

FCC and ISEDC Test Report

Apple Inc
Model: A2289

In accordance with FCC 47 CFR Part 15C,
ISEDC RSS-247 and ISEDC RSS-GEN

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

FCC ID: BCGA2289

IC: 579C-A2289

COMMERCIAL-IN-CONFIDENCE

Document 75947591-10 Issue 02



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SIGNATURE

NAME	JOB TITLE	RESPONSIBLE FOR	ISSUE DATE
Ryan Henley	Sales Manager (RF and Telecoms)	Authorised Signatory	20 March 2020

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD 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, ISEDC RSS-247 and ISEDC RSS-GEN. The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	Mehadi Choudhury	20 March 2020	
Testing	Ahmad Javid	20 March 2020	
Testing	Mohammad Malik	20 March 2020	
Testing	Jay Balendrarajah	20 March 2020	
Testing	Cristian Onaca	20 March 2020	
Testing	Mohamud Mohamud	20 March 2020	
Testing	Faisal Malyar	20 March 2020	

FCC Accreditation

90987 Octagon House, Fareham Test Laboratory

ISEDC Accreditation

12669A 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: 2018, ISEDC RSS-247: Issue 2 (2017-02) and ISEDC RSS-GEN: Issue 5 (04-2018) + A1 (03-2019) 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	06 February 2020
2	Correction to FCC ID	20 March 2020

Table 1

1.2 Introduction

Applicant	Apple Inc
Manufacturer	Apple Inc
Model Number(s)	A2289
Serial Number(s)	C02ZG00CP0C9 and C02ZG009P09V
Hardware Version(s)	REV1.0
Software Version(s)	19D2013 and 19C4
Number of Samples Tested	2
Test Specification/Issue/Date	FCC 47 CFR Part 15C: 2018 ISED RSS-247: Issue 2 (2017-02) ISED RSS-GEN: Issue 5 (04-2018) + A1 (03-2019)
Order Number	0540187743
Date	18-December-2019
Date of Receipt of EUT	02-October-2019
Start of Test	19-November-2019
Finish of Test	13-January-2020
Name of Engineer(s)	Mehadi Choudhury, Ahmad Javid, Mohammad Malik, Jay Balendrarajah, Cristian Onaca, Mohamud Mohamud, Faisal Malyar
Related Document(s)	ANSI C63.10 (2013)



1.3 Brief Summary of Results

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

Section	Specification Clause			Test Description	Result	Comments/Base Standard
	Part 15C	RSS-247	RSS-GEN			
Configuration and Mode: 2.4 GHz Bluetooth - BR/EDR ePA						
2.1	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Average Time of Occupancy	Pass	ANSI C63.10 (2013)
2.2	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Channel Separation	Pass	ANSI C63.10 (2013)
2.3	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Number of Hopping Channels	Pass	ANSI C63.10 (2013)
2.4	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - 20 dB Bandwidth	Pass	ANSI C63.10 (2013)
2.5	15.247 (b)	5.4	6.12	Maximum Conducted Output Power	Pass	ANSI C63.10 (2013)
2.6	15.247 (d)	5.5	-	Authorised Band Edges	Pass	ANSI C63.10 (2013)
2.7	15.205	-	8.10	Restricted Band Edges	Pass	ANSI C63.10 (2013)
2.8	15.247 (d) and 15.205	5.5	6.13	Spurious Radiated Emissions	Pass	ANSI C63.10 (2013)



Section	Specification Clause			Test Description	Result	Comments/Base Standard
	Part 15C	RSS-247	RSS-GEN			
Configuration and Mode: 2.4 GHz Bluetooth - BR/EDR iPA						
2.4	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - 20 dB Bandwidth	Pass	ANSI C63.10 (2013)
2.5	15.247 (b)	5.4	6.12	Maximum Conducted Output Power	Pass	ANSI C63.10 (2013)
2.6	15.247 (d)	5.5	-	Authorised Band Edges	Pass	ANSI C63.10 (2013)
2.7	15.205	-	8.10	Restricted Band Edges	Pass	ANSI C63.10 (2013)
2.8	15.247 (d) and 15.205	5.5	6.13	Spurious Radiated Emissions	Pass	ANSI C63.10 (2013)

Table 2



1.4 Product Information

1.4.1 Technical Description

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

1.4.2 Antenna Gain Table (BT, Core 0)

Frequency (MHz)	Peak Gain (dBi)	Conducted Cable Loss (dB)
2400 - 2480	1.92	1.0

Table 3

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
Model: A2289, Serial Number: C02ZG00CP0C9			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: A2289, Serial Number: C02ZG009P09V			
0	As supplied by the customer	Not Applicable	Not Applicable

Table 4



1.7 Test Location

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

Test Name	Name of Engineer(s)	Accreditation
Configuration and Mode: 2.4 GHz Bluetooth - BR/EDR ePA		
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
Maximum Conducted Output Power	Mehadi Choudhury	UKAS
Authorised Band Edges	Ahmad Javid, Mohammad Malik, Jay Balendrarajah, Cristian Onaca, Mohamud Mohamud, Faisal Malyar	UKAS
Restricted Band Edges	Ahmad Javid, Mohammad Malik, Jay Balendrarajah, Cristian Onaca, Mohamud Mohamud, Faisal Malyar	UKAS
Spurious Radiated Emissions	Ahmad Javid, Mohammad Malik, Jay Balendrarajah, Cristian Onaca, Mohamud Mohamud, Faisal Malyar	UKAS
Configuration and Mode: 2.4 GHz Bluetooth - BR/EDR iPA		
Frequency Hopping Systems - 20 dB Bandwidth	Mehadi Choudhury	UKAS
Maximum Conducted Output Power	Mehadi Choudhury	UKAS
Authorised Band Edges	Ahmad Javid, Mohammad Malik, Jay Balendrarajah, Cristian Onaca, Mohamud Mohamud, Faisal Malyar	UKAS
Restricted Band Edges	Ahmad Javid, Mohammad Malik, Jay Balendrarajah, Cristian Onaca, Mohamud Mohamud, Faisal Malyar	UKAS
Spurious Radiated Emissions	Ahmad Javid, Mohammad Malik, Jay Balendrarajah, Cristian Onaca, Mohamud Mohamud, Faisal Malyar	UKAS

Table 5

Office Address:

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



2 Test Details

2.1 Frequency Hopping Systems - Average Time of Occupancy

2.1.1 Specification Reference

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

2.1.2 Equipment Under Test and Modification State

A2289, S/N: C02ZG00CP0C9 - Modification State 0

2.1.3 Date of Test

13-January-2020

2.1.4 Test Method

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

2.1.5 Environmental Conditions

Ambient Temperature 23.4 °C
Relative Humidity 33.4 %

2.1.6 Test Results

2.4 GHz Bluetooth - BR/EDR ePA

Packet Type	Dwell Time (ms)	Number of Transmissions	Average Occupancy Time (ms)
DH1	0.38	320	121.60
DH3	1.64	160	262.40
DH5	2.86	103	294.58

Table 6

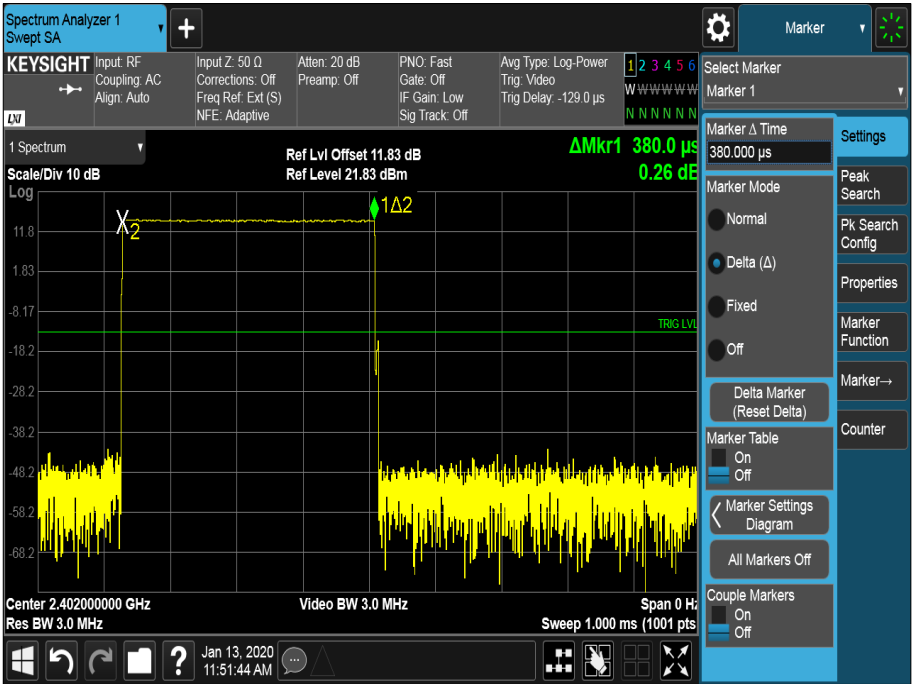


Figure 1 - DH1, Dwell Time

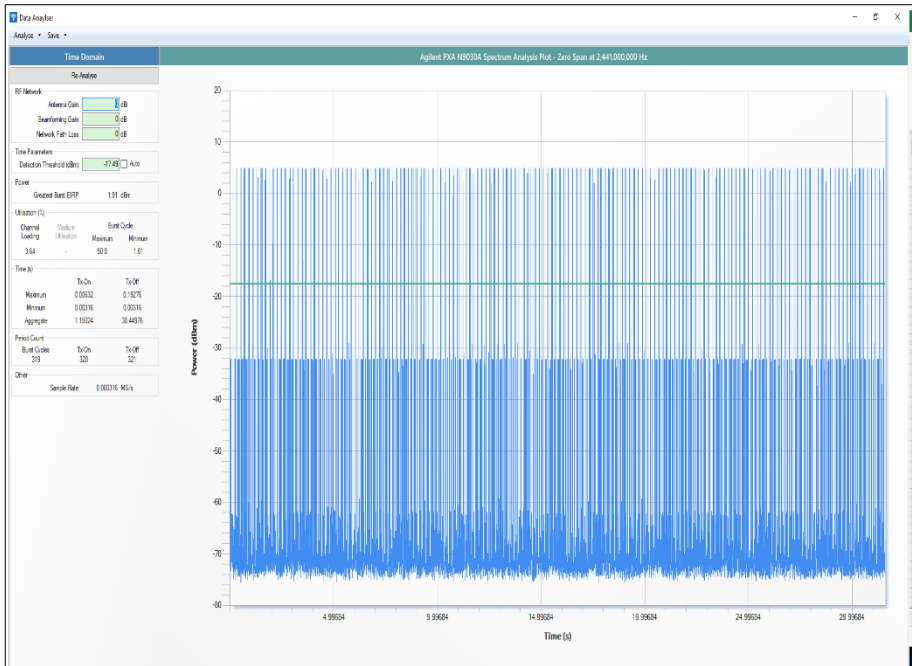


Figure 2 - DH1, Total Average Time of Occupancy



Figure 3 - DH3, Dwell Time

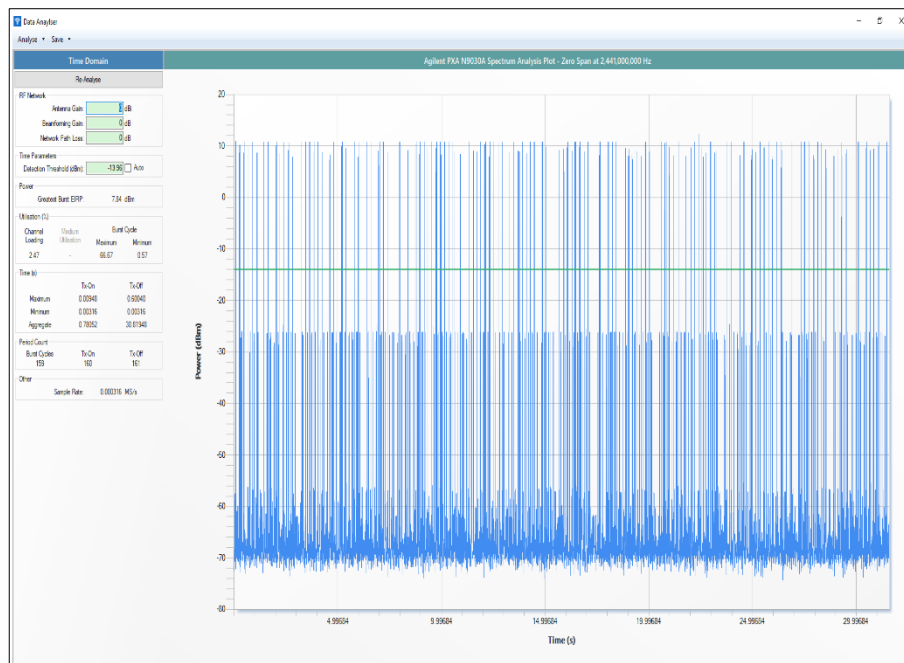


Figure 4 - DH3, Total Average Time of Occupancy

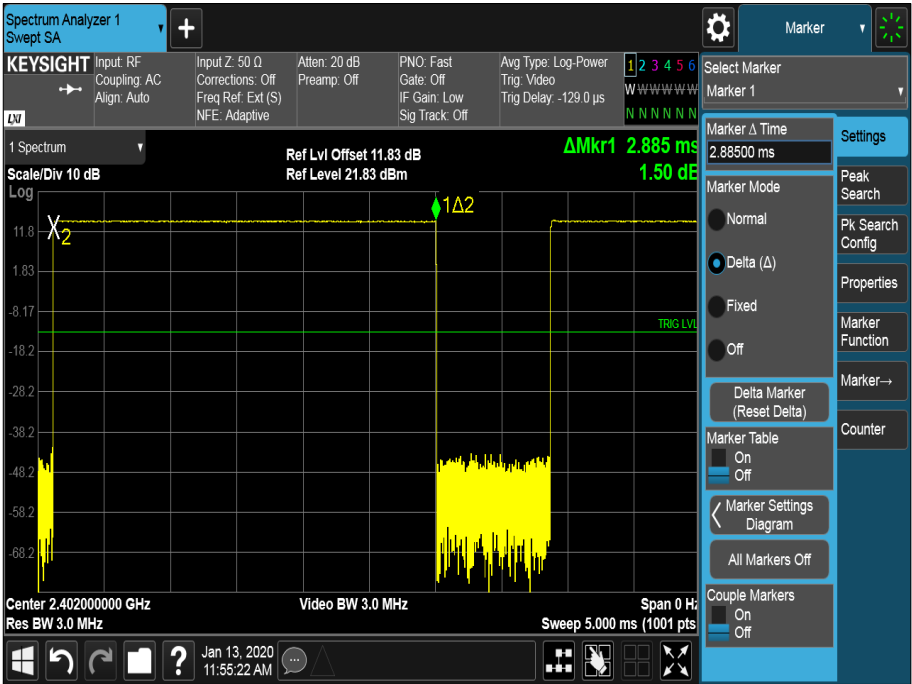


Figure 5 - DH5, Dwell Time

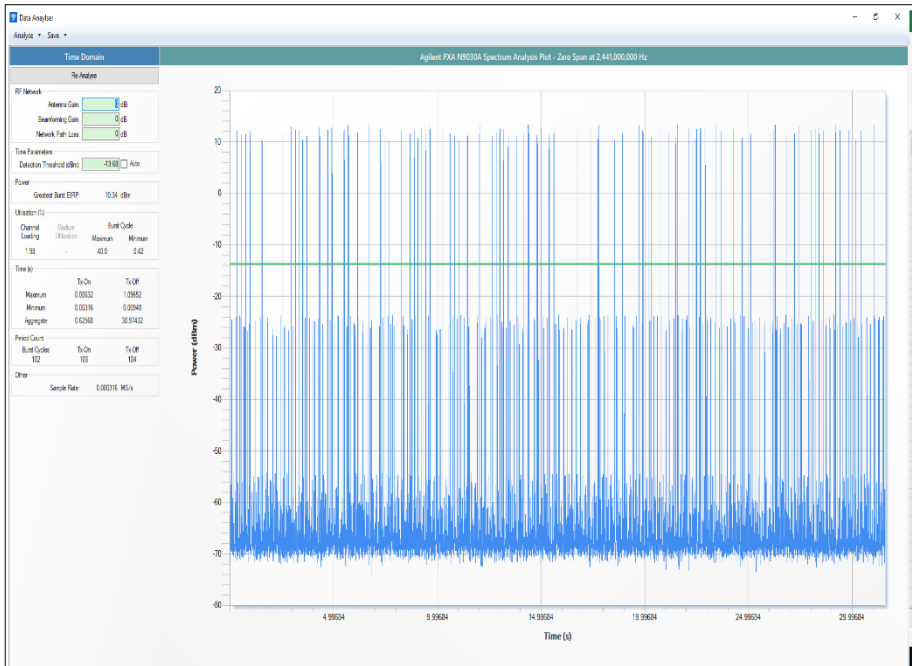


Figure 6 - DH5, Total Average Time of Occupancy



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.

ISED 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.

2.1.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Hygrometer	Rotronic	I-1000	3220	12	25-Sep-2020
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	11-Dec-2020
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	28-Nov-2020
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	16-Apr-2020
EXA	Keysight Technologies	N9010B	4969	24	21-Jan-2020
Cable (40 GHz)	Rosenberger	LU1-001-1000	5022	12	12-Nov-2020

Table 7

2.2 Frequency Hopping Systems - Channel Separation

2.2.1 Specification Reference

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

2.2.2 Equipment Under Test and Modification State

A2289, S/N: C02ZG00CP0C9 - Modification State 0

2.2.3 Date of Test

13-January-2020

2.2.4 Test Method

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

2.2.5 Environmental Conditions

Ambient Temperature 23.4 °C
Relative Humidity 33.4 %

2.2.6 Test Results

2.4 GHz Bluetooth - BR/EDR ePA

Modulation	Channel Separation (MHz)
GFSK	0.999
$\pi/4$ DQPSK	1.002
8-DPSK	1.002

Table 8



Figure 7 - GFSK

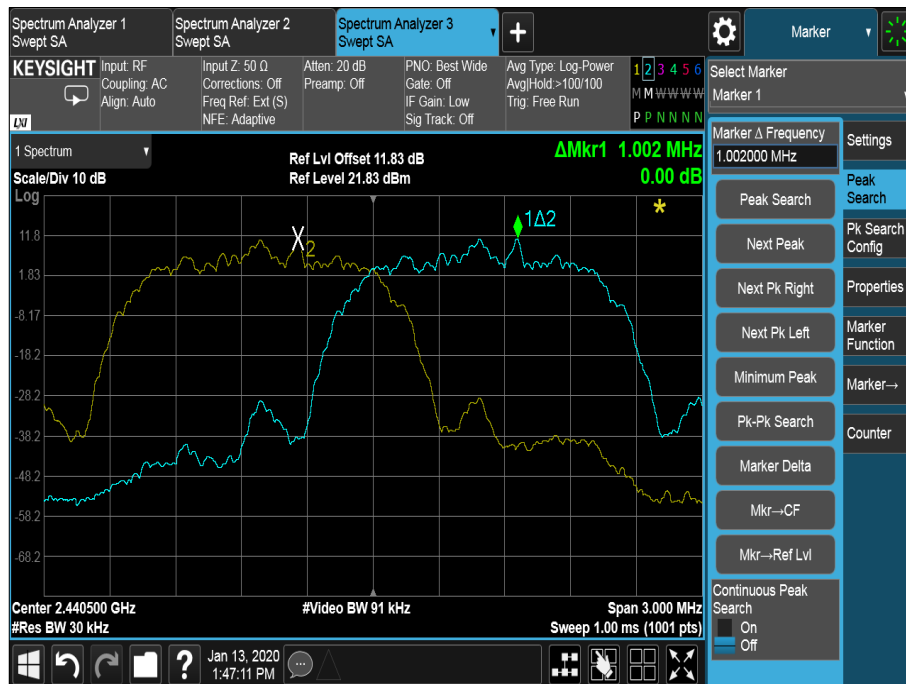


Figure 8 - $\pi/4$ DQPSK



Figure 9 - 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.

ISED 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.

2.2.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Hygrometer	Rotronic	I-1000	3220	12	25-Sep-2020
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	11-Dec-2020
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	28-Nov-2020
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	16-Apr-2020
EXA	Keysight Technologies	N9010B	4969	24	21-Jan-2020
Cable (40 GHz)	Rosenberger	LU1-001-1000	5022	12	12-Nov-2020
Attenuator (20 dB, 2 W)	Pasternack	PE7004-20	489	-	O/P Mon

Table 9

O/P Mon – Output Monitored using calibrated equipment

2.3 Frequency Hopping Systems - Number of Hopping Channels

2.3.1 Specification Reference

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

2.3.2 Equipment Under Test and Modification State

A2289, S/N: C02ZG00CP0C9 - Modification State 0

2.3.3 Date of Test

13-January-2020

2.3.4 Test Method

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

2.3.5 Environmental Conditions

Ambient Temperature 23.4 °C
Relative Humidity 33.4 %

2.3.6 Test Results

2.4 GHz Bluetooth - BR/EDR ePA

Number of Hopping Channels: 79

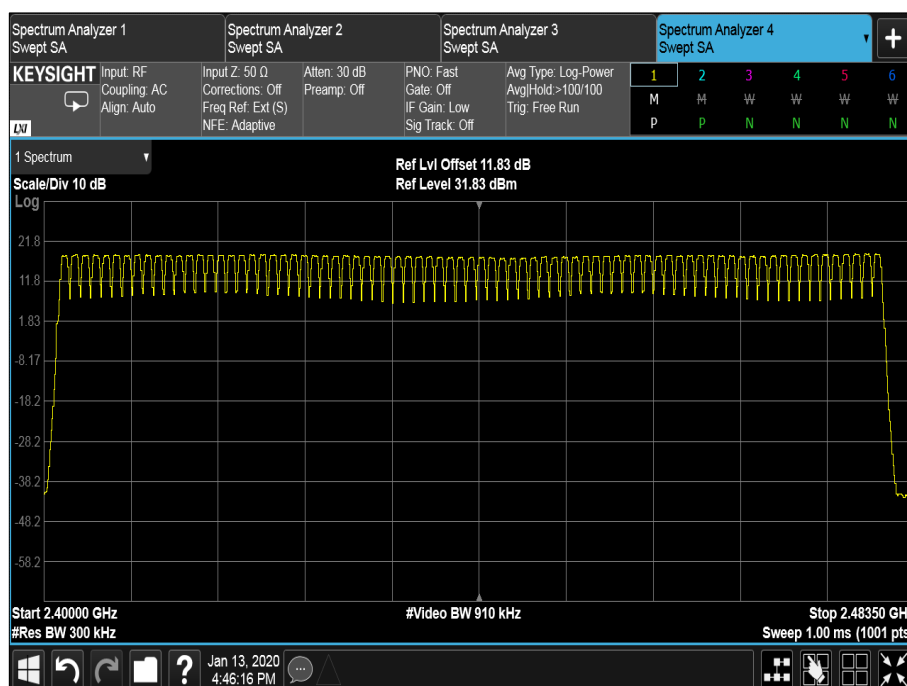


Figure 10 - Measurement Frequency Range: 2400 MHz to 2483.5 MHz



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

≥ 15 channels

ISED RSS-247, Limit Clause 5.1 (d)

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

2.3.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Hygrometer	Rotronic	I-1000	3220	12	25-Sep-2020
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	11-Dec-2020
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	28-Nov-2020
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	16-Apr-2020
EXA	Keysight Technologies	N9010B	4969	24	21-Jan-2020
Cable (40 GHz)	Rosenberger	LU1-001-1000	5022	12	12-Nov-2020
Attenuator (20 dB, 2 W)	Pasternack	PE7004-20	489	-	O/P Mon

Table 10

O/P Mon – Output Monitored using calibrated equipment



2.4 Frequency Hopping Systems - 20 dB Bandwidth

2.4.1 Specification Reference

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

2.4.2 Equipment Under Test and Modification State

A2289, S/N: C02ZG00CP0C9 - Modification State 0

2.4.3 Date of Test

10-January-2020

2.4.4 Test Method

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

2.4.5 Environmental Conditions

Ambient Temperature 23.6 °C
Relative Humidity 27.0 %

2.4.6 Test Results

2.4 GHz Bluetooth - BR/EDR ePA

Frequency (MHz)	20 dB Bandwidth (kHz)		
	GFSK	$\pi/4$ DQPSK	8-DPSK
2402	933.20	1342.00	1303.00
2441	934.40	1342.00	1302.00
2480	933.20	1344.00	1303.00

