

Report on the FCC and IC Testing of: Apple Inc. Model: A1993

In accordance with FCC 47 CFR Part 15C and Industry Canada RSS-247 / RSS-GEN

Prepared for: Apple Inc.
One Apple Park Way
Cupertino
California 95014
USA

FCC ID: BCGA1993

IC: 579C-A1993



Product Service

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Document Number: 75942779-10 | Issue: 02

SIGNATURE

NAME	JOB TITLE	RESPONSIBLE FOR	ISSUE DATE
Simon Bennett	Chief Engineer	Authorised Signatory	09 October 2018

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD Product Service document control rules.

ENGINEERING STATEMENT

The measurements shown in this report were made in accordance with the procedures described on test pages. All reported testing was carried out on a sample equipment to demonstrate limited compliance with FCC 47 CFR Part 15C and Industry Canada RSS-247 and Industry Canada RSS-GEN. The sample tested was found to comply with the requirements defined in the applied rules.

SIGNATURE

NAME	JOB TITLE	RESPONSIBLE FOR	ISSUE DATE
Mehadi Choudhury	Test Engineer	Testing	09 October 2018

FCC Accreditation
90987 Octagon House, Fareham Test Laboratory

Industry Canada Accreditation
IC2932B-1 Octagon House, Fareham Test Laboratory

EXECUTIVE SUMMARY

A sample of this product was tested and found to be compliant with FCC 47 CFR Part 15C: 2017 Industry Canada RSS-247: Issue 2 (2017-02) and Industry Canada RSS-GEN: Issue 5 (2018-04) for the tests detailed in section 1.3.



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1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	26 September 2018
2	Second Issue - FCCID and ICID updated	09 October 2018

Table 1

1.2 Introduction

Applicant	Apple Inc.
Manufacturer	Apple Inc.
Model Number(s)	A1993
Serial Number(s)	C07WR00KK2T5 and C07WT00HK2V0
Hardware Version(s)	EVT
Software Version(s)	18B2034
Number of Samples Tested	2
Test Specification/Issue/Date	FCC 47 CFR Part 15C (2017) Industry Canada RSS-247 Issue 2 (2017-02) Industry Canada RSS-GEN: Issue 5 (2018-04)
Order Number	0540058293
Date	18-May-2018
Date of Receipt of EUT	12-July-2018 and 20-June-2018
Start of Test	30-June-2018
Finish of Test	18-July-2018
Name of Engineer(s)	Mehadi Choudhury, Graeme Lawler, Tony Hubbard Malik Mohammed & Sharif Sendagire
Related Document(s)	ANSI C63.10 (2013)



Product Service

1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC 47 CFR Part 15C, Industry Canada RSS-247 and Industry Canada RSS-GEN is shown below.

Section	Specification Clause			Test Description	Result	Comments/Base Standard
	Part 15C	RSS-247	RSS-GEN			
Configuration and Mode: Bluetooth BR (DH5)						
2.1	15.247 (b)	5.4	6.12	Maximum Conducted Output Power	Pass	ANSI C63.10
2.2	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Average Time of Occupancy	Pass	ANSI C63.10
2.3	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Channel Separation	Pass	ANSI C63.10
2.4	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Number of Hopping Channels	Pass	ANSI C63.10
2.5	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - 20 dB Bandwidth	Pass	ANSI C63.10
2.6	15.247 (d)	5.5	-	Authorised Band Edges	Pass	ANSI C63.10
2.7	15.205	-	8.10	Restricted Band Edges	Pass	ANSI C63.10
2.8	15.247 (d), 15.205	5.5	6.13	Spurious Radiated Emissions	Pass	ANSI C63.10
Configuration and Mode: Bluetooth EDR (2DH5)						
2.1	15.247 (b)	5.4	6.12	Maximum Conducted Output Power	Pass	ANSI C63.10
2.2	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Average Time of Occupancy	Pass	ANSI C63.10
2.3	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Channel Separation	Pass	ANSI C63.10
2.5	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - 20 dB Bandwidth	Pass	ANSI C63.10
2.6	15.247 (d)	5.5	-	Authorised Band Edges	Pass	ANSI C63.10
2.7	15.205	-	8.10	Restricted Band Edges	Pass	ANSI C63.10
Configuration and Mode: Bluetooth EDR (3DH5)						
2.1	15.247 (b)	5.4	6.12	Maximum Conducted Output Power	Pass	ANSI C63.10
2.2	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Average Time of Occupancy	Pass	ANSI C63.10



Product Service

Section	Specification Clause			Test Description	Result	Comments/Base Standard
	Part 15C	RSS-247	RSS-GEN			
2.3	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Channel Separation	Pass	ANSI C63.10
2.5	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - 20 dB Bandwidth	Pass	ANSI C63.10
2.6	15.247 (d)	5.5	-	Authorised Band Edges	Pass	ANSI C63.10
2.7	15.205	-	8.10	Restricted Band Edges	Pass	ANSI C63.10



1.4 Product Information

1.4.1 Technical Description

The Equipment Under Test (EUT) was a desktop computer, with Bluetooth, Bluetooth Low Energy and 802.11 b/g/n/ac capabilities in the 2.4GHz and 5GHz bands.

1.5 Deviations from the Standard

No deviations from the applicable test standard were made during testing.

1.6 EUT Modification Record

The table below details modifications made to the EUT during the test programme.
The modifications incorporated during each test are recorded on the appropriate test pages.

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
Serial Number: C07WT00HK2V0			
0	As supplied by the customer	Not Applicable	Not Applicable
Serial Number: C07WR00KK2T5			
0	As supplied by the customer	Not Applicable	Not Applicable

Table 2



1.7 Test Location

TÜV SÜD Product Service conducted the following tests at our Fareham Test Laboratory.

Test Name	Name of Engineer(s)	Accreditation
Configuration and Mode: Bluetooth BR (DH5)		
Maximum Conducted Output Power	Mehadi Choudhury	UKAS
Frequency Hopping Systems - Average Time of Occupancy	Mehadi Choudhury	UKAS
Frequency Hopping Systems - Channel Separation	Mehadi Choudhury	UKAS
Frequency Hopping Systems - Number of Hopping Channels	Mehadi Choudhury	UKAS
Frequency Hopping Systems - 20 dB Bandwidth	Mehadi Choudhury	UKAS
Authorised Band Edges	Graeme Lawler, Tony Hubbard, Malik Mohammed & Sharif Sendagire	UKAS
Restricted Band Edges		UKAS
Spurious Radiated Emissions		UKAS
Configuration and Mode: Bluetooth EDR (2DH5)		
Maximum Conducted Output Power	Mehadi Choudhury	UKAS
Frequency Hopping Systems - Average Time of Occupancy	Mehadi Choudhury	UKAS
Frequency Hopping Systems - Channel Separation	Mehadi Choudhury	UKAS
Frequency Hopping Systems - 20 dB Bandwidth	Mehadi Choudhury	UKAS
Authorised Band Edges	Graeme Lawler, Tony Hubbard, Malik Mohammed & Sharif Sendagire	UKAS
Restricted Band Edges		UKAS
Configuration and Mode: Bluetooth EDR (3DH5)		
Maximum Conducted Output Power	Mehadi Choudhury	UKAS
Frequency Hopping Systems - Average Time of Occupancy	Mehadi Choudhury	UKAS
Frequency Hopping Systems - Channel Separation	Mehadi Choudhury	UKAS
Frequency Hopping Systems - 20 dB Bandwidth	Mehadi Choudhury	UKAS
Authorised Band Edges	Graeme Lawler, Tony Hubbard, Malik Mohammed & Sharif Sendagire	UKAS
Restricted Band Edges		UKAS

Table 3

Office Address:
Octagon House
Concorde Way
Segensworth North
Fareham
Hampshire
PO15 5RL
United Kingdom



2 Test Details

2.1 Maximum Conducted Output Power

2.1.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (b)(1)
Industry Canada RSS-247, Clause 5.4

2.1.2 Equipment Under Test and Modification State

A1993, S/N: C07WR00KK2T5 - Modification State 0

2.1.3 Date of Test

18-July-2018

2.1.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 7.8.5.

2.1.5 Environmental Conditions

Ambient Temperature 23.8 °C
Relative Humidity 46.6 %

2.1.6 Test Results

Bluetooth BDR (DH5)

Testing was performed on the modulation/packet type with the highest conducted output power. This modulation/packet type was GFSK/DH5.

Frequency (MHz)	Maximum Output Power	
	dBm	mW
2402	12.68	18.54
2441	12.57	18.07
2480	12.55	17.99

Table 4 - Maximum Conducted Output Power Results

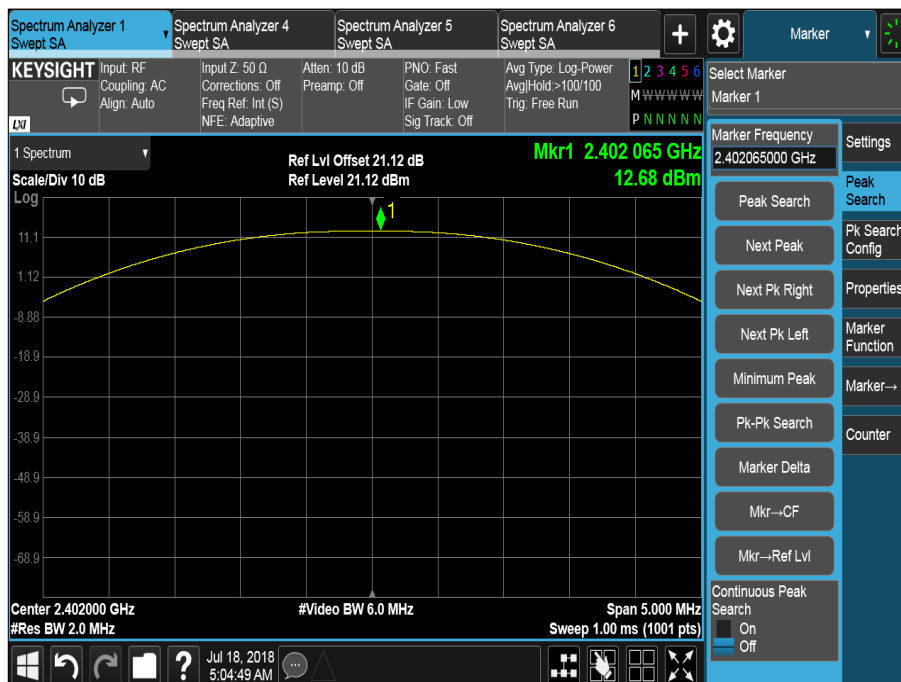


Figure 1 - 2402 MHz - Maximum Output Power

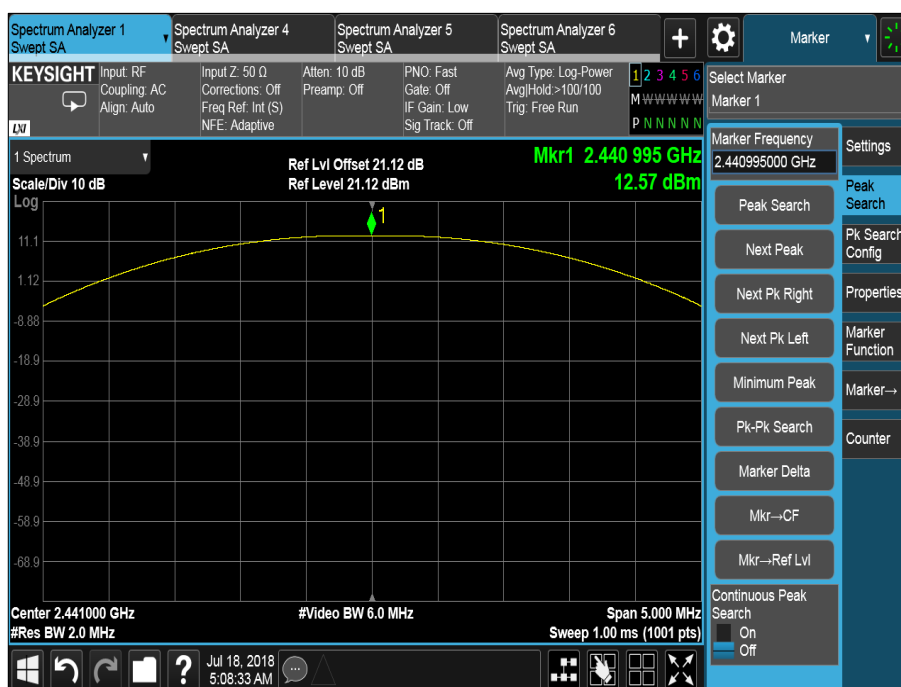


Figure 2 - 2441 MHz - Maximum Output Power



Product Service

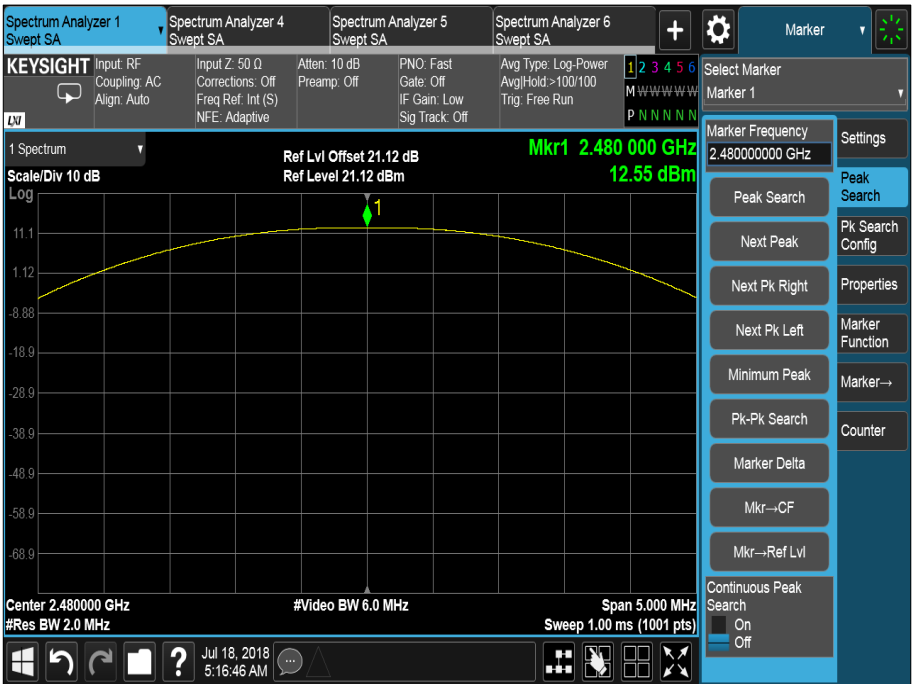


Figure 3 - 2480 MHz - Maximum Output Power



Bluetooth EDR (2DH5)

Testing was performed on the modulation/packet type with the highest conducted output power. This modulation/packet type was $\pi/4$ -DQPSK/2DH5.

Frequency (MHz)	Maximum Output Power	
	dBm	mW
2402	10.94	12.42
2441	11.09	12.85
2480	10.96	12.47

Table 5 - Maximum Conducted Output Power Results

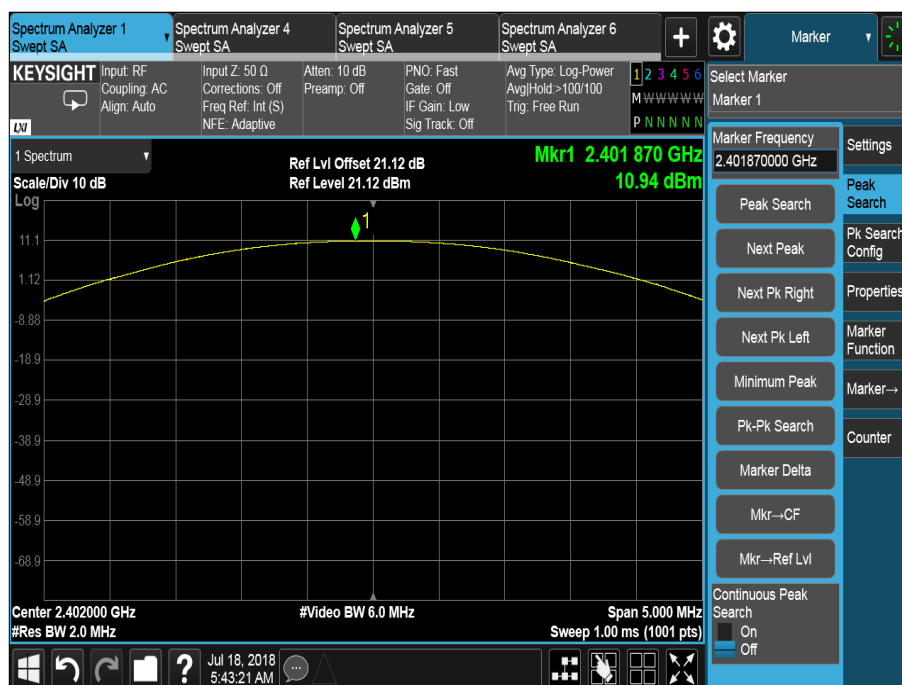


Figure 4 - 2402 MHz - Maximum Output Power



Figure 5 - 2441 MHz - Maximum Output Power

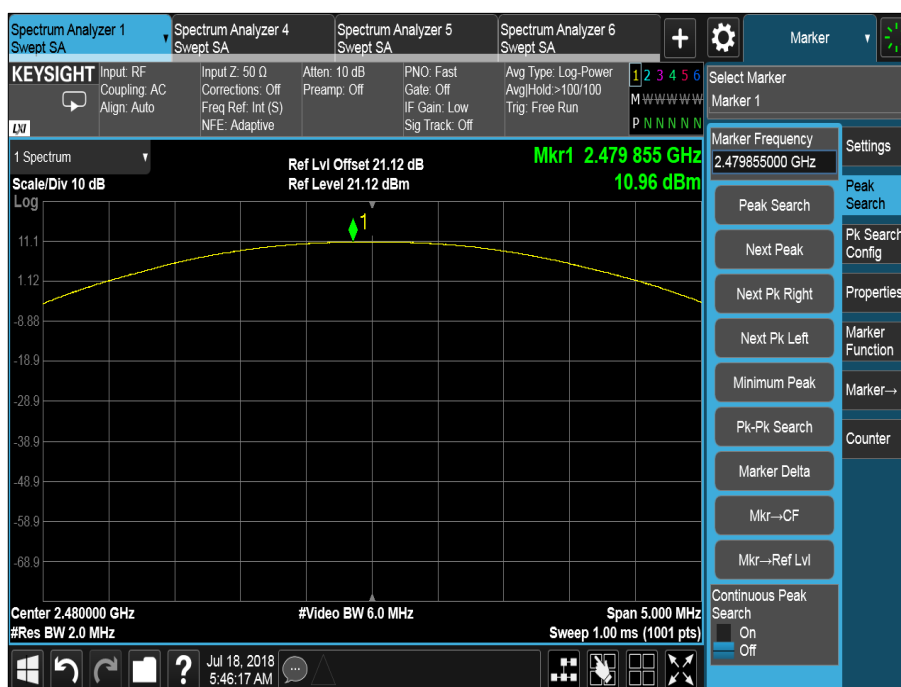


Figure 6 - 2480 MHz - Maximum Output Power



Bluetooth EDR (3DH5)

Testing was performed on the modulation/packet type with the highest conducted output power. This modulation/packet type was 8-DPSK/3DH5.

