No. of Burst in 3.16s (31.6s Period)	Burst On Time (ms)	Dwell Time (ms)	Dwell Time limit (ms)
8*10	2.9	232	400



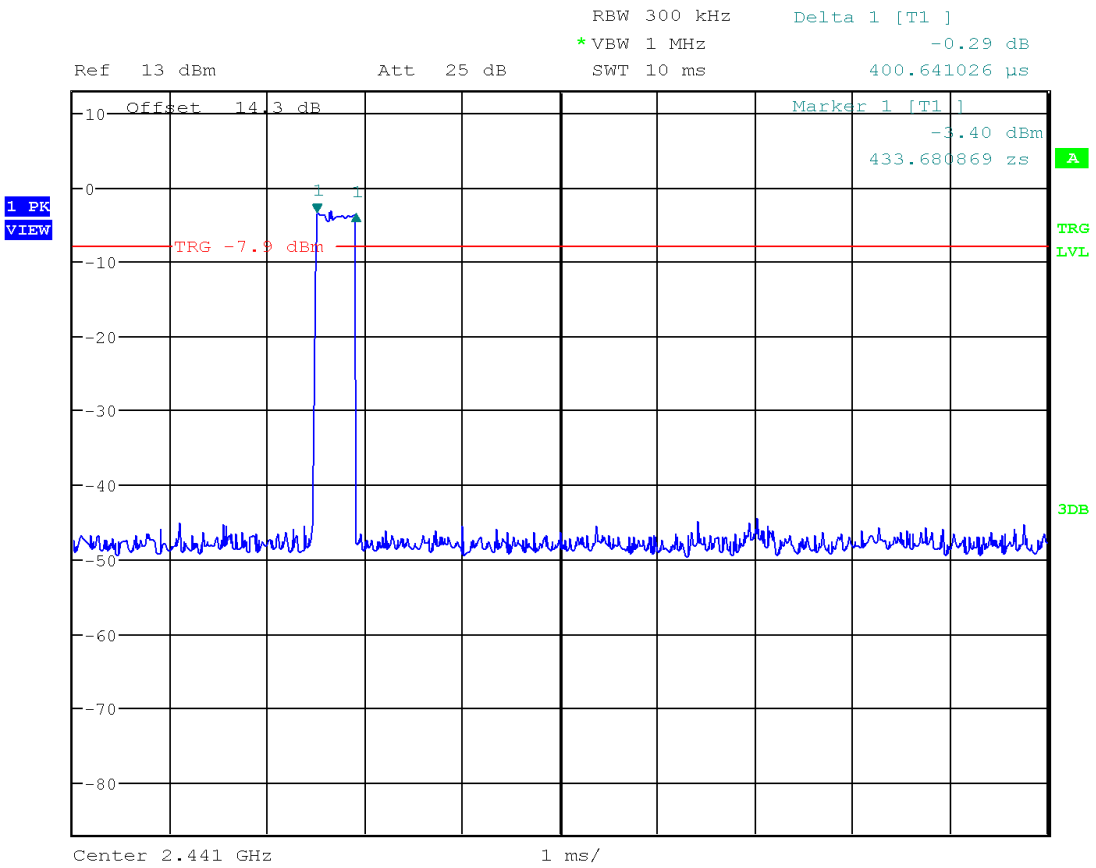


Date: 27.SEP.2018 19:21:07

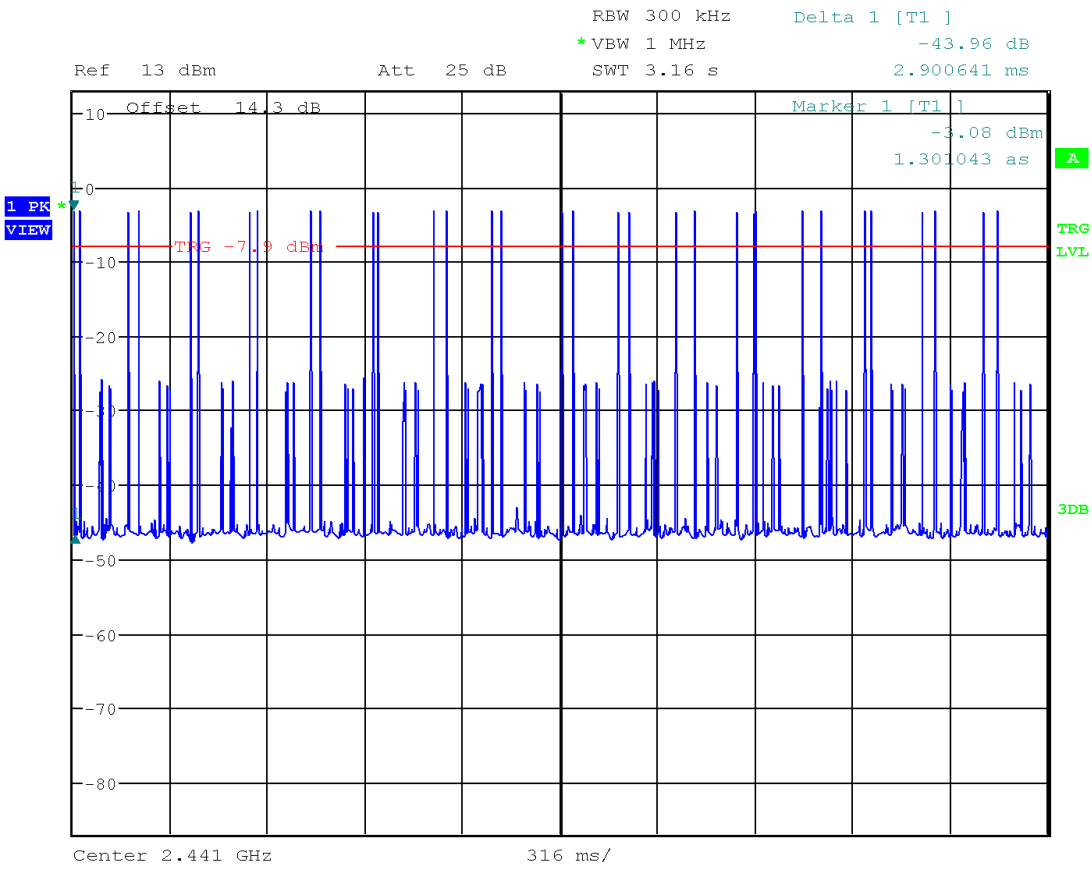
4.5.3 Test Results (Continued)