Table 11



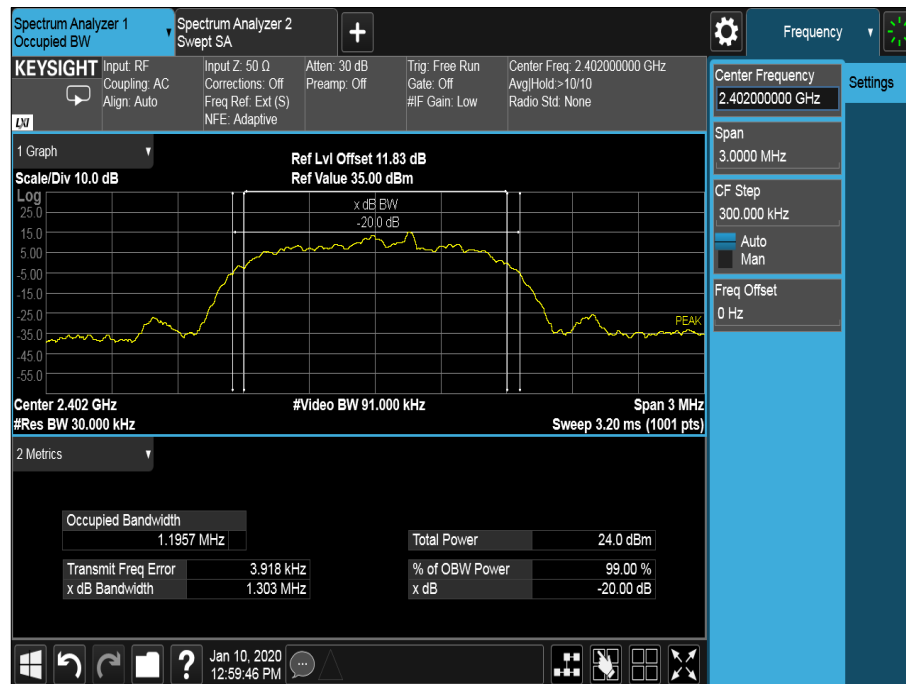


Figure 13 - 2402 MHz - 8-DPSK



Figure 14 - 2441 MHz - GFSK

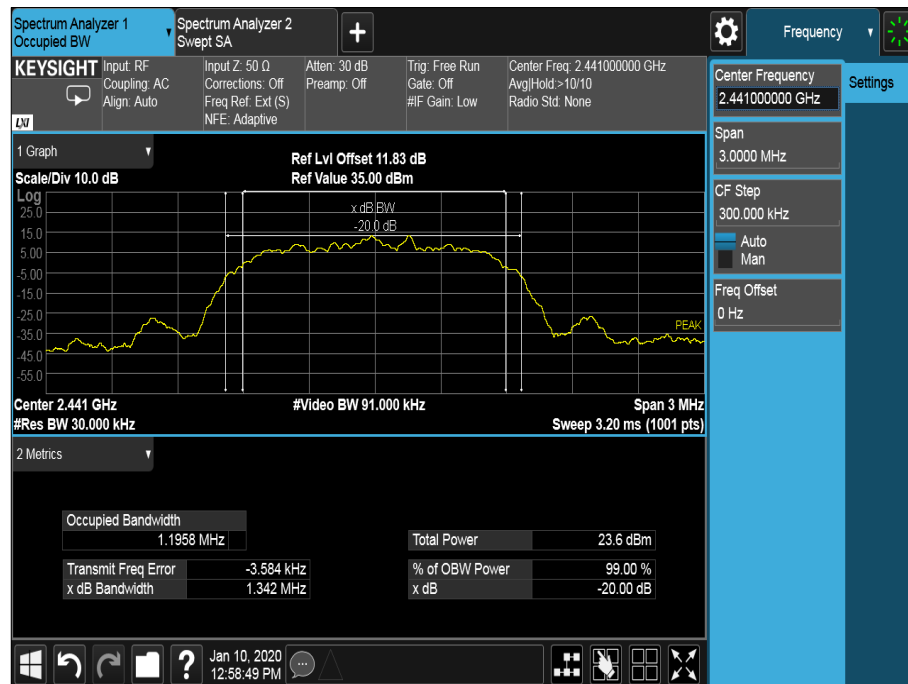


Figure 15 - 2441 MHz - $\pi/4$ DQPSK



Figure 16 - 2441 MHz - 8-DPSK





Figure 19 - 2480 MHz - 8-DPSK

2.4 GHz Bluetooth - BR/EDR iPA

Frequency (MHz)	20 dB Bandwidth (kHz)		
	GFSK	$\pi/4$ DQPSK	8-DPSK
2402	923.40	1343.00	1303.00
2441	933.00	1342.00	1303.00
2480	933.90	1343.00	1303.00

Table 12



Figure 20 - 2402 MHz - GFSK

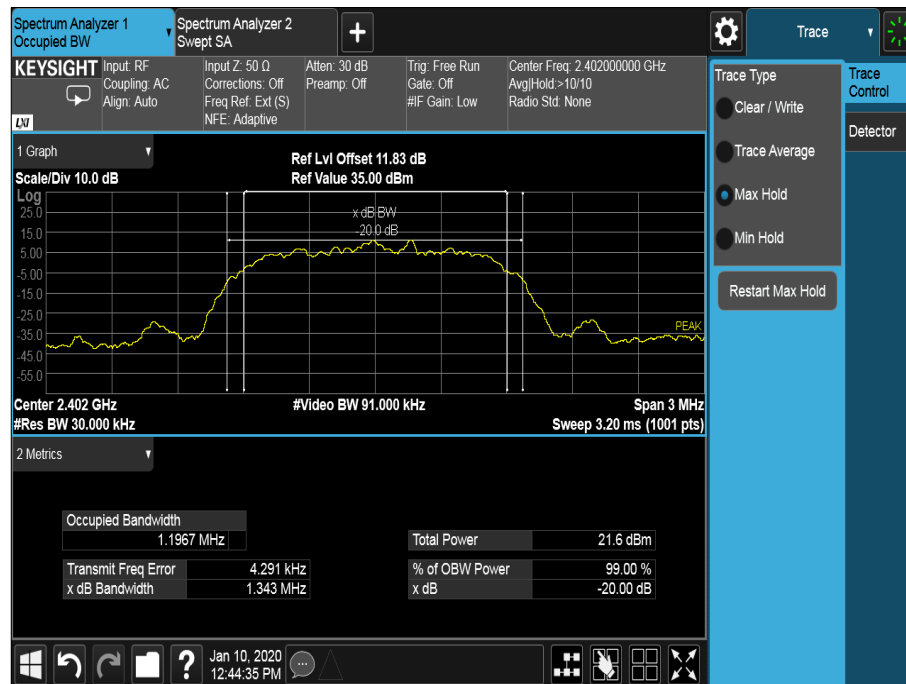


Figure 21 - 2402 MHz - $\pi/4$ DQPSK



Figure 22 - 2402 MHz - 8-DPSK



Figure 23 - 2441 MHz - GFSK

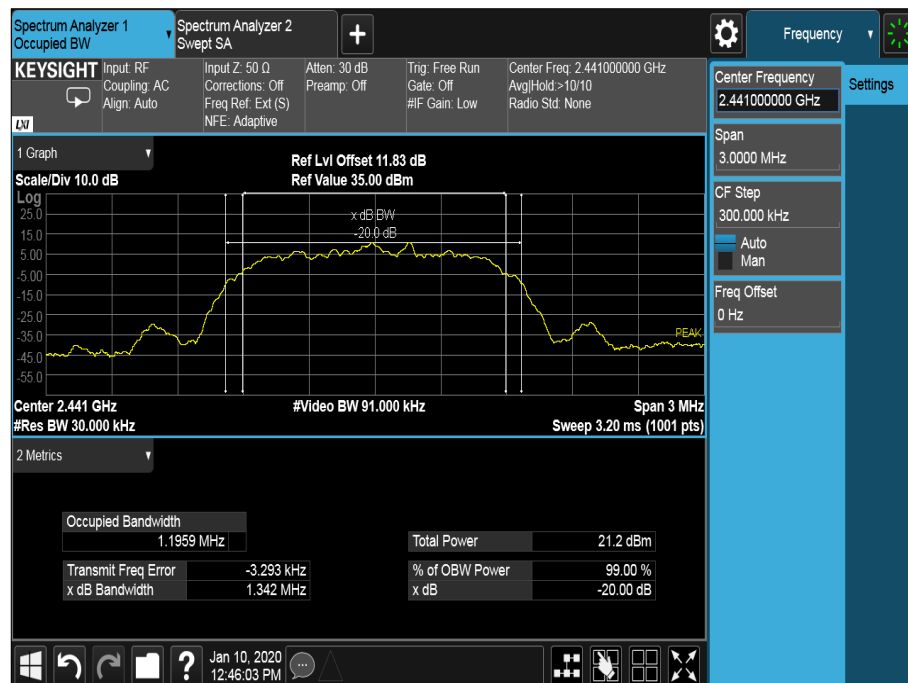


Figure 24 - 2441 MHz - $\pi/4$ DQPSK

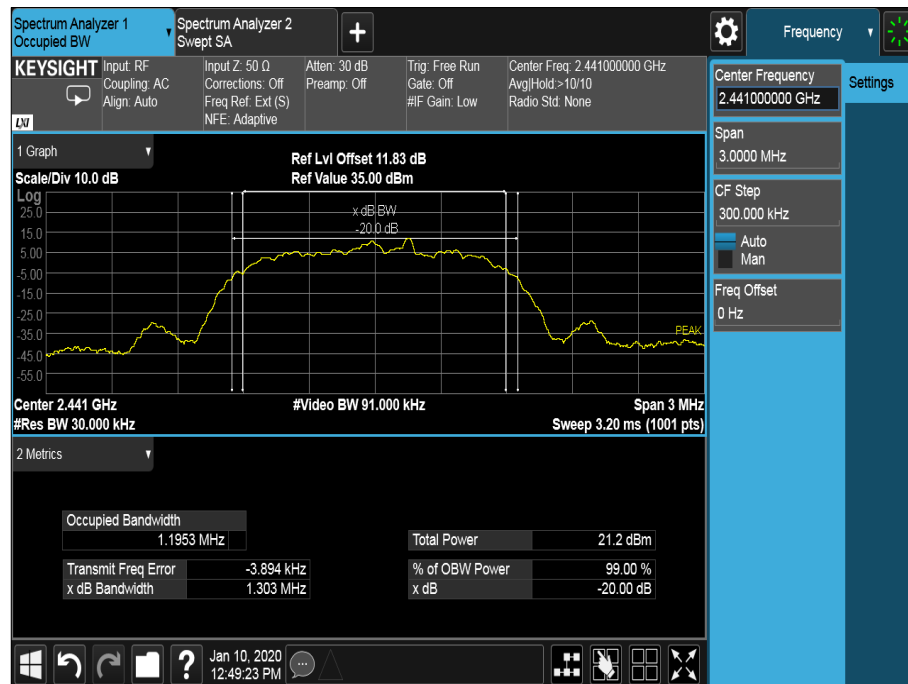


Figure 25 - 2441 MHz - 8-DPSK



Figure 26 - 2480 MHz - GFSK

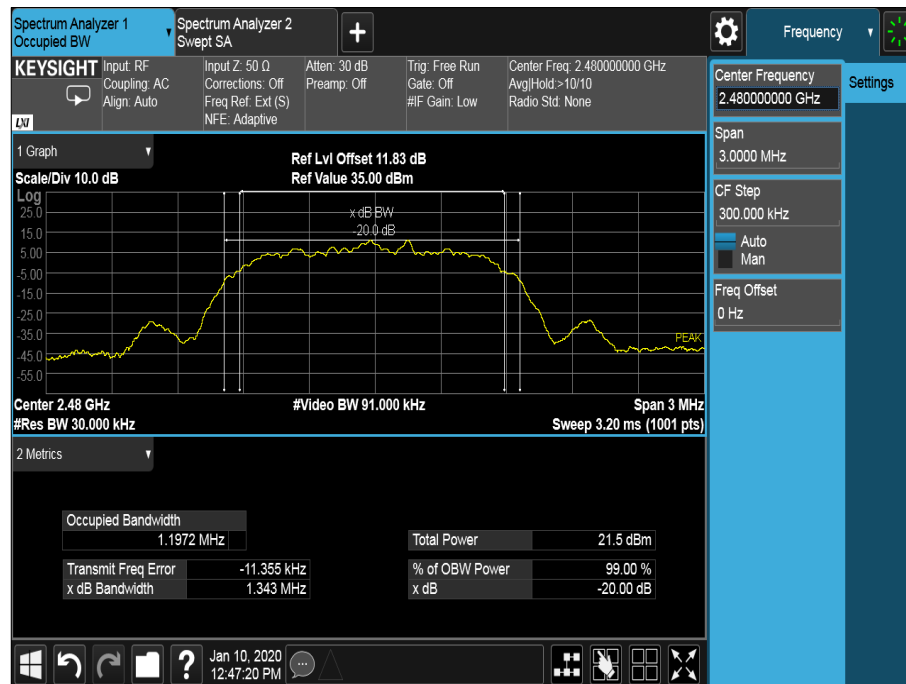


Figure 27 - 2480 MHz - $\pi/4$ DQPSK



Figure 28 - 2480 MHz - 8-DPSK

FCC 47 CFR Part 15 and ISEDC RSS-247 Limit Clause

None specified.



2.4.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Hygrometer	Rotronic	I-1000	3220	12	25-Sep-2020
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	11-Dec-2020
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	28-Nov-2020
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	16-Apr-2020
EXA	Keysight Technologies	N9010B	4969	24	21-Jan-2020
Cable (40 GHz)	Rosenberger	LU1-001-1000	5022	12	12-Nov-2020

Table 13



2.5 Maximum Conducted Output Power

2.5.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (b)
ISED RSS-247, Clause 5.4
ISED RSS-GEN, Clause 6.12

2.5.2 Equipment Under Test and Modification State

A2289, S/N: C02ZG00CP0C9 - Modification State 0

2.5.3 Date of Test

08-January-2020

2.5.4 Test Method

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

2.5.5 Environmental Conditions

Ambient Temperature	26.0 °C
Relative Humidity	36.7 %

2.5.6 Test Results

2.4 GHz Bluetooth - BR/EDR ePA

Frequency (MHz)	Modulation Scheme	Maximum Output Power	
		dBm	mW
2402	GFSK	17.90	61.66
2402	$\pi/4$ DQPSK	16.25	42.17
2402	8-DPSK	16.35	43.15
2441	GFSK	17.95	62.37
2441	$\pi/4$ DQPSK	16.41	43.75
2441	8-DPSK	16.49	44.57
2480	GFSK	17.94	62.23
2480	$\pi/4$ DQPSK	16.18	41.50
2480	8-DPSK	16.24	42.07