Frequency (MHz)	Maximum Output Power	
	dBm	mW
2402	11.18	13.12
2441	11.15	13.03
2480	11.23	13.27

Table 6 - Maximum Conducted Output Power Results

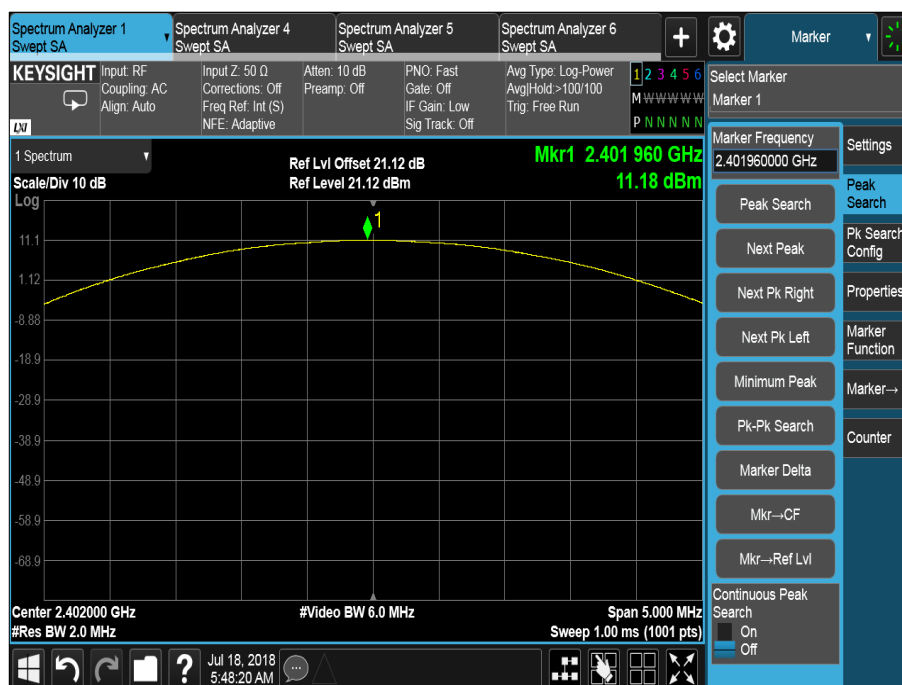


Figure 7 - 2402 MHz - Maximum Output Power

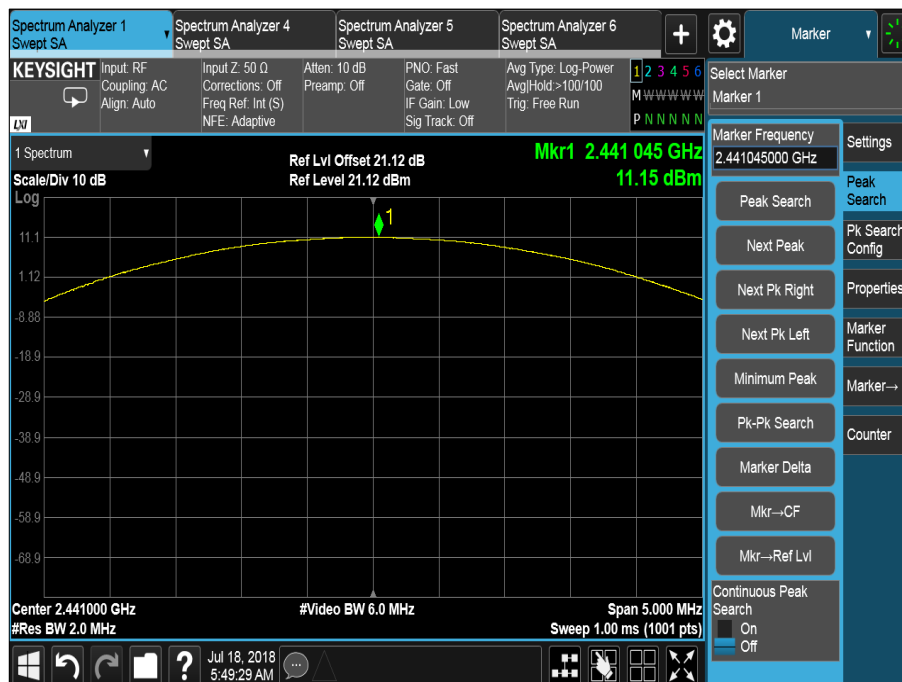


Figure 8 - 2441 MHz - Maximum Output Power

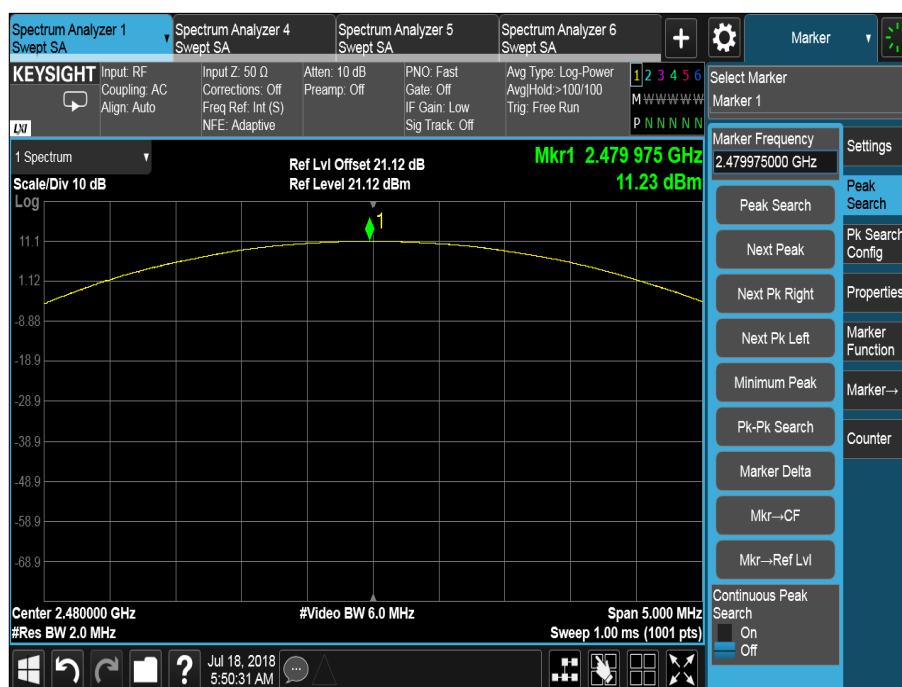


Figure 9 - 2480 MHz - Maximum Output Power



FCC 47 CFR Part 15, Limit Clause 15.247 (b)

The maximum peak conducted output power of the intentional radiator shall not exceed the following:

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 5725-5850MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

Industry Canada RSS-247, Limit Clause 5.4 (b)

For FHSs operating in the band 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W if the hopset uses 75 or more hopping channel; the maximum peak conducted output power shall not exceed 0.125 W if the hopset uses less than 75 hopping channel. The e.i.r.p. shall not exceed 4 W except as provided in section 5.4(e) of the specification.

2.1.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 3.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
20dB/2W Attenuator	Narda	4772-20	462	-	O/P Mon
Mains Voltage Monitor	TUV SUD Product Service	MVM1	1378	12	17-Apr-2019
Cable (3m, SMA(m) - SMA(m))	Reynolds	262-0248-3000	2402	12	19-Sep-2018
Hygrometer	Rotronic	I-1000	2891	12	30-Aug-2018
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	02-Oct-2018
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	06-Mar-2019
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	20-Oct-2018
EXA	Keysight Technologies	N9010B	4969	12	21-Dec-2018

Table 7

O/P Mon – Output Monitored using calibrated equipment



2.2 Frequency Hopping Systems - Average Time of Occupancy

2.2.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(1)
Industry Canada RSS-247, Clause 5.1

2.2.2 Equipment Under Test and Modification State

A1993, S/N: C07WR00KK2T5 - Modification State 0

2.2.3 Date of Test

18-July-2018

2.2.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 7.8.4.

2.2.5 Environmental Conditions

Ambient Temperature 23.8 °C
Relative Humidity 46.6 %

2.2.6 Test Results

Bluetooth

Packet Type	Dwell Time (ms)	Number of Transmissions	Average Occupancy Time (ms)
DH5	2.88	102	293.76
2DH5	2.88	94	270.72
3DH5	2.88	99	285.12