π/4-DQPSK, DH1

No. of Burst in 3.16s (31.6s Period)	Burst On Time (ms)	Dwell Time (ms)	Dwell Time limit (ms)
32*10	0.4	128	400



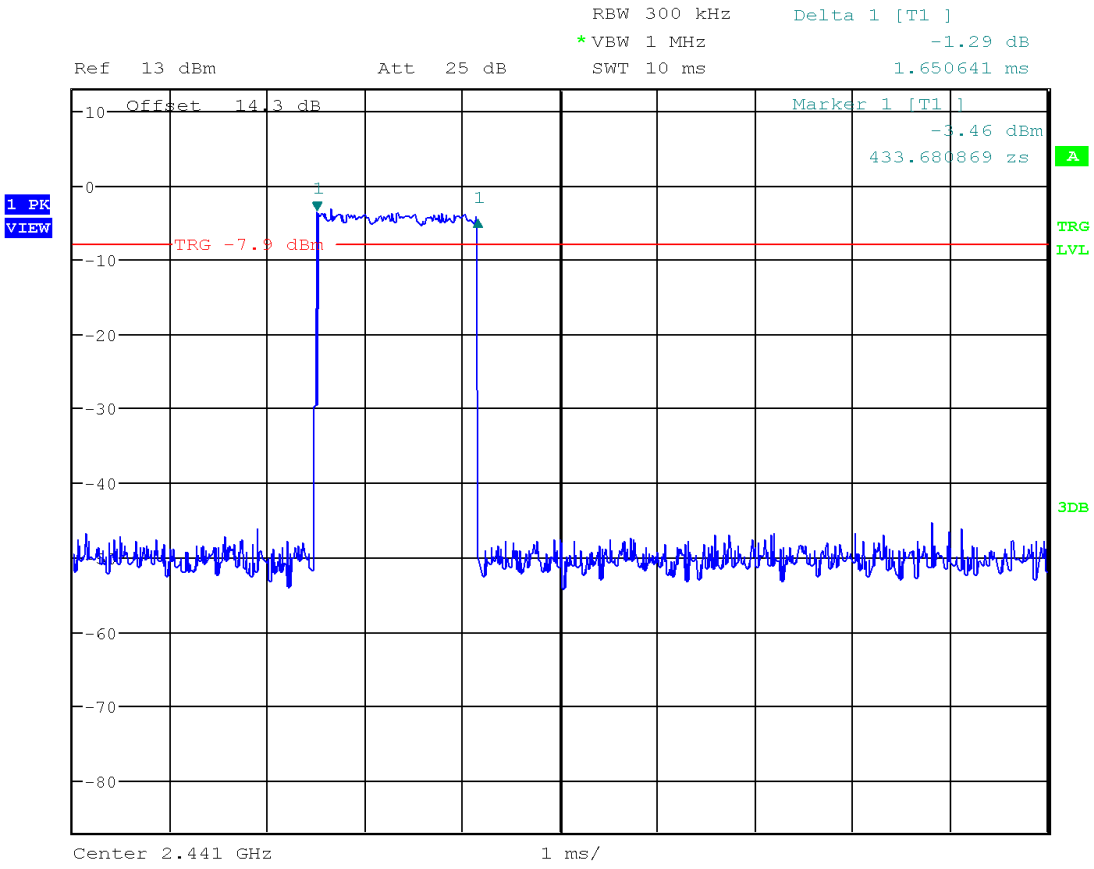
Date: 27.SEP.2018 19:01:28



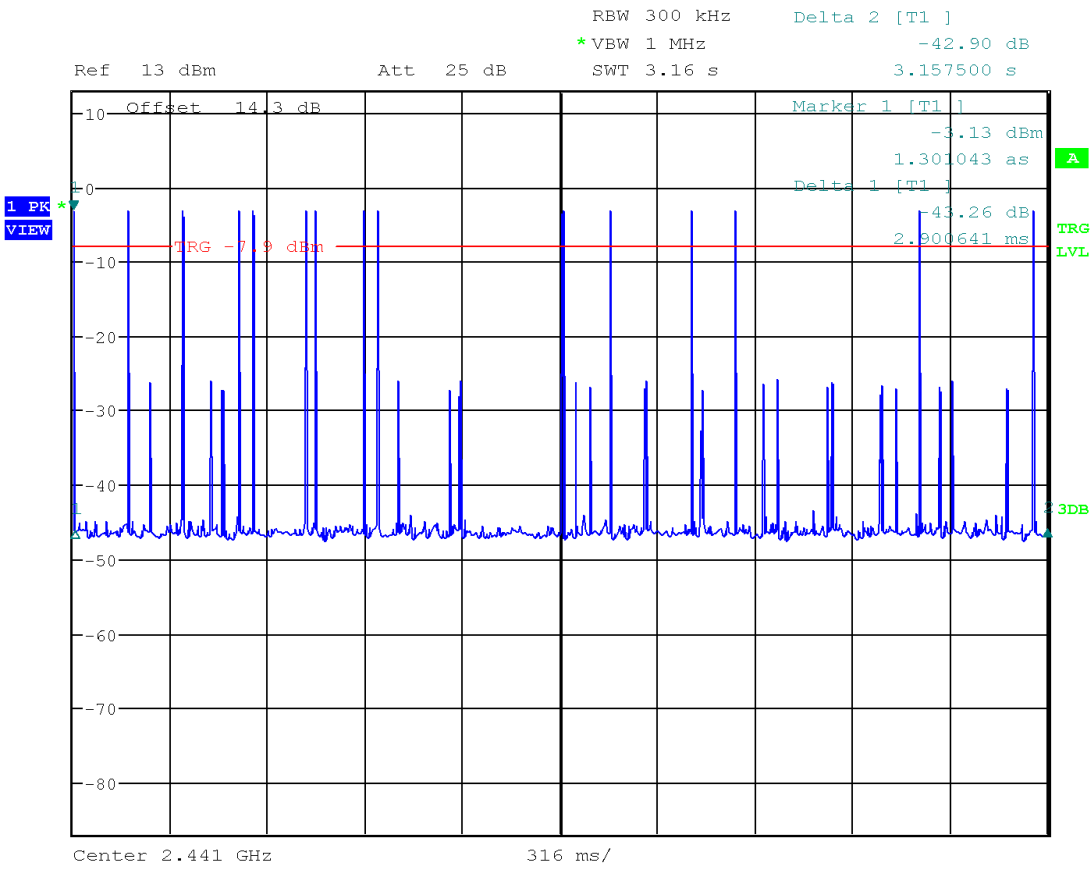
Date: 27.SEP.2018 19:13:16

π/4-DQPSK, DH3

No. of Burst in 3.16s (31.6s Period)	Burst On Time (ms)	Dwell Time (ms)	Dwell Time limit (ms)
15*10	1.65	247.5	400