Table 14 - Maximum Conducted Output Power Results

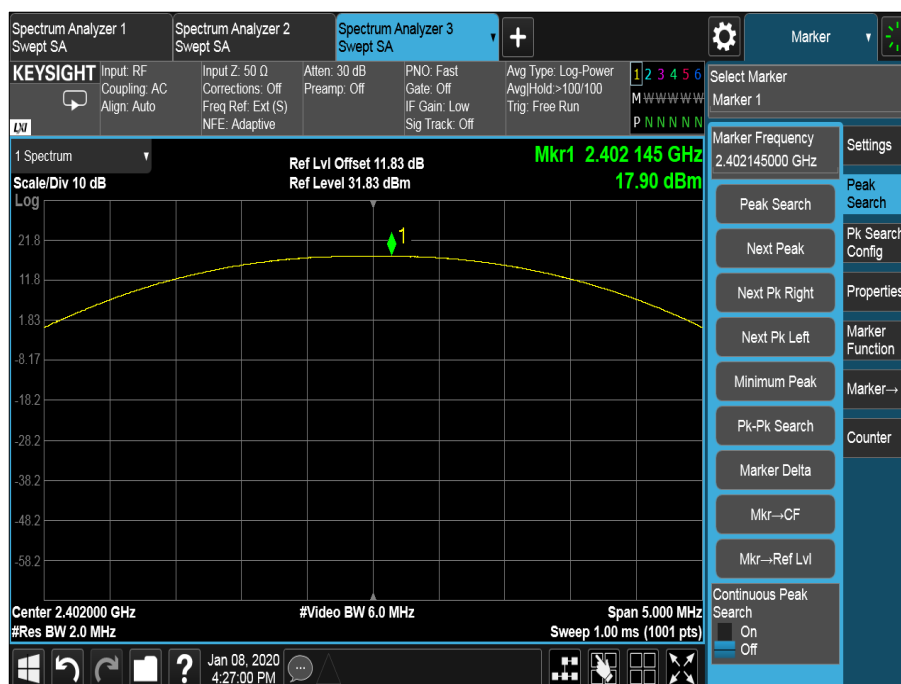


Figure 29 - 2402 MHz, GFSK - Maximum Output Power

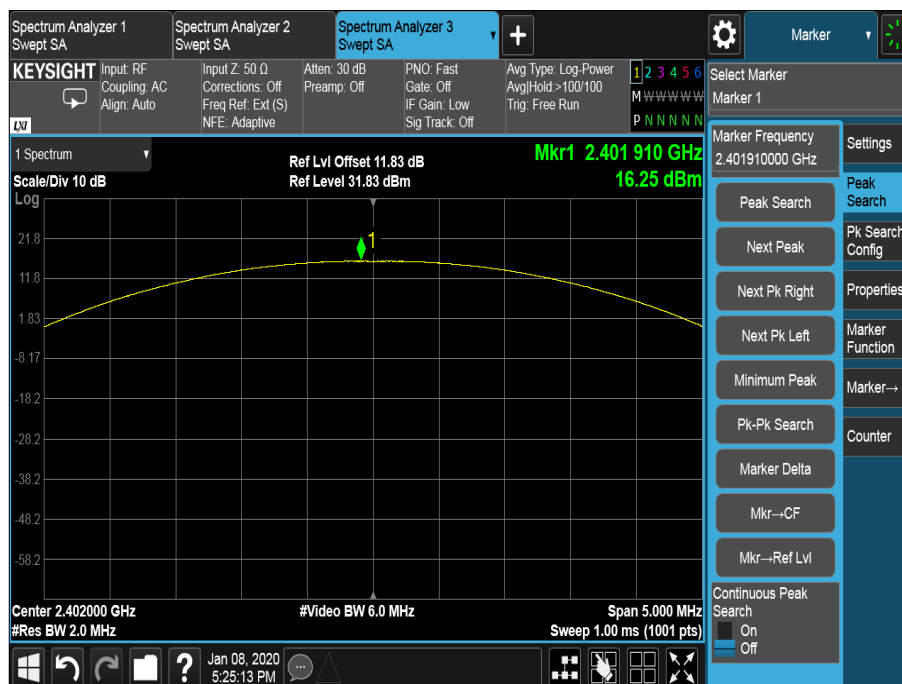


Figure 30 - 2402 MHz, $\pi/4$ DQPSK - Maximum Output Power

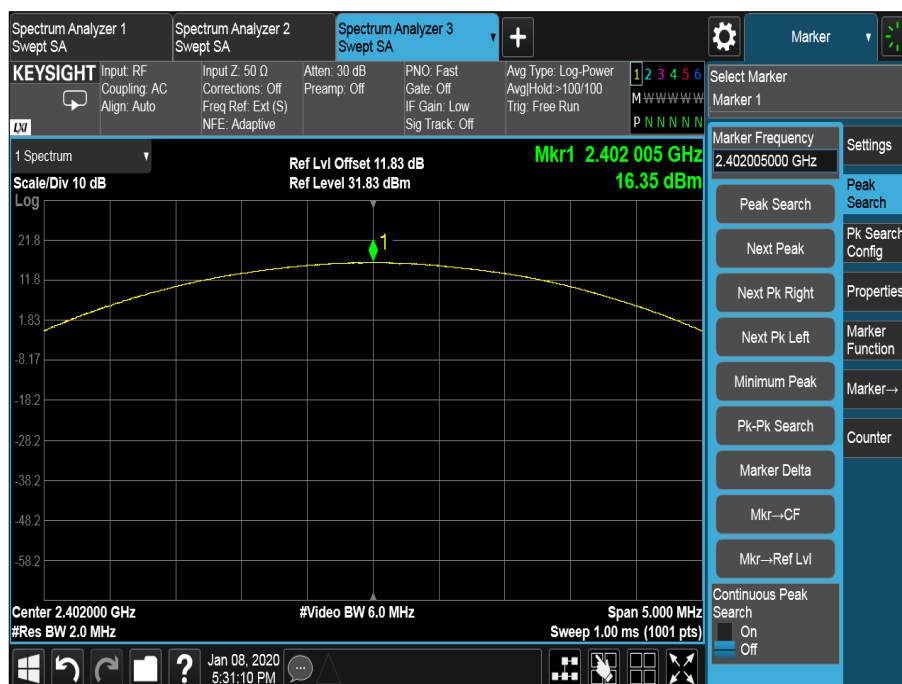


Figure 31 - 2402 MHz, 8-DPSK - Maximum Output Power

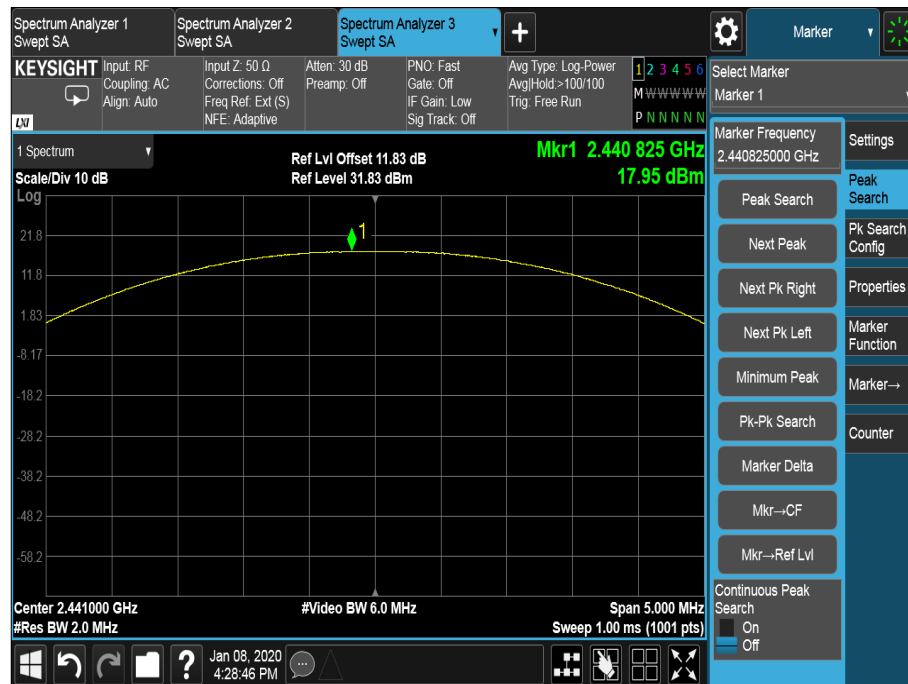


Figure 32 - 2441 MHz, GFSK - Maximum Output Power

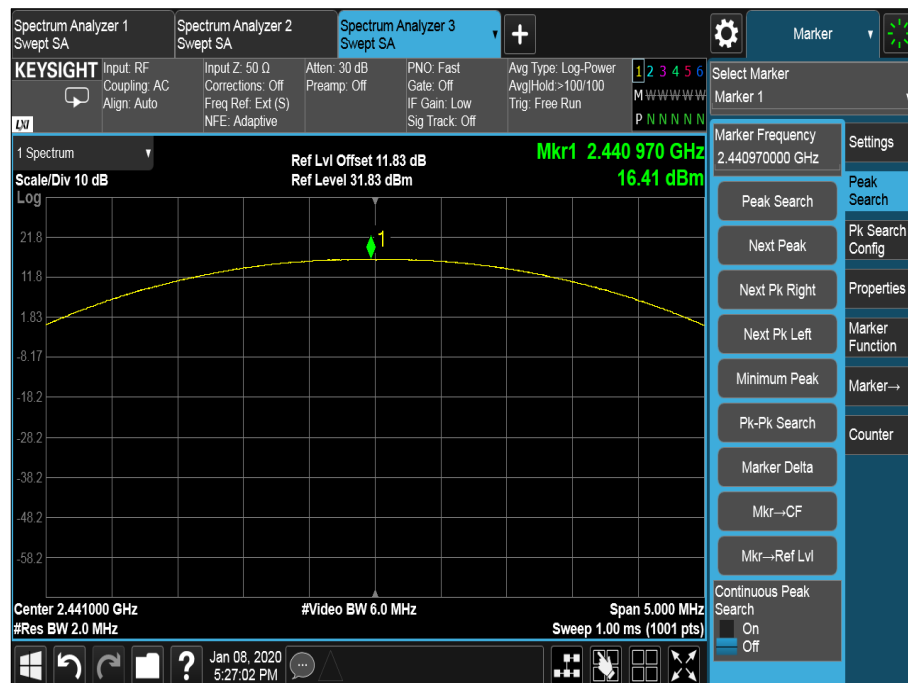


Figure 33 - 2441 MHz, $\pi/4$ DQPSK - Maximum Output Power

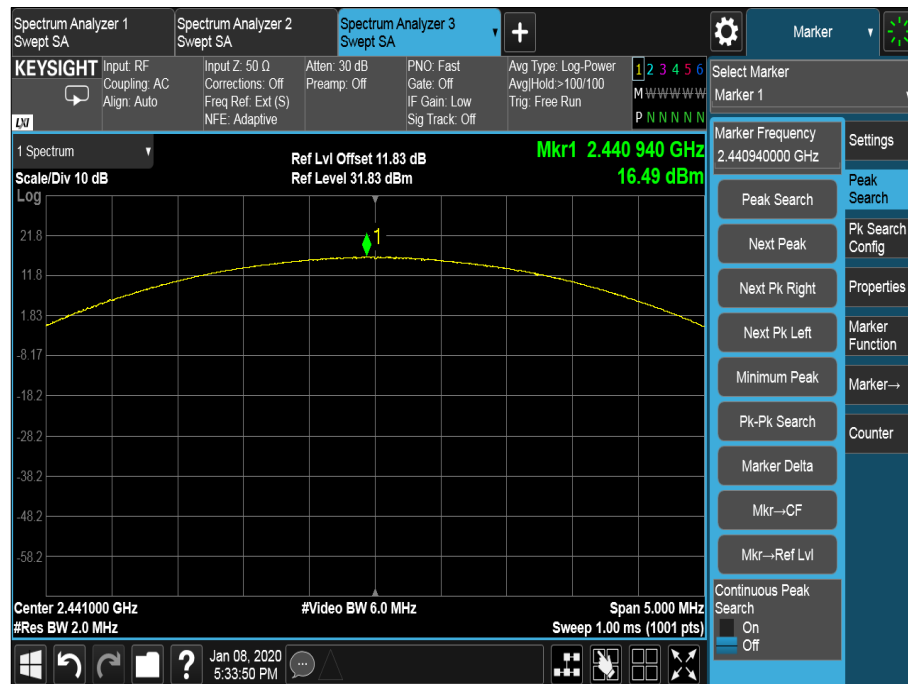


Figure 34 - 2441 MHz, 8-DPSK - Maximum Output Power

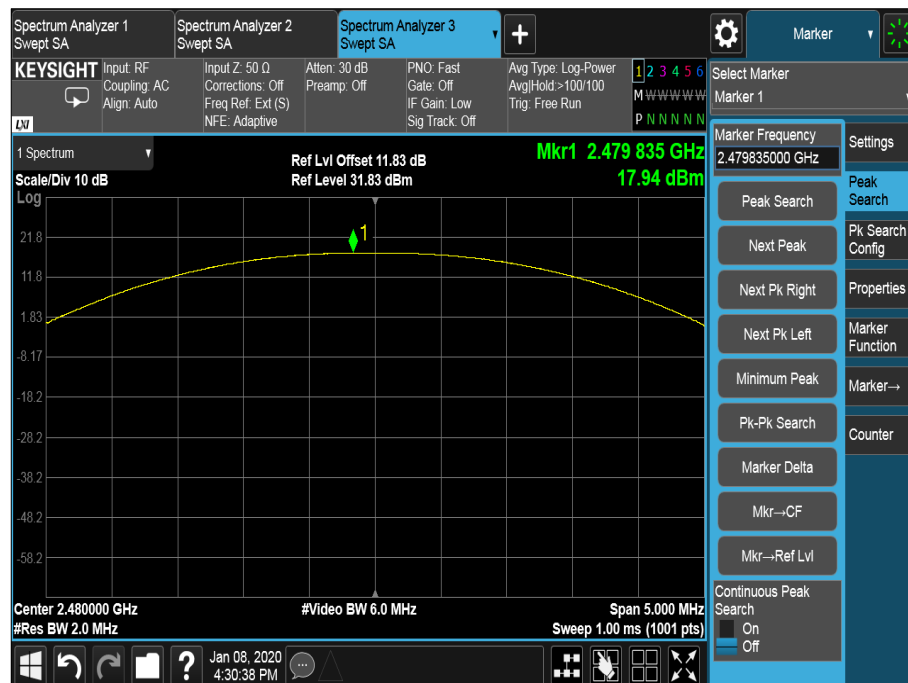


Figure 35 - 2480 MHz, GFSK - Maximum Output Power

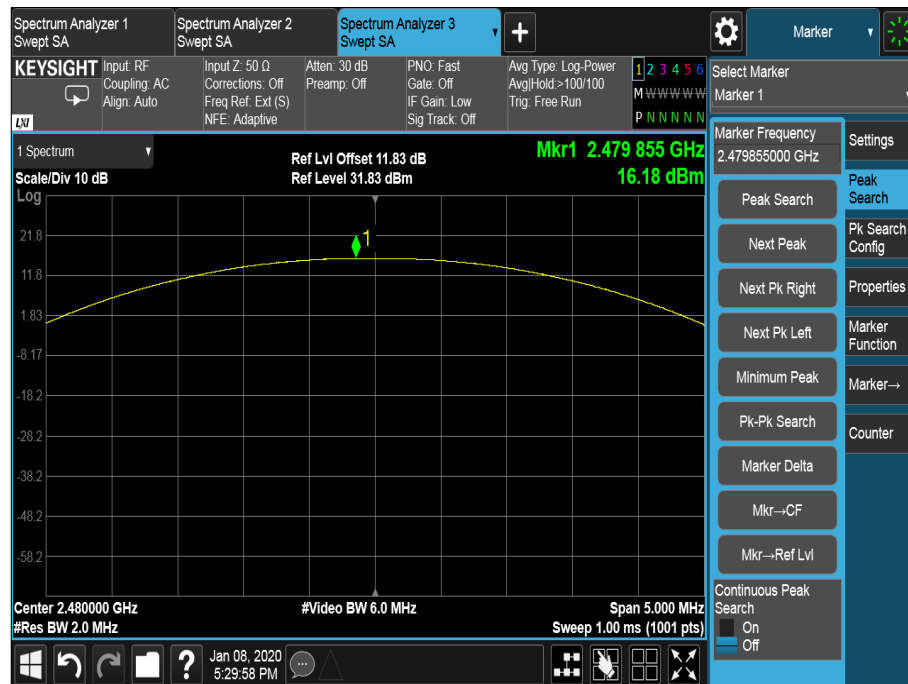


Figure 36 - 2480 MHz, $\pi/4$ DQPSK - Maximum Output Power

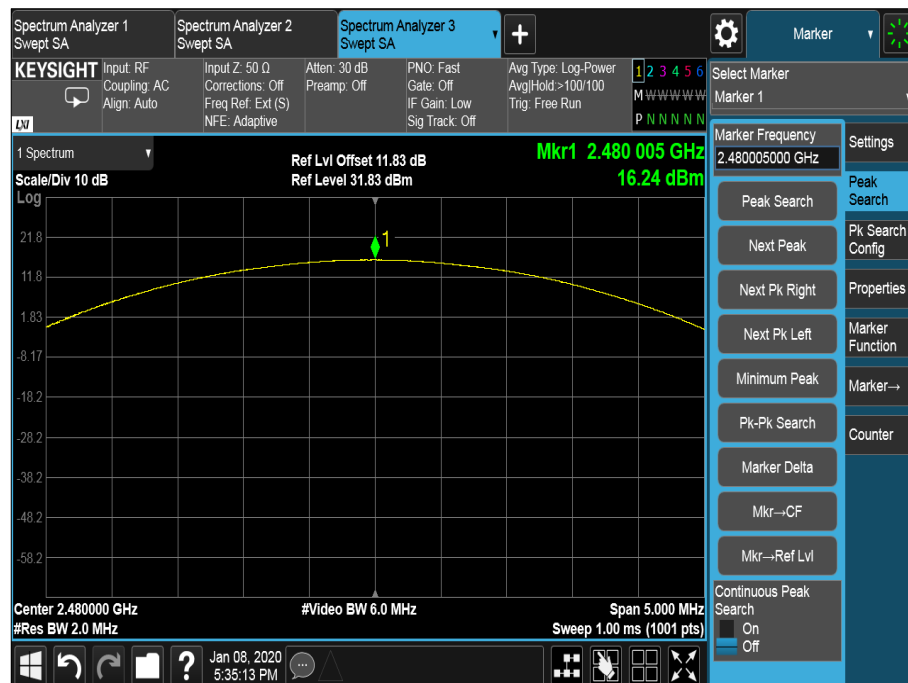


Figure 37 - 2480 MHz, 8-DPSK - Maximum Output Power

2.4 GHz Bluetooth - BR/EDR iPA

Frequency (MHz)	Modulation Scheme	Maximum Output Power	
		dBm	mW
2402	GFSK	11.75	14.76
2402	$\pi/4$ DQPSK	9.61	9.14
2402	8-DPSK	9.87	9.71
2441	GFSK	11.75	14.76
2441	$\pi/4$ DQPSK	9.95	9.86
2441	8-DPSK	9.80	9.55
2480	GFSK	11.93	15.60
2480	$\pi/4$ DQPSK	9.84	9.64
2480	8-DPSK	9.74	9.42

Table 15 - Maximum Conducted Output Power Results

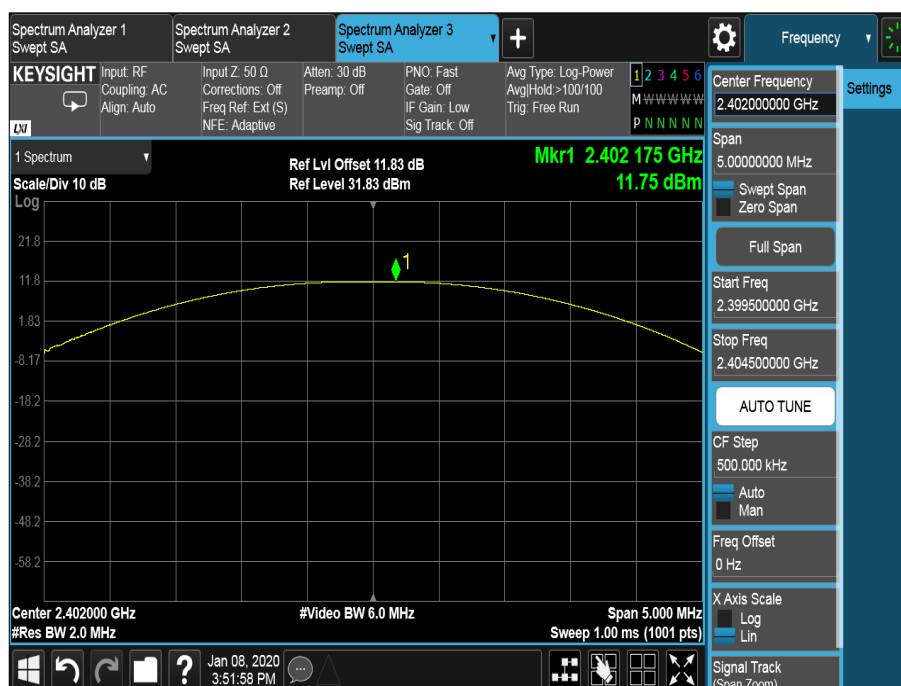


Figure 38 - 2402 MHz, GFSK - Maximum Output Power

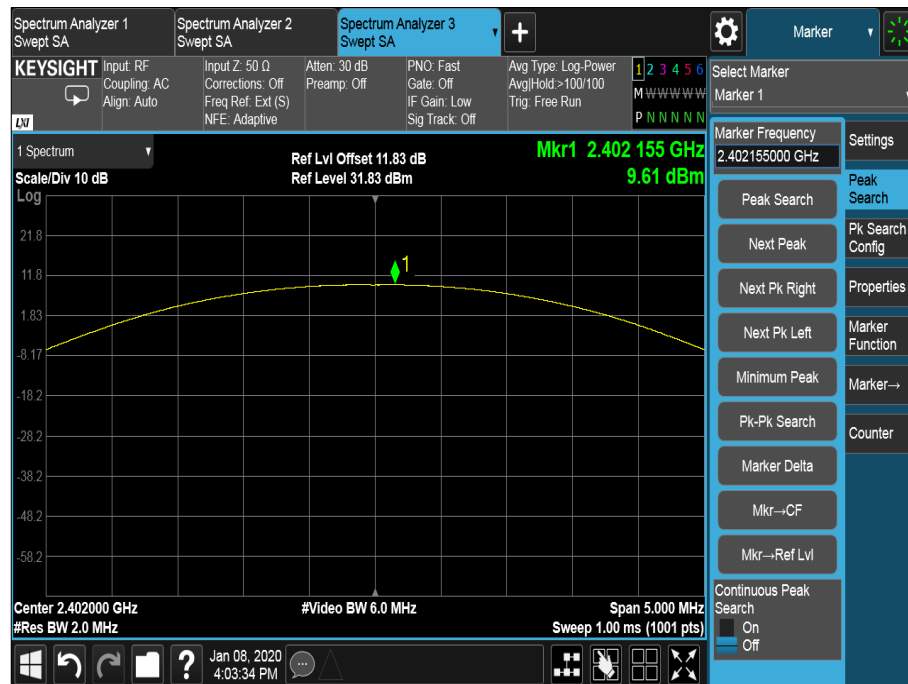


Figure 39 - 2402 MHz, $\pi/4$ DQPSK - Maximum Output Power

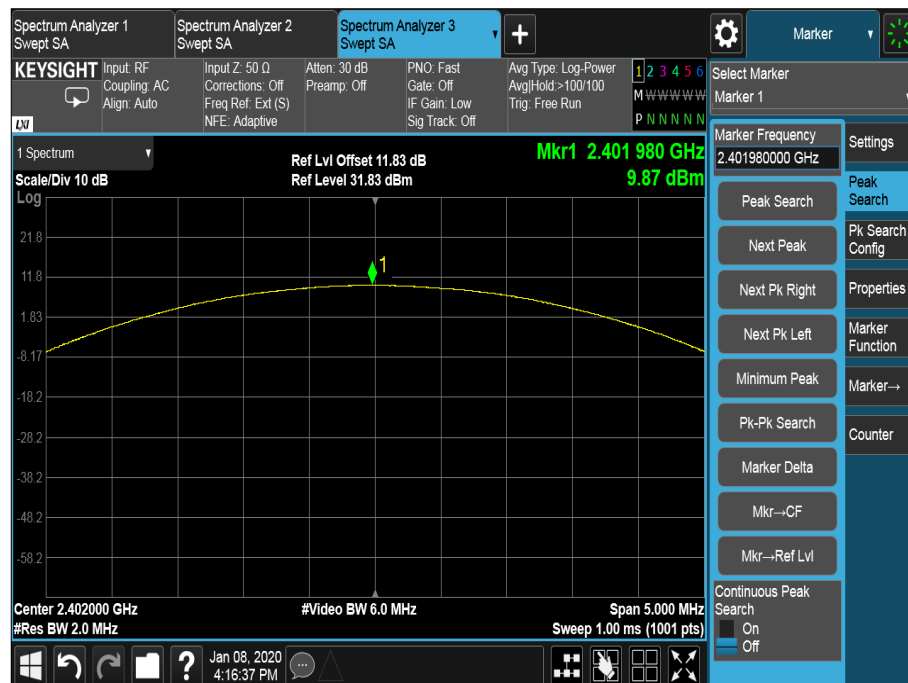


Figure 40 - 2402 MHz, 8-DPSK - Maximum Output Power

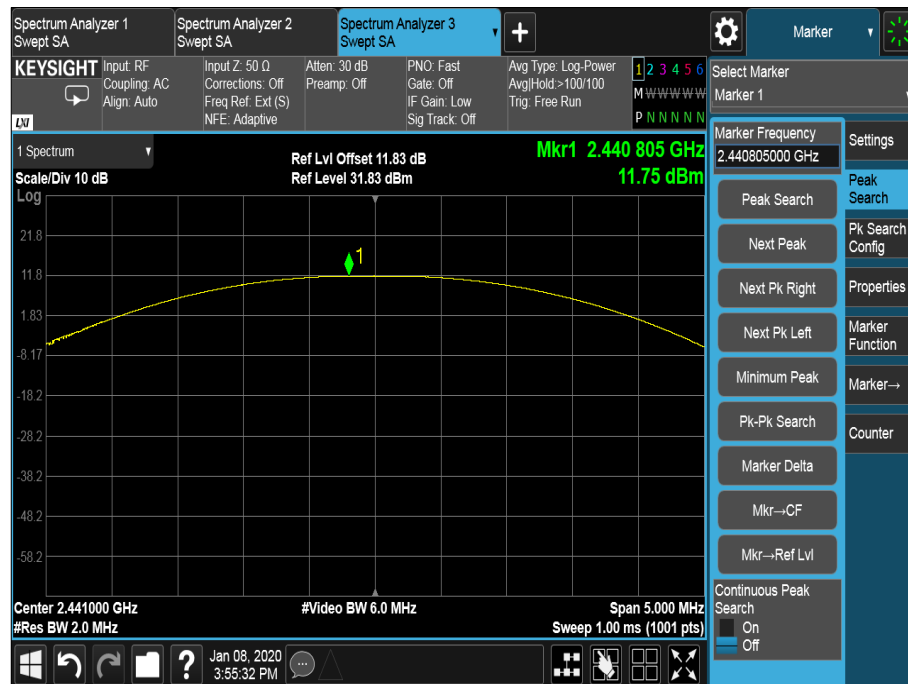


Figure 41 - 2441 MHz, GFSK - Maximum Output Power

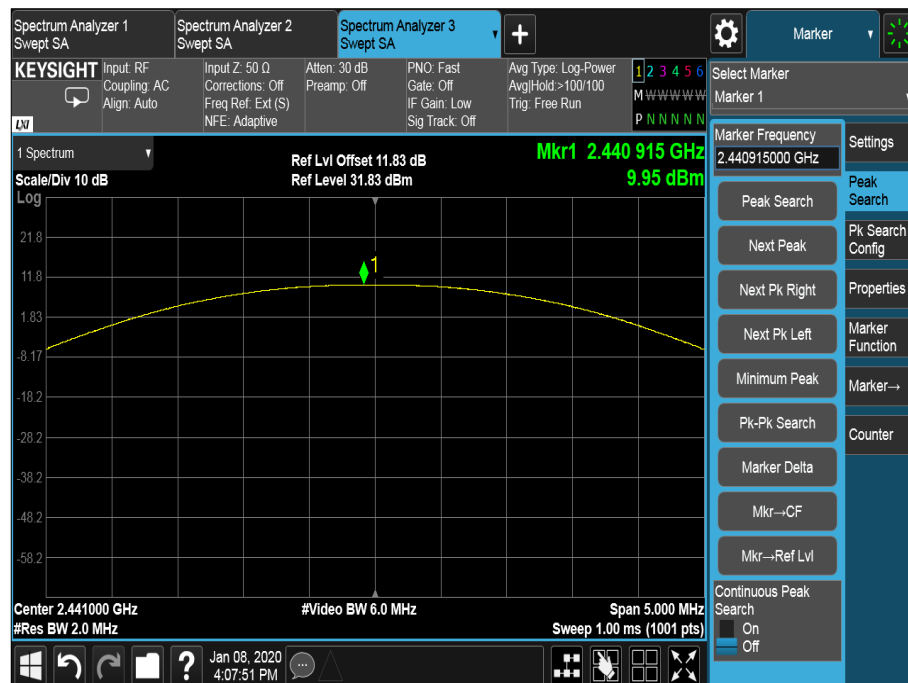


Figure 42 - 2441 MHz, $\pi/4$ DQPSK - Maximum Output Power

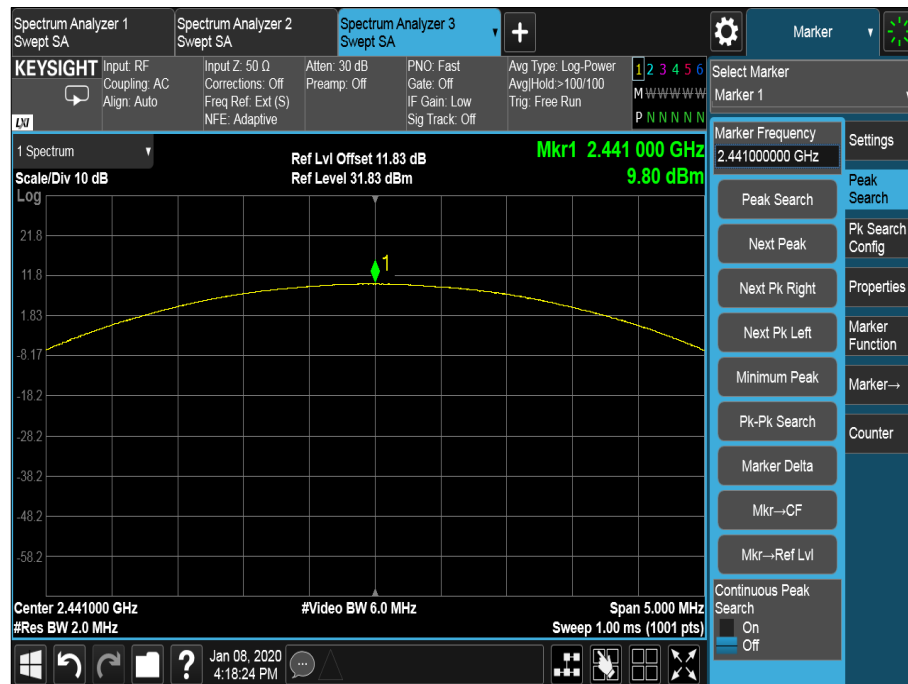


Figure 43 - 2441 MHz, 8-DPSK - Maximum Output Power

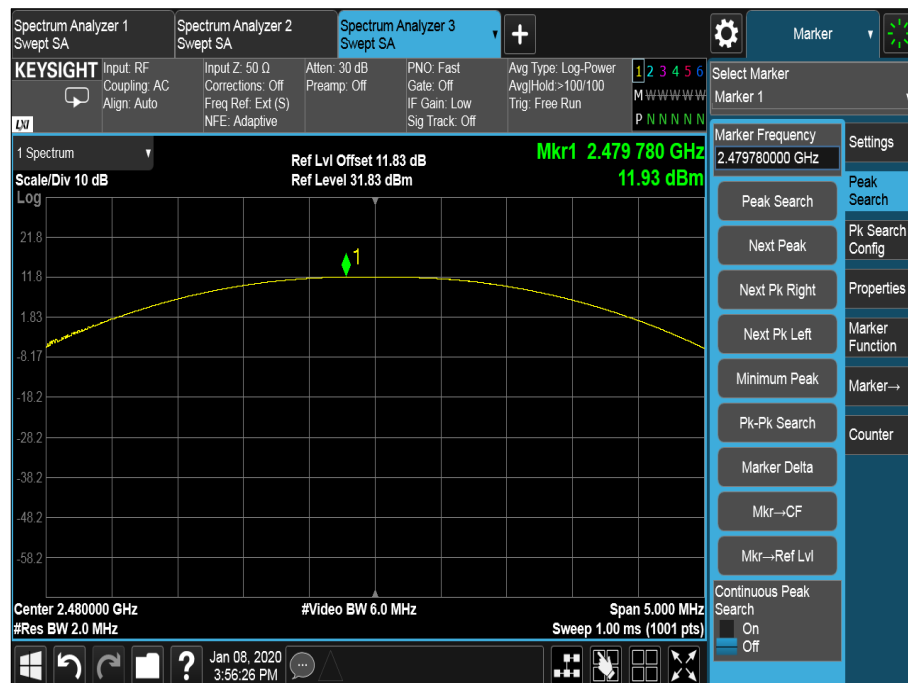


Figure 44 - 2480 MHz, GFSK - Maximum Output Power

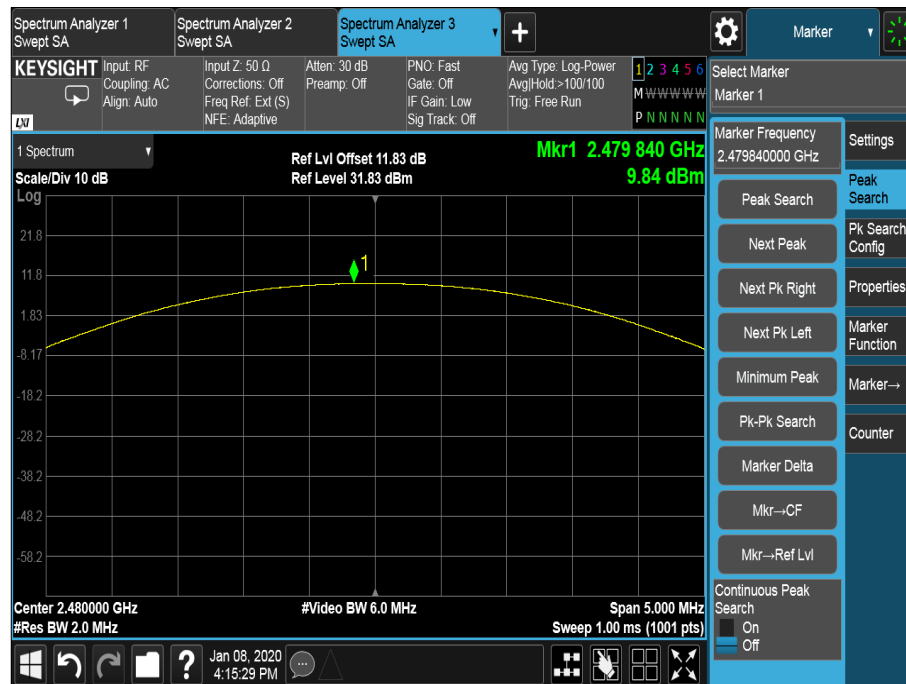


Figure 45 - 2480 MHz, $\pi/4$ DQPSK - Maximum Output Power

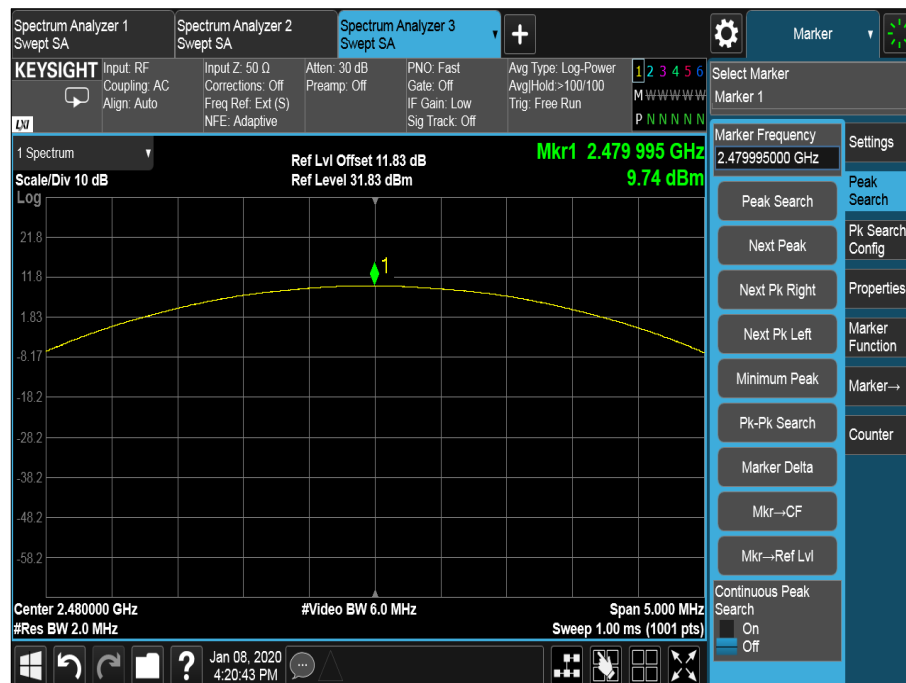


Figure 46 - 2480 MHz, 8-DPSK - Maximum Output Power



FCC 47 CFR Part 15, Limit Clause 15.247 (b)(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 5725-5850MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

ISED 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.