Table 8



Product Service

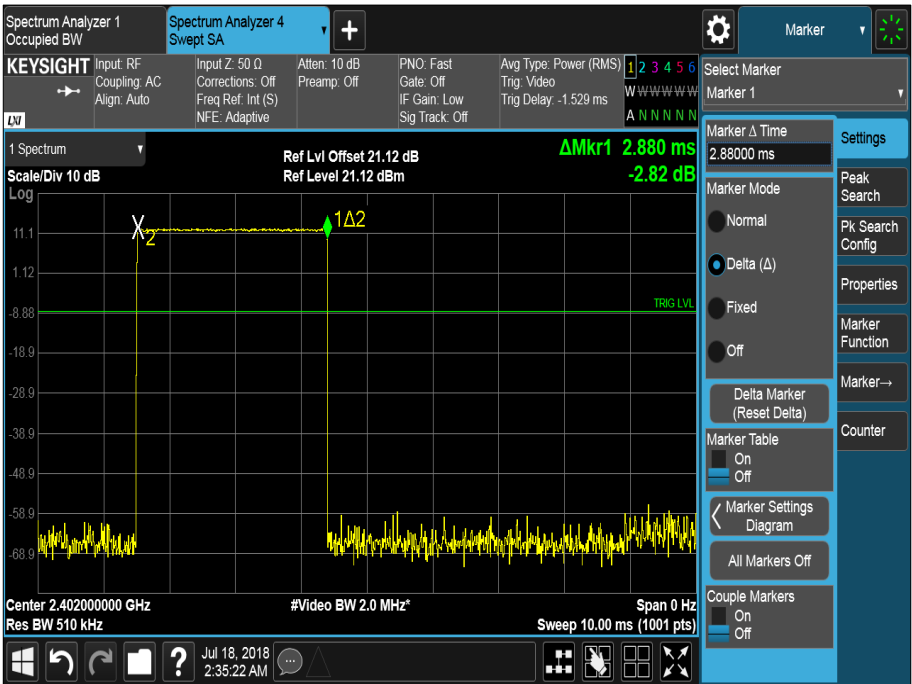


Figure 10 - DH5, Dwell Time

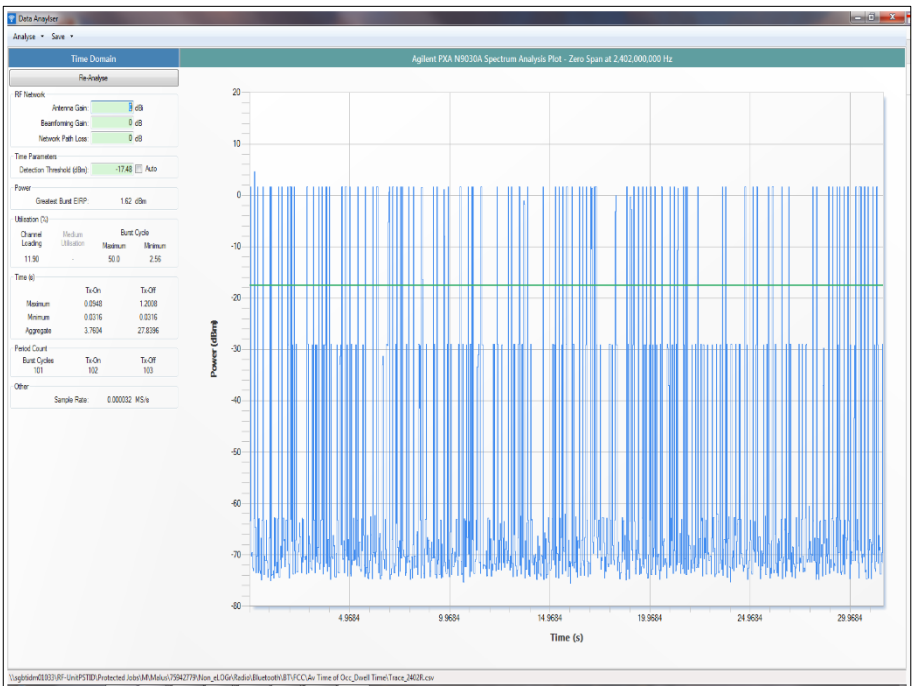


Figure 11 - DH5, Total Average Time of Occupancy

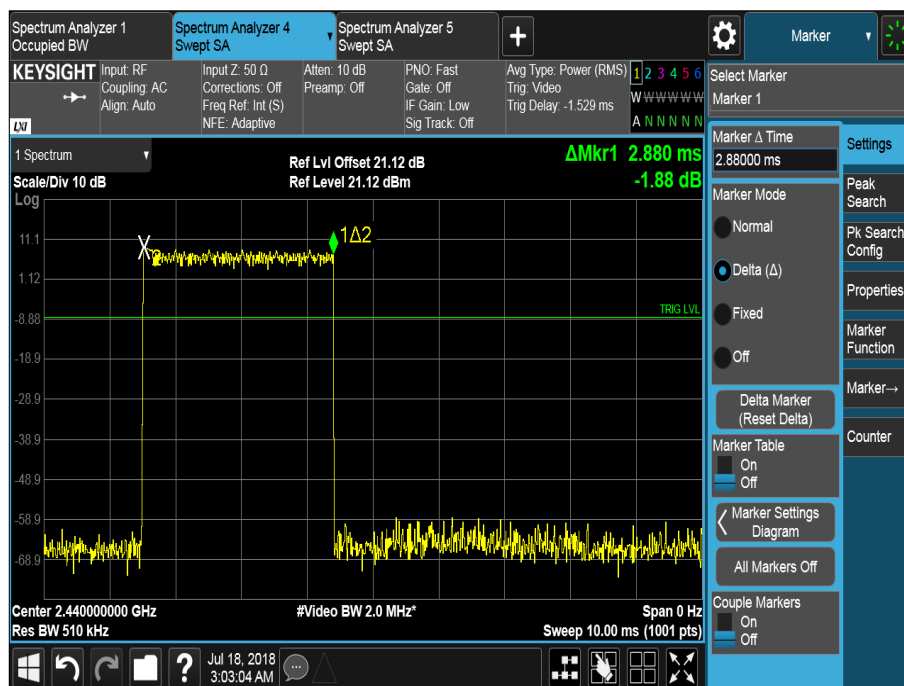


Figure 12 - 2DH5, Dwell Time

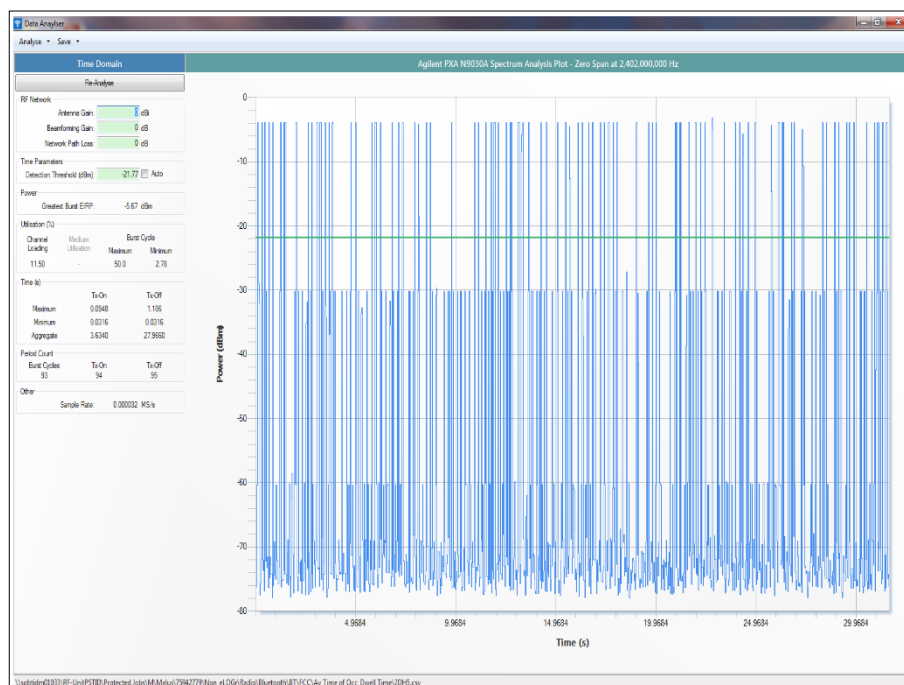


Figure 13 - 2DH5, Total Average Time of Occupancy

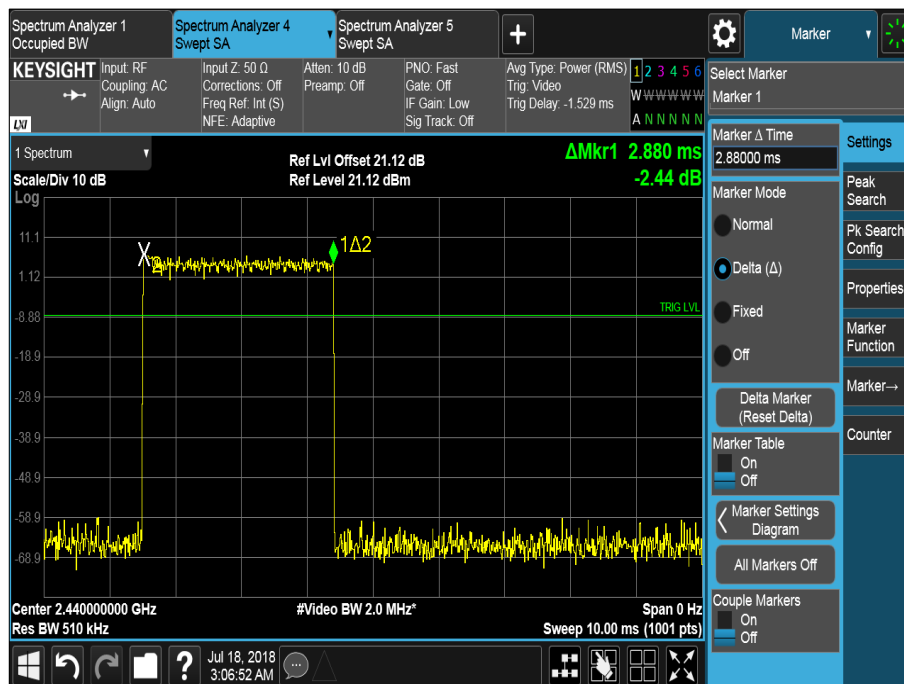


Figure 14 - 3DH5, Dwell Time

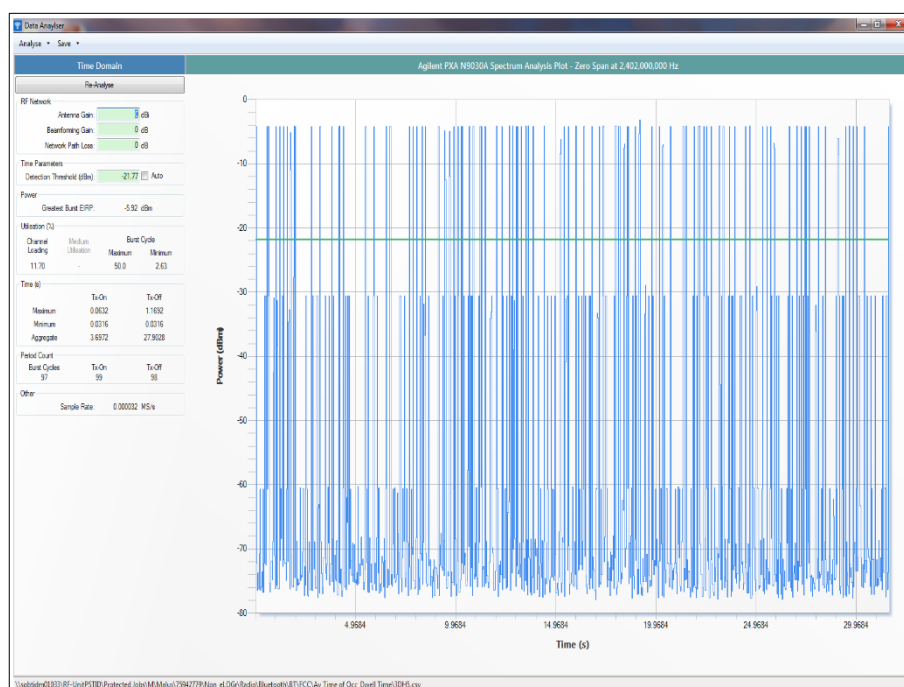


Figure 15 - 3DH5, Total Average Time of Occupancy



FCC 47 CFR Part 15, Limit Clause 15.247 (a)(1)(iii)

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

Industry Canada RSS-247, Limit Clause 5.1 (d)

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed.

2.2.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 3.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
20dB/2W Attenuator	Narda	4772-20	462	-	O/P Mon
Mains Voltage Monitor	TUV SUD Product Service	MVM1	1378	12	17-Apr-2019
Cable (3m, SMA(m) - SMA(m))	Reynolds	262-0248-3000	2402	12	19-Sep-2018
Hygrometer	Rotronic	I-1000	2891	12	30-Aug-2018
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	02-Oct-2018
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	06-Mar-2019
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	20-Oct-2018
EXA	Keysight Technologies	N9010B	4969	12	21-Dec-2018

Table 9

O/P Mon – Output Monitored using calibrated equipment



Product Service

2.3 Frequency Hopping Systems - Channel Separation

2.3.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(1)
Industry Canada RSS-247, Clause 5.1

2.3.2 Equipment Under Test and Modification State

A1993, S/N: C07WR00KK2T5 - Modification State 0

2.3.3 Date of Test

18-July-2018

2.3.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 7.8.2.

2.3.5 Environmental Conditions

Ambient Temperature 23.8 °C
Relative Humidity 46.6 %

2.3.6 Test Results

Bluetooth

Modulation	Channel Separation (MHz)
GFSK	1.002
$\pi/4$ DQPSK	1.002
8-DPSK	1.002

Table 10



Product Service



Figure 16 - GFSK

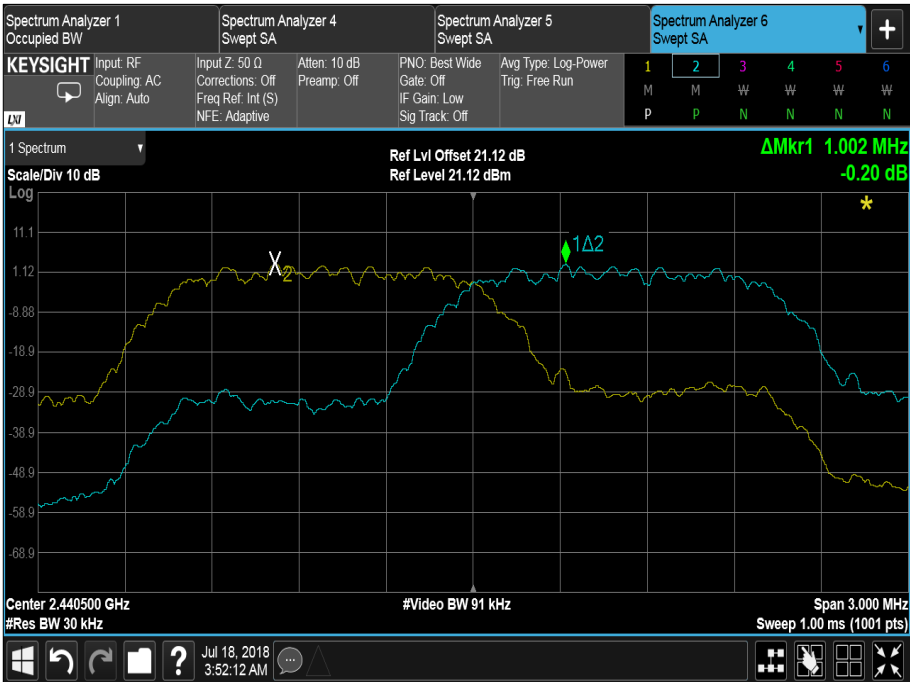


Figure 17 - $\pi/4$ DQPSK

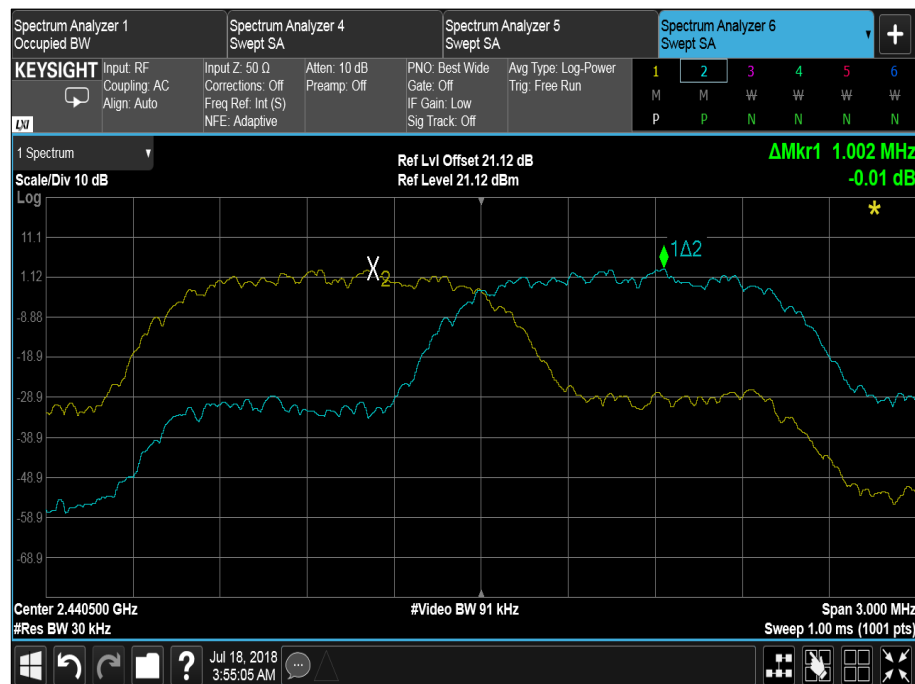


Figure 18 - 8-DPSK

FCC 47 CFR Part 15, Limit Clause 15.247 (a)(1)

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

Alternatively, frequency hopping systems operating in the band 2400-2483.5 MHz 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 0.125 W.

Industry Canada RSS-247, Limit Clause 5.1 (b)

FHSS 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, FHSS operating in the band 2400-2483.5 MHz 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 that the systems operate with an output power no greater than 0.125 W.



2.3.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 3.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
20dB/2W Attenuator	Narda	4772-20	462	-	O/P Mon
Mains Voltage Monitor	TUV SUD Product Service	MVM1	1378	12	17-Apr-2019
Cable (3m, SMA(m) - SMA(m))	Reynolds	262-0248-3000	2402	12	19-Sep-2018
Hygrometer	Rotronic	I-1000	2891	12	30-Aug-2018
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	02-Oct-2018
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	06-Mar-2019
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	20-Oct-2018
EXA	Keysight Technologies	N9010B	4969	12	21-Dec-2018

Table 11

O/P Mon – Output Monitored using calibrated equipment



2.4 Frequency Hopping Systems - Number of Hopping Channels

2.4.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(1)
Industry Canada RSS-247, Clause 5.1

2.4.2 Equipment Under Test and Modification State

A1993, S/N: C07WR00KK2T5 - Modification State 0

2.4.3 Date of Test

18-July-2018

2.4.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 7.8.3.

2.4.5 Environmental Conditions

Ambient Temperature 23.8 °C
Relative Humidity 46.6 %

2.4.6 Test Results

Bluetooth BDR (DH5)

Number of Hopping Channels: 79

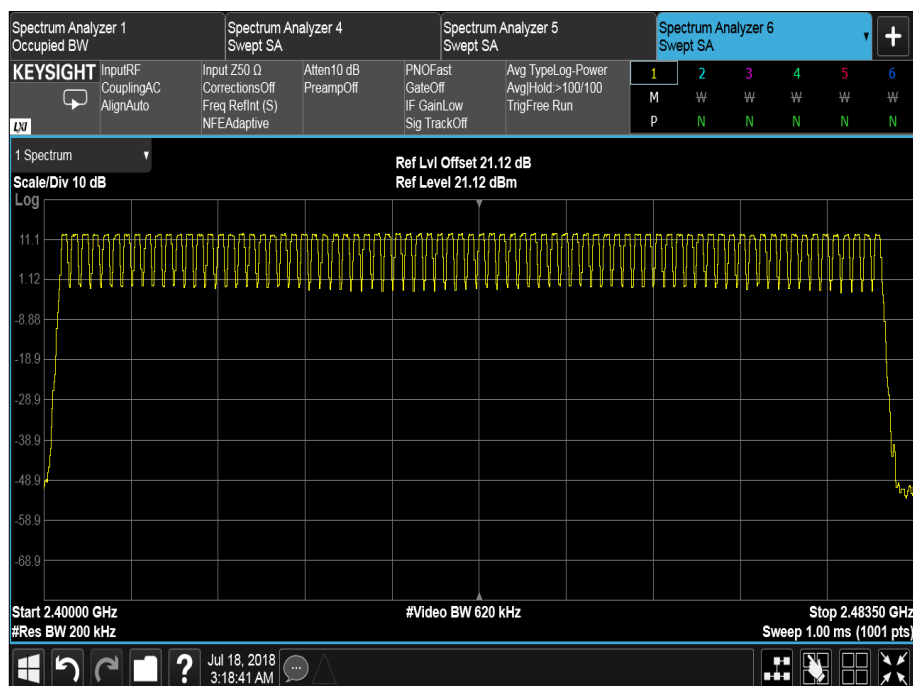


Figure 19 - Measurement Frequency Range: 2400 MHz to 2483.5 MHz



FCC 47 CFR Part 15, Limit Clause 15.247 (a)(1)(iii)

≥ 15 channels

Industry Canada RSS-247, Limit Clause 5.1 (d)

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

2.4.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 3.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
20dB/2W Attenuator	Narda	4772-20	462	-	O/P Mon
Mains Voltage Monitor	TUV SUD Product Service	MVM1	1378	12	17-Apr-2019
Cable (3m, SMA(m) - SMA(m))	Reynolds	262-0248-3000	2402	12	19-Sep-2018
Hygrometer	Rotronic	I-1000	2891	12	30-Aug-2018
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	02-Oct-2018
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	06-Mar-2019
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	20-Oct-2018
EXA	Keysight Technologies	N9010B	4969	12	21-Dec-2018

Table 12

O/P Mon – Output Monitored using calibrated equipment



2.5 Frequency Hopping Systems - 20 dB Bandwidth

2.5.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(1)
Industry Canada RSS-247, Clause 5.1

2.5.2 Equipment Under Test and Modification State

A1993, S/N: C07WR00KK2T5 - Modification State 0

2.5.3 Date of Test

18-July-2018

2.5.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 6.9.2

2.5.5 Environmental Conditions

Ambient Temperature 23.8 °C
Relative Humidity 46.6 %

2.5.6 Test Results

Bluetooth

Frequency (MHz)	20 dB Bandwidth (kHz)		
	GFSK	$\pi/4$ DQPSK	8-DPSK
2402	960.20	1383	1366
2441	955.60	1387	1377
2480	956.00	1385	1369

Table 13



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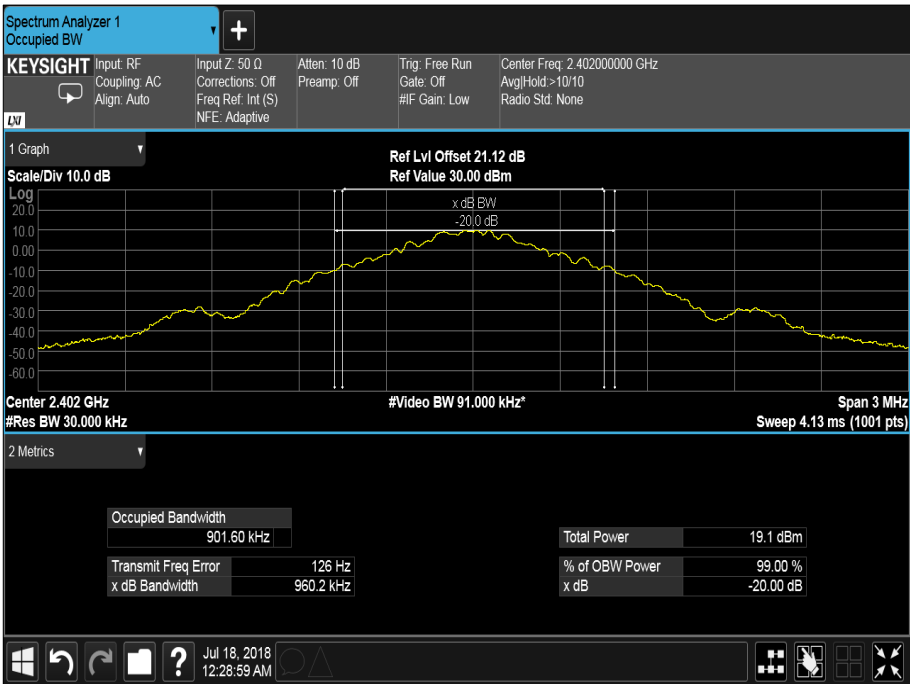