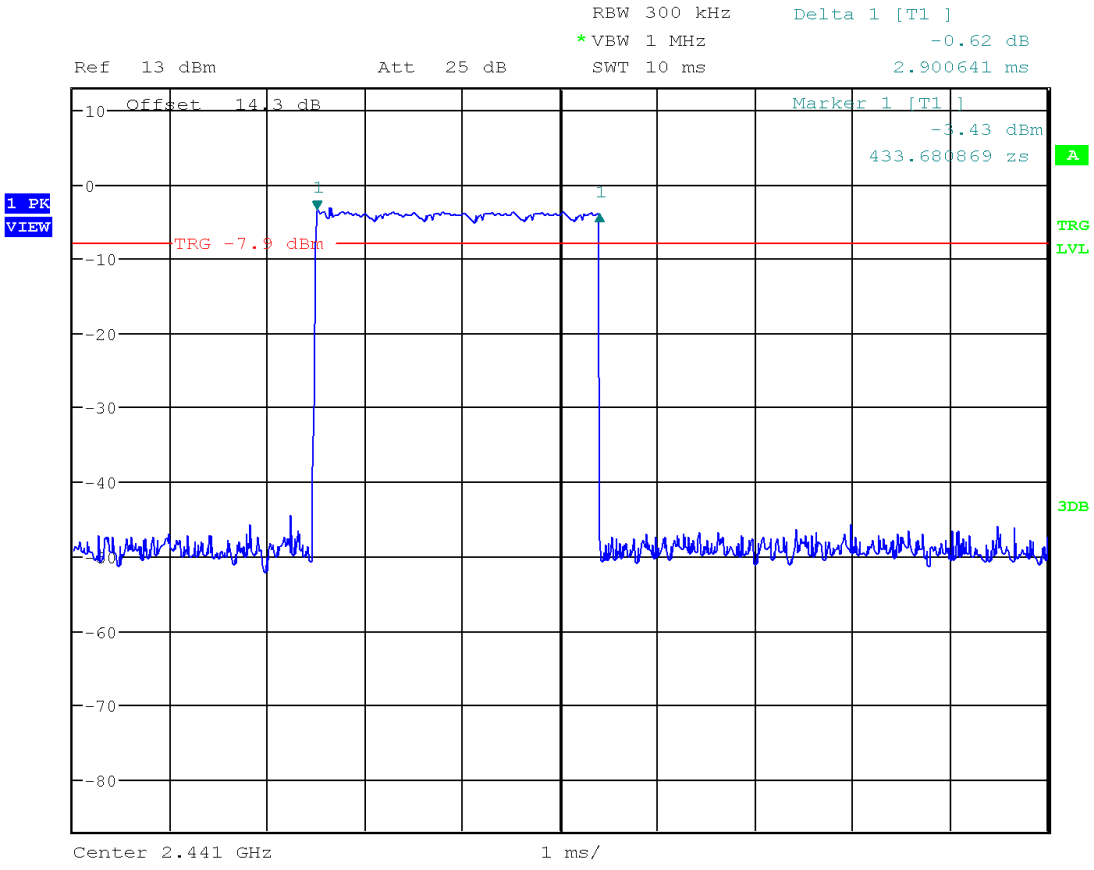
Date: 27.SEP.2018 19:02:26



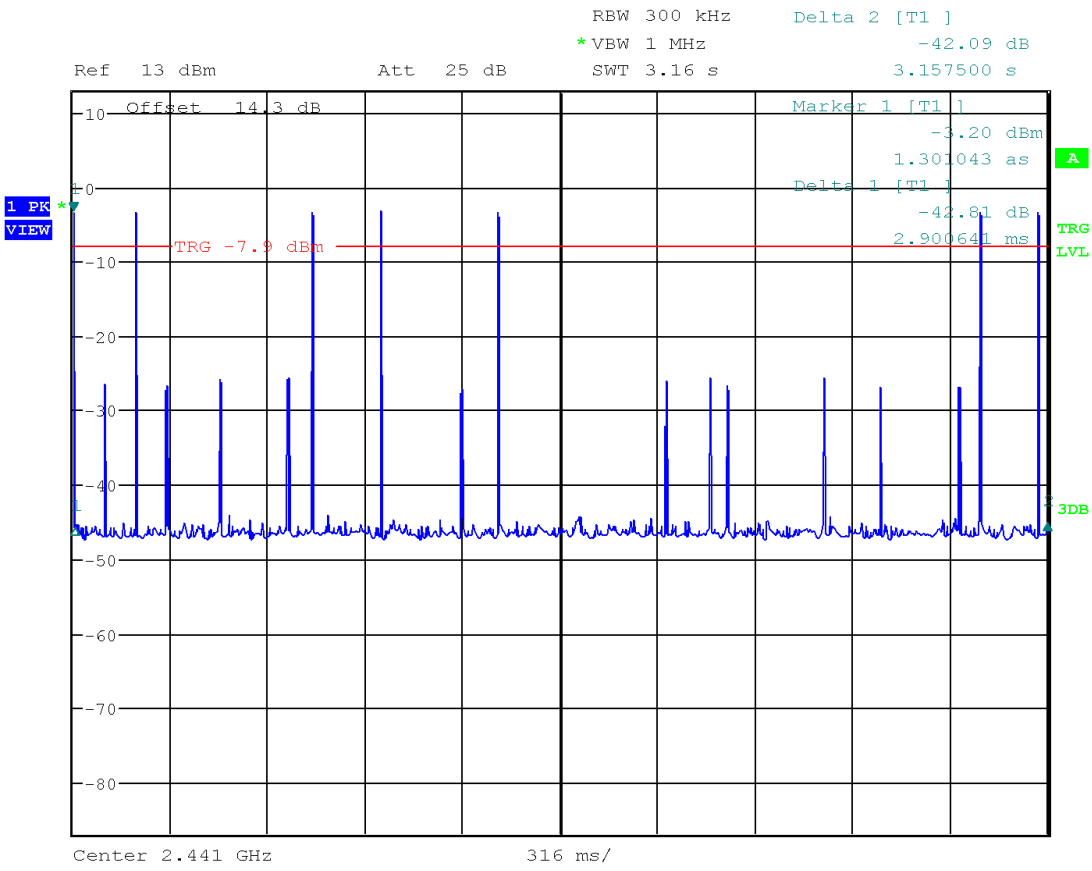
Date: 27.SEP.2018 19:15:16

π/4-DQPSK, DH5

No. of Burst in 3.16s (31.6s Period)	Burst On Time (ms)	Dwell Time (ms)	Dwell Time limit (ms)
7*10	2.9	203	400