2.5.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	16-Apr-2020
Hygrometer	Rotronic	I-1000	3220	12	25-Sep-2020
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	11-Dec-2020
1800-6000 MHz Power Splitter	Mini-Circuits	ZN2PD-63-S+	4055	-	O/P Mon
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	28-Nov-2020
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	16-Apr-2020
PXA Signal Analyser	Keysight Technologies	N9030A	4653	12	06-Feb-2020
Power splitter - 2 port	Mini-Circuits	ZN2PD-63-S+	4743	12	23-Sep-2020
EXA	Keysight Technologies	N9010B	4969	24	21-Jan-2020
Cable (40 GHz)	Rosenberger	LU1-001-1000	5022	12	12-Nov-2020
Cable (18 GHz)	Rosenberger	LU7-071-2000	5108	12	06-Oct-2020
USB Power Sensor	Boonton	RTP5006	5184	12	09-Jan-2021
Power Splitter, 4 way	Mini-Circuits	ZN4PD1-63-S+	5235	-	O/P Mon
Power Splitter, 4 way	Mini-Circuits	ZN4PD1-63-S+	5236	-	O/P Mon
USB Power Sensor	Boonton	RTP5006	5280	12	09-Apr-2020

Table 16

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)
ISED RSS-247, Clause 5.5

2.6.2 Equipment Under Test and Modification State

A2289, S/N: C02ZG009P09V - Modification State 0

2.6.3 Date of Test

19-November-2019 to 20-December-2019

2.6.4 Test Method

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

2.6.5 Environmental Conditions

Ambient Temperature	21.8 °C
Relative Humidity	50.9 %

2.6.6 Test Results

2.4 GHz Bluetooth - BR/EDR ePA

Mode	Modulation	Packet Type	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
Static	GFSK	DH5	2402	2400.0	-65.25
Static	$\pi/4$ DQPSK	2DH5	2402	2400.0	-55.32
Static	8-DPSK	3DH5	2402	2400.0	-55.34
Hopping	GFSK	DH5	2402	2400.0	-66.88
Hopping	$\pi/4$ DQPSK	2DH5	2402	2400.0	-59.30
Hopping	8-DPSK	3DH5	2402	2400.0	-58.66

Table 17 - Authorised Band Edge Results

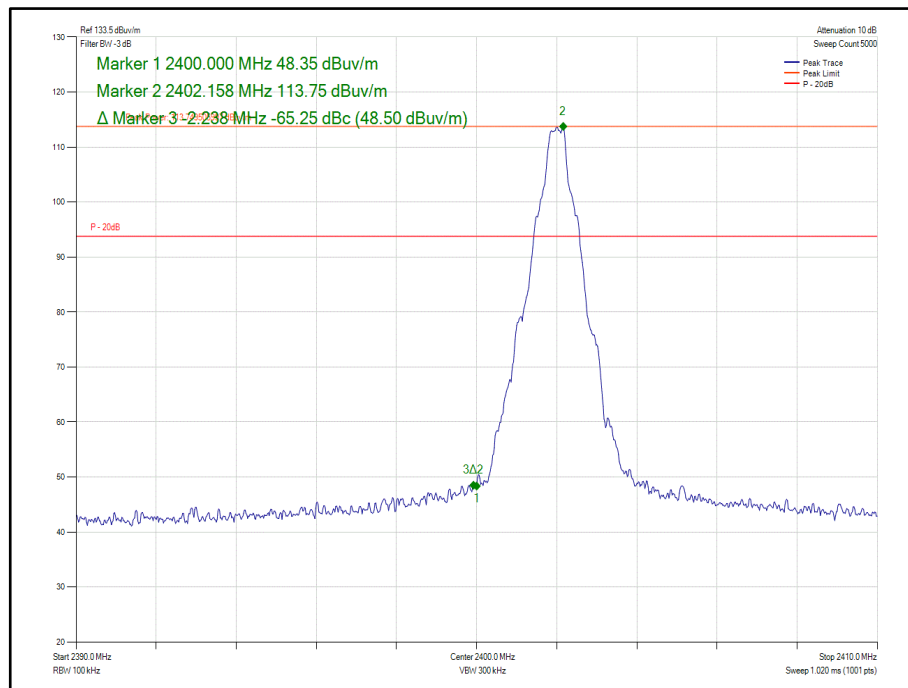


Figure 47 - Static - GFSK/DH5 - 2402 MHz - Band Edge Frequency 2400.0 MHz

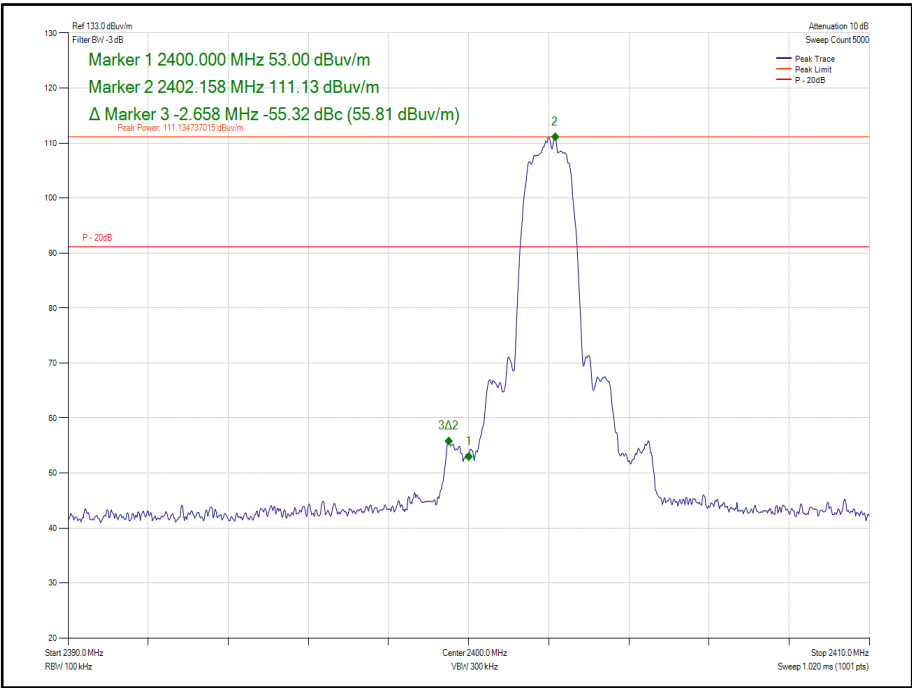


Figure 48 - Static - $\pi/4$ DQPSK/2DH5 - 2402 MHz - Band Edge Frequency 2400.0 MHz

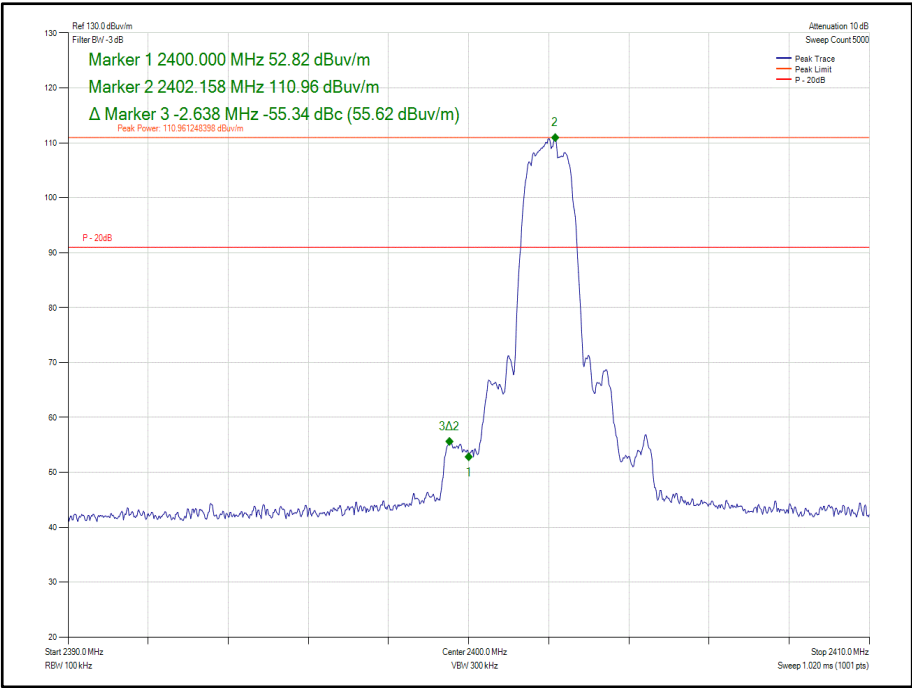


Figure 49 - Static - 8-DPSK/3DH5 - 2402 MHz - Band Edge Frequency 2400.0 MHz

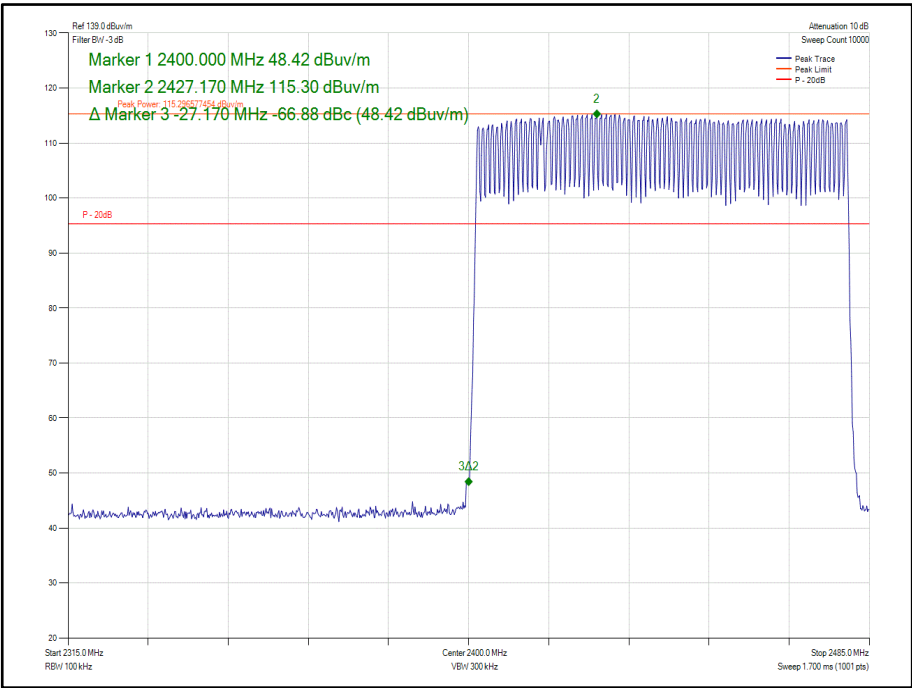


Figure 50 - Hopping - GFSK/DH5 - Band Edge Frequency 2400.0 MHz

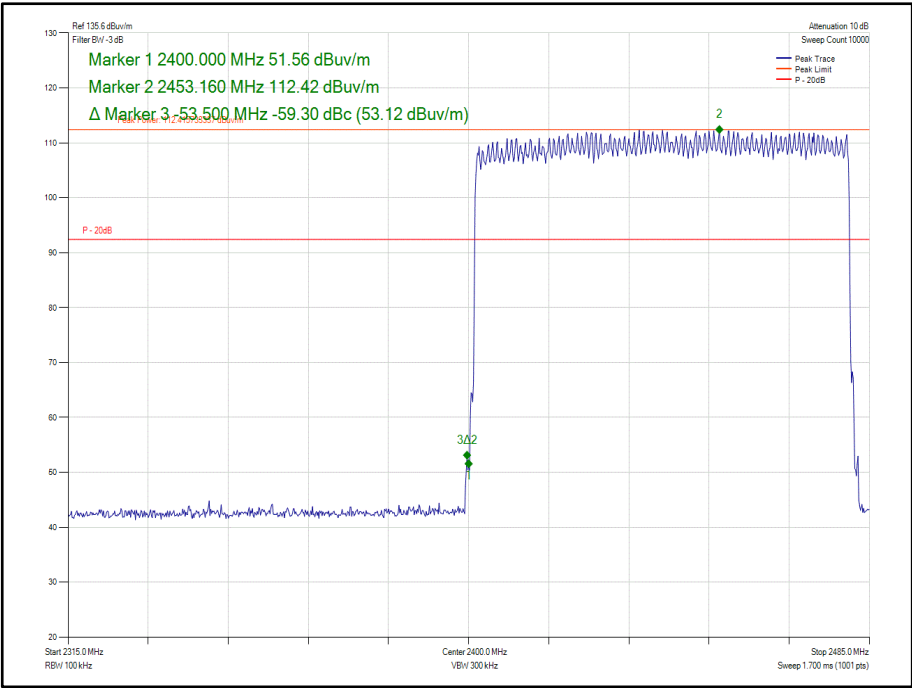


Figure 51 - Hopping - $\pi/4$ DQPSK/2DH5 - Band Edge Frequency 2400.0 MHz

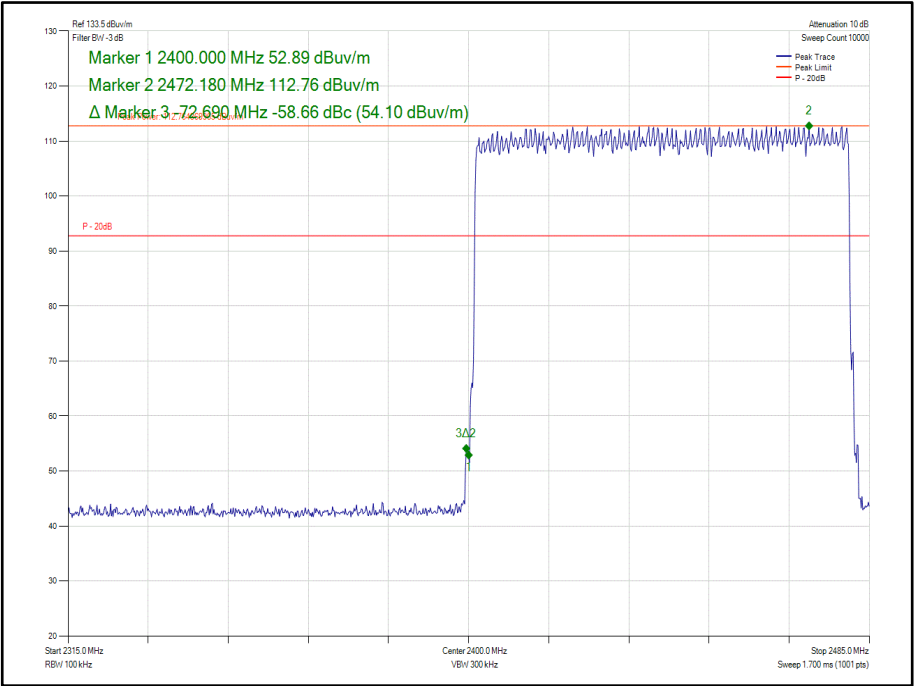


Figure 52 - Hopping - 8-DPSK/3DH5 - Band Edge Frequency 2400.0 MHz

2.4 GHz Bluetooth - BR/EDR iPA

Mode	Modulation	Packet Type	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
Static	GFSK	DH5	2402	2400.0	-53.02
Static	$\pi/4$ DQPSK	2DH5	2402	2400.0	-40.88
Static	8-DPSK	3DH5	2402	2400.0	-40.56
Hopping	GFSK	DH5	2402	2400.0	-63.94
Hopping	$\pi/4$ DQPSK	2DH5	2402	2400.0	-46.52
Hopping	8-DPSK	3DH5	2402	2400.0	-45.28

Table 18 - Authorised Band Edge Results

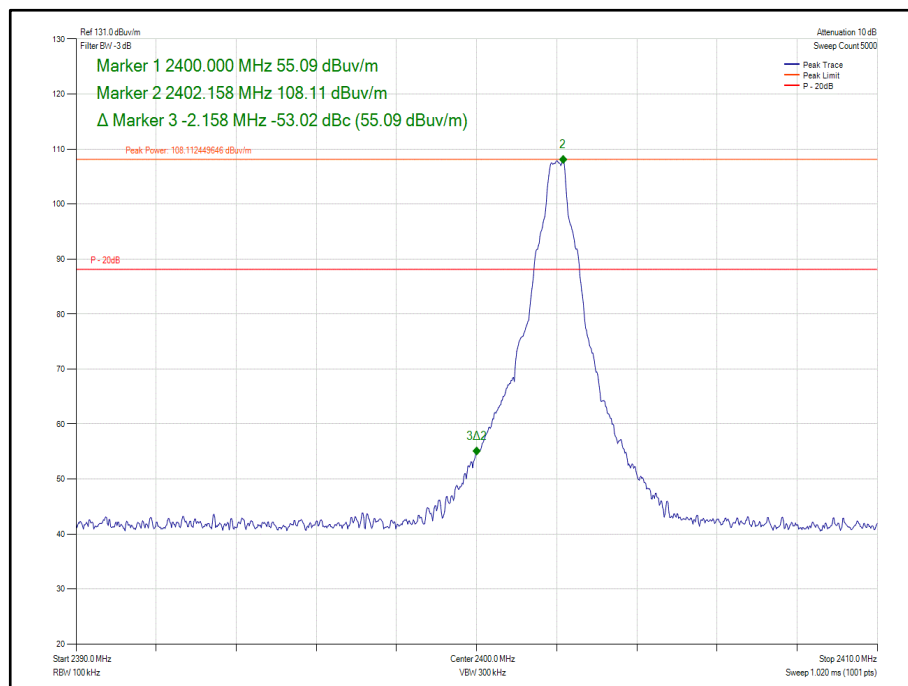


Figure 53 - Static - GFSK/DH5 - 2402 MHz - Band Edge Frequency 2400.0 MHz

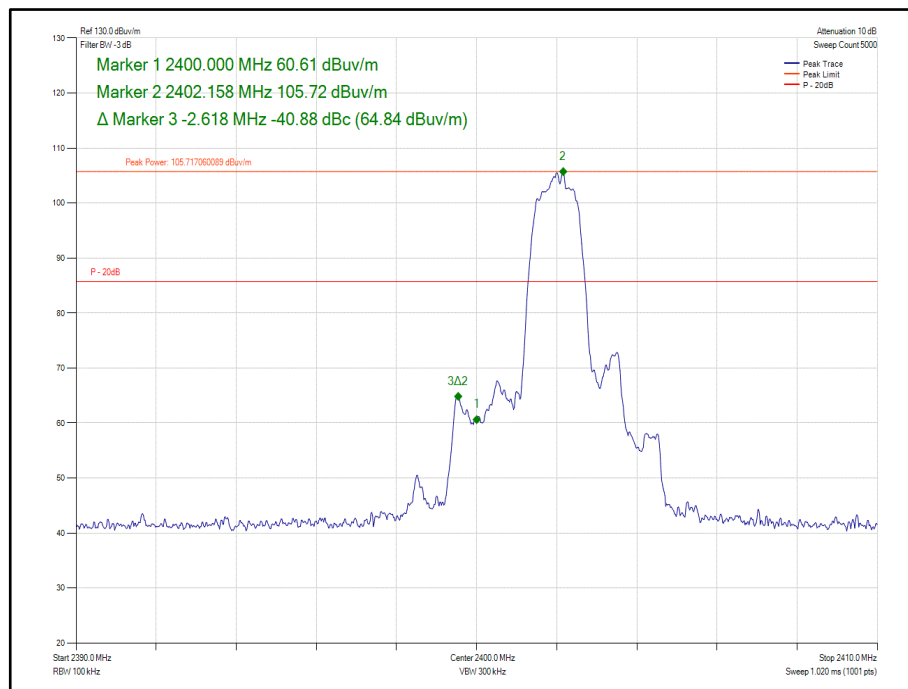


Figure 54 - Static - $\pi/4$ DQPSK/2DH5 - 2402 MHz - Band Edge Frequency 2400.0 MHz