Figure 20 - 2402 MHz - GFSK

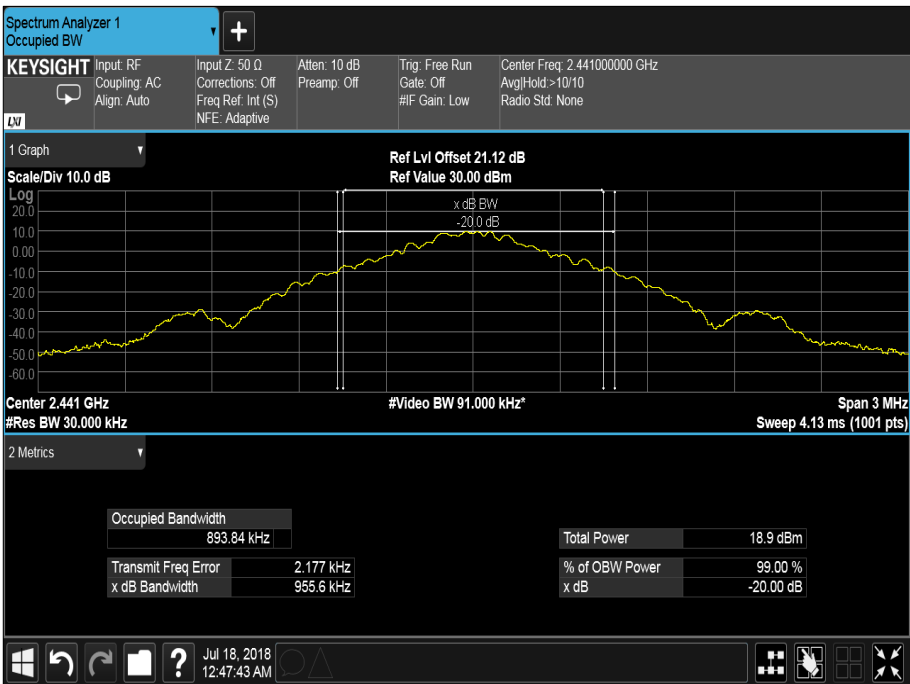


Figure 21 - 2441 MHz - GFSK



Figure 22 - 2480 MHz - GFSK

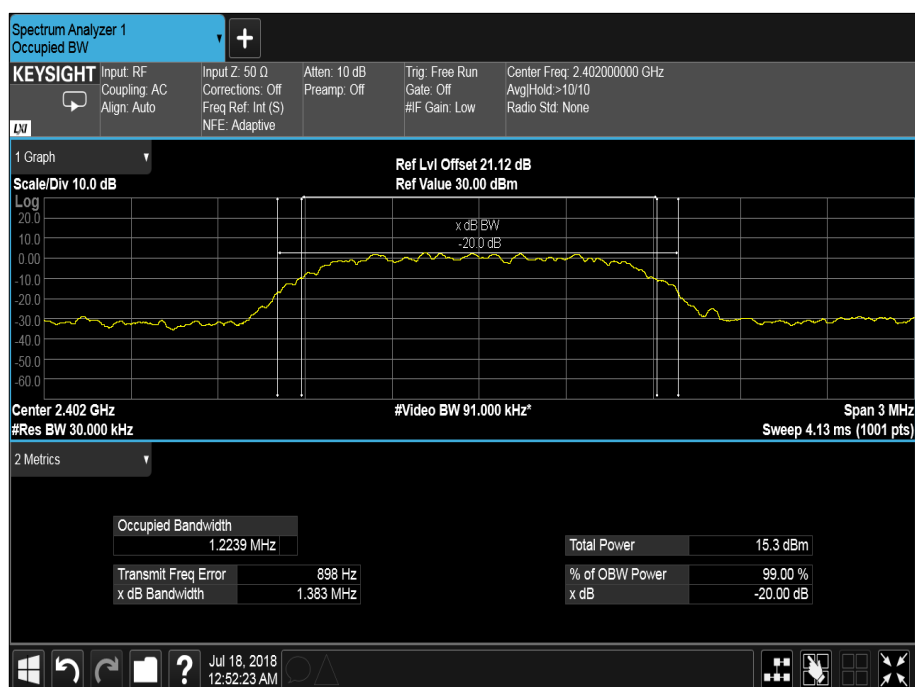


Figure 23 - 2402 MHz - $\pi/4$ DQPSK



Product Service

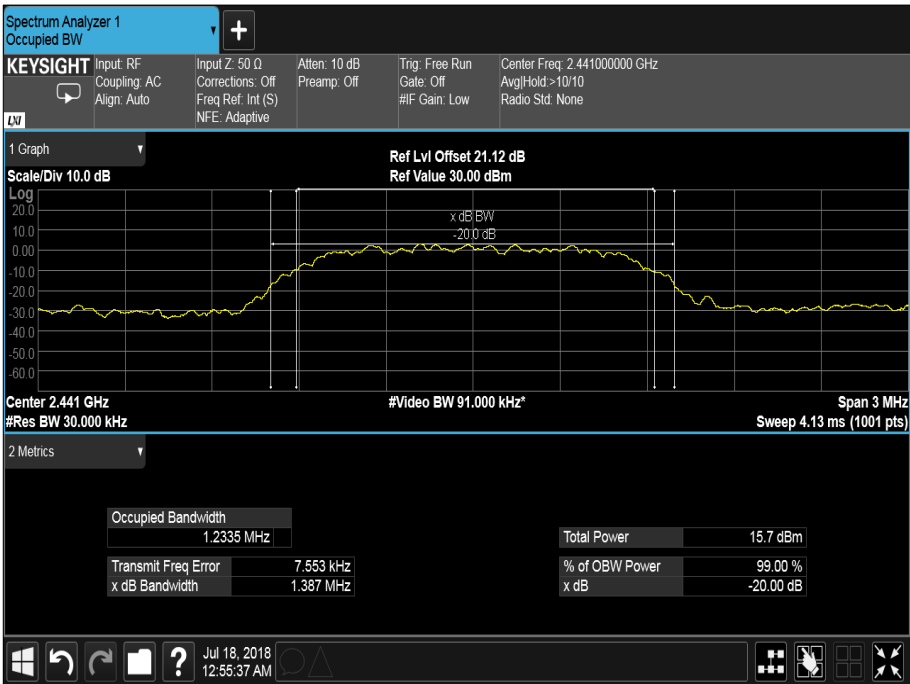


Figure 24 - 2441 MHz - $\pi/4$ DQPSK

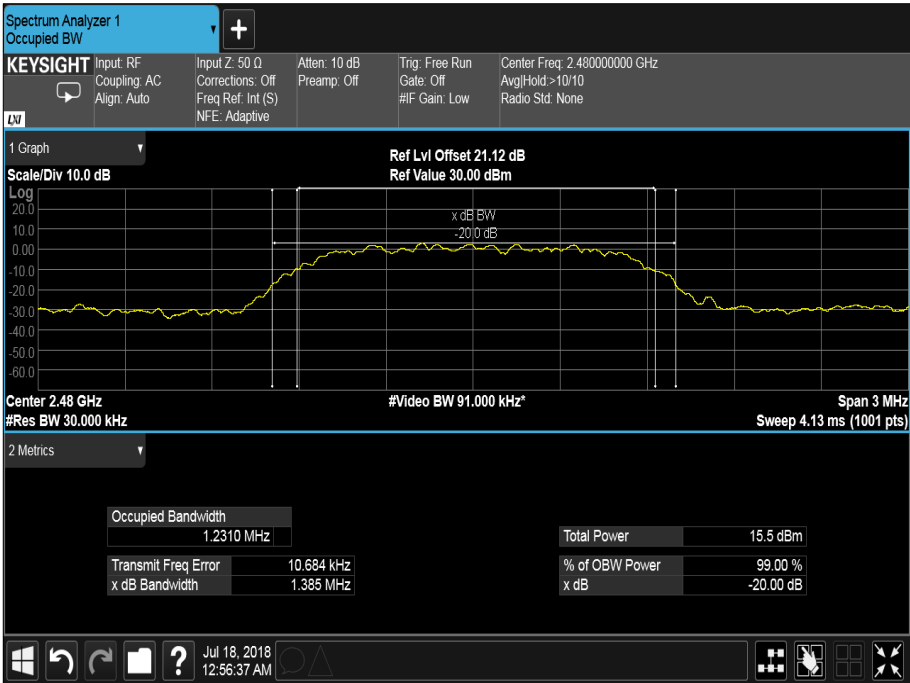


Figure 25 - 2480 MHz - $\pi/4$ DQPSK

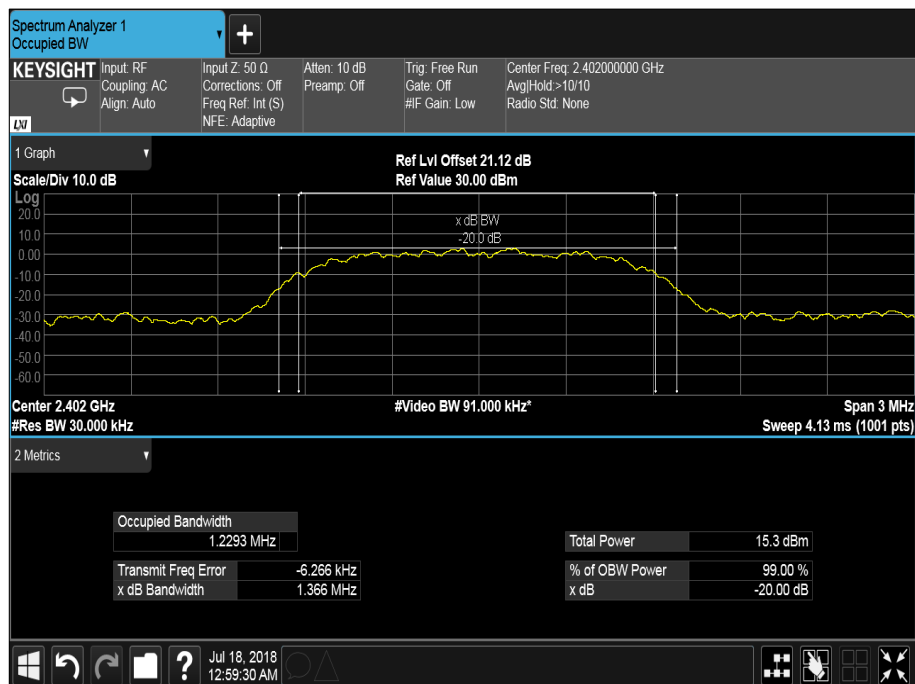


Figure 26 - 2402 MHz - 8-DPSK

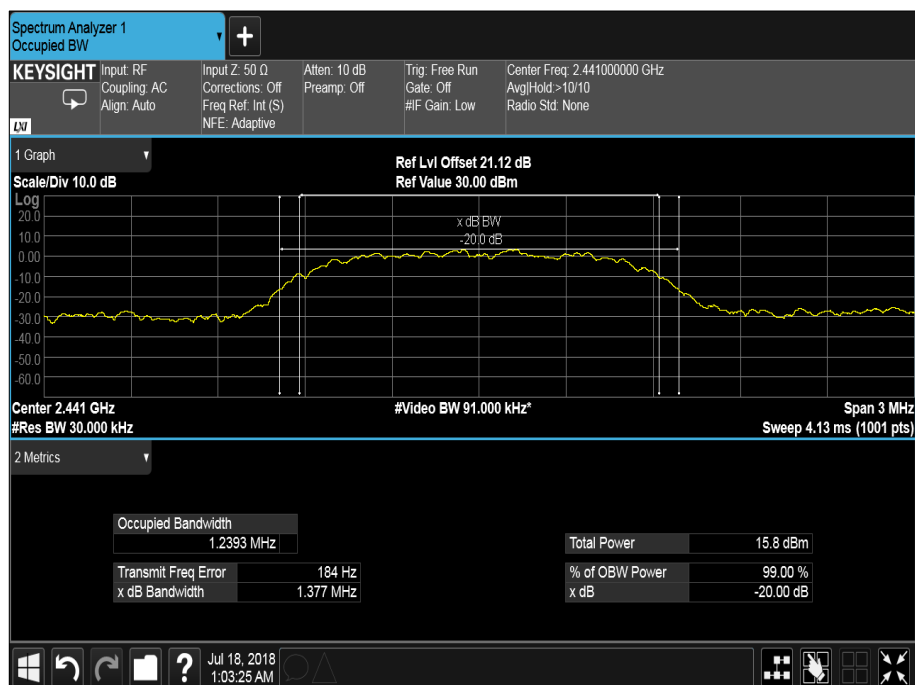


Figure 27 - 2441 MHz - 8-DPSK

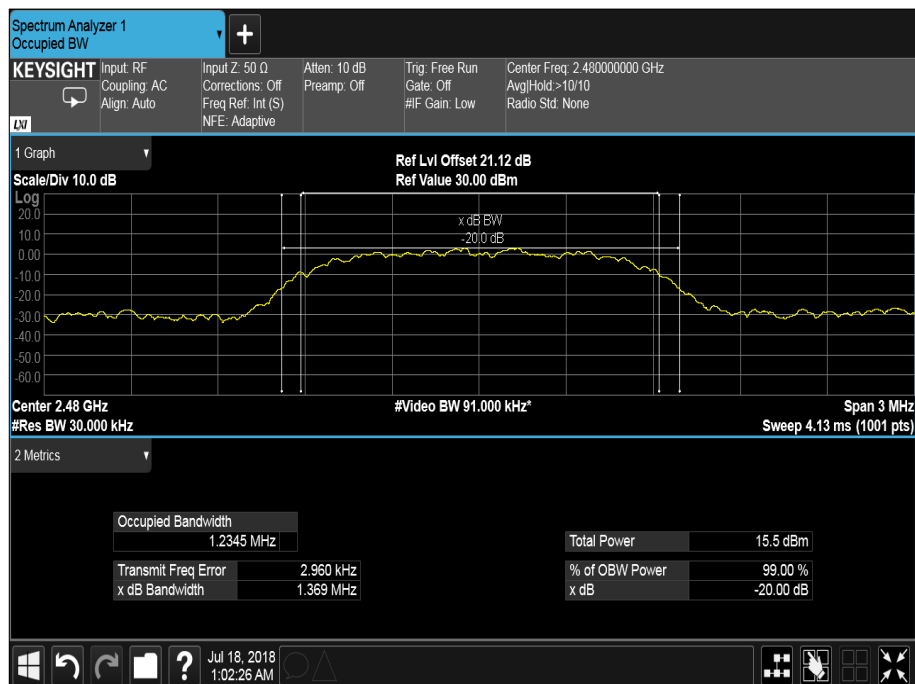


Figure 28 - 2480 MHz - 8-DPSK

2.5.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 3.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
20dB/2W Attenuator	Narda	4772-20	462	-	O/P Mon
Mains Voltage Monitor	TUV SUD Product Service	MVM1	1378	12	17-Apr-2019
Cable (3m, SMA(m) - SMA(m))	Reynolds	262-0248-3000	2402	12	19-Sep-2018
Hygrometer	Rotronic	I-1000	2891	12	30-Aug-2018
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	02-Oct-2018
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	06-Mar-2019
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	20-Oct-2018
EXA	Keysight Technologies	N9010B	4969	12	21-Dec-2018

Table 14

O/P Mon – Output Monitored using calibrated equipment



2.6 Authorised Band Edges

2.6.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (d)
Industry Canada RSS-247, Clause 5.5

2.6.2 Equipment Under Test and Modification State

A1993, S/N: C07WT00HK2V0 - Modification State 0

2.6.3 Date of Test

30-June-2018

2.6.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 6.10.4.

Note: 2483.5 MHz is both an Authorised Bandwidth and a Restricted Band Edge. Of the two limits, the Restricted Band Edge is the most stringent and therefore demonstrates compliance with the 20 dBc Authorised Bandwidth requirement.

2.6.5 Environmental Conditions

Ambient Temperature 23.6 °C
Relative Humidity 50.8 %

2.6.6 Test Results

Mode	Modulation	Packet Type	Frequency (MHz)	Measured Frequency (MHz)	Level (dBc)
Static	GFSK	DH5	2402	2400.0	-62.89
Static	$\pi/4$ DQPSK	2DH5	2402	2400.0	-55.90
Static	8-DPSK	3DH5	2402	2400.0	-56.70
Hopping	GFSK	DH5	2402	2400.0	-65.58
Hopping	$\pi/4$ DQPSK	2DH5	2402	2400.0	-62.17
Hopping	8-DPSK	3DH5	2402	2400.0	-61.54

Table 15

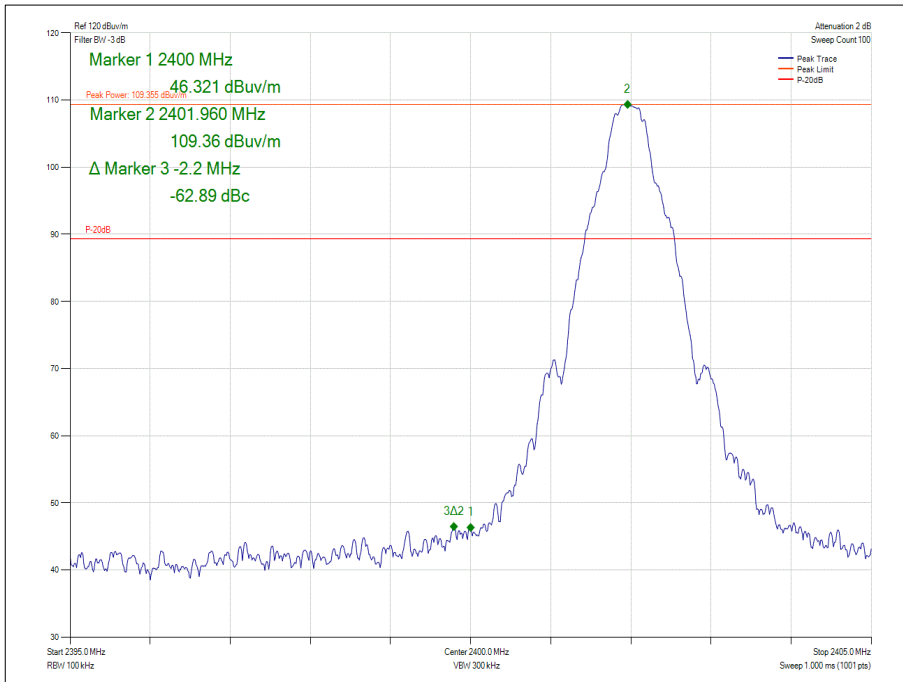


Figure 29 - Static - GFSK/DH5 - 2402 MHz - Measured Frequency 2400.0 MHz

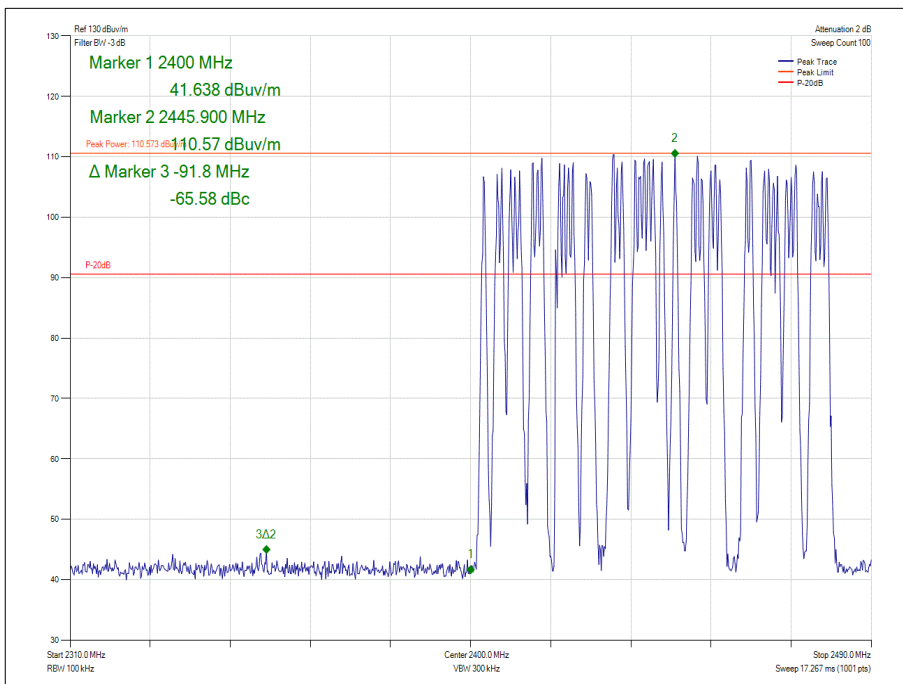


Figure 30 - Hopping - GFSK/DH5 - 2402 MHz - Measured Frequency 2400.0 MHz

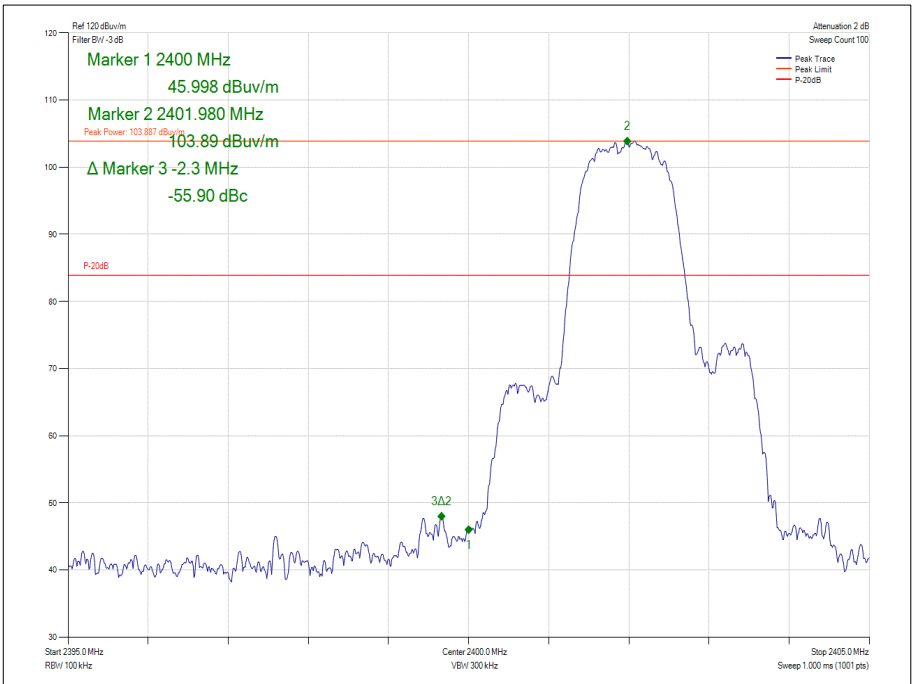


Figure 31 - Static - $\pi/4$ DQPSK/2DH5 - 2402 MHz - Measured Frequency 2400.0 MHz