Date: 27.SEP.2018 19:03:56

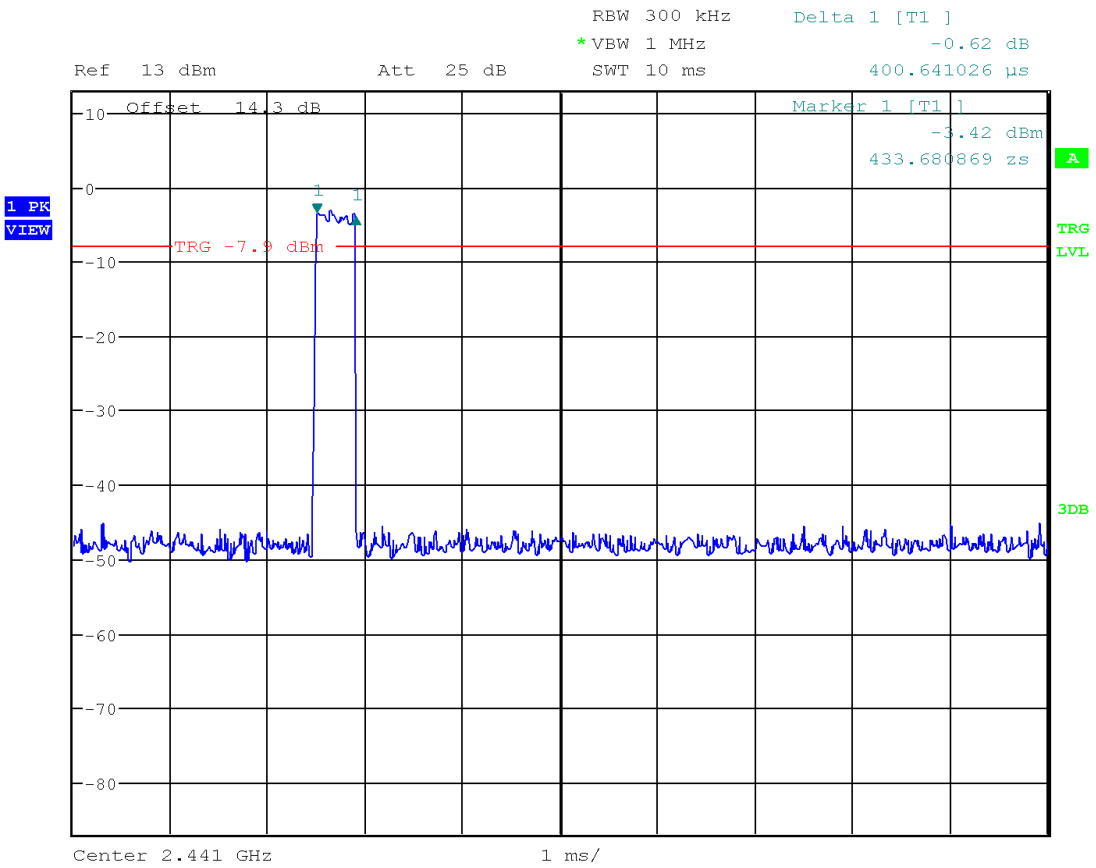


Date: 27.SEP.2018 19:16:44

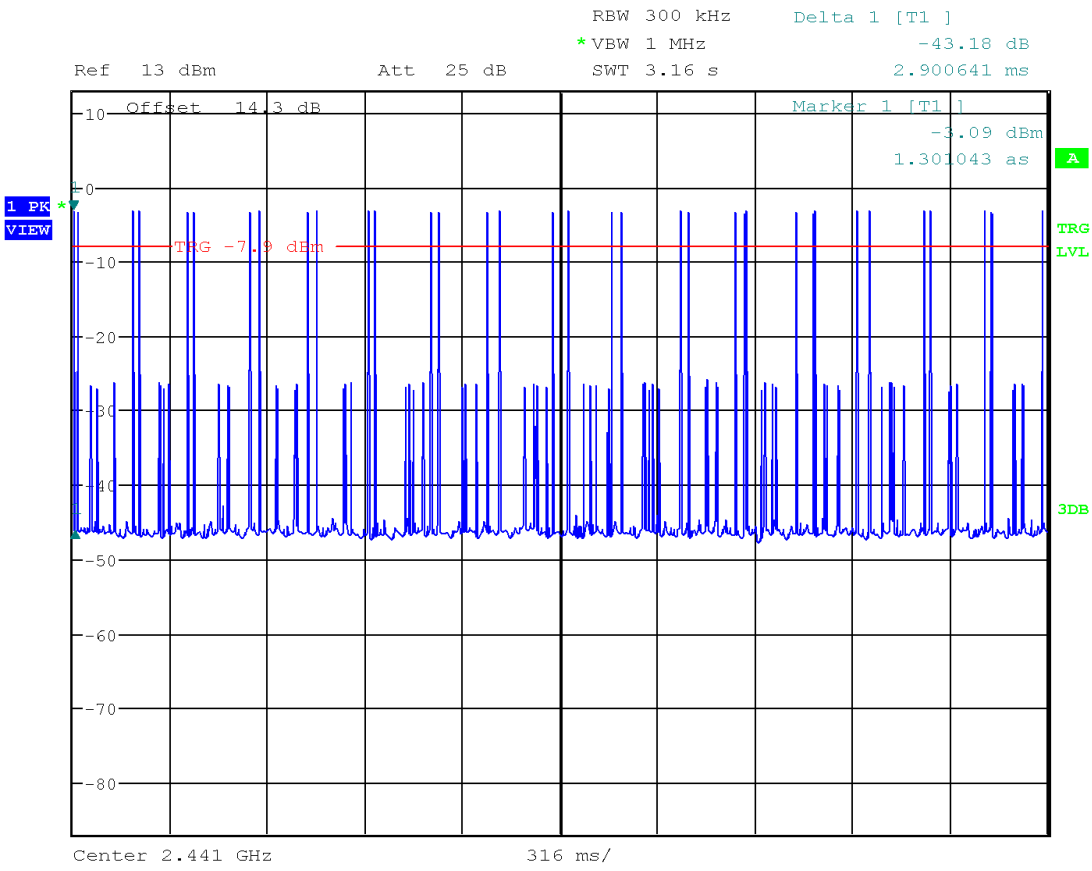
4.5.3 Test Results (Continued)