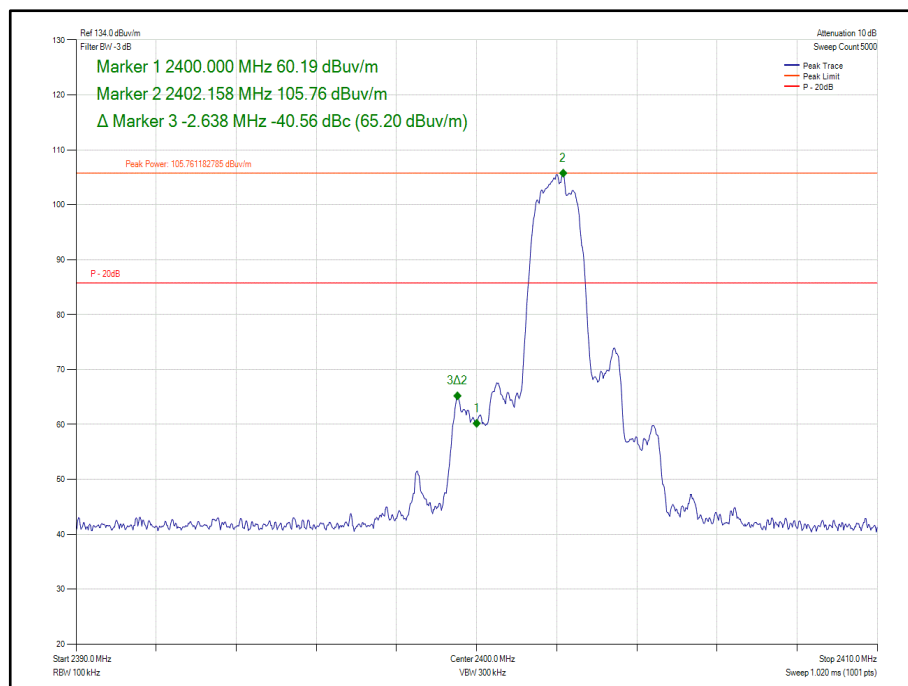


Figure 55 - Static - 8-DPSK/3DH5 - 2402 MHz - Band Edge Frequency 2400.0 MHz

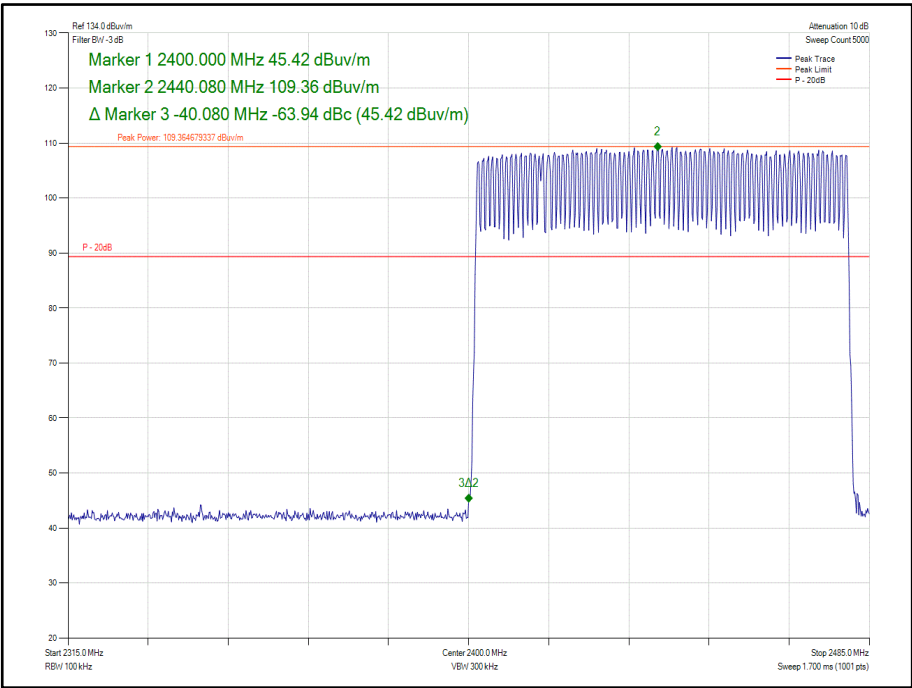


Figure 56 - Hopping - GFSK/DH5 - Band Edge Frequency 2400.0 MHz

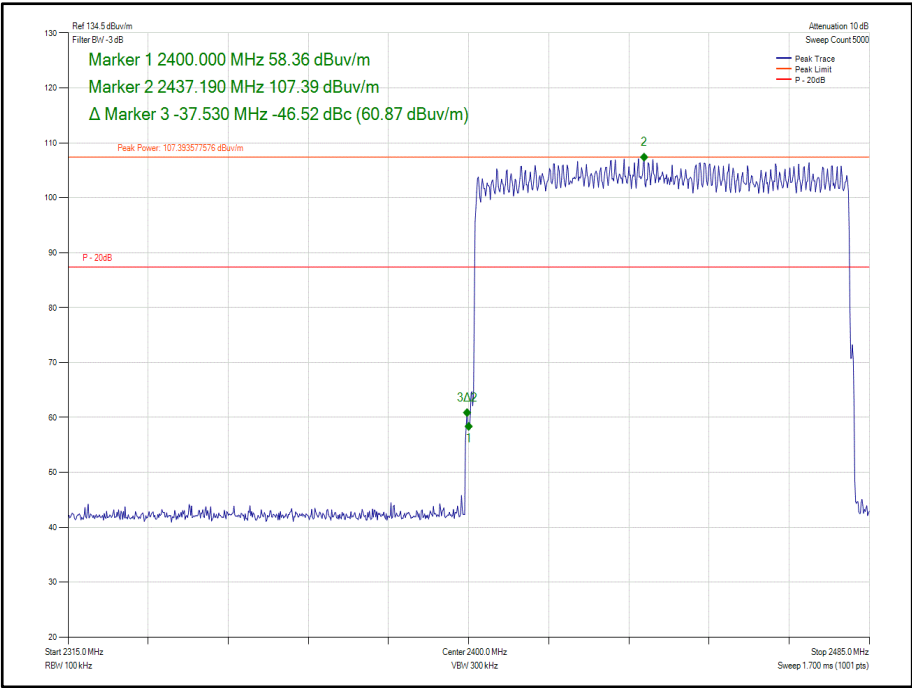


Figure 57 - Hopping - $\pi/4$ DQPSK/2DH5 - Band Edge Frequency 2400.0 MHz

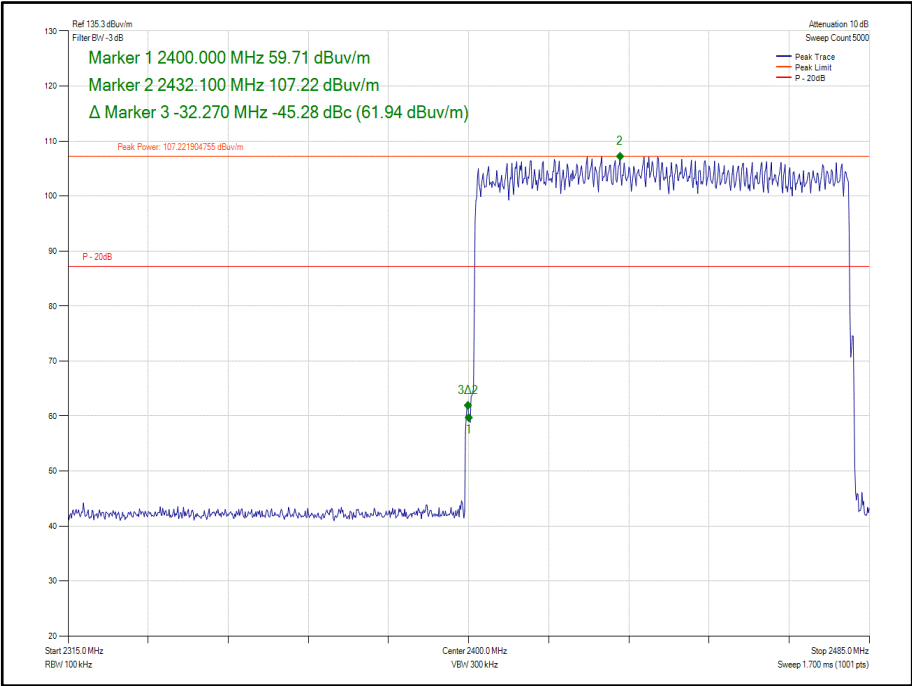


Figure 58 - Hopping - 8-DPSK/3DH5 - Band Edge Frequency 2400.0 MHz



2.6.7 Test Location and Test Equipment Used

This test was carried out in RF Chamber 11.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
10dB/1W SMA Attenuator dc - 18GHz	Sealectro	60-674-1010-89	395	-	O/P Mon
1GHz to 8GHz Low Noise Amplifier	Wright Technologies	APS04-0085	4365	12	14-Nov-2020
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	11-Mar-2020
Hygrometer	Rotronic	HP21	4989	12	02-May-2020
EMI Test Receiver	Rohde & Schwarz	ESW44	5084	12	28-Nov-2020
Cable (18 GHz)	Rosenberger	LU7-071-1000	5103	12	06-Oct-2020
Cable (18 GHz)	Rosenberger	LU7-071-1000	5104	12	09-Dec-2020
Cable (18 GHz)	Rosenberger	LU7-071-1000	5105	12	06-Oct-2020
Cable (18 GHz)	Rosenberger	LU7-071-2000	5107	12	06-Oct-2020
EmX Emissions Software	TUV SUD	EmX	5125	-	Software
Screened Room (11)	Rainford	Rainford	5136	36	01-Nov-2021
Mast	Maturo	TAM 4.0-P	5158	-	TU
Mast and Turntable Controller	Maturo	Maturo NCD	5159	-	TU
Turntable	Maturo	TT 15WF	5160	-	TU
8 Meter Cable	Teledyne	PR90-088-8MTR	5212	12	30-Aug-2020
Horn Antenna (1-10GHz)	Schwarzbeck	BBHA 9120 B	5215	12	11-Mar-2020
Pre Amp 1 - 26.5 GHz	Agilent Technologies	8449B	5445	-	O/P Mon

Table 19

TU - Traceability Unscheduled

O/P Mon - Output Monitored using calibrated equipment



2.7 Restricted Band Edges

2.7.1 Specification Reference

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

2.7.2 Equipment Under Test and Modification State

A2289, S/N: C02ZG009P09V - Modification State 0

2.7.3 Date of Test

19-November-2019 to 20-December-2019

2.7.4 Test Method

This test 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 4.1.4.2.5. These are shown for information purposes and were used to determine the worst case measurement point. Final average measurements were then taken in accordance with ANSI C63.10 clause 4.1.4.2.2. to obtain the measurement result recorded in the test results tables.

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

2.7.5 Environmental Conditions

Ambient Temperature	21.8 °C
Relative Humidity	50.9 %

2.7.6 Test Results

2.4 GHz Bluetooth - BR/EDR ePA

Mode	Modulation	Packet Type	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBμV/m)	Average Level (dBμV/m)
Static	GFSK	DH5	2402	2390.0	53.87	39.76
Static	$\pi/4$ DQPSK	2DH5	2402	2390.0	53.74	39.6
Static	8-DPSK	3DH5	2402	2390.0	54.17	39.62
Static	GFSK	DH5	2480	2483.5	55.25	42.59
Static	$\pi/4$ DQPSK	2DH5	2480	2483.5	55.66	42.17
Static	8-DPSK	3DH5	2480	2483.5	55.26	42.34

Table 20 - Restricted Band Edge Results

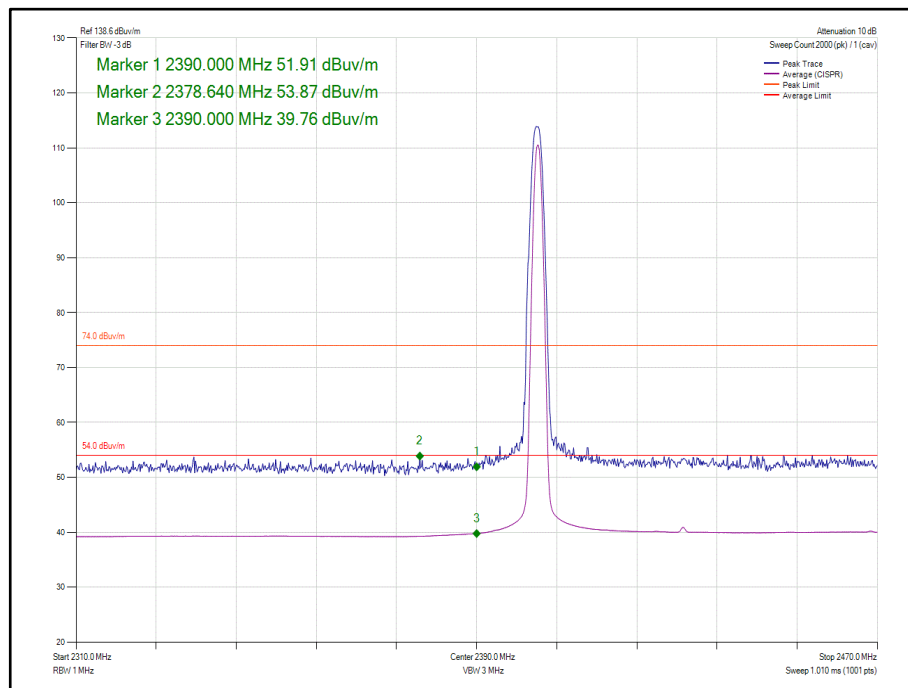


Figure 59 - Static - GFSK/DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

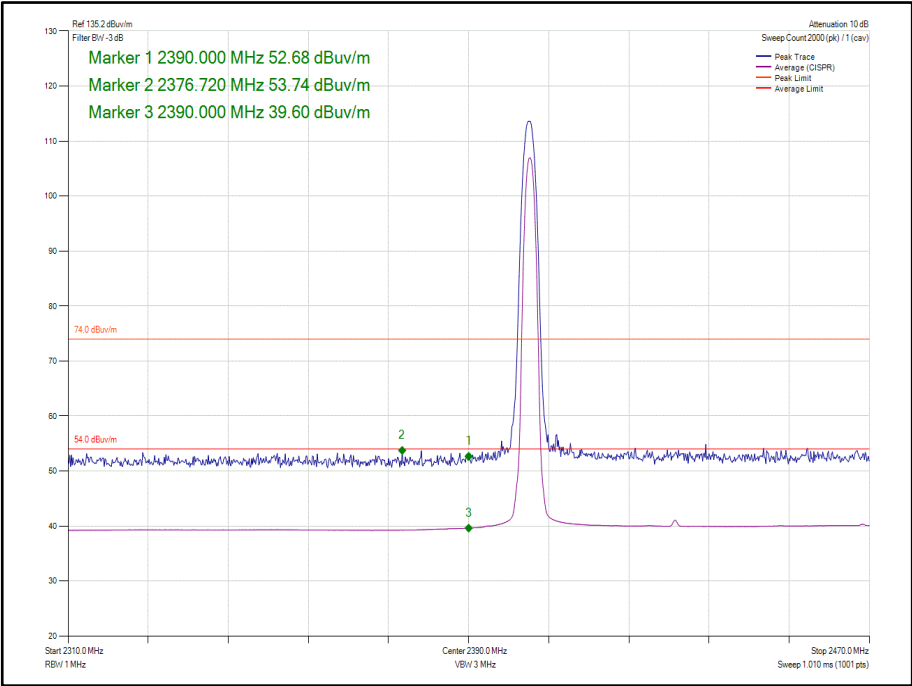


Figure 60 - Static - $\pi/4$ DQPSK/2DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

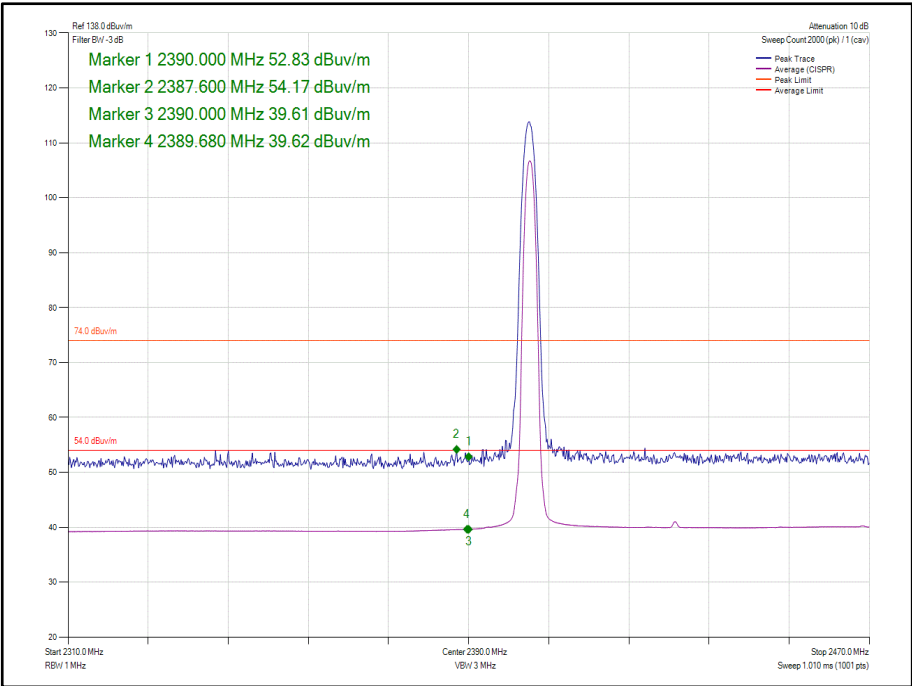


Figure 61 - Static - 8-DPSK/3DH5 - 2402 MHz Band Edge Frequency 2390.0 MHz

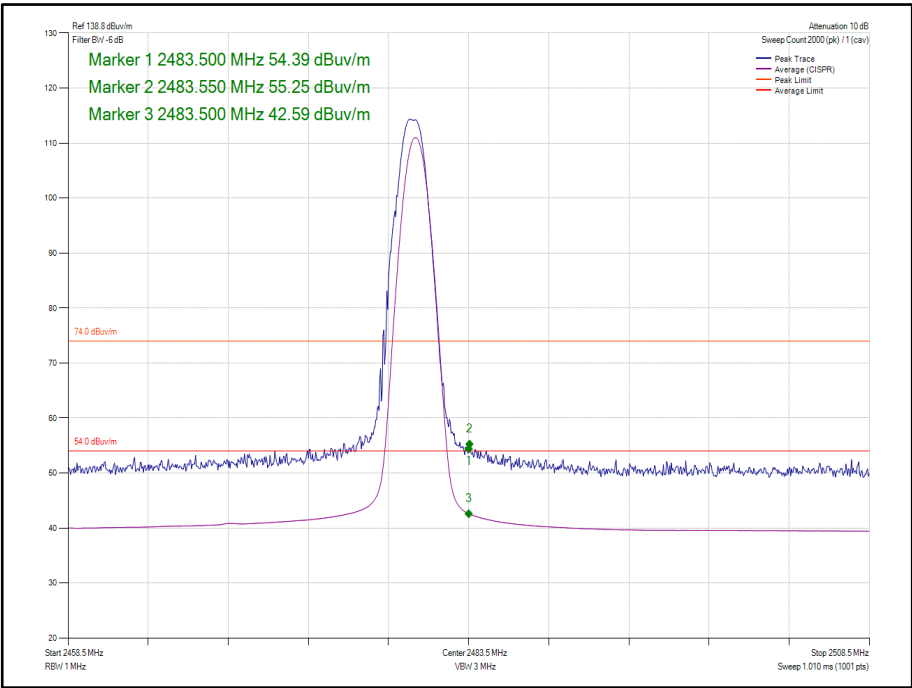


Figure 62 - Static - GFSK/DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

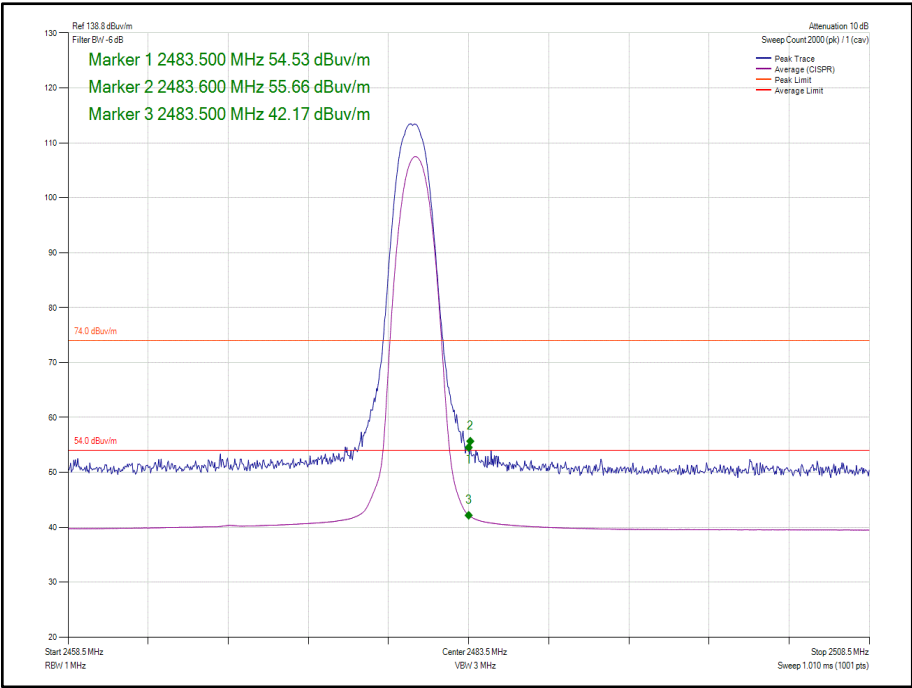


Figure 63 - Static - $\pi/4$ DQPSK/2DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

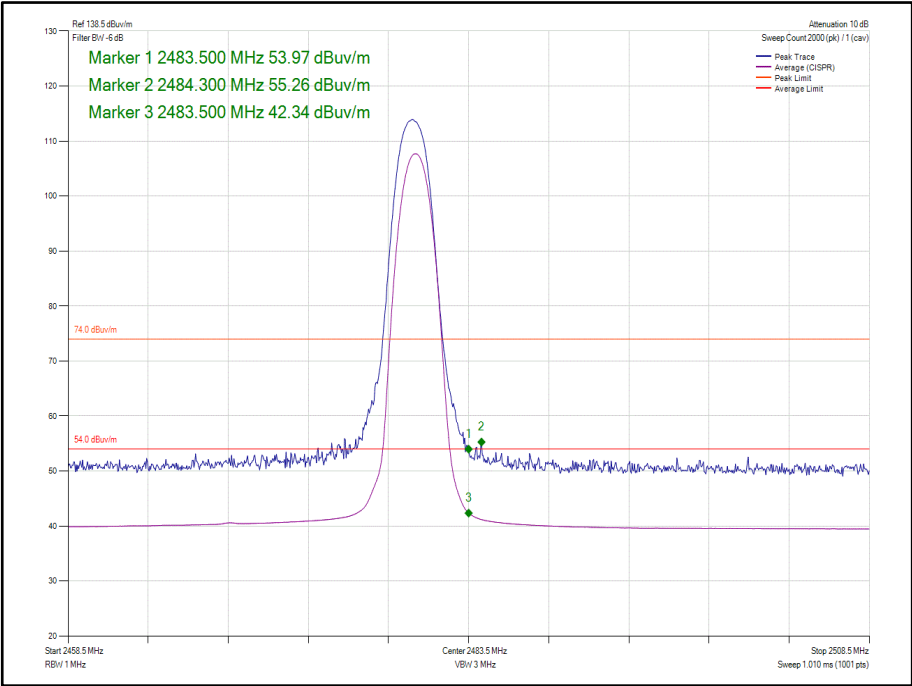


Figure 64 - Static - 8-DPSK/3DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

2.4 GHz Bluetooth - BR/EDR iPA

Mode	Modulation	Packet Type	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBμV/m)	Average Level (dBμV/m)
Static	GFSK	DH5	2402	2390.0	53.70	39.35
Static	$\pi/4$ DQPSK	2DH5	2402	2390.0	53.88	39.27
Static	8-DPSK	3DH5	2402	2390.0	55.34	39.28
Static	GFSK	DH5	2480	2483.5	52.20	39.92
Static	$\pi/4$ DQPSK	2DH5	2480	2483.5	53.69	41.24
Static	8-DPSK	3DH5	2480	2483.5	54.19	41.13

Table 21 - Restricted Band Edge Results

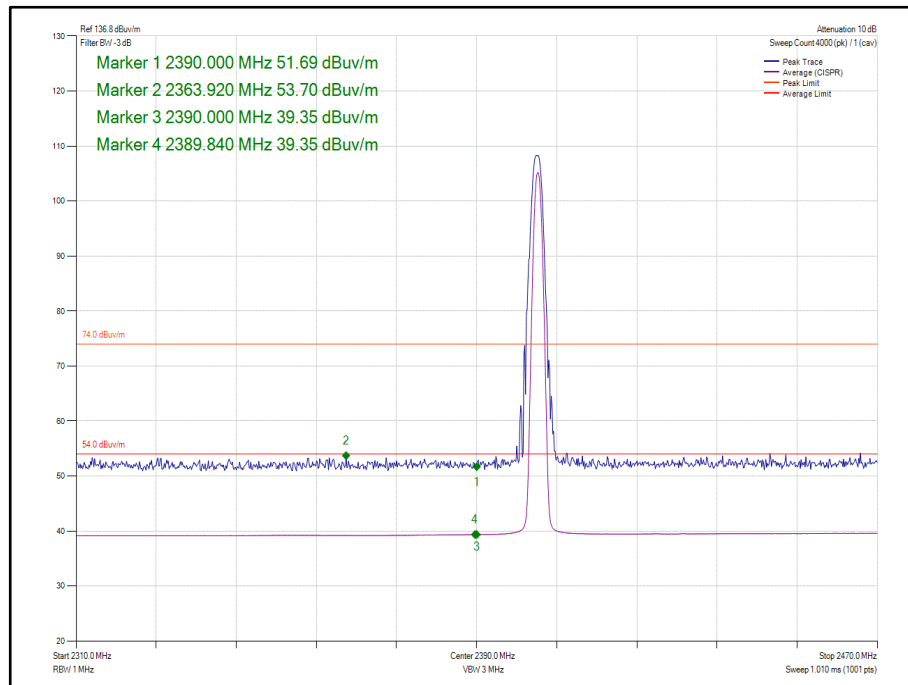


Figure 65 - Static - GFSK/DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

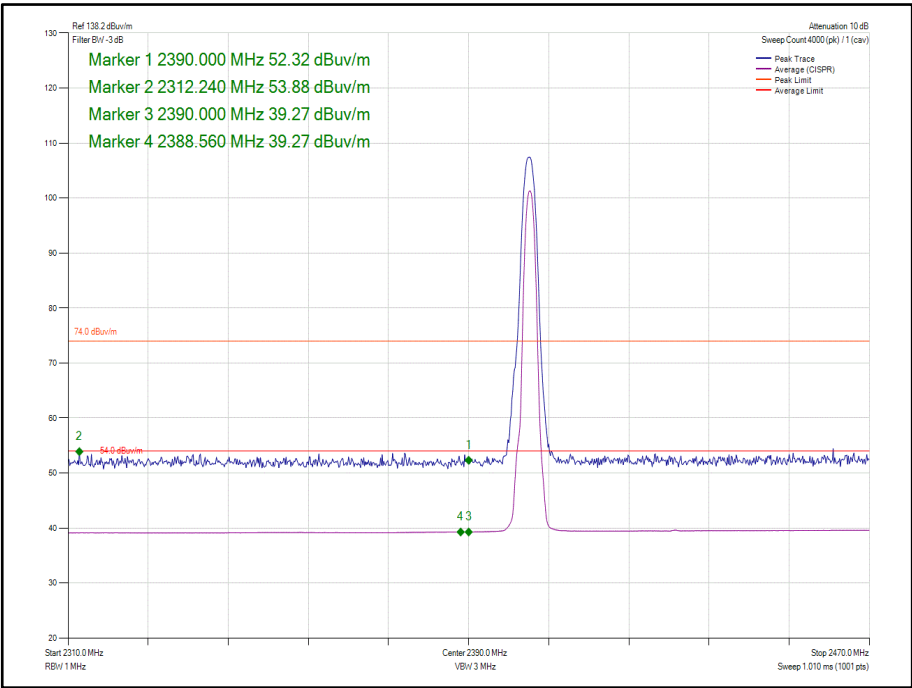


Figure 66 - Static - $\pi/4$ DQPSK/2DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