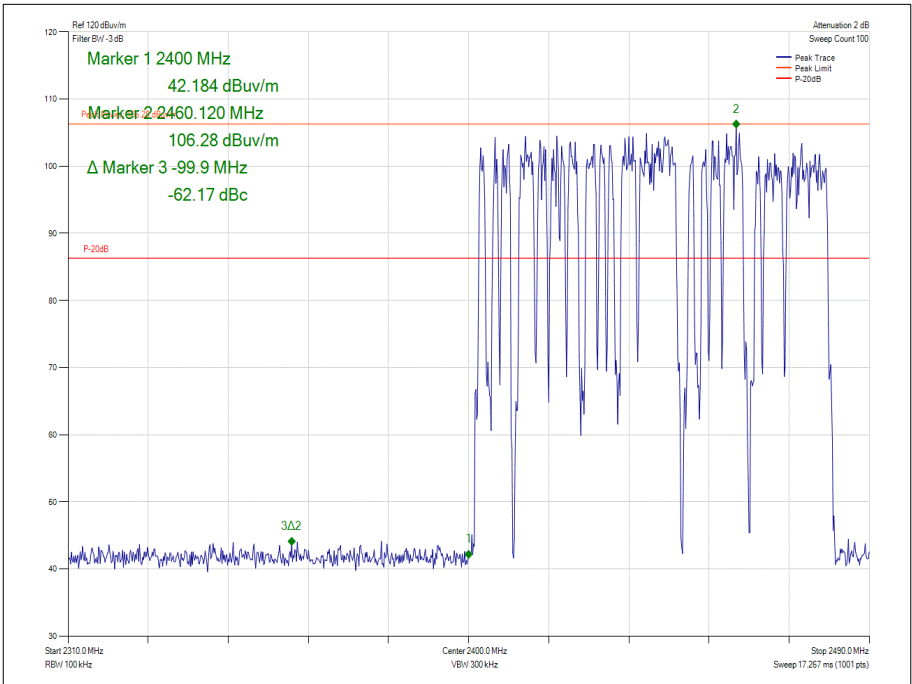


Figure 32 - Hopping - $\pi/4$ DQPSK/2DH5 - 2402 MHz - Measured Frequency 2400.0 MHz

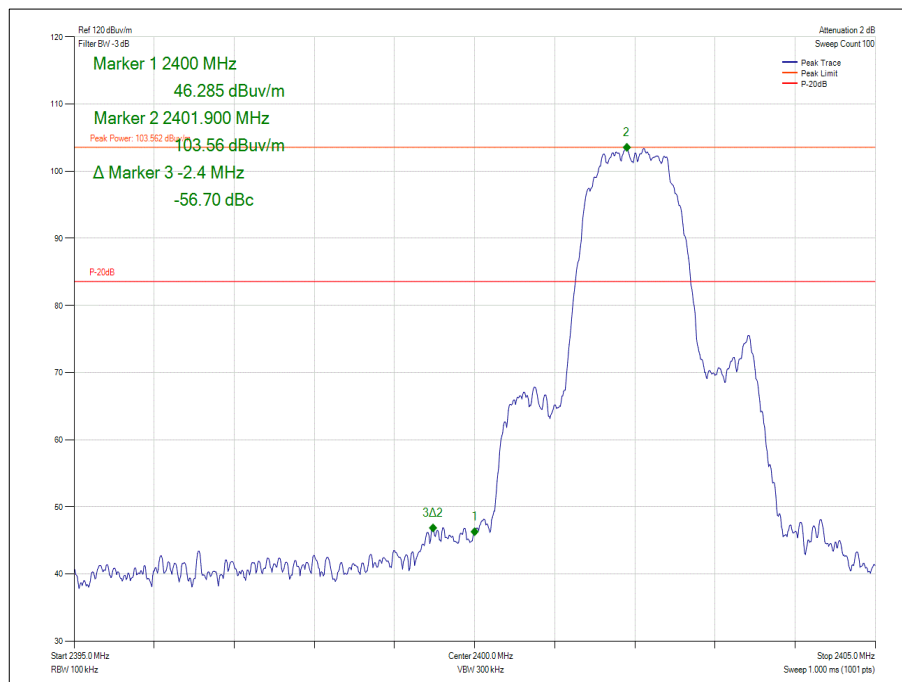


Figure 33- Static - 8-DPSK/3DH5 - 2402 MHz - Measured Frequency 2400.0 MHz

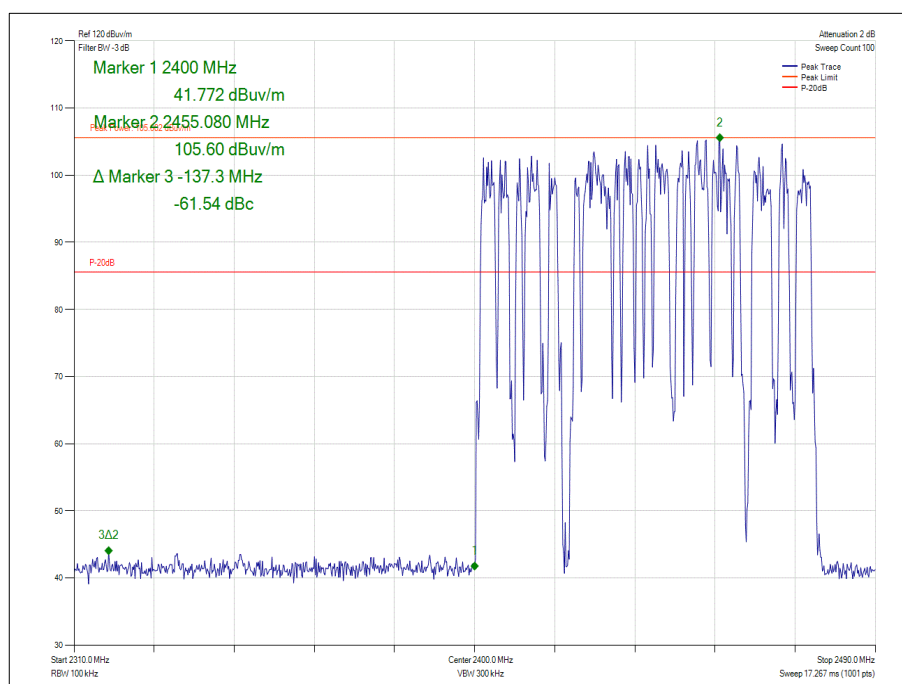


Figure 34 - Hopping - 8-DPSK/3DH5 - 2402 MHz - Measured Frequency 2400.0 MHz



FCC 47 CFR Part 15, Limit Clause 15.247 (d)

20 dB below the fundamental measured in a 100 kHz bandwidth using a peak detector. If the transmitter complies with the conducted power limits, based on the use of RMS averaging over a time interval, the attenuation required shall be 30 dB below the fundamental instead of 20 dB.

Industry Canada RSS-247, Limit Clause 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

2.6.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
10dB/1W SMA Attenuator dc - 18GHz	Sealectro	60-674-1010-89	3	12	31-Aug-2018
Screened Room (5)	Rainford	Rainford	1545	36	23-Jan-2021
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	22-Nov-2018
1 Metre SMA Cable	Rhophase	3PS-1801A-1000-3PS	4099	12	19-Sep-2018
Cable (Rx, Nm-Nm, 7m)	Scott Cables	SLU18-NMNM-07.00M	4498	-	O/P Mon
Cable (Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4526	6	31-Aug-2018
EMI Receiver	Keysight Technologies	N9038A MXE	4628	12	4-Jul-2019
EMI Receiver	Keysight Technologies	N9038A MXE	4629	12	13-Sep-2018
Mast Controller	Maturo GmbH	NCD	4810	-	TU
Tilt Antenna Mast	Maturo GmbH	TAM 4.0-P	4811	-	TU
9m N type RF cable	Rosenberger	2303-0 9.0m PNm PNm	4827	6	4-Jan-2019
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	12-Feb-2019
Hygrometer	Rotronic	HP21	4989	12	26-Apr-2019

Table 16

TU - Traceability Unscheduled

O/P Mon – Output Monitored using calibrated equipment



Product Service

2.7 Restricted Band Edges

2.7.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.205
Industry Canada RSS-GEN, Clause 8.10

2.7.2 Equipment Under Test and Modification State

A1993, S/N: C07WT00HK2V0 - Modification State 0

2.7.3 Date of Test

30-June-2018

2.7.4 Test Method

Testing was performed in accordance with ANSI C63.10, clause 6.10.5

Plots for average measurements were taken in accordance with ANSI C63.10, clause 4.1.4.2.3

Final average measurements were taken in accordance with ANSI C63.10, clause 4.1.4.2.2

The following conversion can be applied to convert from dB μ V/m to μ V/m:
 $10^{\frac{\text{Field Strength in dB}\mu\text{V/m}}{20}}$

2.7.5 Environmental Conditions

Ambient Temperature	23.6 °C
Relative Humidity	50.8 %

2.7.6 Test Results

Bluetooth

Mode	Modulation	Packet Type	Frequency (MHz)	Measured Frequency (MHz)	Peak Level (dBμV/m)	Average Level (dBμV/m)
Static	GFSK	DH5	2402	2390.0	50.44	41.49
Static	GFSK	DH5	2402	2389.16	52.42	
Static	GFSK	DH5	2402	2382.05		41.83
Static	$\pi/4$ DQPSK	2DH5	2402	2390.0	49.51	41.48
Static	$\pi/4$ DQPSK	2DH5	2402	2388.41	52.64	
Static	$\pi/4$ DQPSK	2DH5	2402	2380.16		42.02
Static	8-DPSK	3DH5	2402	2390.0	49.10	41.59
Static	8-DPSK	3DH5	2402	2384.09	52.40	
Static	8-DPSK	3DH5	2402	2384.21		41.84
Static	GFSK	DH5	2480	2483.5	49.18	41.81
Static	GFSK	DH5	2480	2483.71	52.54	
Static	GFSK	DH5	2480	2483.57		42.15
Static	$\pi/4$ DQPSK	2DH5	2480	2483.5	50.78	41.10
Static	$\pi/4$ DQPSK	2DH5	2480	2483.69	52.62	
Static	$\pi/4$ DQPSK	2DH5	2480	2483.56		41.20
Static	8-DPSK	3DH5	2480	2483.5	50.16	40.73
Static	8-DPSK	3DH5	2480	2488.33	51.63	
Static	8-DPSK	3DH5	2480	2483.71		41.26

