FCC and ISED Test Report

Apple Inc. Model: A2615

In accordance with FCC 47 CFR Part 15C, ISED RSS-247 and ISED RSS-GEN (2.4 GHz Bluetooth FHSS)

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

FCC ID: BCGA2615 IC: 579C-A2615

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Document 75952325-09 Issue 01

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SIGNATURE			
Stephen Marshall Digitally signed by Stephen Marshall Date: 2022.02.14 11:25:39 Z			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Steve Marshall	Senior Engineer	Authorised Signatory	02 February 2022

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, ISED RSS-247 and ISED RSS-GEN. The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	Faisal Malyar	02 February 2022	
Testing	Danial Shafique	02 February 2022	
Testing	Jaiyanth Balendrarajah	02 February 2022	
Testing	Liang Tian	02 February 2022	
Testing	Colin Brain	02 February 2022	
Testing	Daniel Cameron	02 February 2022	

FCC Accreditation
90987 Octagon House, Fareham Test Laboratory

ISED 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: 2020, ISED RSS-247: Issue 2 (02-2017) and ISED RSS-GEN: Issue 5 (04-2018) + A2 (02-2021) for the tests detailed in section 1.3.

ACCREDITATION

Our UKAS Accreditation does not cover opinions and interpretations and any expressed are outside the scope of our UKAS Accreditation. Results of tests not covered by our UKAS Accreditation Schedule are marked NUA (Not UKAS Accredited).

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Contents

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	02-February-2022

Table 1

1.2 Introduction

Applicant	Apple Inc
Manufacturer	Apple Inc
Model Number(s)	A2615
Serial Number(s)	P1F4F29DL4 and H617C20363
Hardware Version(s)	REV1.0
Software Version(s)	21B30220I
Number of Samples Tested	2
Test Specification/Issue/Date	FCC 47 CFR Part 15C: 2020 ISED RSS-247: Issue 2 (02-2017) ISED RSS-GEN: Issue 5 (04-2018) + A2 (02-2021)
Order Number Date	0540220896 25-May-2021
Date of Receipt of EUT	25-October-2021
Start of Test	25-October-2021
Finish of Test	04-January-2022
Name of Engineer(s)	Faisal Malyar, Danial Shafique, Jaiyanth Balendrarajah, Liang Tian, Colin Brain and Daniel Cameron
Related Document(s)	ANSI C63.4 (2014) ANSI C63.10 (2013) KDB 662911 D01 v02r01

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 - FHSS						
-	15.203	-	-	Antenna Requirement	N/T	The device complies with the provisions of this section, as it uses permanently attached integral antennas.
2.1	15.205	-	8.10	Restricted Band Edges	Pass	
2.2	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Average Time of Occupancy	Pass	
2.3	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Channel Separation	Pass	
2.4	15.247 (a)(1)	5.1	-	Frequency Hopping Systems - Number of Hopping Channels	Pass	
2.5	15.247 (a)(1)	5.1	6.7	Frequency Hopping Systems - 20 dB Bandwidth	Pass	
2.6	15.247 (b)	5.4	6.12	Maximum Conducted Output Power	Pass	
2.7	15.247 (d) and 15.209	3.3 and 5.5	6.13 and 8.9	Spurious Radiated Emissions	Pass	
2.8	15.247 (d)	5.5	-	Authorised Band Edges	Pass	

Table 2

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 a/b/g/n/ac/ax capabilities in the 2.4 GHz and 5 GHz bands.

1.4.2 Test Setup

For conducted tests, a conducted test point was provided by the manufacturer via a flex strip and UFL connector and cable. The loss of these test cables were known and compensated for in any conducted measurements.

For tests in SISO operation, conducted tests were performed on the BT Dedicated Core as well as the Core with the highest antenna gain as Core 0 and Core 1 are identical but with unequal antenna gains. The EUT supports TxBF on Core 0 + Core 1.

Bluetooth BDR/EDR was assessed as a FHSS system. The EUT supports Bluetooth on the following mode of operations across its antenna ports:

BT Dedicated Core (Core 2) – SISO (iPA)
BT Core 0 – SISO (iPA and ePA), TxBF (iPA and ePA)
BT Core 1 – SISO (iPA and ePA), TxBF (iPA and ePA)

For all tests, the EUT was put into a continuous transmit test mode with the manufacturer's test commands via a script running in the EUTs terminal application. The EUT then transmitted the required type of modulation/packet type on either a static channel selected within the test script or frequency hopping over the maximum number of supported channels.

All testing was performed with the EUT powered via a 120 V AC, 60 Hz source.