8DPSK, DH1

No. of Burst in 3.16s (31.6s Period)	Burst On Time (ms)	Dwell Time (ms)	Dwell Time limit (ms)
33*10	0.4	132	400



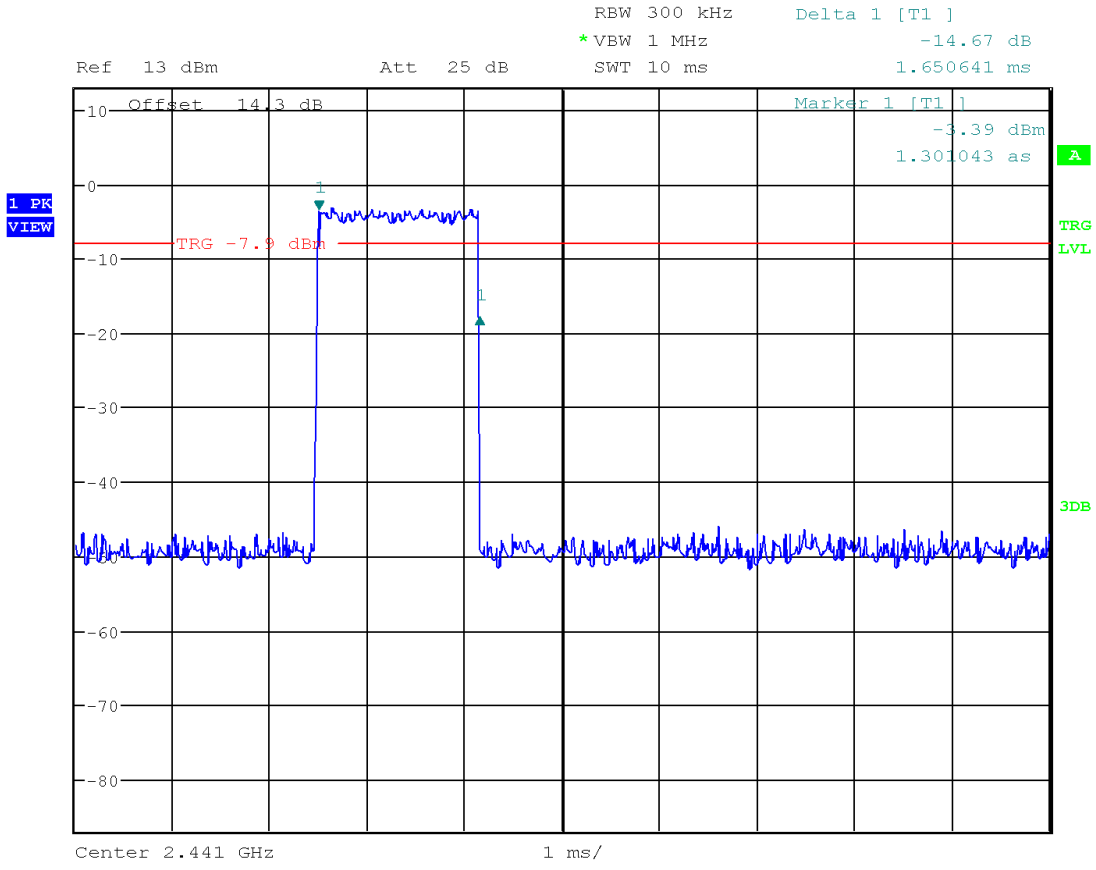
Date: 27.SEP.2018 19:05:35



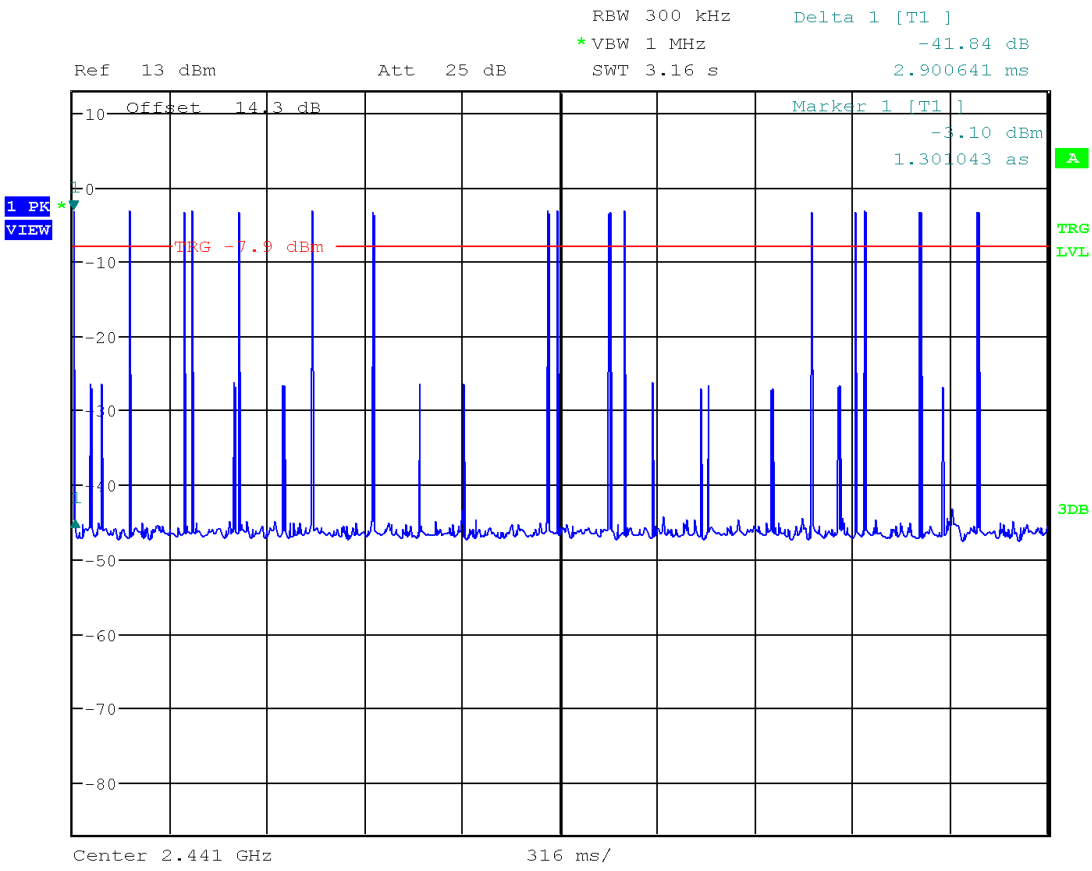
Date: 27.SEP.2018 19:11:47

8DPSK, DH3

No. of Burst in 3.16s (31.6s Period)	Burst On Time (ms)	Dwell Time (ms)	Dwell Time limit (ms)
16*10	1.65	264	400