Table 17

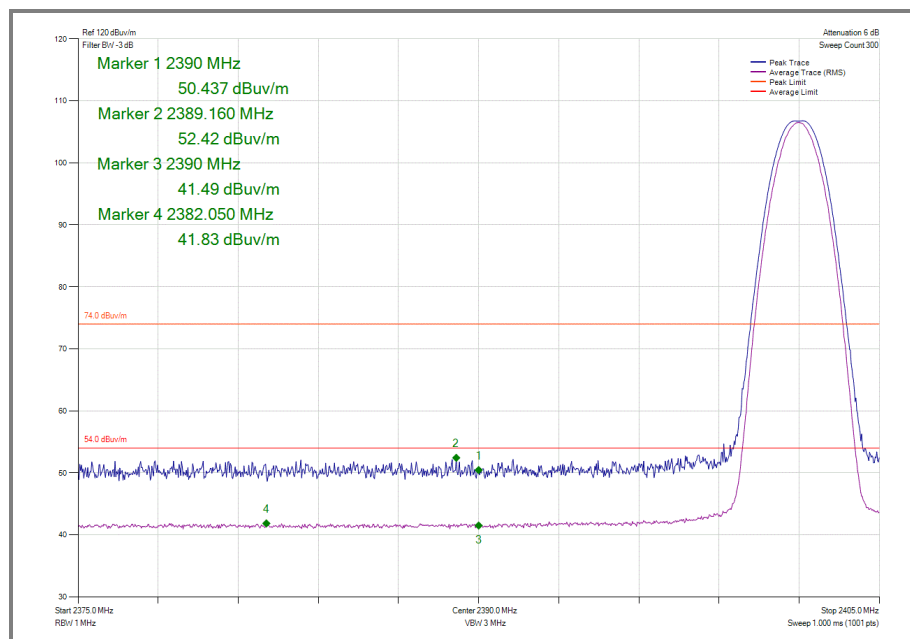


Figure 35 Static - GFSK/DH5 - 2402 MHz - Measured Frequency 2390.0 MHz

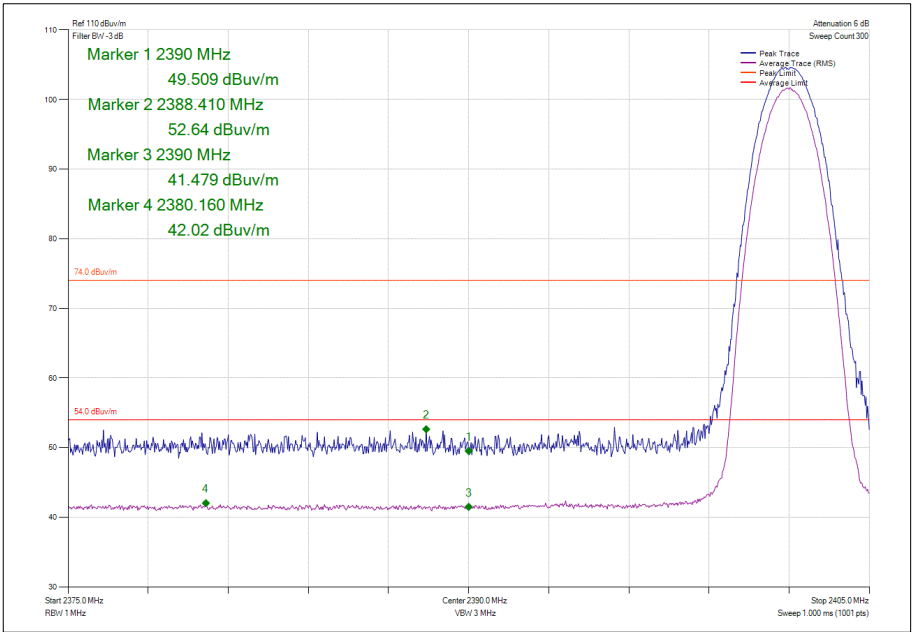


Figure 36 Static - $\pi/4$ DQPSK/2DH5 - 2402 MHz - Measured Frequency 2390.0 MHz

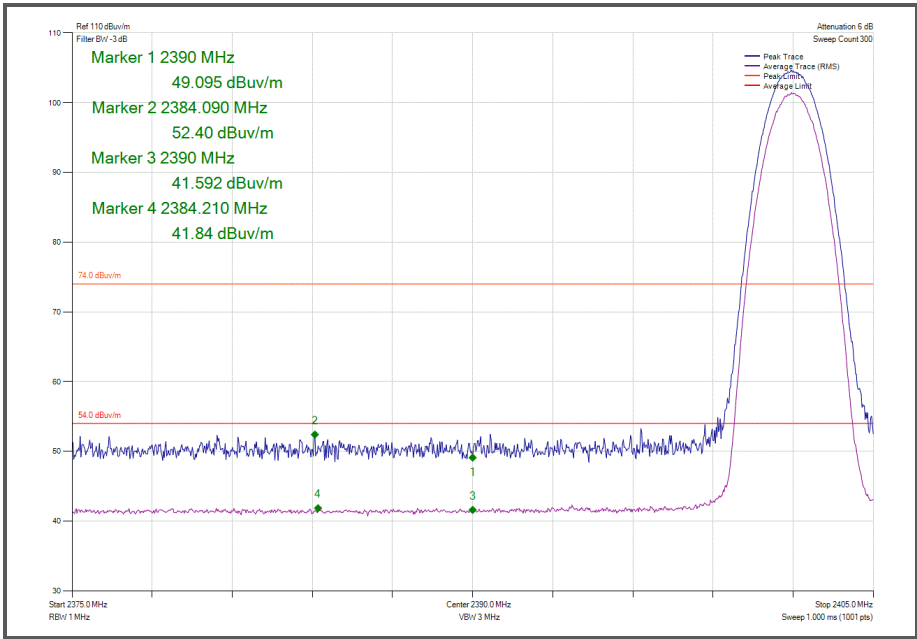


Figure 37 Static - 8-DPSK/3DH5 - 2402 MHz - Measured Frequency 2390.0 MHz

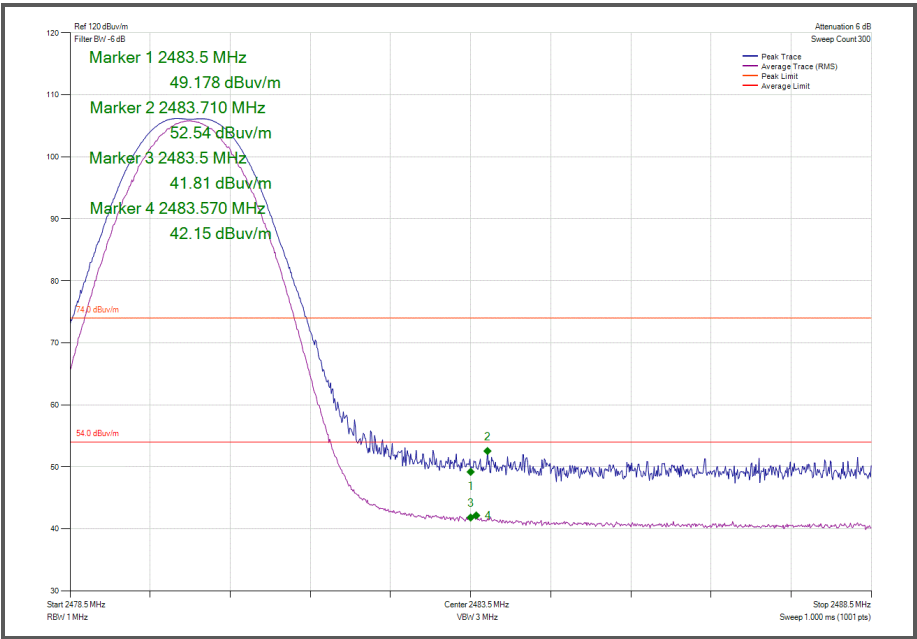


Figure 38 Static - GFSK/DH5 - 2480 MHz - Measured Frequency 2483.5 MHz

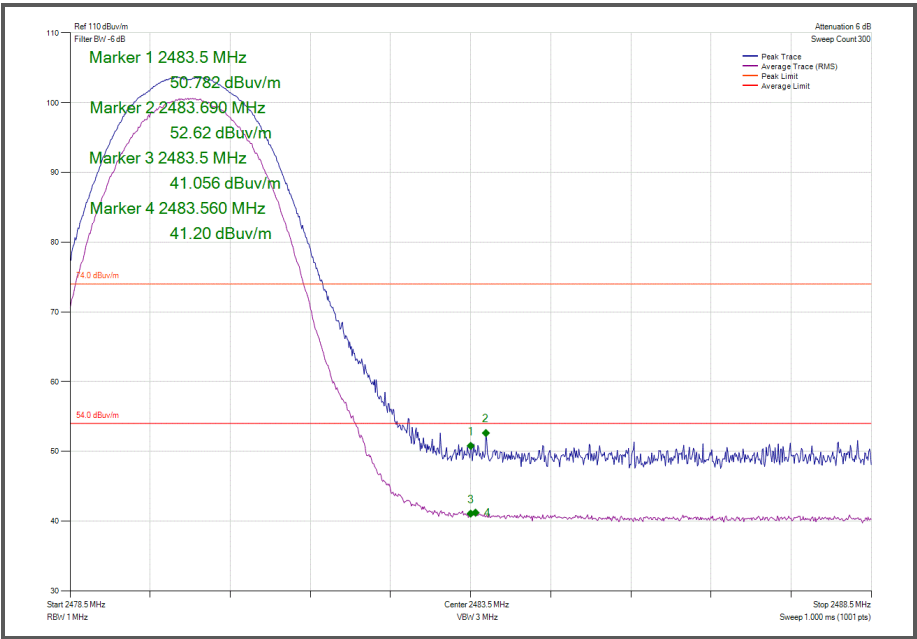


Figure 39 Static - $\pi/4$ DQPSK/2DH5 - 2480 MHz - Measured Frequency 2483.5 MHz

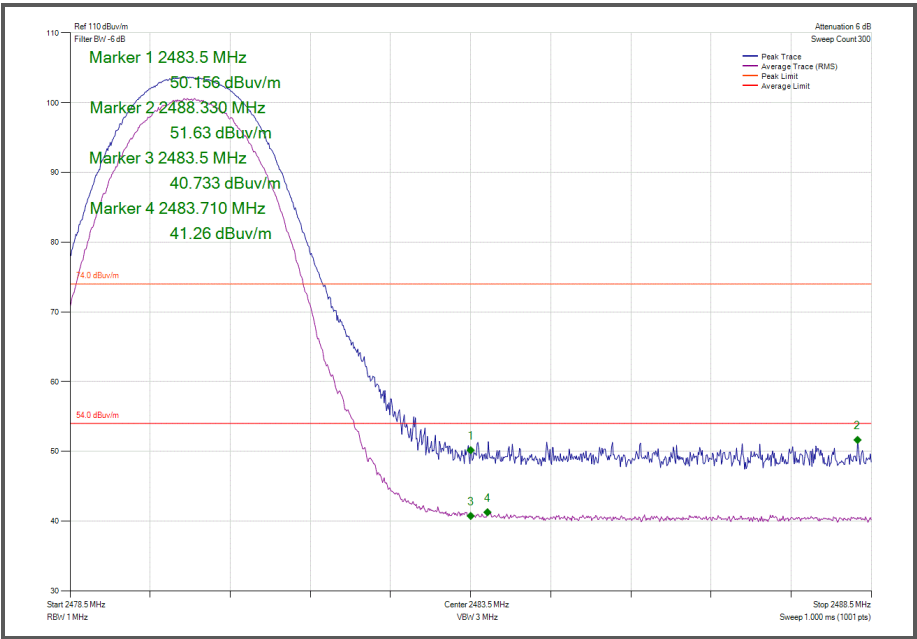


Figure 40 Static - 8-DPSK/3DH5 - 2480 MHz - Measured Frequency 2483.5 MHz

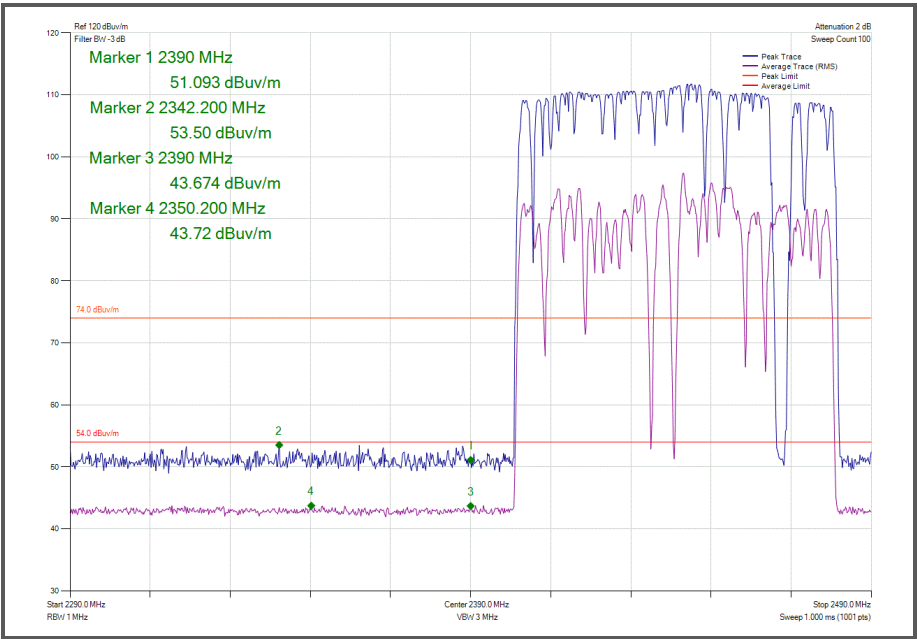


Figure 41 Hopping - GFSK/DH5 - 2402 MHz - Measured Frequency 2390.0 MHz

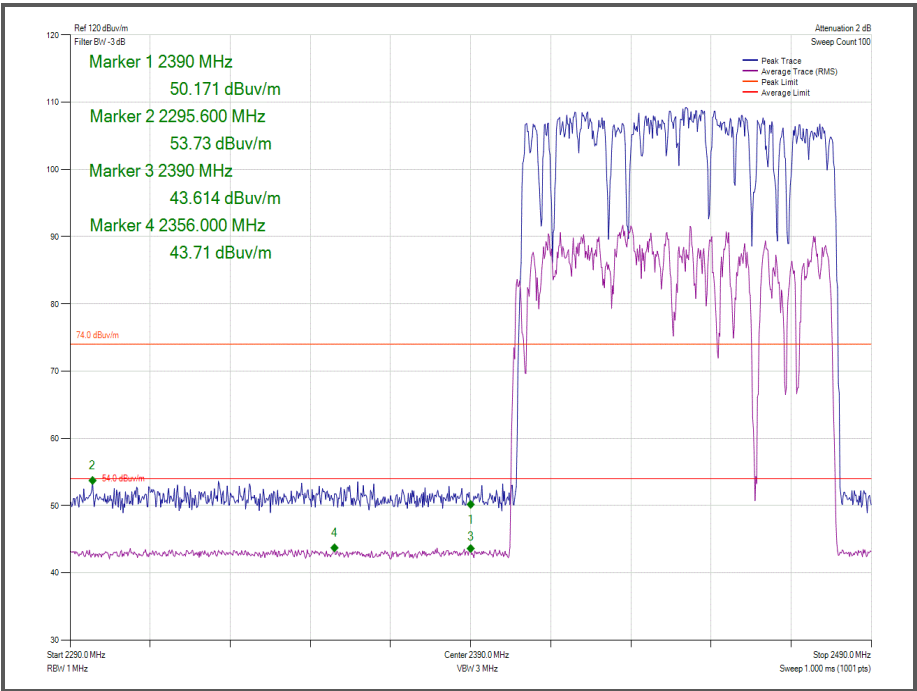


Figure 42 Hopping - $\pi/4$ DQPSK/2DH5 - 2402 MHz - Measured Frequency 2390.0 MHz

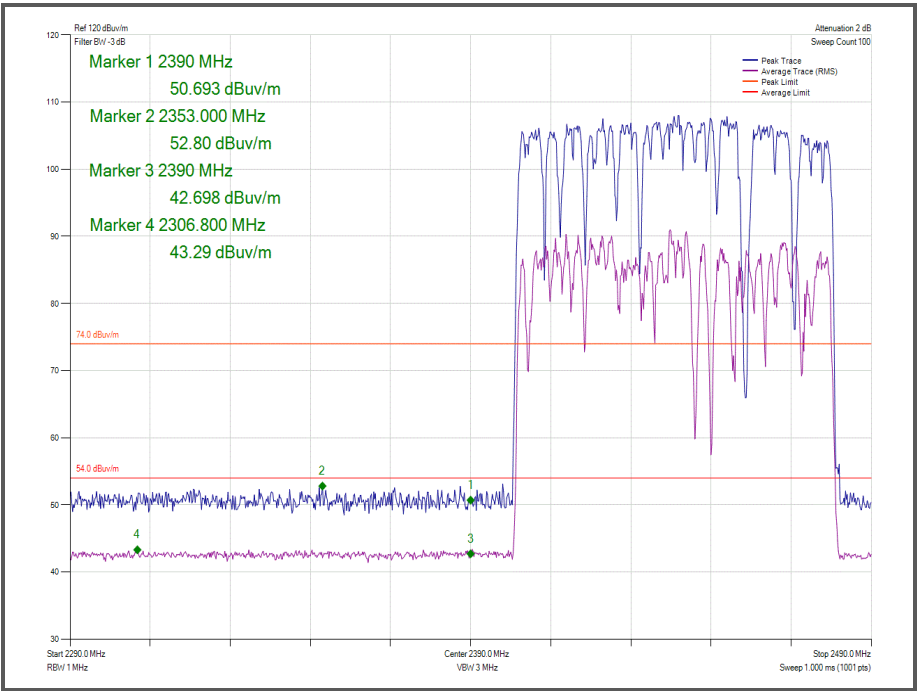


Figure 43 Hopping - 8-DPSK/3DH5 - 2402 MHz - Measured Frequency 2390.0 MHz

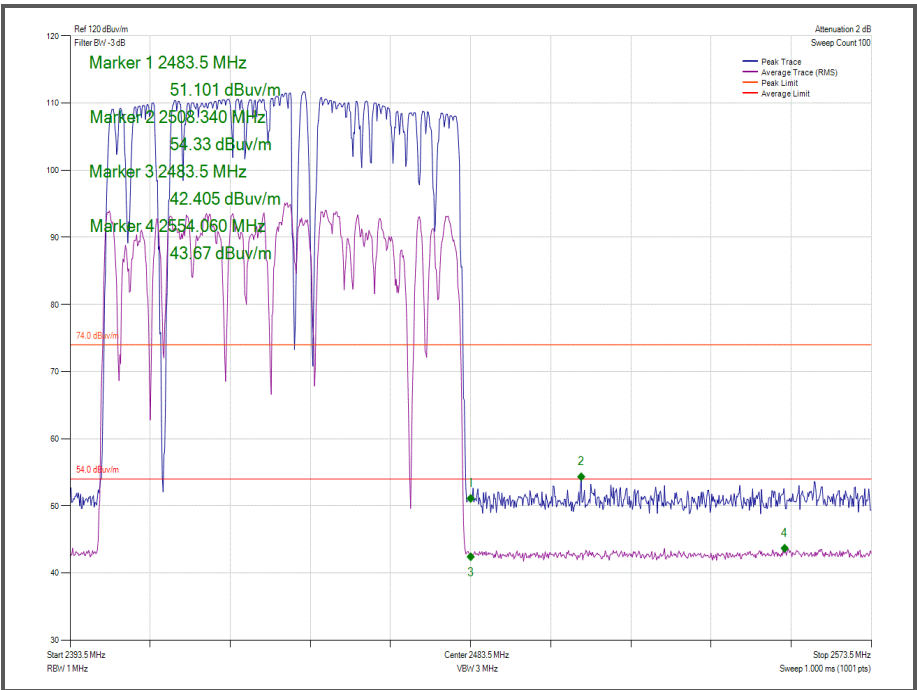


Figure 44 Hopping - GFSK/DH5 - 2480 MHz - Measured Frequency 2483.5 MHz

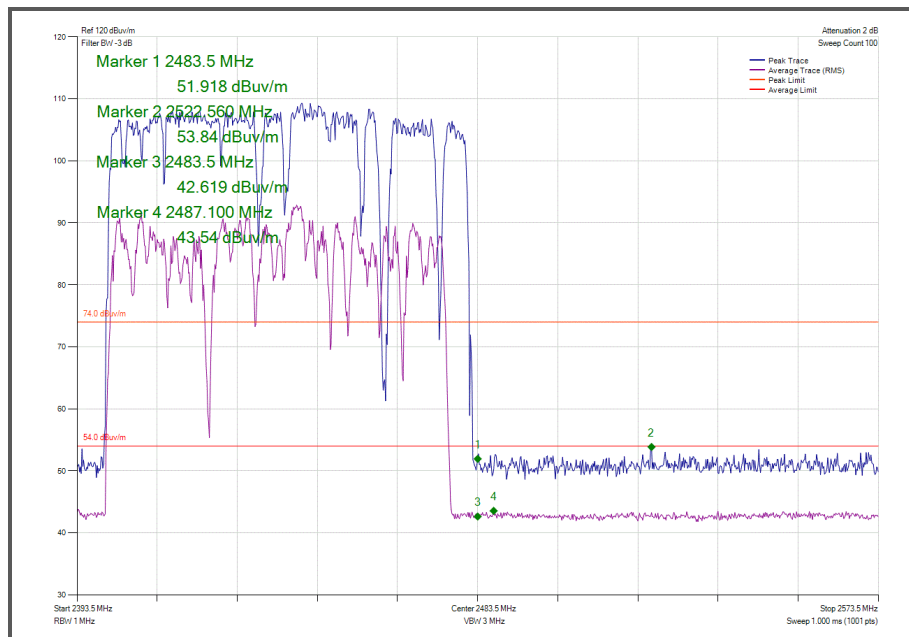


Figure 45 Hopping - $\pi/4$ DQPSK/2DH5 - 2480 MHz - Measured Frequency 2483.5 MHz

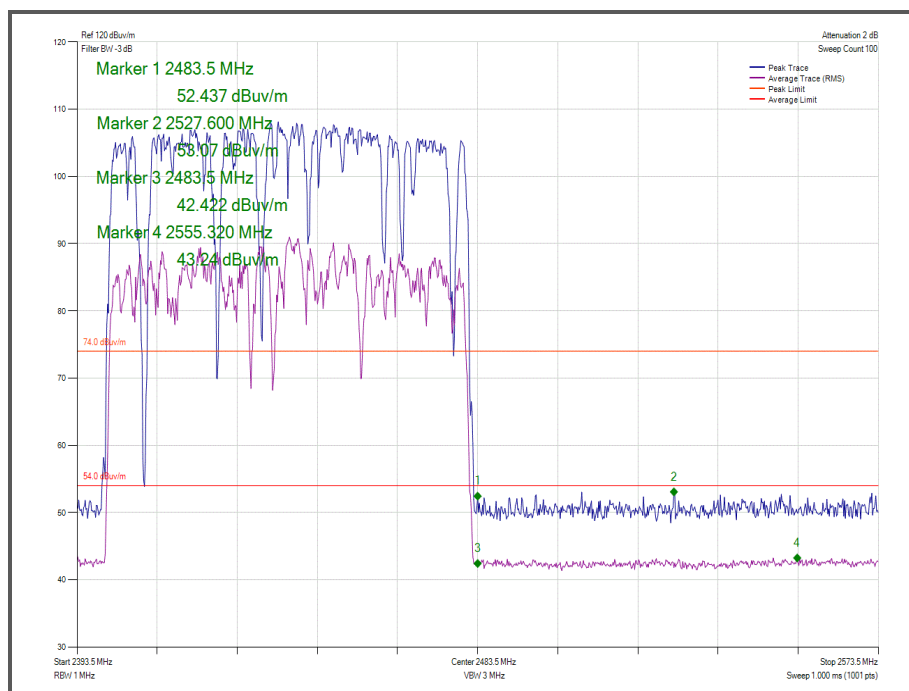


Figure 46 Hopping - 8-DPSK/3DH5 - 2480 MHz - Measured Frequency 2483.5 MHz



FCC 47 CFR Part 15C, Limit Clause 15.205

	Peak (dB μ V/m)	Average (dB μ V/m)
Restricted Bands of Operation	74	54

Table 18

Industry Canada RSS-GEN, Limit Clause 8.9

Frequency (MHz)	Field Strength (μ V/m at 3 metres)
30-88	100
88-216	150
216-960	200
Above 960*	500

Table 19

*Unless otherwise specified, for all frequencies greater than 1 GHz, the radiated emission limits for licence-exempt radio apparatus stated in applicable RSSs (including RSS-Gen) are based on measurements using a linear average detector function having a minimum resolution bandwidth of 1 MHz. If an average limit is specified for the EUT, then the peak emission shall also be measured with instrumentation properly adjusted for such factors as pulse desensitization to ensure the peak emission is less than 20 dB above the average limit.