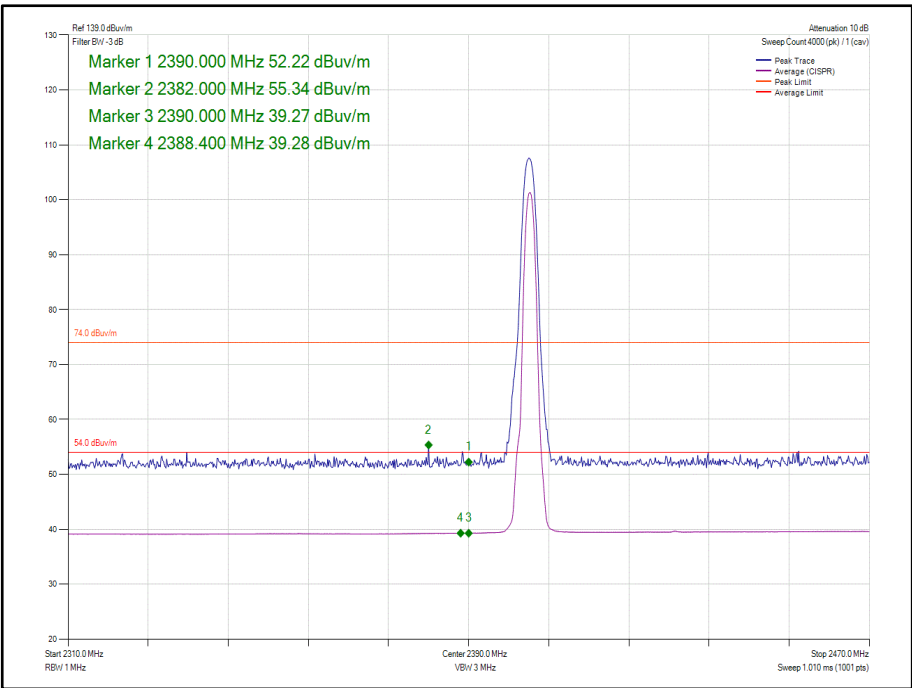


Figure 67 - Static - 8-DPSK/3DH5 - 2402 MHz Band Edge Frequency 2390.0 MHz

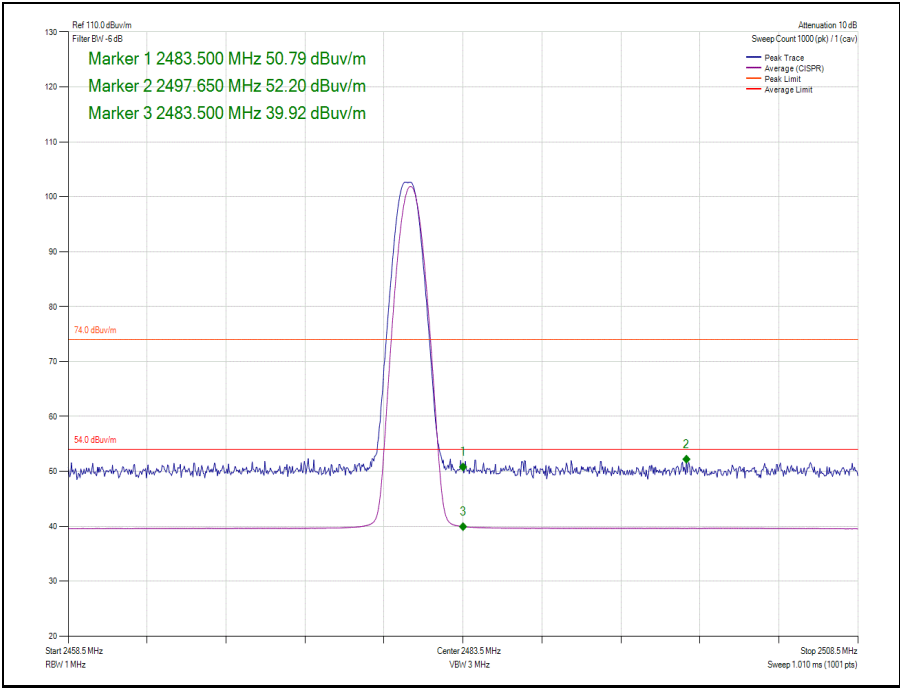


Figure 68 - Static - GFSK/DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

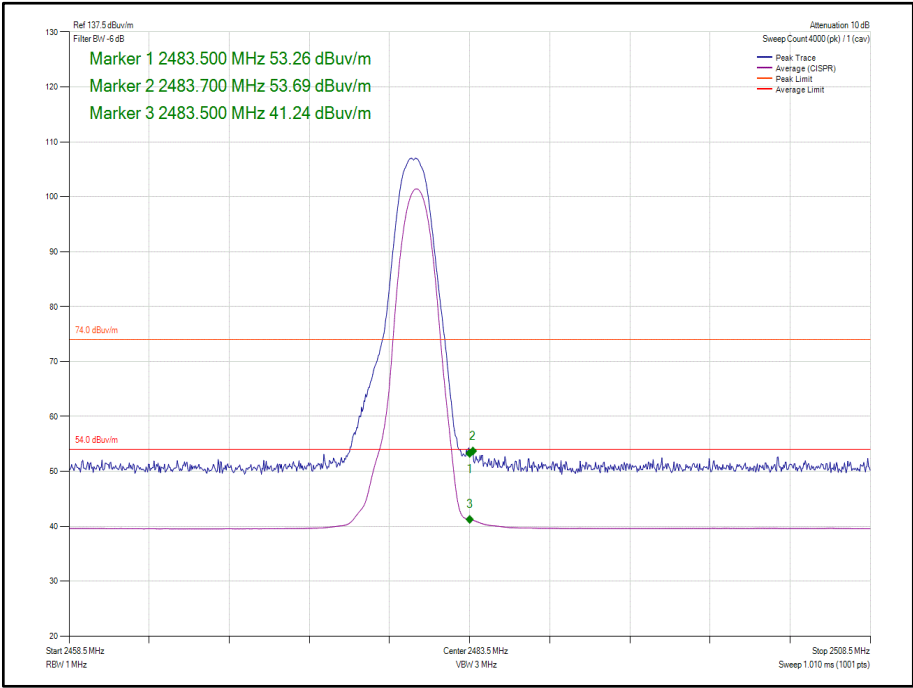


Figure 69 - Static - $\pi/4$ DQPSK/2DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

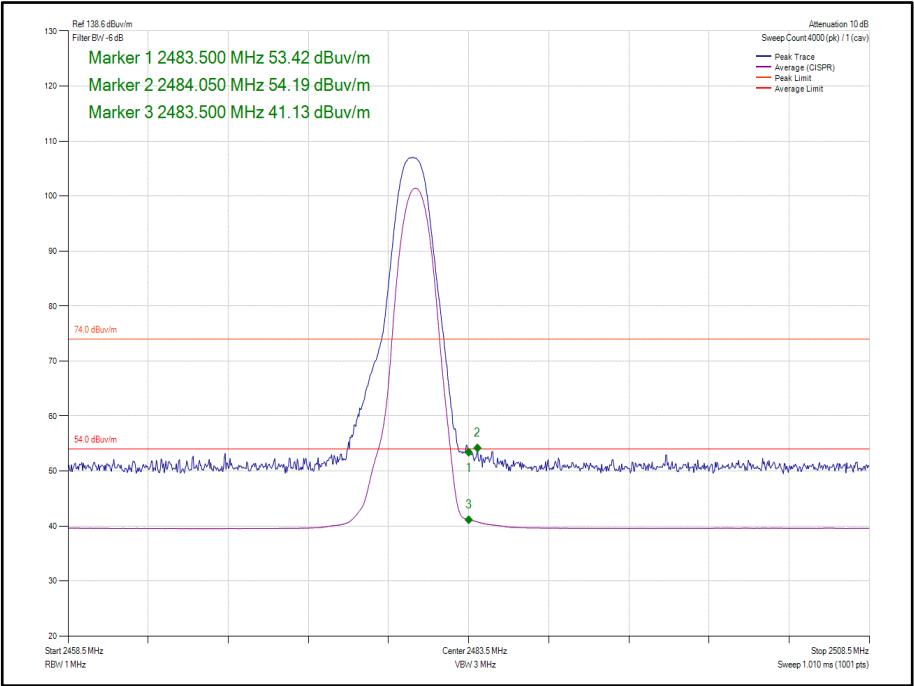


Figure 70 - Static - 8-DPSK/3DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz



2.7.7 Test Location and Test Equipment Used

This test was carried out in RF Chamber 11.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
10dB/1W SMA Attenuator dc - 18GHz	Sealectro	60-674-1010-89	395	-	O/P Mon
1GHz to 8GHz Low Noise Amplifier	Wright Technologies	APS04-0085	4365	12	14-Nov-2020
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	11-Mar-2020
Hygrometer	Rotronic	HP21	4989	12	02-May-2020
EMI Test Receiver	Rohde & Schwarz	ESW44	5084	12	28-Nov-2020
Cable (18 GHz)	Rosenberger	LU7-071-1000	5103	12	06-Oct-2020
Cable (18 GHz)	Rosenberger	LU7-071-1000	5104	12	09-Dec-2020
Cable (18 GHz)	Rosenberger	LU7-071-1000	5105	12	06-Oct-2020
Cable (18 GHz)	Rosenberger	LU7-071-2000	5107	12	06-Oct-2020
EmX Emissions Software	TUV SUD	EmX	5125	-	Software
Screened Room (11)	Rainford	Rainford	5136	36	01-Nov-2021
Mast	Maturo	TAM 4.0-P	5158	-	TU
Mast and Turntable Controller	Maturo	Maturo NCD	5159	-	TU
Turntable	Maturo	TT 15WF	5160	-	TU
8 Meter Cable	Teledyne	PR90-088-8MTR	5212	12	30-Aug-2020
Horn Antenna (1-10GHz)	Schwarzbeck	BBHA 9120 B	5215	12	11-Mar-2020
Pre Amp 1 - 26.5 GHz	Agilent Technologies	8449B	5445	-	O/P Mon

Table 22

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
ISED RSS-247, Clause 5.5
ISED RSS-GEN, Clause 6.13

2.8.2 Equipment Under Test and Modification State

A2289, S/N: C02ZG009P09V - Modification State 0

2.8.3 Date of Test

07-November-2019 to 19-December-2019

2.8.4 Test Method

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

In the 30 MHz to 1 GHz range pre-scans were only performed on the mid channel (2440 MHz) and any emissions identified then measured on bottom (2412 MHz) and top (2472 MHz).

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 (Peak) and 30 dBc (Average) 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:
 $10^{(\text{Field Strength in dBuV/m} / 20)}$.

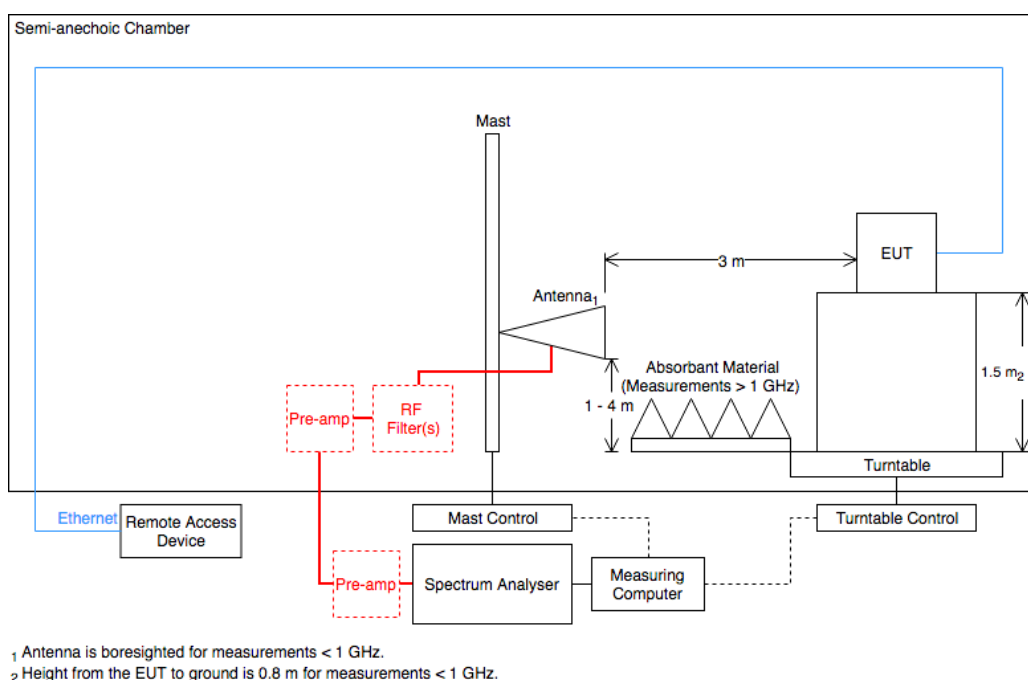


Figure 71 - Radiated Emissions Test Setup Diagram



2.8.5 Environmental Conditions

Ambient Temperature 21.8 °C
Relative Humidity 50.9 %

2.8.6 Test Results

2.4 GHz Bluetooth - BR/EDR ePA

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
*								

Table 23 – 2440 MHz, 30 MHz to 1 GHz Emissions Results

*No emissions were detected within 10 dB of the limit

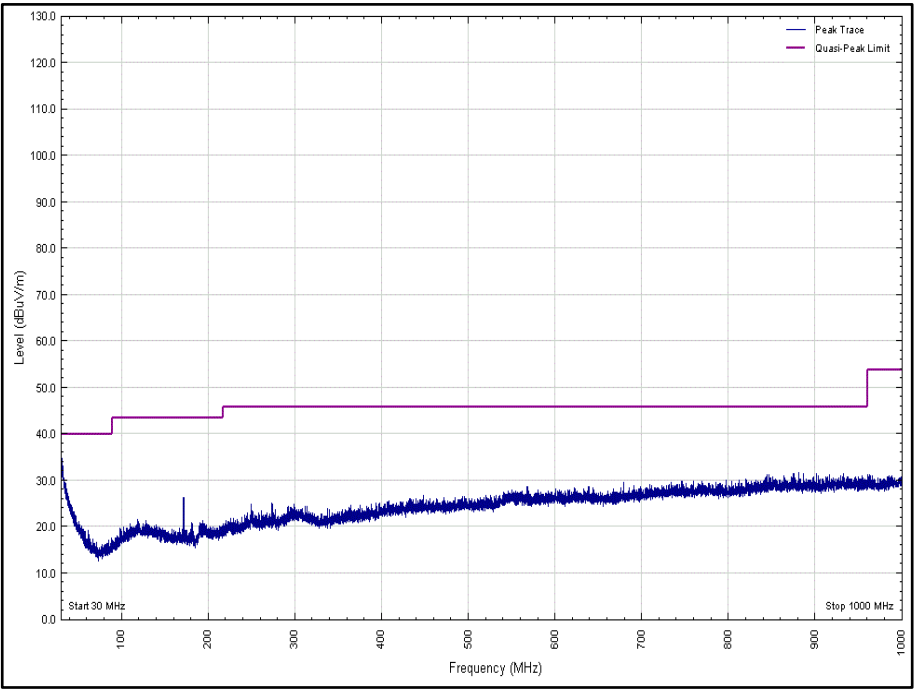


Figure 72 - 2440 MHz, 30 MHz to 1 GHz, Polarity: Horizontal

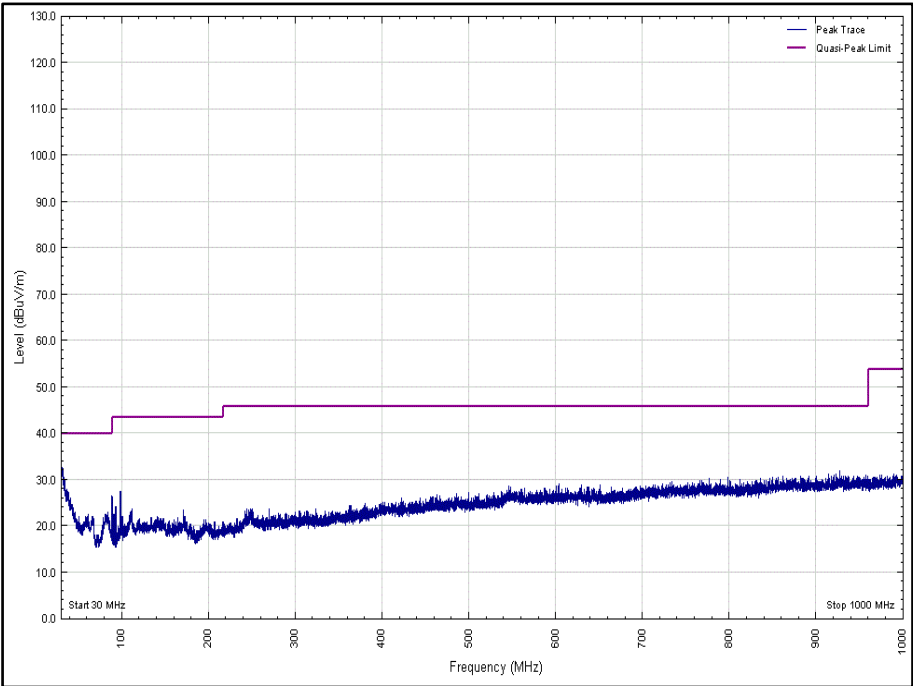


Figure 73 - 2440 MHz, 30 MHz to 1 GHz, Polarity: Vertical



Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
*								

Table 24 - 2402 MHz - 1 GHz to 26 GHz – Radiated Emissions Results

*No emissions were detected within 10 dB of the limit

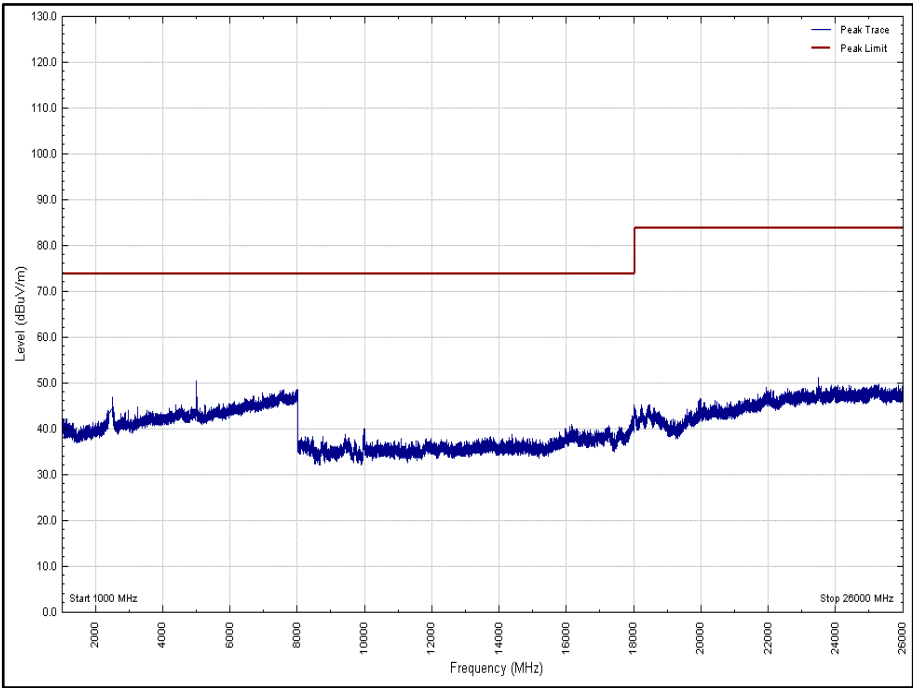


Figure 74 - 2402 MHz - 1 GHz to 26 GHz, Polarity: Horizontal (Peak)

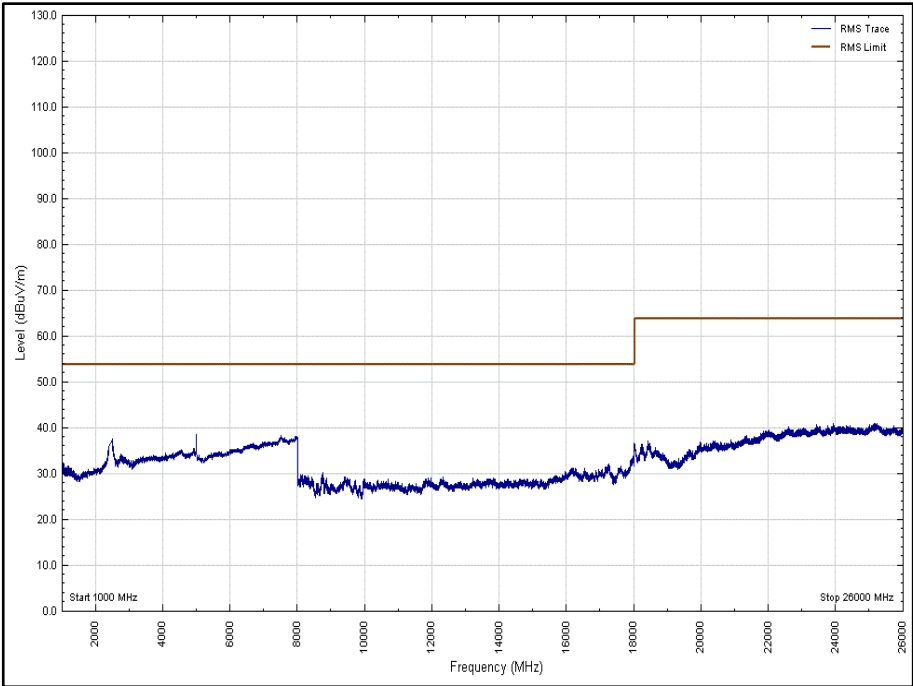


Figure 75 - 2402 MHz - 1 GHz to 26 GHz, Polarity: Horizontal (Average)

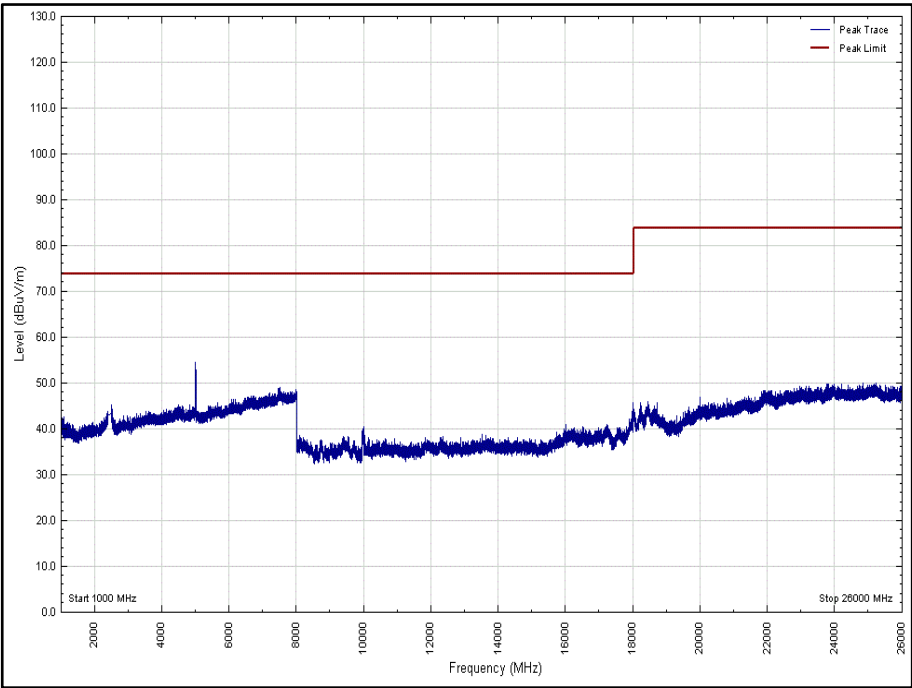


Figure 76 - 2402 MHz - 1 GHz to 26 GHz, Polarity: Vertical (Peak)

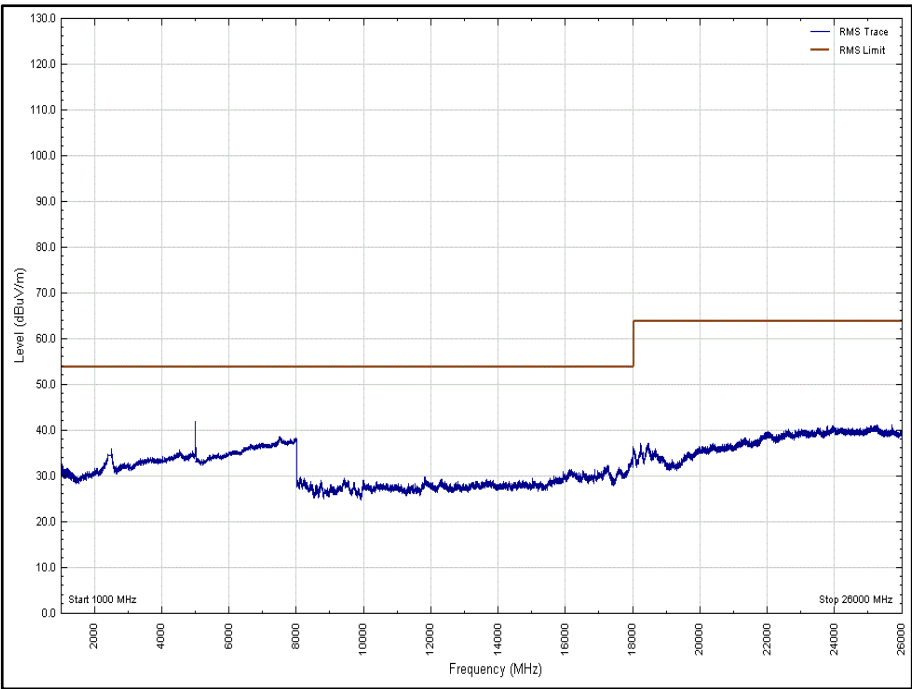


Figure 77 - 2402 MHz - 1 GHz to 26 GHz, Polarity: Vertical (Average)



Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
*								

Table 25 - 2440 MHz - 1 GHz to 26 GHz – Emissions Results

*No emissions were detected within 10 dB of the limit

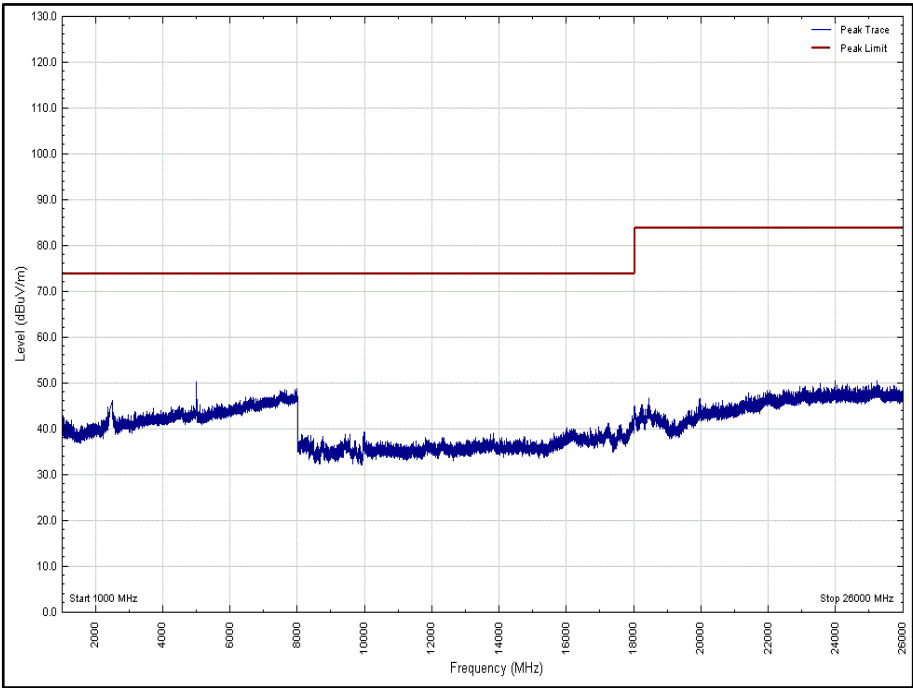


Figure 78 - 2440 MHz - 1 GHz to 26 GHz, Polarity: Horizontal (Peak)

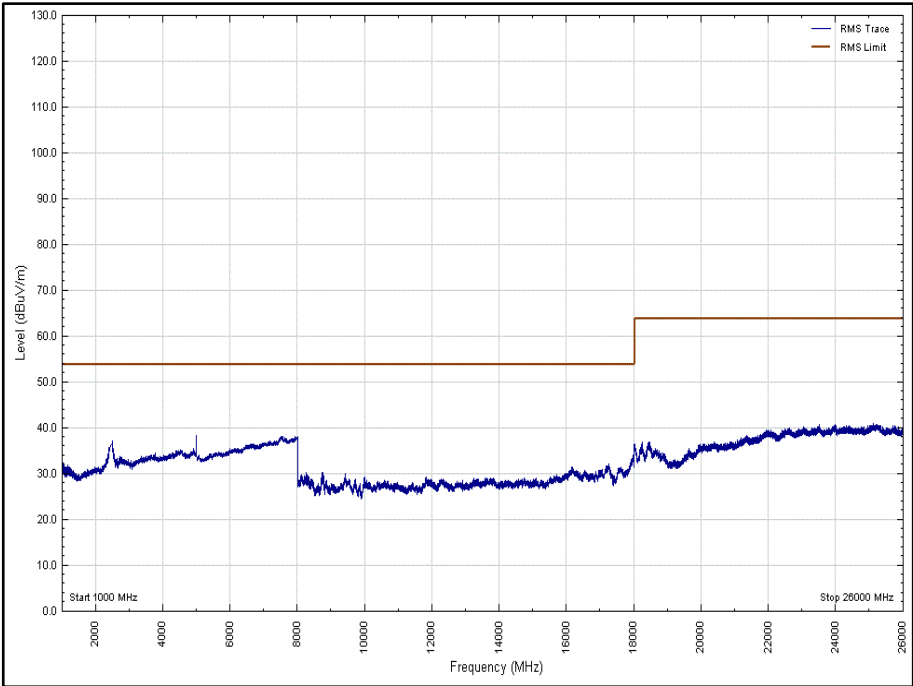


Figure 79 - 2440 MHz - 1 GHz to 26 GHz, Polarity: Horizontal (Average)

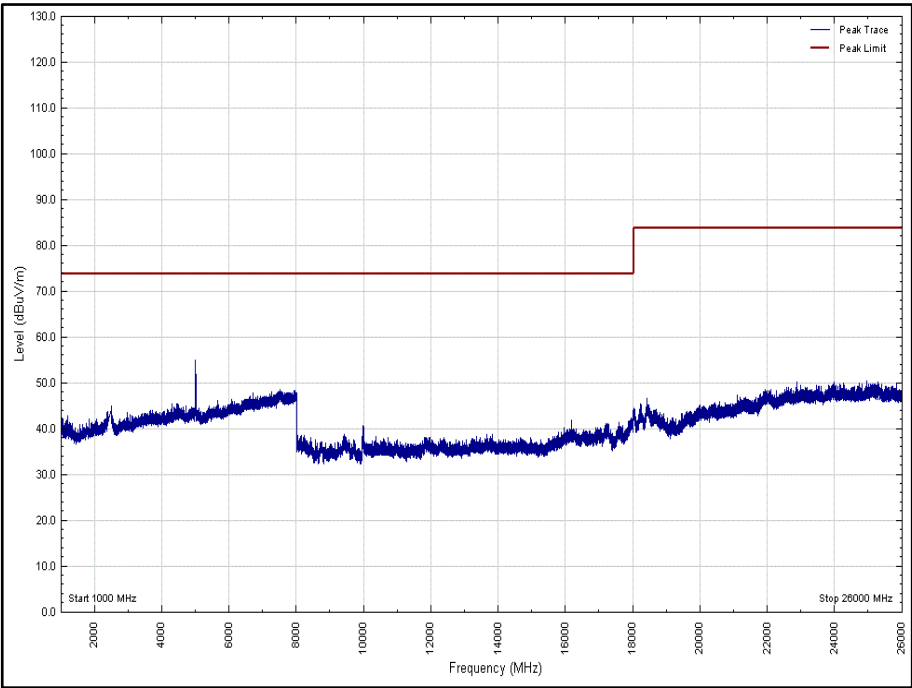


Figure 80 - 2440 MHz - 1 GHz to 26 GHz, Polarity: Vertical (Peak)

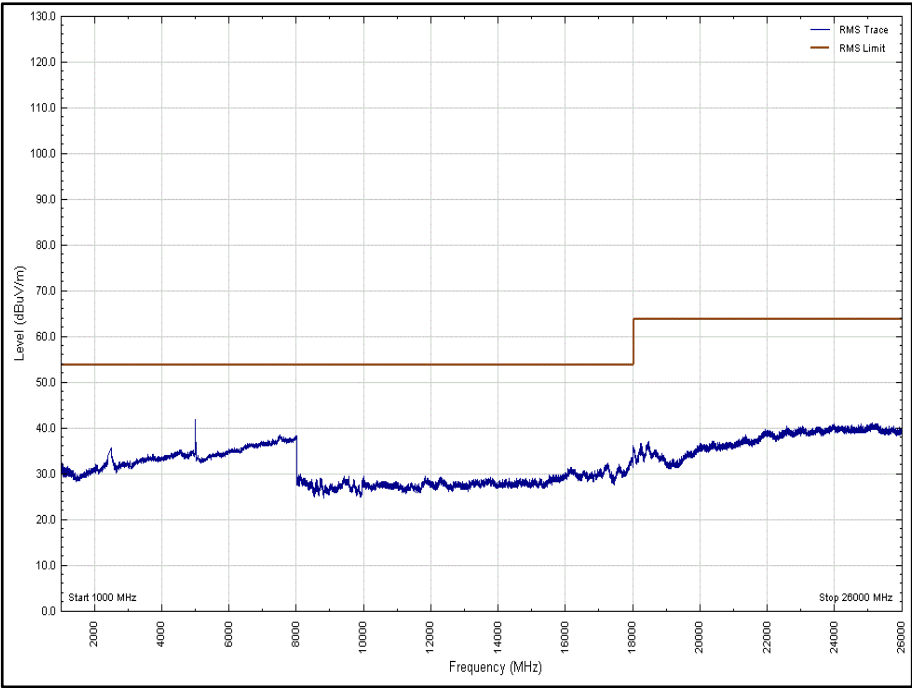


Figure 81 - 2440 MHz - 1 GHz to 26 GHz, Polarity: Vertical (Average)



Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
*								

Table 26 - 2480 MHz - 1 GHz to 26 GHz – Radiated Emissions Results

*No emissions were detected within 10 dB of the limit

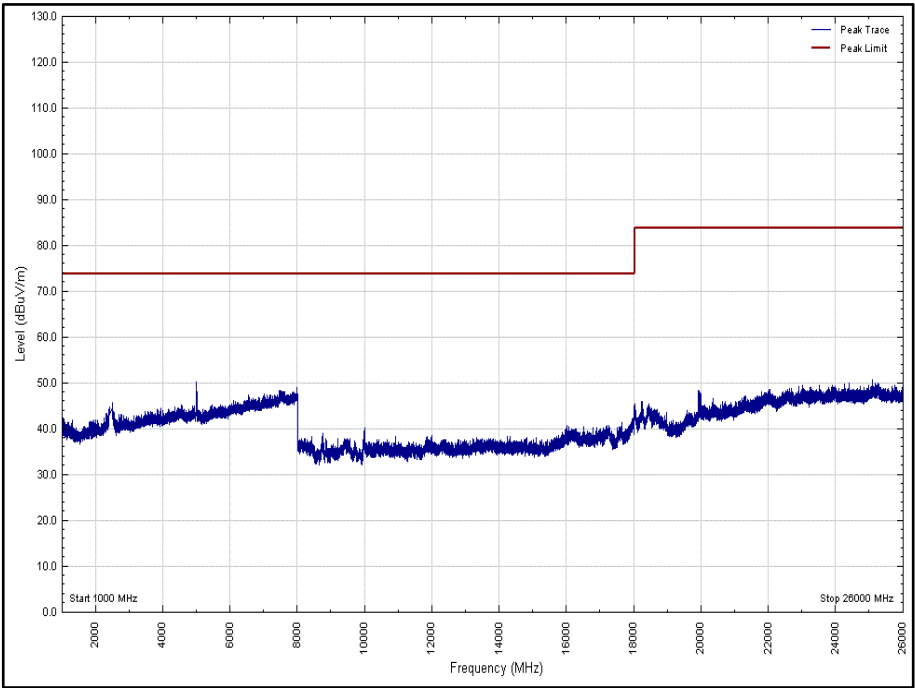


Figure 82 - 2480 MHz - 1 GHz to 26 GHz, Polarity: Horizontal (Peak)

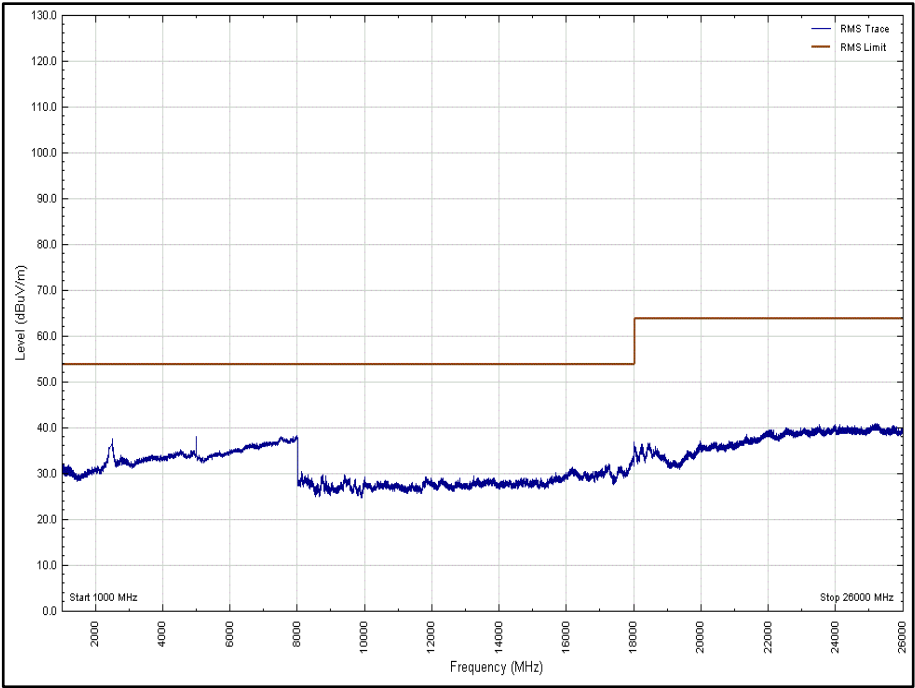


Figure 83 - 2480 MHz - 1 GHz to 26 GHz, Polarity: Horizontal (Average)

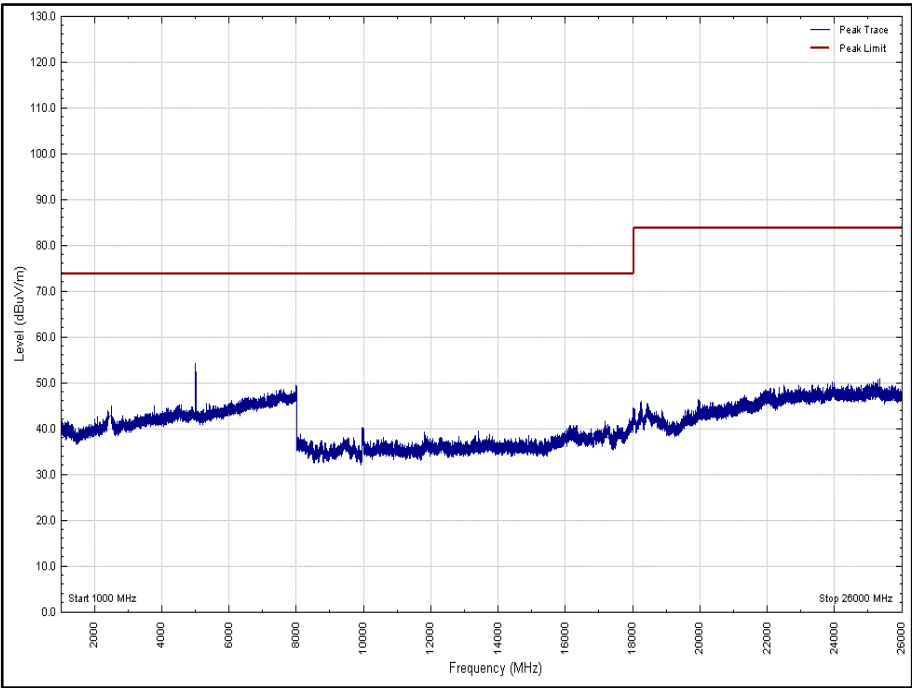


Figure 84 - 2480 MHz - 1 GHz to 26 GHz, Polarity: Vertical (Peak)

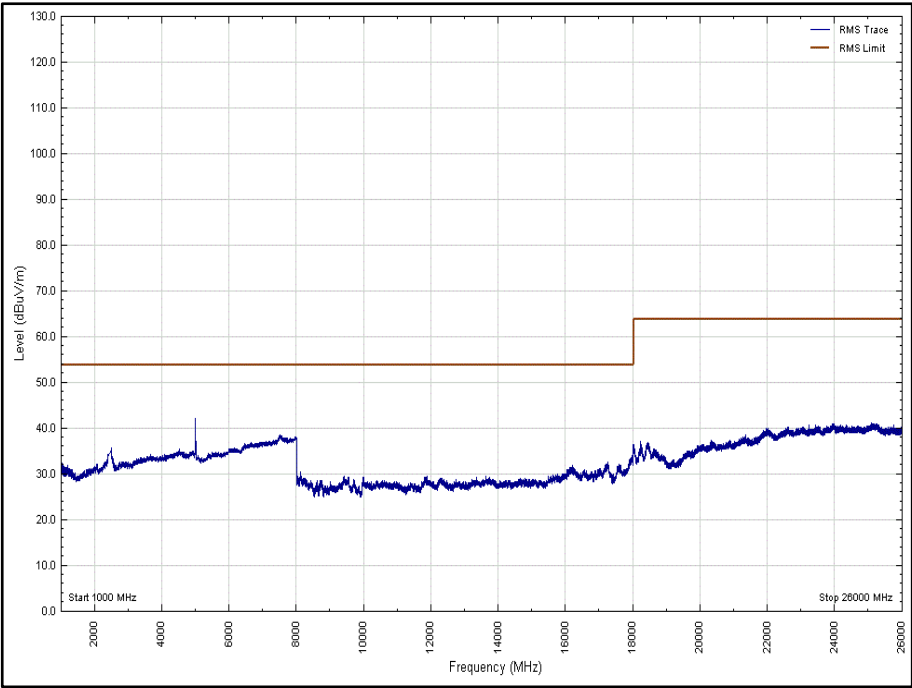


Figure 85 - 2480 MHz - 1 GHz to 26 GHz, Polarity: Vertical (Average)



2.4 GHz Bluetooth - BR/EDR iPA

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
*								

Table 27 – 2440 MHz, 30 MHz to 1 GHz Emissions Results

*No emissions were detected within 10 dB of the limit

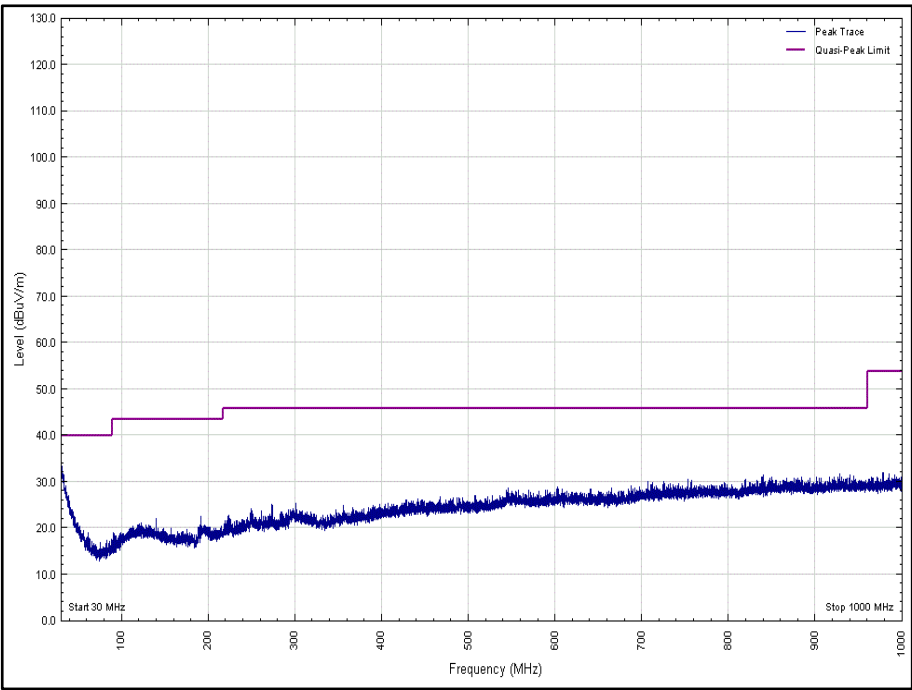


Figure 86 - 2440 MHz, 30 MHz to 1 GHz, Polarity: Horizontal

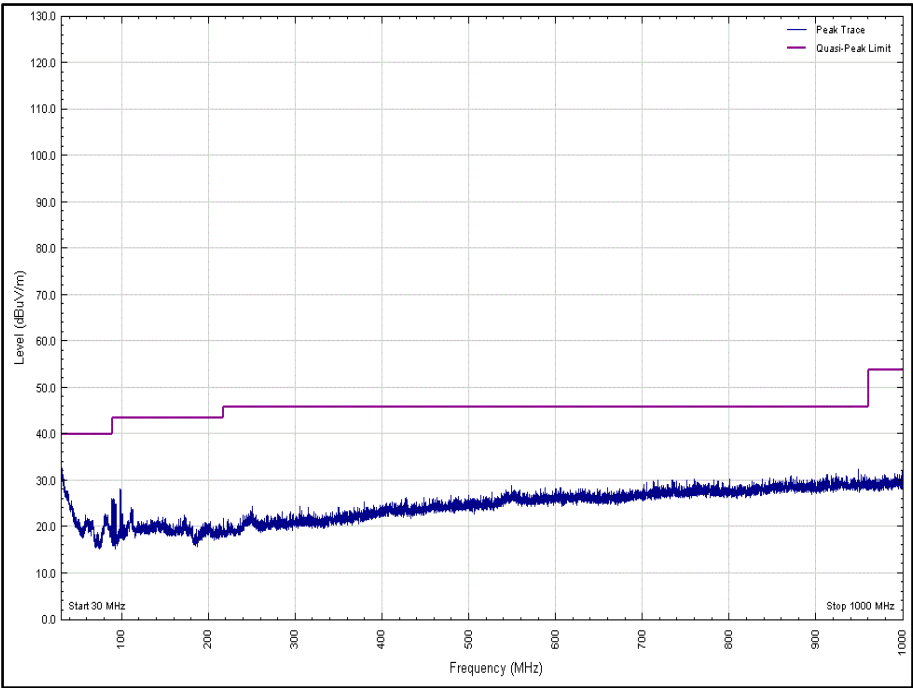


Figure 87 - 2440 MHz, 30 MHz to 1 GHz, Polarity: Vertical

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
4.981	56.89	74.00	17.11	Peak	192	220	Vertical	-
4.992	35.13	54.00	18.87	Average	192	100	Vertical	-

Table 28 - 2402 MHz - 1 GHz to 26 GHz – Emissions Results

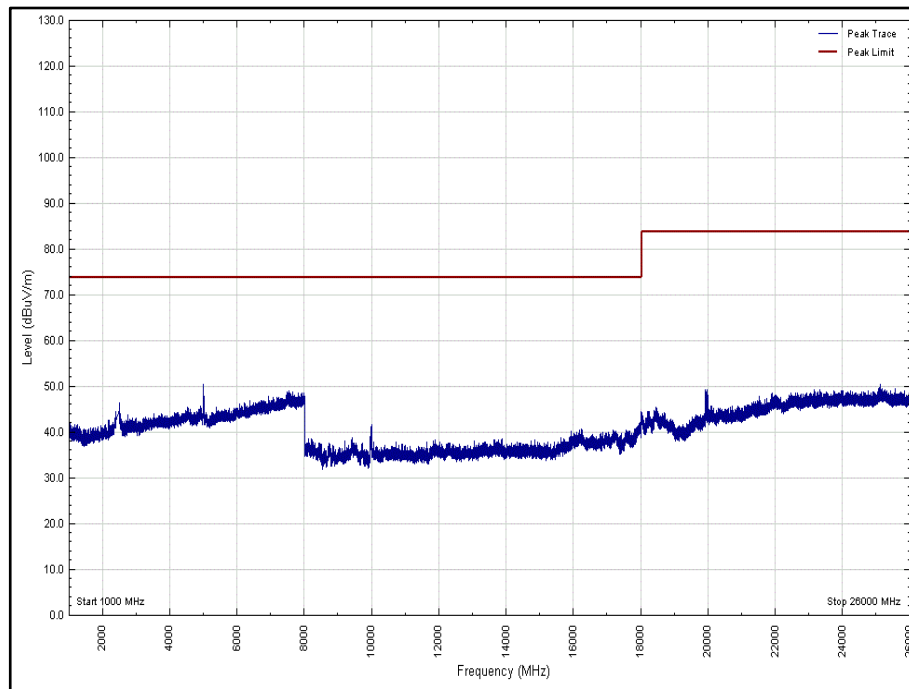


Figure 88 - 2402 MHz - 1 GHz to 26 GHz, Polarity: Horizontal (Peak)