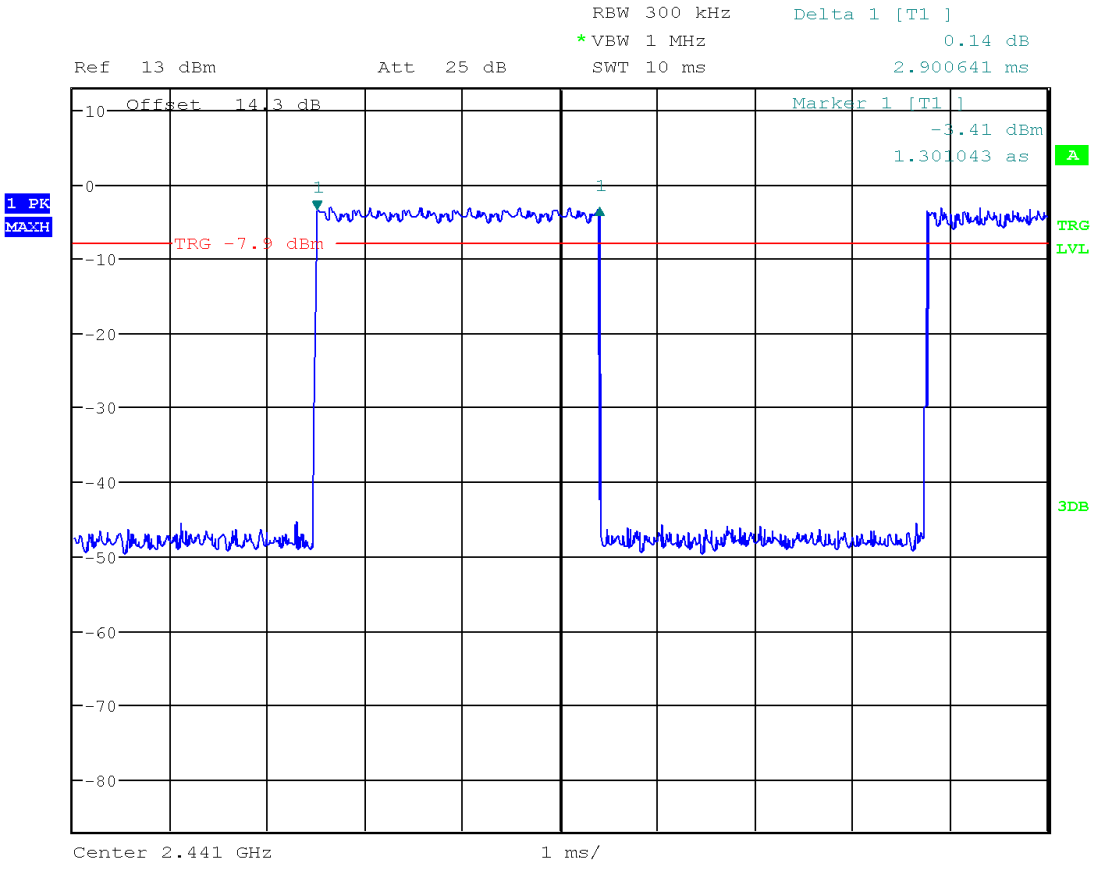
Date: 27.SEP.2018 19:07:04

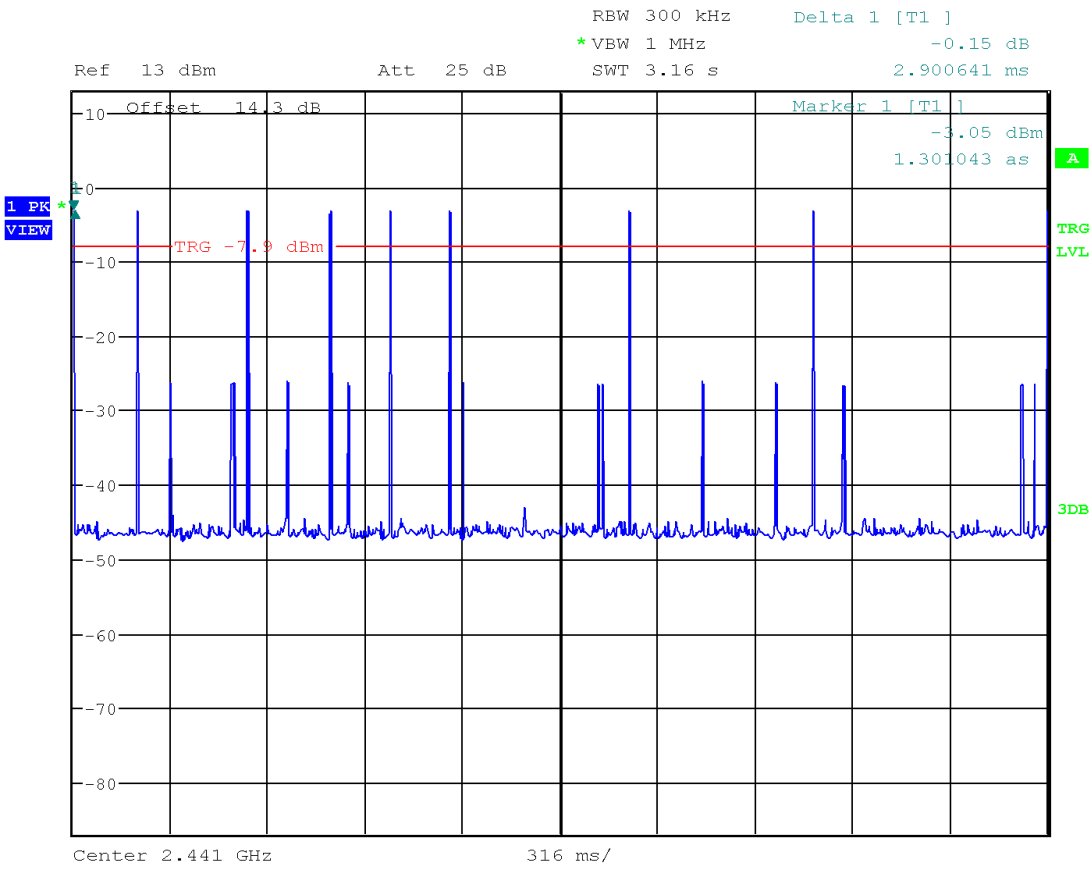


Date: 27.SEP.2018 19:10:05

8DPSK, DH5

No. of Burst in 3.16s (31.6s Period)	Burst On Time (ms)	Dwell Time (ms)	Dwell Time limit (ms)
8*10	2.9	232	400





Date: 27.SEP.2018 19:09:14

4.6 Out-of-Band Conducted Emissions
FCC 15.247(d)

4.6.1 Requirement

In any 100 kHz bandwidths outside the EUT pass-band, the RF power shall be at least 20dB (peak) or 30 dB (average) below that of the maximum in-band 100 kHz emissions.

4.6.2 Procedure

The procedure described in FCC Publication 558074 D01 Meas Guidance v05 was used. Specifically, Section 7.8.8 of ANSI C63.10:2013 for Frequency Hopping Spread Spectrum Systems was used to determine the Out-of-Band Conducted Emissions.

- Span = wide enough to capture the peak level of the in-band emission and all spurious
- emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the
- 10th harmonic. Typically, several plots are required to cover this entire span.
- RBW = 100 kHz
- VBW = 3 x RBW
- Sweep = auto