2.7.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
10dB/1W SMA Attenuator dc - 18GHz	Sealectro	60-674-1010-89	3	12	31-Aug-2018
Screened Room (5)	Rainford	Rainford	1545	36	23-Jan-2021
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	22-Nov-2018
1 Metre SMA Cable	Rhophase	3PS-1801A-1000-3PS	4099	12	19-Sep-2018
Cable (Rx, Nm-Nm, 7m)	Scott Cables	SLU18-NMNM-07.00M	4498	-	O/P Mon
Cable (Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4526	6	31-Aug-2018
EMI Receiver	Keysight Technologies	N9038A MXE	4628	12	4-Jul-2019
EMI Receiver	Keysight Technologies	N9038A MXE	4629	12	13-Sep-2018
Mast Controller	Maturo GmbH	NCD	4810	-	TU
Tilt Antenna Mast	Maturo GmbH	TAM 4.0-P	4811	-	TU
9m N type RF cable	Rosenberger	2303-0 9.0m PNm PNm	4827	6	4-Jan-2019
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	12-Feb-2019
Hygrometer	Rotronic	HP21	4989	12	26-Apr-2019

Table 20

TU - Traceability Unscheduled

O/P Mon – Output Monitored using calibrated equipment



2.8 Spurious Radiated Emissions

2.8.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (d) and 15.205
Industry Canada RSS-247, Clause 5.5
Industry Canada RSS-GEN, Clause 6.13

2.8.2 Equipment Under Test and Modification State

A1993, S/N: C07WT00HK2V0 - Modification State 0

2.8.3 Date of Test

10-July-2018 to 17-July-2018

2.8.4 Test Method

Testing was performed in accordance with ANSI C63.10 clause 6.3, 6.5 and 6.6.

In the 30MHz to 1GHz range pre-scans were only performed on mid channel (2441 MHz) and any emissions identified then measured on bottom (2402 MHz) and top (2480 MHz).

Plots for average measurements were taken in accordance with ANSI C63.10-2013 clause 4.1.4.2.3 to characterize the EUT. Where emissions were detected, final average measurements were taken in accordance with ANSI C63.10-2013 clause 4.1.4.2.2.

The plots shown are the characterization of the EUT. The limits on the plots represent the most stringent case for restricted bands, (54/74 dBuV/m @ 3m and 64/84 dBuV/m @ 1m) when compared to 20 dBc outside restricted bands. The limits shown have been used as a threshold to determine where further measurements are necessary. Where results are within 10 dB of the limits shown on the plots, further investigation was carried out and reported in results tables.

The following conversion can be applied to convert from dBuV/m to uV/m:
 $10^{(\text{Field Strength in dBuV/m}/20)}$

2.8.5 Environmental Conditions

Ambient Temperature 20.4 °C
Relative Humidity 60.8 %

2.8.6 Test Results

Bluetooth

Testing was performed on the modulation and packet type which resulted in the highest conducted output power. The Modulation/Packet type was GFSK/DH5.

Frequency (GHz)	Result (dBuV/m)		Limit (dBuV/m)		Margin (dBuV/m)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 21 - 2441 MHz - 30 MHz to 1 GHz Emissions Results

*No emissions were detected within 10 dB of the limit.

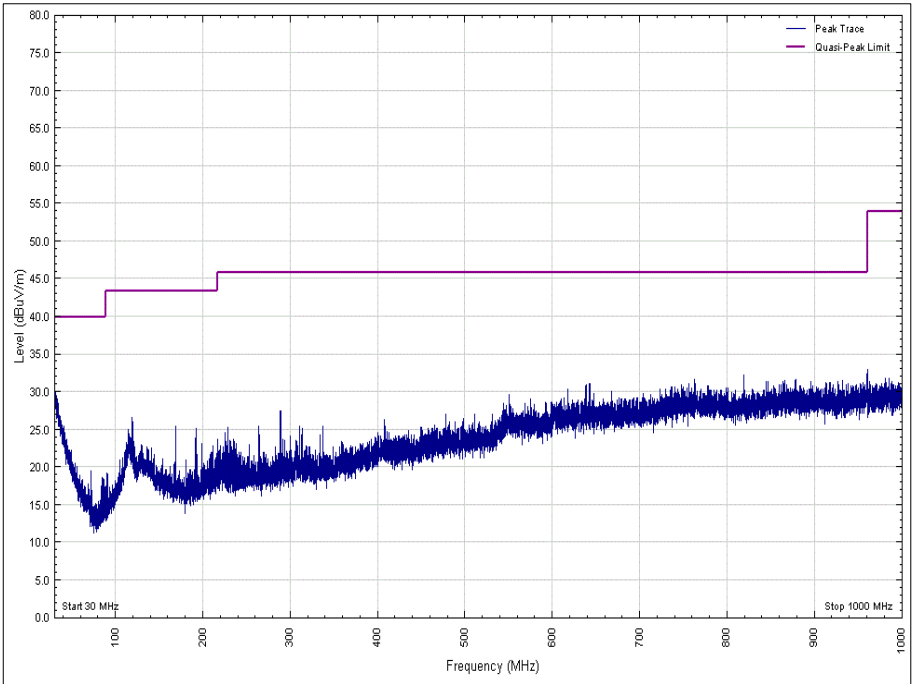


Figure 47 - 2441 MHz - 30 MHz to 1 GHz Horizontal

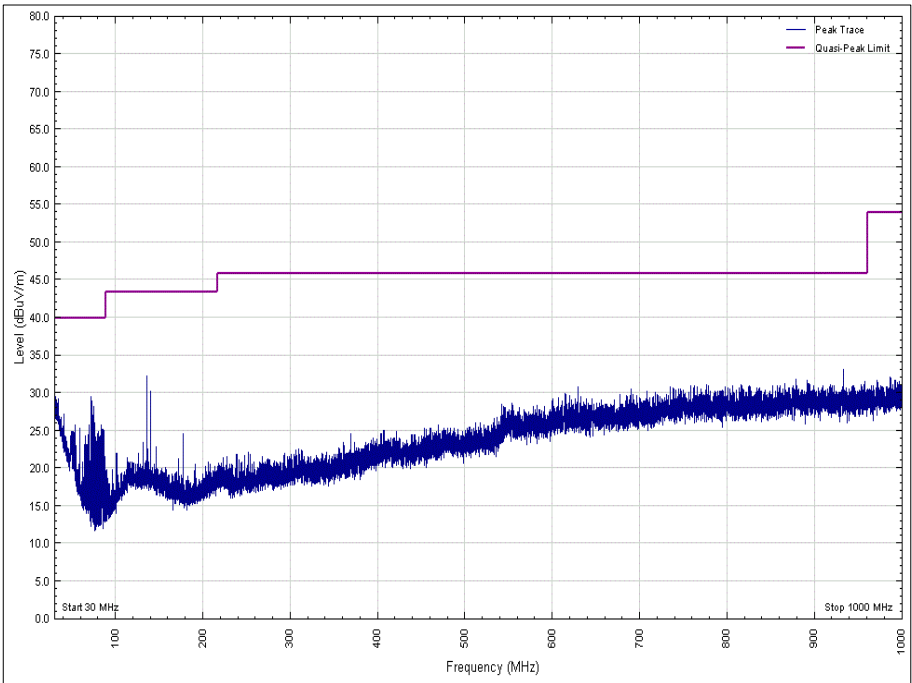


Figure 48 - 2441 MHz - 30 MHz to 1 GHz Vertical



2402 MHz

Frequency (GHz)	Result (µV/m)		Limit (µV/m)		Margin (µV/m)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 22 - 1 GHz to 26 GHz - Radiated

*No emissions were detected within 10 dB of the limit.

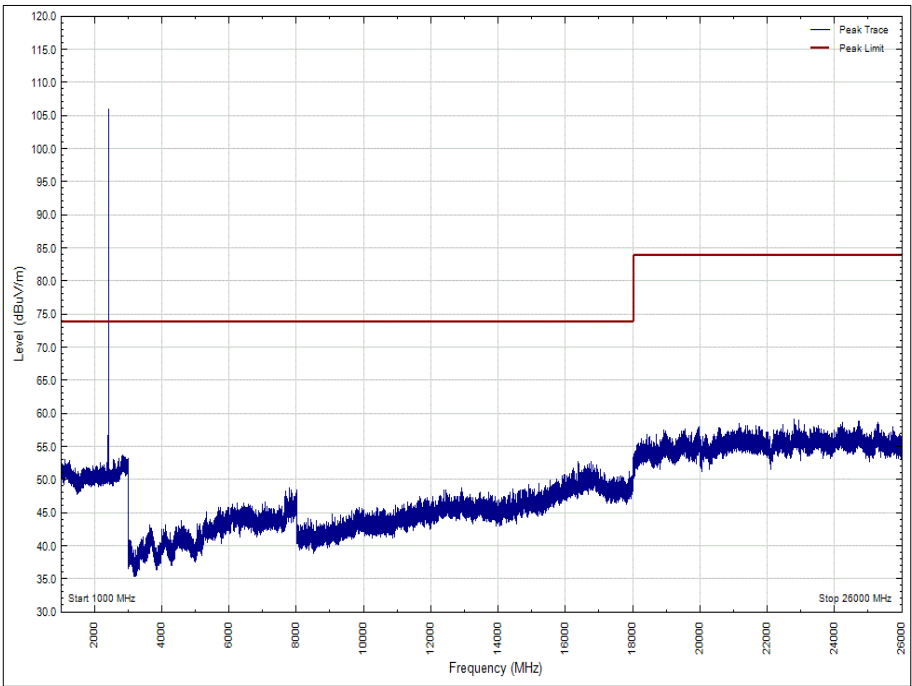


Figure 49 - 2402 MHz - 1 GHz to 26 GHz – Horizontal (Peak)

Note - The emissions seen at 2402 MHz is the EUT’s intentional transmitter frequency and is therefore not subject to this test.

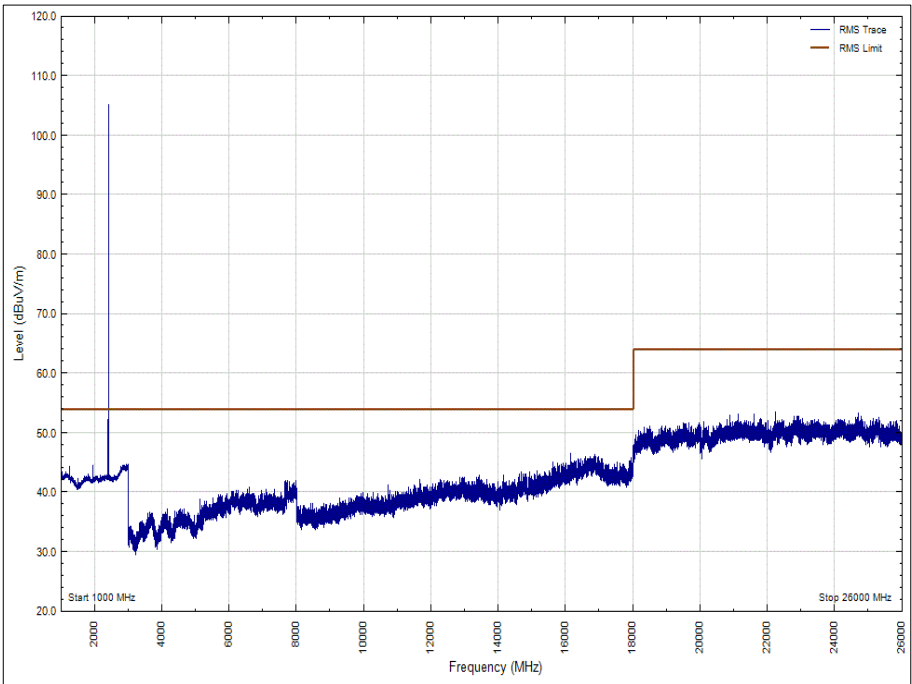


Figure 50 - 2402 MHz - 1 GHz to 26 GHz – Horizontal (Average)

Note - The emissions seen at 2402 MHz is the EUT’s intentional transmitter frequency and is therefore not subject to this test.

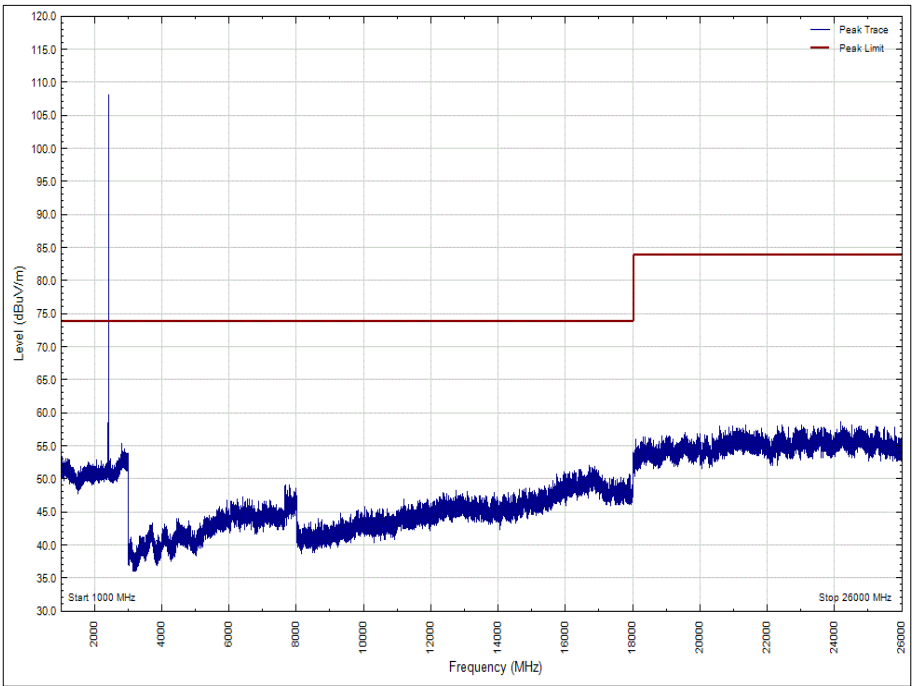


Figure 51 - 2402 MHz - 1 GHz to 26 GHz - Vertical (Peak)

Note - The emissions seen at 2402 MHz is the EUT’s intentional transmitter frequency and is therefore not subject to this test.

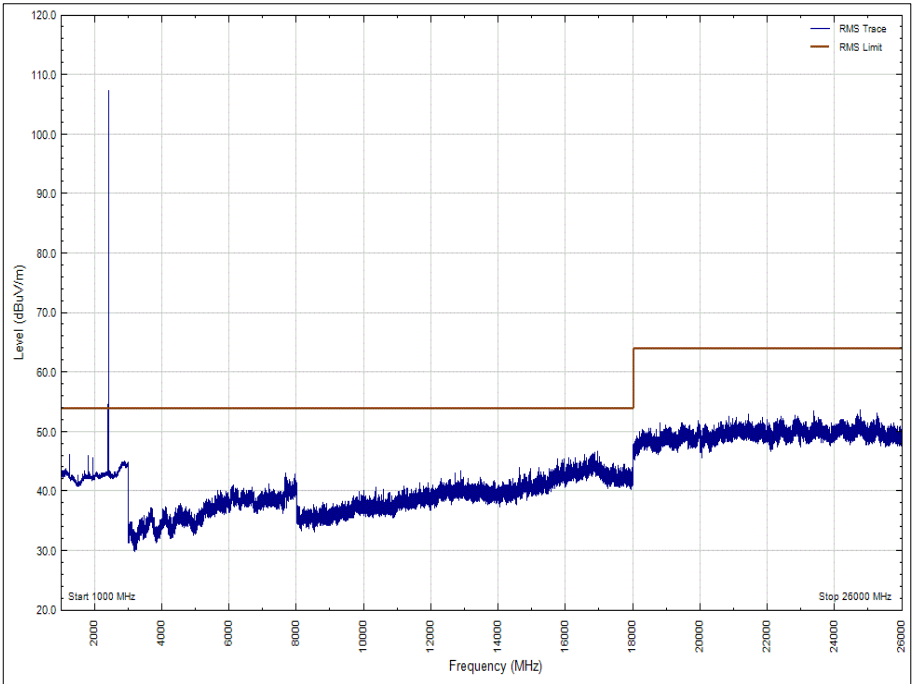


Figure 52 - 2402 MHz - 1 GHz to 26 GHz – Vertical (Average)

Note - The emissions seen at 2402 MHz is the EUT's intentional transmitter frequency and is therefore not subject to this test.



Frequency (GHz)	Result (µV/m)		Limit (µV/m)		Margin (µV/m)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 23 - 1 GHz to 26 GHz - Radiated

*No emissions were detected within 10 dB of the limit.

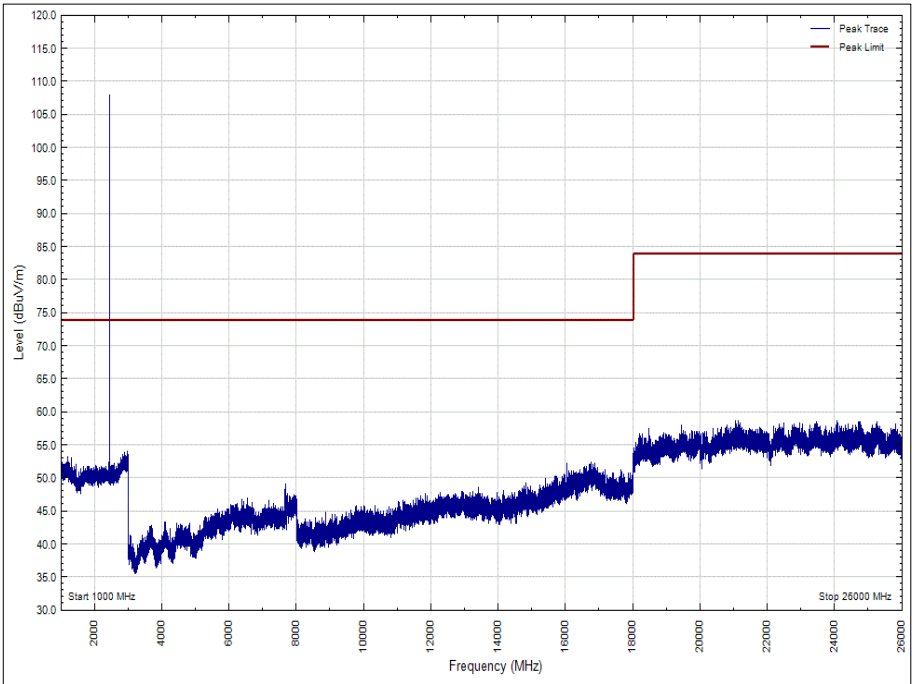


Figure 53 - 2441 MHz - 1 GHz to 26 GHz Horizontal (Peak)

Note - The emissions seen at 2441 MHz is the EUT's intentional transmitter frequency and is therefore not subject to this test.