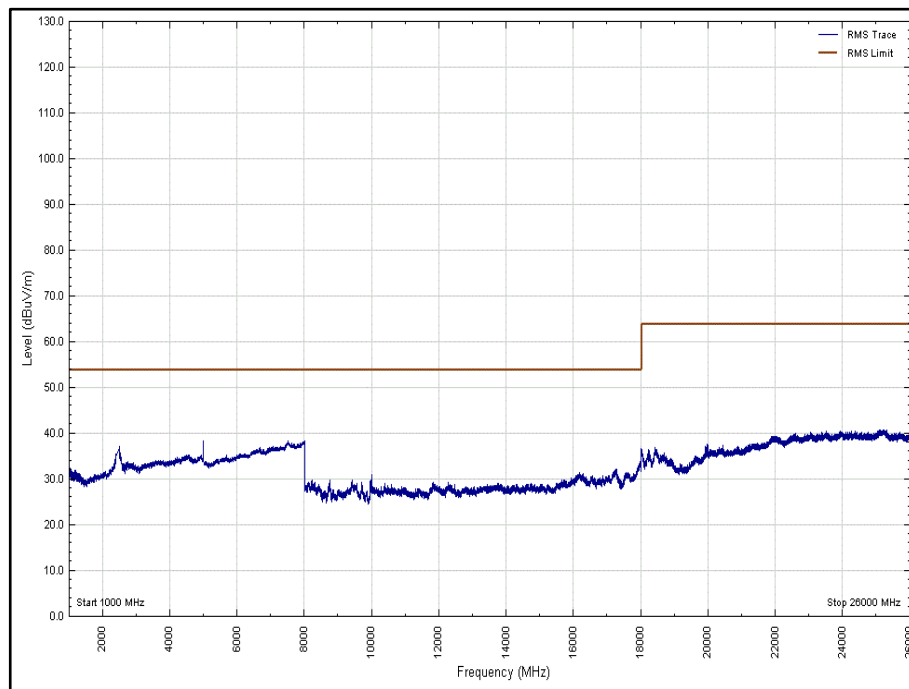


Figure 89 - 2402 MHz - 1 GHz to 26 GHz, Polarity: Horizontal (Average)

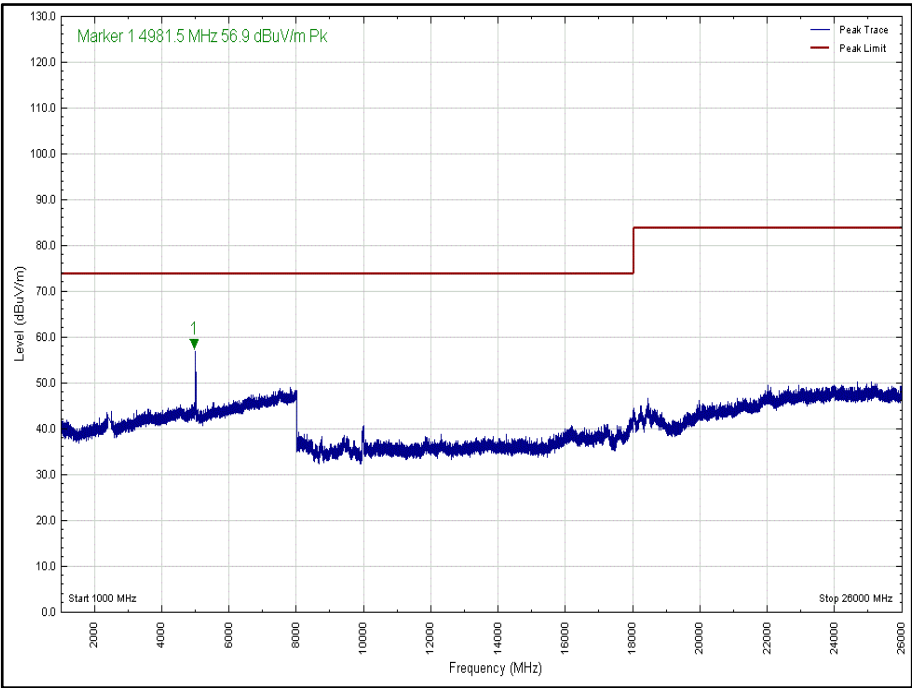


Figure 90 - 2402 MHz - 1 GHz to 26 GHz, Polarity: Vertical (Peak)

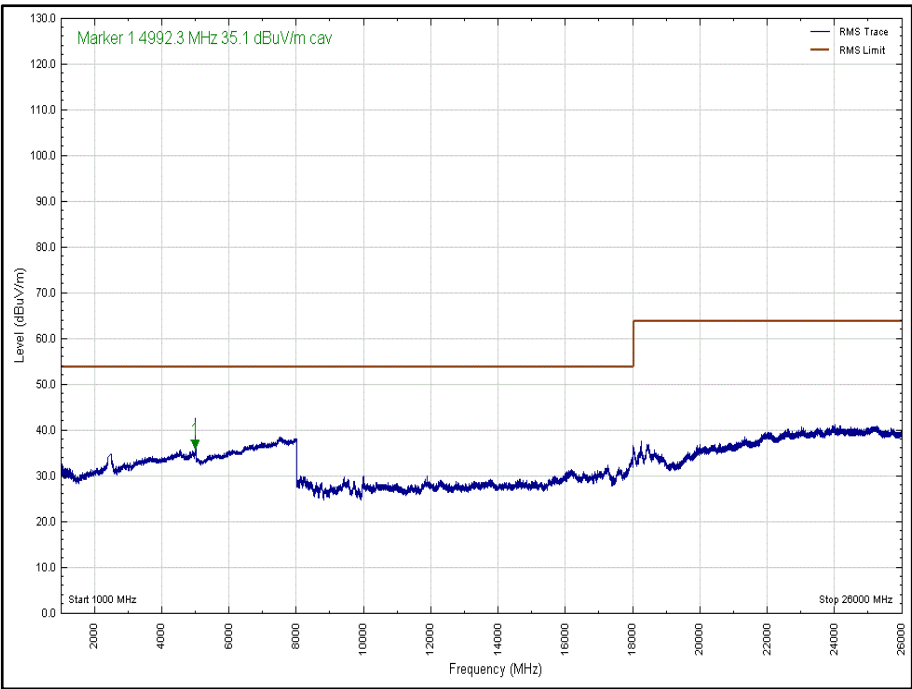


Figure 91 - 2402 MHz - 1 GHz to 26 GHz, Polarity: Vertical (Average)



Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
*								

Table 29 - 2440 MHz - 1 GHz to 26 GHz – Emissions Results

*No emissions were detected within 10 dB of the limit

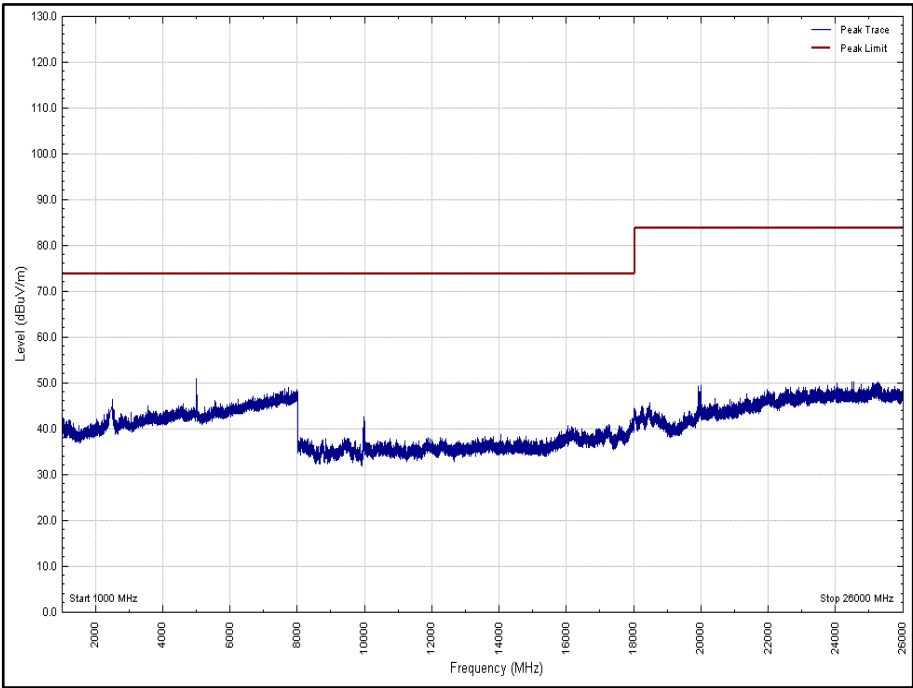


Figure 92 - 2440 MHz - 1 GHz to 26 GHz, Polarity: Horizontal (Peak)

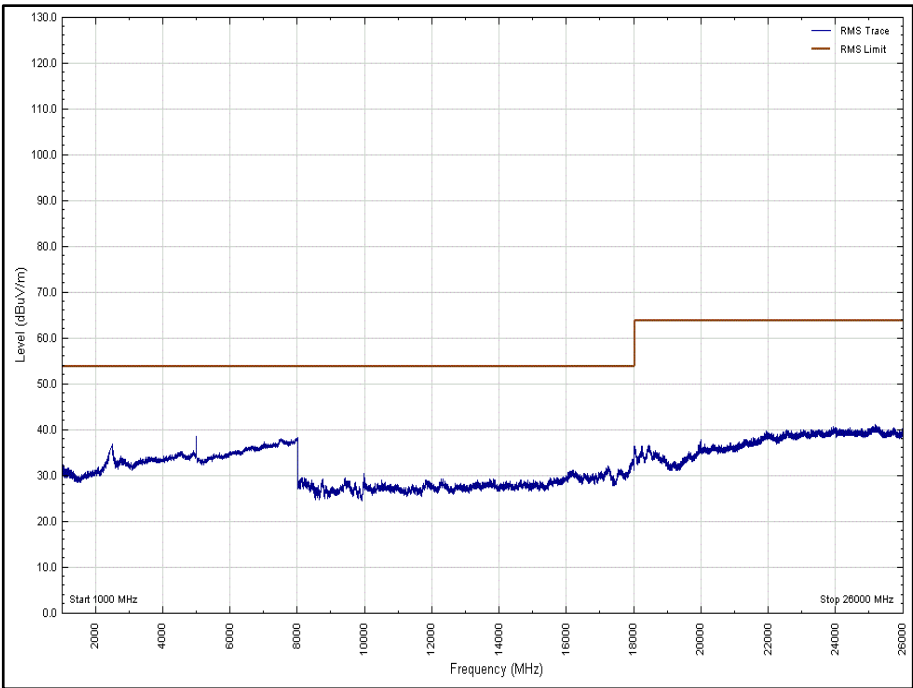


Figure 93 - 2440 MHz - 1 GHz to 26 GHz, Polarity: Horizontal (Average)

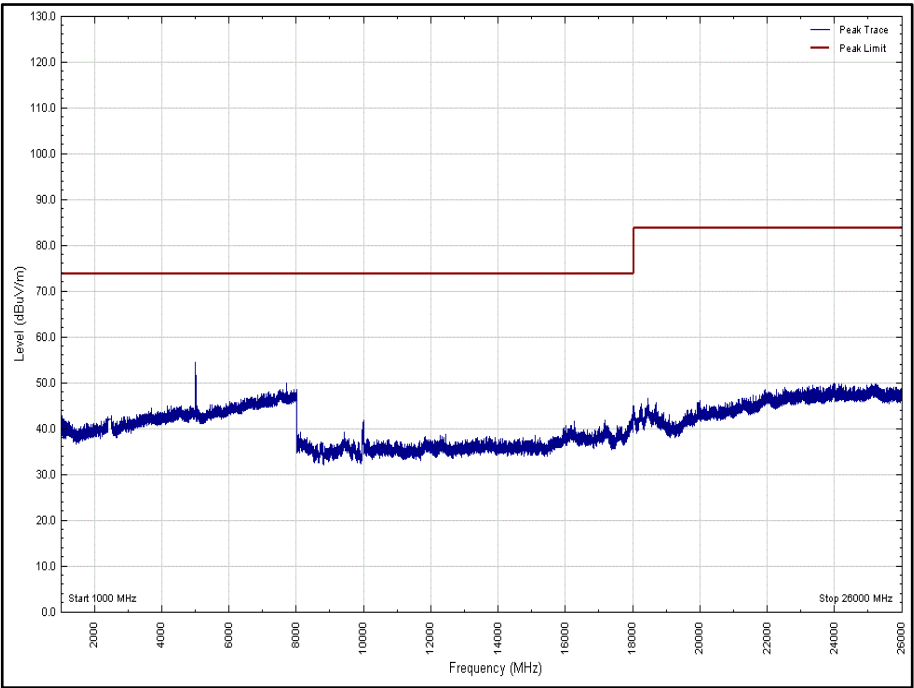


Figure 94 - 2440 MHz - 1 GHz to 26 GHz, Polarity: Vertical (Peak)

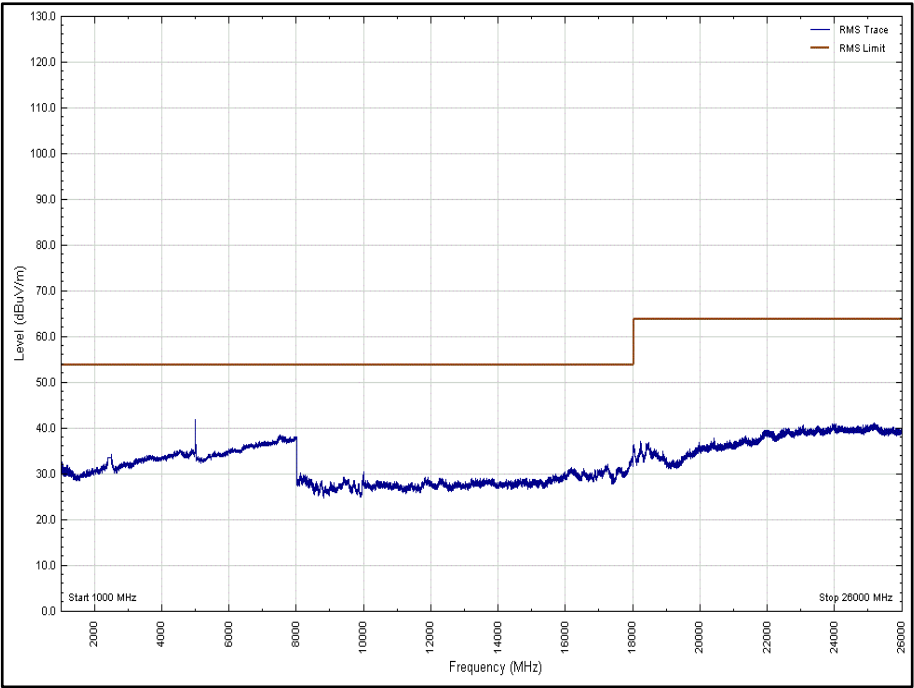


Figure 95 - 2440 MHz - 1 GHz to 26 GHz, Polarity: Vertical (Average)



Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector	Angle (°)	Height (cm)	Polarisation	Orientation
*								

Table 30 - 2480 MHz - 1 GHz to 26 GHz –Emissions Results

*No emissions were detected within 10 dB of the limit

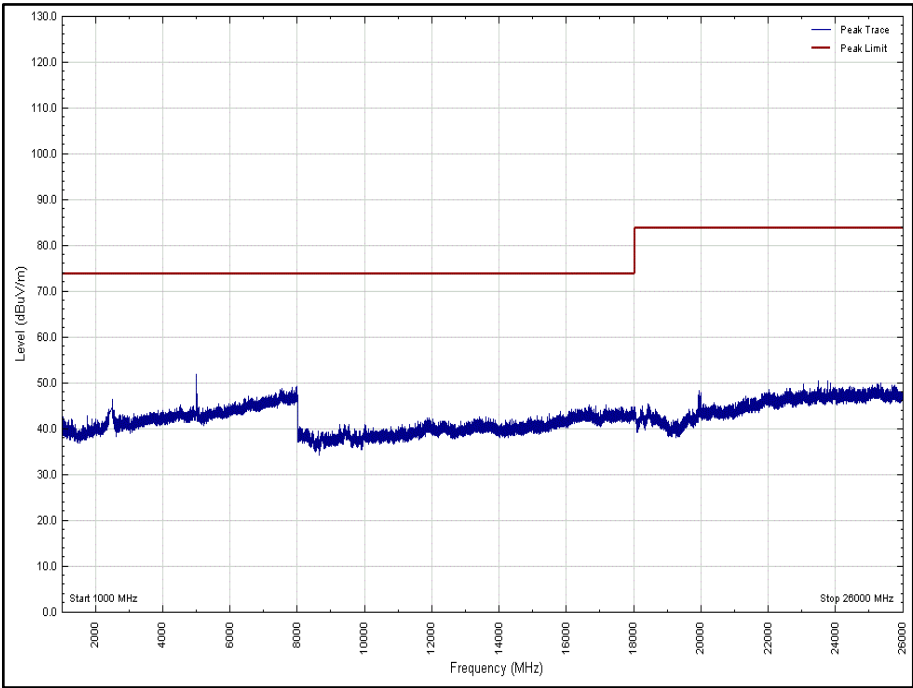


Figure 96 - 2480 MHz - 1 GHz to 26 GHz, Polarity: Horizontal (Peak)

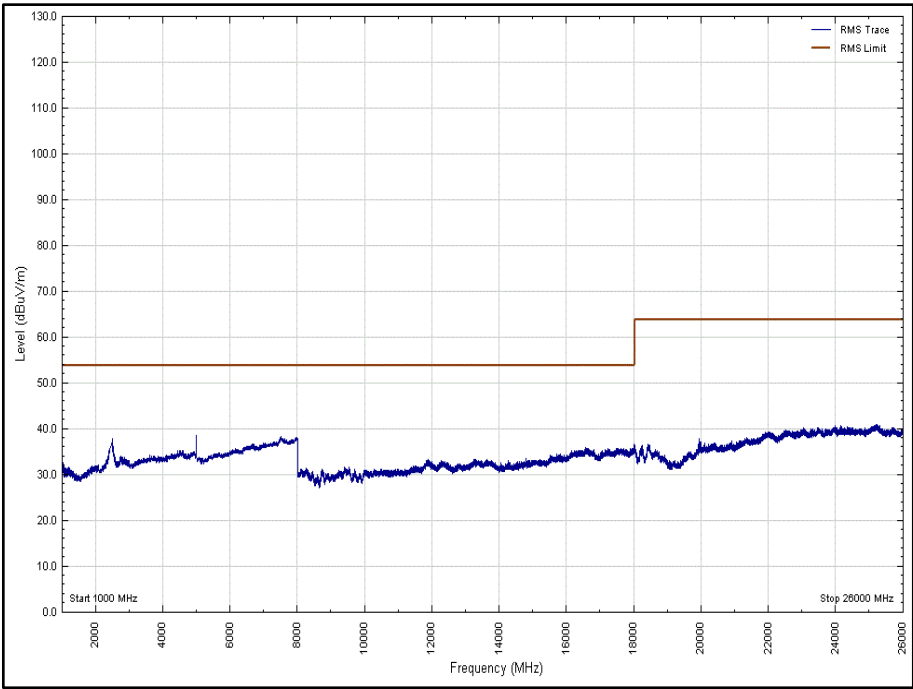


Figure 97 - 2480 MHz - 1 GHz to 26 GHz, Polarity: Horizontal (Average)

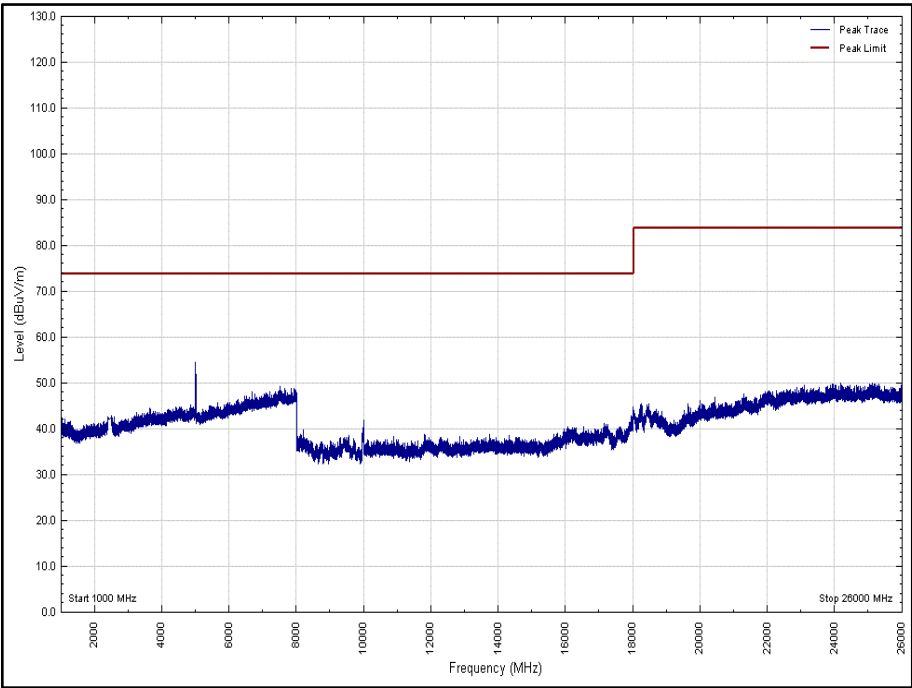


Figure 98 - 2480 MHz - 1 GHz to 26 GHz, Polarity: Vertical (Peak)

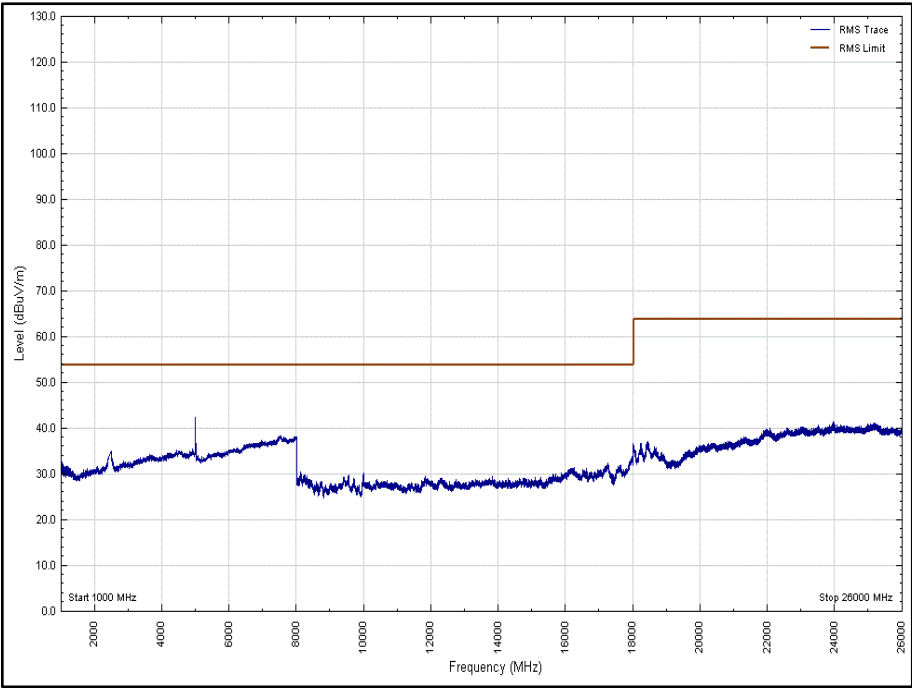


Figure 99 - 2480 MHz - 1 GHz to 26 GHz, Polarity: Vertical (Average)



2.8.7 Test Location and Test Equipment Used

This test was carried out in RF Chamber 11.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Antenna with permanent attenuator (Bilog)	Schaffner	CBL6143	287	24	15-May-2020
10dB/1W SMA Attenuator dc - 18GHz	Sealectro	60-674-1010-89	395	-	O/P Mon
Pre-Amplifier	Phase One	PS04-0086	1533	12	08-Feb-2020
1GHz to 8GHz Low Noise Amplifier	Wright Technologies	APS04-0085	4365	12	14-Nov-2020
High Pass Filter (4GHz)	K&L Microwave	11SH10-4000/X18000-0/0	4599	12	05-Sep-2020
Double Ridge Broadband Horn Antenna	Schwarzbeck	BBHA 9120 B	4848	12	11-Mar-2020
Band Reject Filter - 2.425 GHz	Wainwright	WRCGV14-2390-2400-2450-2460-50SS	5066	12	01-Oct-2020
Band Reject Filter - 2.425 GHz	Wainwright	WRCGV14-2390-2400-2450-2460-50SS	5067	12	01-Oct-2020
Band Reject Filter - 2.4585 GHz	Wainwright	WRCGV14-2423.5-2433.5-2483.5-2493.5-50SS	5068	12	01-Oct-2020
Band Reject Filter - 2.4585 GHz	Wainwright	WRCGV14-2423.5-2433.5-2483.5-2493.5-50SS	5069	12	01-Oct-2020
EMI Test Receiver	Rohde & Schwarz	ESW44	5084	12	28-Nov-2020
Cable (18 GHz)	Rosenberger	LU7-071-1000	5104	12	09-Dec-2020
EmX Emissions Software	TUV SUD	EmX	5125	-	Software
Screened Room (11)	Rainford	Rainford	5136	36	01-Nov-2021
Mast	Maturo	TAM 4.0-P	5158	-	TU
Mast and Turntable Controller	Maturo	Maturo NCD	5159	-	TU
Turntable	Maturo	TT 15WF	5160	-	TU
8 Meter Cable	Teledyne	PR90-088-8MTR	5212	12	30-Aug-2020
Horn Antenna (1-10GHz)	Schwarzbeck	BBHA 9120 B	5215	12	11-Mar-2020
DRG Horn Antenna (7.5-18GHz)	Schwarzbeck	HWRD750	5216	12	11-Mar-2020
Horn Antenna (15-40GHz)	Schwarzbeck	BBHA 9170	5217	12	09-Apr-2020
Preamplifier (30dB 18-40GHz)	Schwarzbeck	BBV 9721	5218	12	09-Apr-2020

Table 31

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

Table 32

Measurement Uncertainty Decision Rule

Determination of conformity with the specification limits is based on the decision rule according to IEC Guide 115: 2007, clause 4.4.3 and 4.5.1.