- Detector function = peak
- Trace = max hold

Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded. The level displayed must comply with the limit specified in this Section.

A spectrum analyzer was connected to the antenna port of the transmitter. Analyzer Resolution Bandwidth was set to 100 kHz. For each channel investigated, the in-band and out-of-band emission measurements were performed. The out-of-band emissions were measured from 30 MHz to 26 GHz.

Tested By:	Minh Ly
Test Date:	October 03, 2018

4.6.3 Test Result

Refer to the following plots and out-of-band conducted spurious emissions at the Band-Edge, Table 4.1 & 4.2 for the test results:

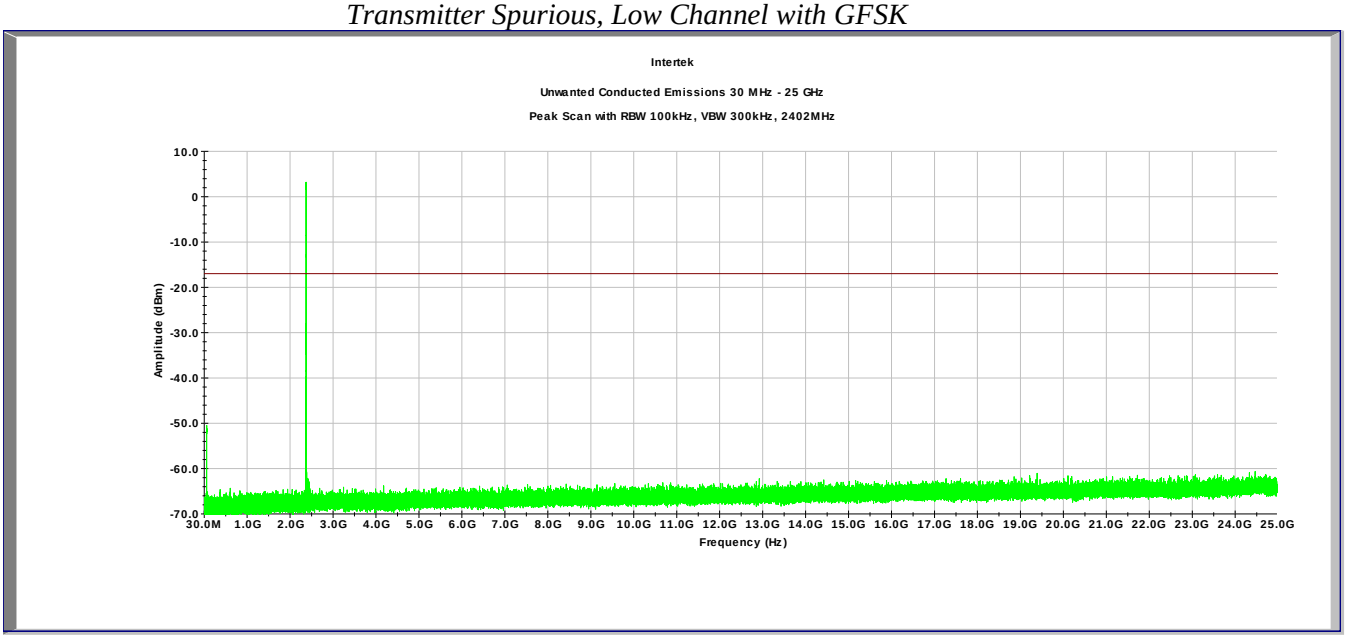
Table 4.1

Radio	Channel	Frequency MHz	Description	Plot #
GFSK	0	2402	Scan 30 MHz – 25 GHz	4.1
	39	2441	Scan 30 MHz – 25 GHz	4.2
	78	2480	Scan 30 MHz – 25 GHz	4.3
π/4-DQPSK	0	2402	Scan 30 MHz – 25 GHz	4.4
	39	2441	Scan 30 MHz – 25 GHz	4.5
	78	2480	Scan 30 MHz – 25 GHz	4.6
8DPSK	0	2402	Scan 30 MHz – 25 GHz	4.7
	39	2441	Scan 30 MHz – 25 GHz	4.8
	78	2480	Scan 30 MHz – 25 GHz	4.9