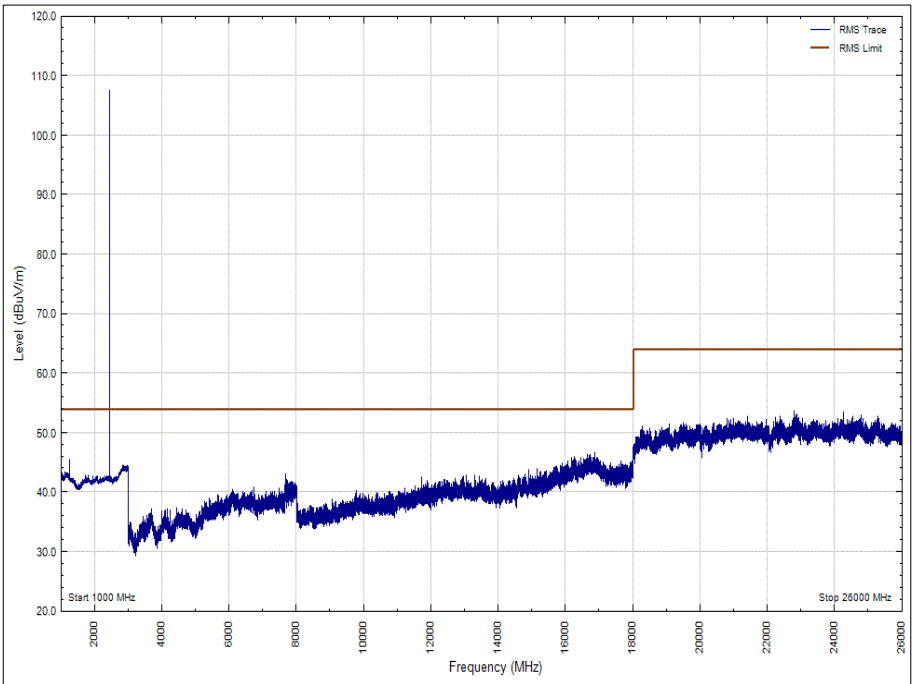


Figure 54 - 2441 MHz - 1 GHz to 26 GHz Horizontal (Average)

Note - The emissions seen at 2441 MHz is the EUT’s intentional transmitter frequency and is therefore not subject to this test.

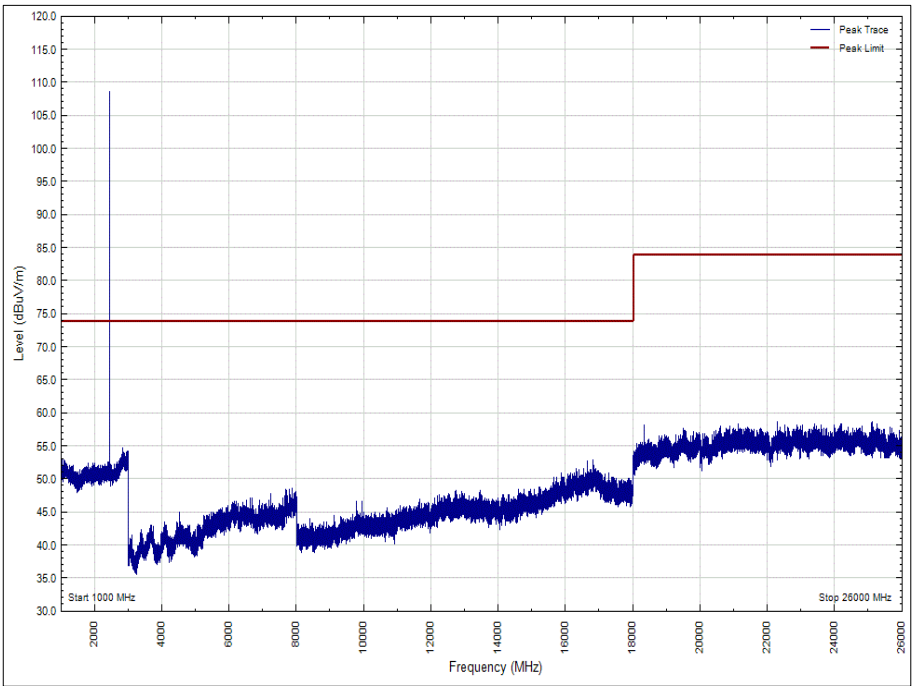


Figure 55 - 2441 MHz - 1 GHz to 26 GHz Vertical (Peak)

Note - The emissions seen at 2441 MHz is the EUT’s intentional transmitter frequency and is therefore not subject to this test.

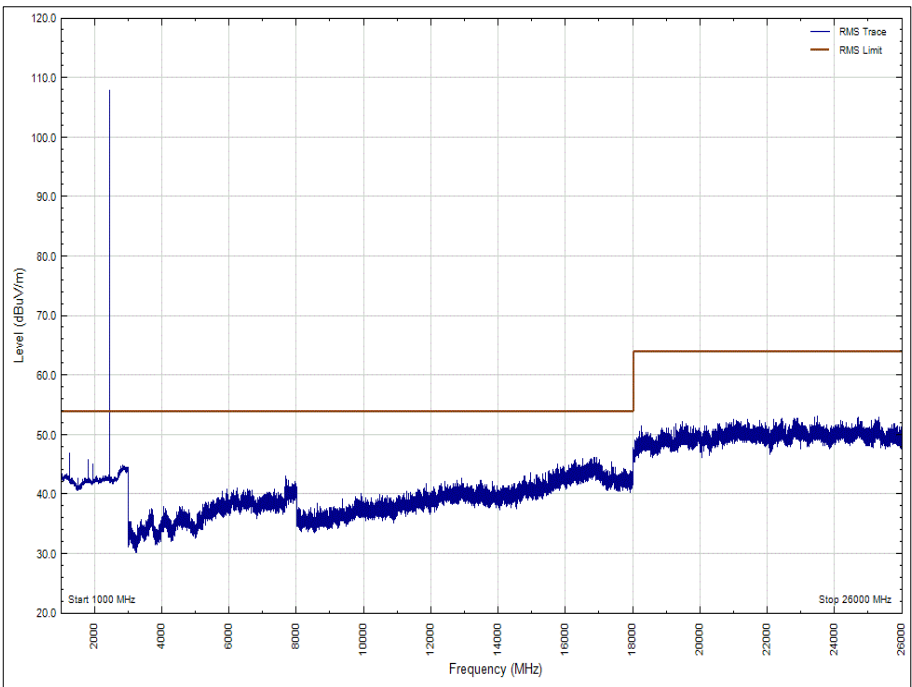


Figure 56 - 2441 MHz - 1 GHz to 26 GHz Vertical (Average)

Note - The emissions seen at 2441 MHz is the EUT's intentional transmitter frequency and is therefore not subject to this test.



2480 MHz

Frequency (GHz)	Result (µV/m)		Limit (µV/m)		Margin (µV/m)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 24 - 1 GHz to 26 GHz - Radiated

*No emissions were detected within 10 dB of the limit.

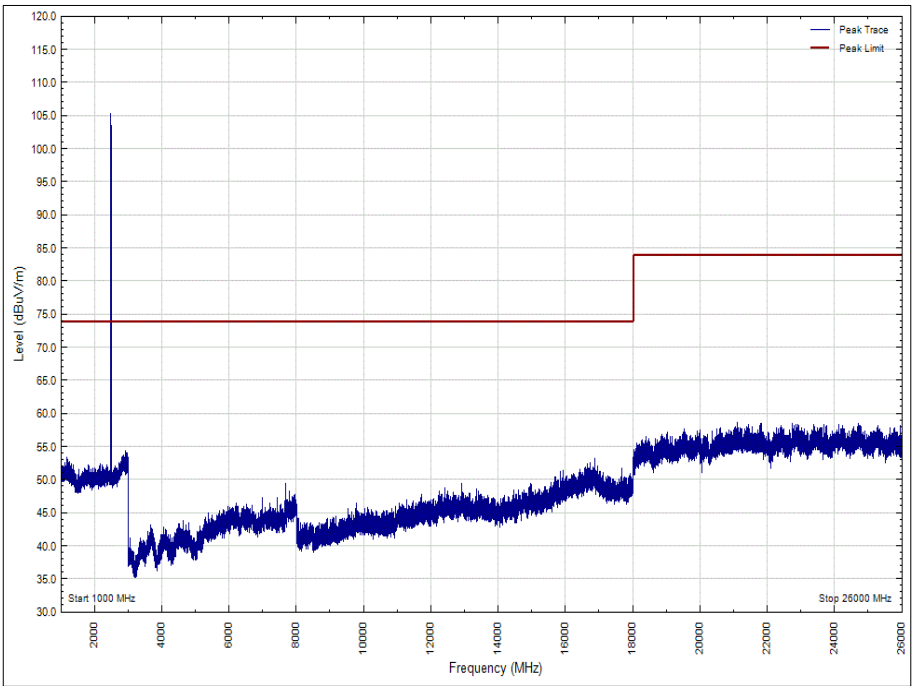


Figure 57 - 2480 MHz - 1 GHz to 26 GHz Horizontal (Peak)

Note - The emissions seen at 2480 MHz is the EUT’s intentional transmitter frequency and is therefore not subject to this test.

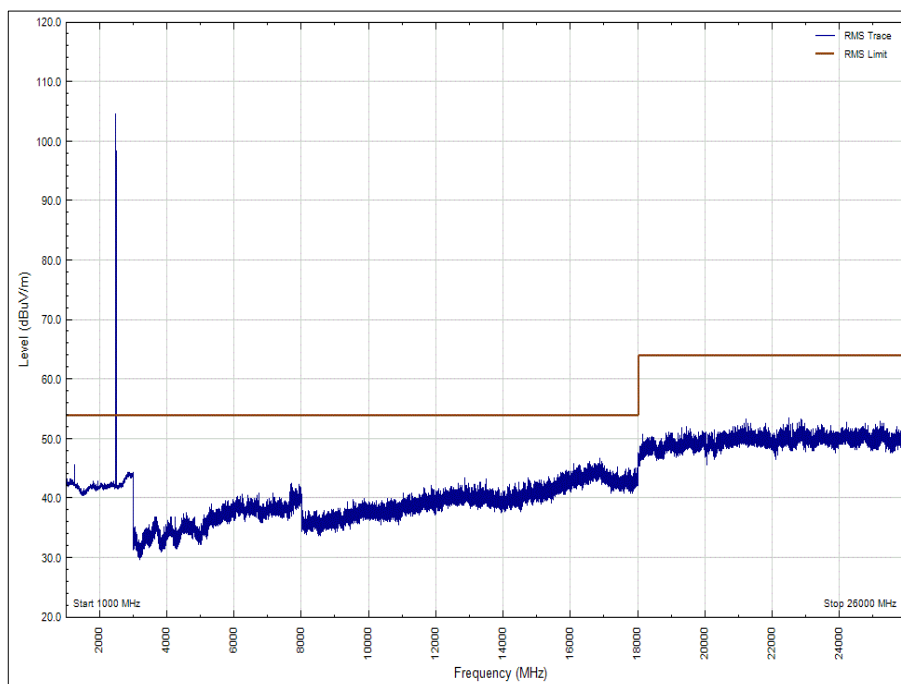


Figure 58 - 2480 MHz - 1 GHz to 26 GHz Horizontal (Average)

Note - The emissions seen at 2480 MHz is the EUT's intentional transmitter frequency and is therefore not subject to this test.

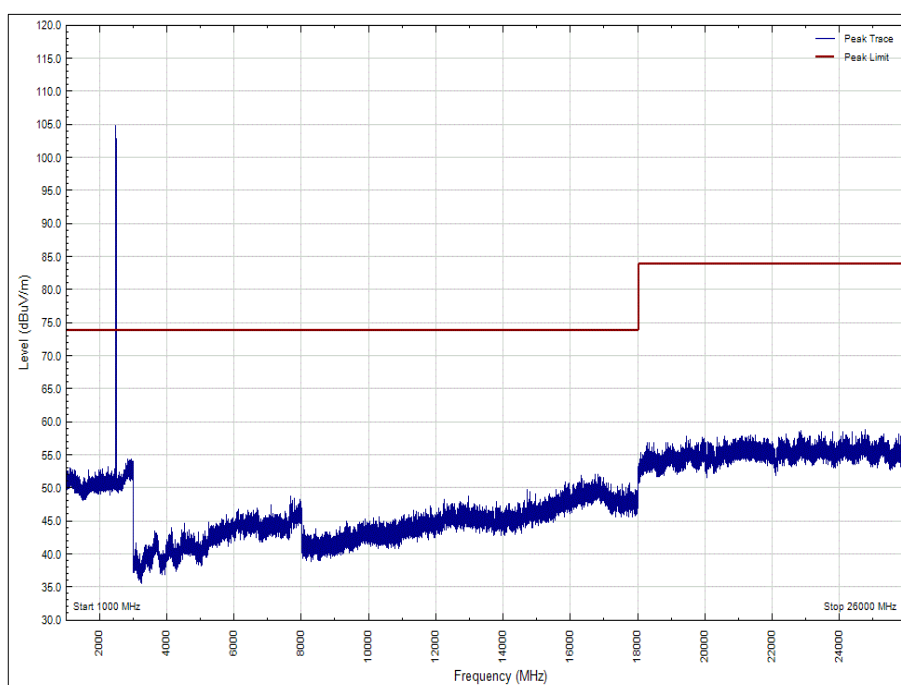


Figure 59 - 2480 MHz - 1 GHz to 26 GHz Vertical (Peak)

Note - The emissions seen at 2480 MHz is the EUT's intentional transmitter frequency and is therefore not subject to this test.

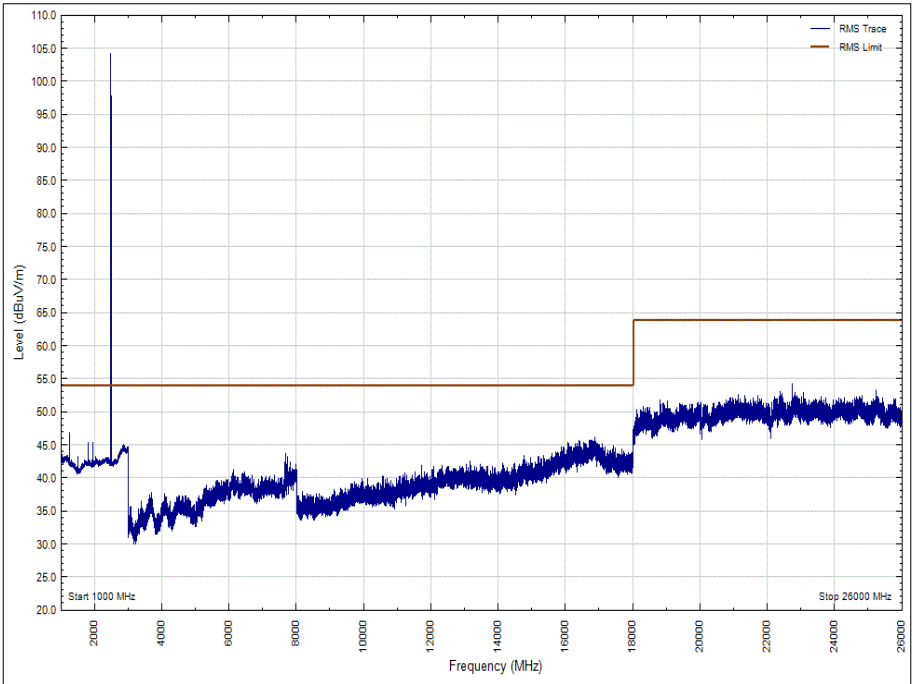


Figure 60 - 2480 MHz - 1 GHz to 26 GHz Vertical (Average)

Note - The emissions seen at 2480 MHz is the EUT's intentional transmitter frequency and is therefore not subject to this test.



FCC 47 CFR Part 15, Limit Clause 15.247 (d)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in 15.209(a)

Industry Canada RSS-247, Limit Clause 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.



2.8.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
10dB/1W SMA Attenuator dc -18GHz	Sealectro	60-674-1010-89	3	12	31-Aug-2018
Multimeter	White Gold	WG022	190	12	24-Nov-2018
Antenna 18-40GHz (Double Ridge Guide)	Link Microtek Ltd	AM180HA-K-TU2	230	24	2-May-2020
Antenna (Bilog)	Schaffner	CBL6143	287	24	15-May-2020
Dual Power Supply Unit	Thurlby	PL320	288	-	TU
Filter (High Pass)	Lorch	SHP7-7000-SR	566	12	10-May-2019
Pre-Amplifier	Phase One	PS04-0086	1533	12	12-Jan-2019
18GHz - 40GHz Pre-Amplifier	Phase One	PS04-0087	1534	12	2-Feb-2019
Screened Room (5)	Rainford	Rainford	1545	36	23-Jan-2021
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Antenna (Bilog)	Chase	CBL6143	2904	24	8-Aug-2019
Cable (N-N, 8m)	Rhophase	NPS-2302-8000-NPS	3248	-	O/P Mon
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	22-Nov-2018
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	2-Oct-2018
1 Metre SMA Cable	Rhophase	3PS-1801A-1000-3PS	4099	12	19-Sep-2018
1501A 4.0M Km Km Cable	Rhophase	KPS-1501A-4000-KPS	4301	12	19-Feb-2019
1GHz to 8GHz Low Noise Amplifier	Wright Technologies	APS04-0085	4365	12	18-Oct-2018
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	06-Mar-2019
Cable (Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4526	6	31-Aug-2018
Cable (Rx, SMAM-SMAM0.5m)	Scott Cables	SLSLL18-SMSM-00.50M	4528	6	15-Aug-2018
EMI Receiver	Keysight Technologies	N9038A MXE	4628	12	04-July-2019
Double Ridged Waveguide Horn Antenna	ETS-Lindgren	3117	4722	12	1-Mar-2019
Mast Controller	Maturo GmbH	NCD	4810	-	TU
Tilt Antenna Mast	Maturo GmbH	TAM 4.0-P	4811	-	TU
9m N type RF cable	Rosenberger	2303-0 9.0m PNm PNm	4827	6	4-Jan-2019
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	12-Feb-2019
4dB Attenuator	Pasternack	PE7047-4	4935	12	28-Nov-2018
Hygrometer	Rotronic	HP21	4989	12	26-Apr-2019



Product Service

Cable (26.5GHz	Rosenberger	LU7-133-5000	5019	-	O/P Mon
Cable (40GHz	Rosenberger	LU1-001-2000	5020	-	O/P Mon

Table 25

TU - Traceability Unscheduled
O/P Mon – Output Monitored using calibrated equipment



3 Measurement Uncertainty

For a 95% confidence level, the measurement uncertainties for defined systems are:

Test Name	Measurement Uncertainty
Maximum Conducted Output Power	± 3.2 dB
Frequency Hopping Systems - Average Time of Occupancy	-
Frequency Hopping Systems - Channel Separation	± 30.43 kHz
Frequency Hopping Systems - Number of Hopping Channels	-
Frequency Hopping Systems - 20 dB Bandwidth	± 30.43 kHz
Authorised Band Edges	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB
Restricted Band Edges	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB
Spurious Radiated Emissions	30 MHz to 1 GHz: ± 5.2 dB 1 GHz to 40 GHz: ± 6.3 dB

Table 26