1.4.3 Antenna Gain Table

Antenna Port	Frequency Range (MHz)	Peak Gain (dBi)	Conducted Cable Loss (dB)
BT Dedicated Core (Core 2)	2400 to 2480	1.70	1.00
BT Core 0	2400 to 2480	2.20	1.00
BT Core 1	2400 to 2480	1.40	1.00

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: A2615, Serial Number: P1F4F29DL4			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: A2615, Serial Number: H617C20363			
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 - FHSS		
Restricted Band Edges	Faisal Malyar, Danial Shafique, Jaiyanth Balendrarajah and Liang Tian	UKAS
Frequency Hopping Systems - Average Time of Occupancy	Daniel Cameron	UKAS
Frequency Hopping Systems - Channel Separation	Daniel Cameron	UKAS
Frequency Hopping Systems - Number of Hopping Channels	Daniel Cameron	UKAS
Frequency Hopping Systems - 20 dB Bandwidth	Daniel Cameron	UKAS
Maximum Conducted Output Power	Daniel Cameron	UKAS
Spurious Radiated Emissions	Jaiyanth Balendrarajah, Danial Shafique, Colin Brain and Taha Shafique	UKAS
Authorised Band Edges	Faisal Malyar, Danial Shafique, Jaiyanth Balendrarajah and Liang Tian	UKAS

Table 5

Office Address:

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Octagon House
Concorde Way
Fareham
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PO15 5RL
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2 Test Details

2.1 Restricted Band Edges

2.1.1 Specification Reference

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

2.1.2 Equipment Under Test and Modification State

A2615, S/N: P1F4F29DL4 - Modification State 0

2.1.3 Date of Test

25-October-2021 to 27-October-2021

2.1.4 Test Method

The 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 dBµV/m to µV/m:
10^(Field Strength in dBµV/m/20).

2.1.5 Environmental Conditions

Ambient Temperature	20.8 - 22.8 °C
Relative Humidity	46.9 – 52.5 %

2.1.6 Test Results

2.4 GHz Bluetooth (FHSS)

iPA

Mode	Modulation	Core	Packet Type	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
Static	GFSK	0	DH5	2402	2390.0	54.27	39.71
Static	π/4 DQPSK	0	2DH5	2402	2390.0	54.40	39.77
Static	8-DPSK	0	3DH5	2402	2390.0	54.26	39.76
Static	GFSK	0	DH5	2480	2483.5	53.83	40.41
Static	π/4 DQPSK	0	2DH5	2480	2483.5	52.94	41.04
Static	8-DPSK	0	3DH5	2480	2483.5	53.43	41.22

Table 6 - Restricted Band Edge Results

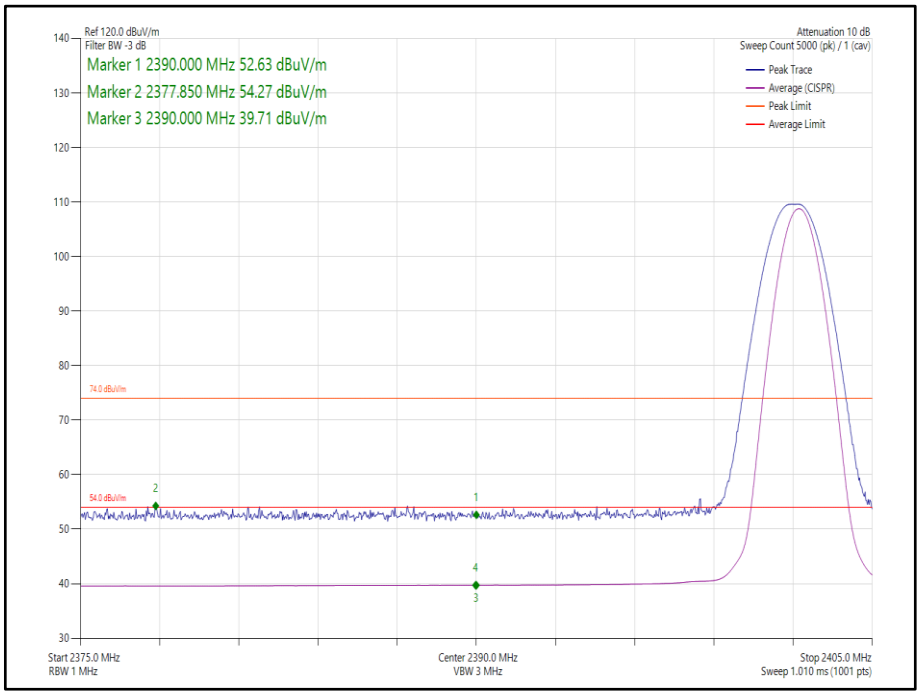

Figure 1 Core 0- Static - GFSK/DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