Results	Complies

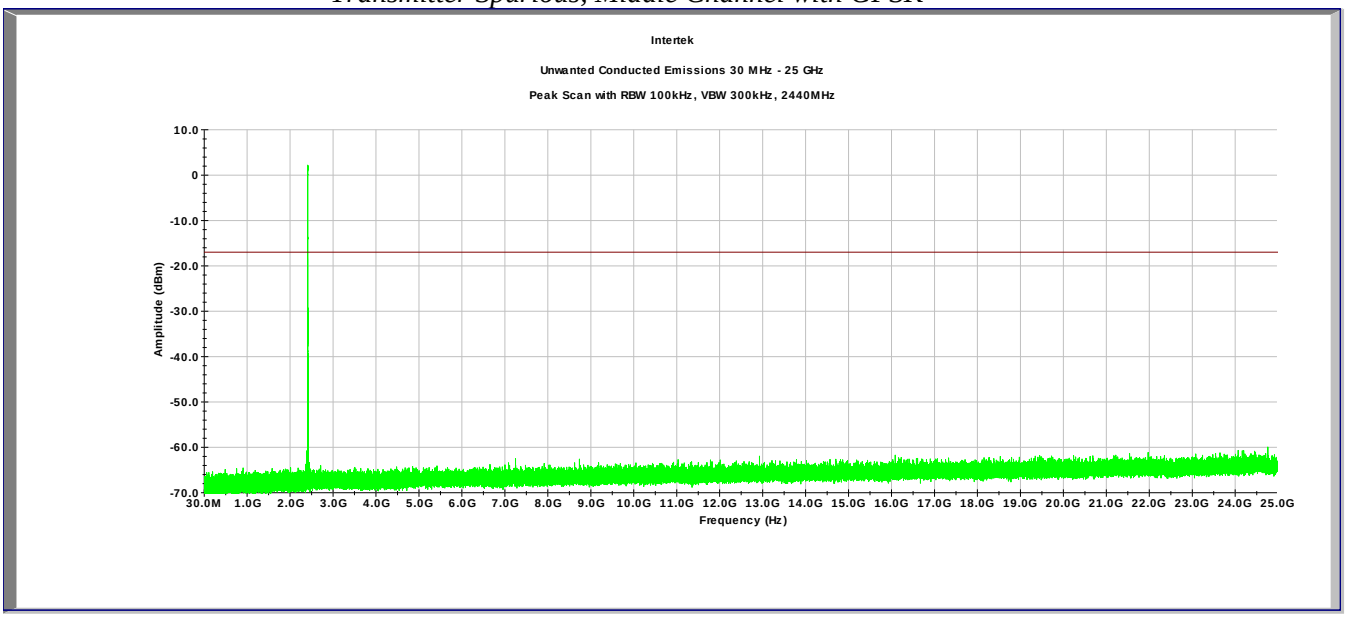
Plot 4.1

Transmitter Spurious, Low Channel with GFSK

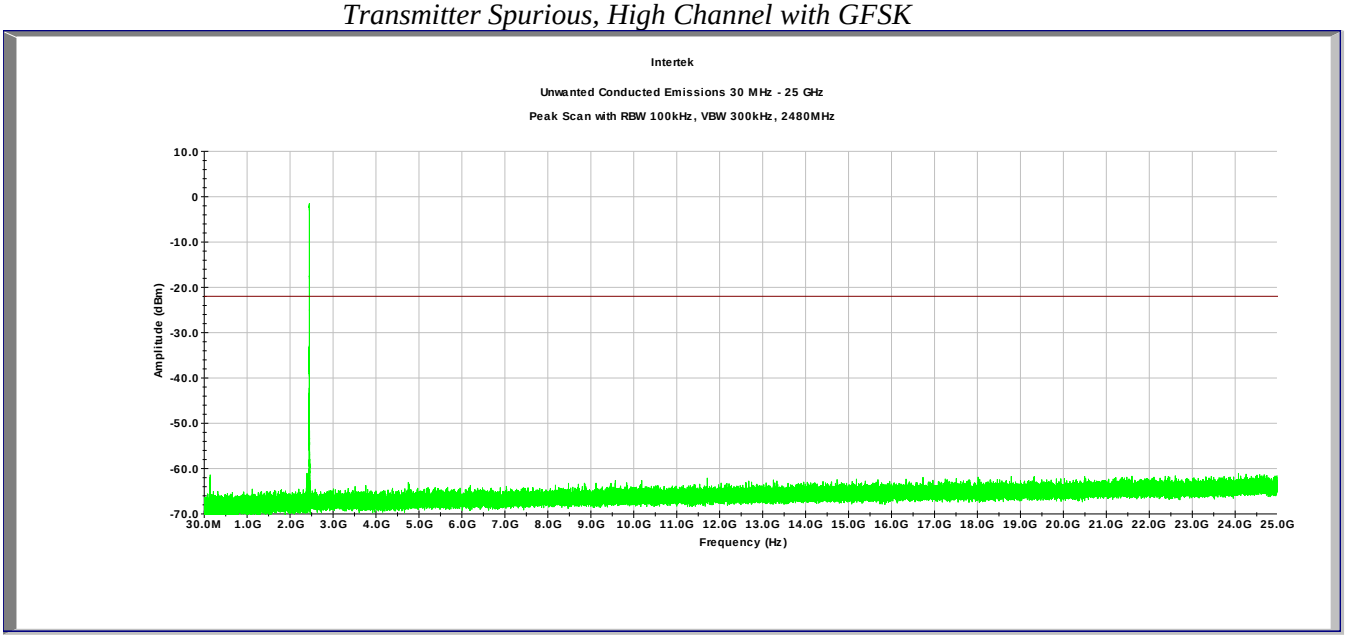


Plot 4.2

Transmitter Spurious, Middle Channel with GFSK



Plot 4.3
Transmitter Spurious, High Channel with GFSK



Plot 4.4
Transmitter Spurious, Low Channel with π/4-DQPSK