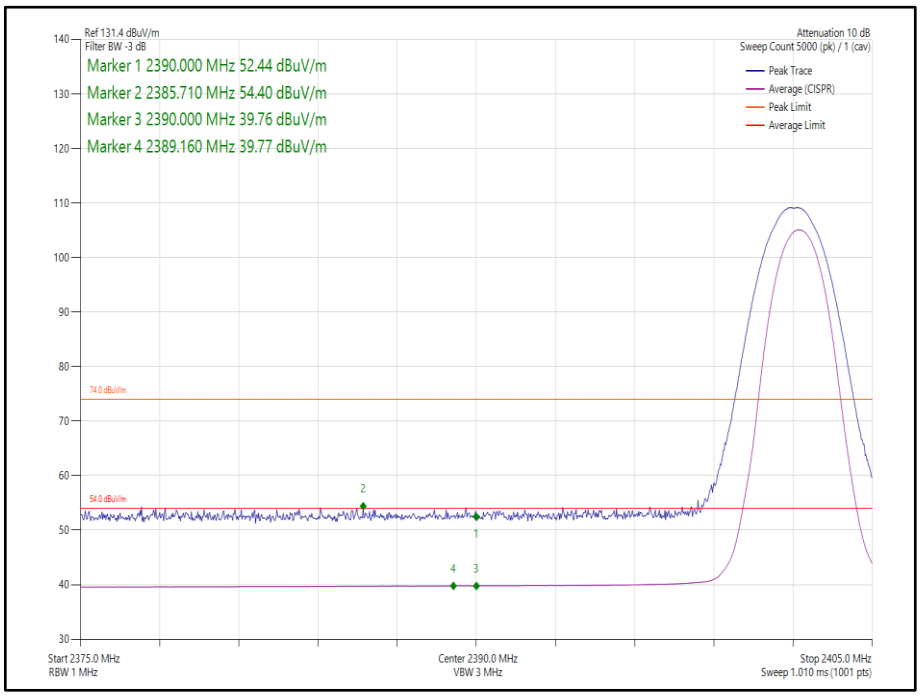

Figure 2 Core 0- Static - π/4 DQPSK/2DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

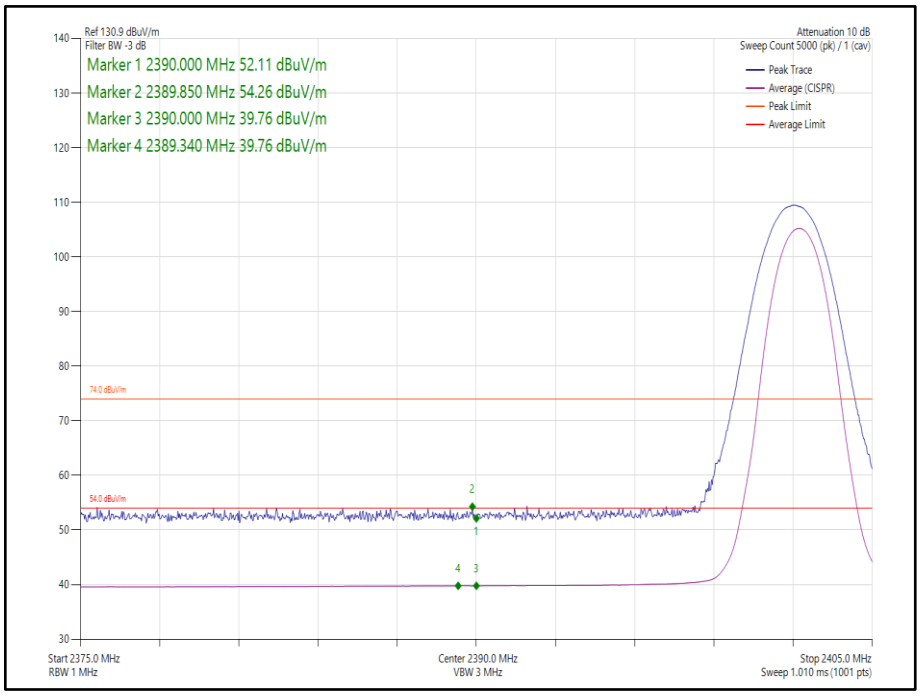

Figure 3 Core 0- Static - 8-DPSK/3DH5 - 2402 MHz Band Edge Frequency 2390.0 MHz

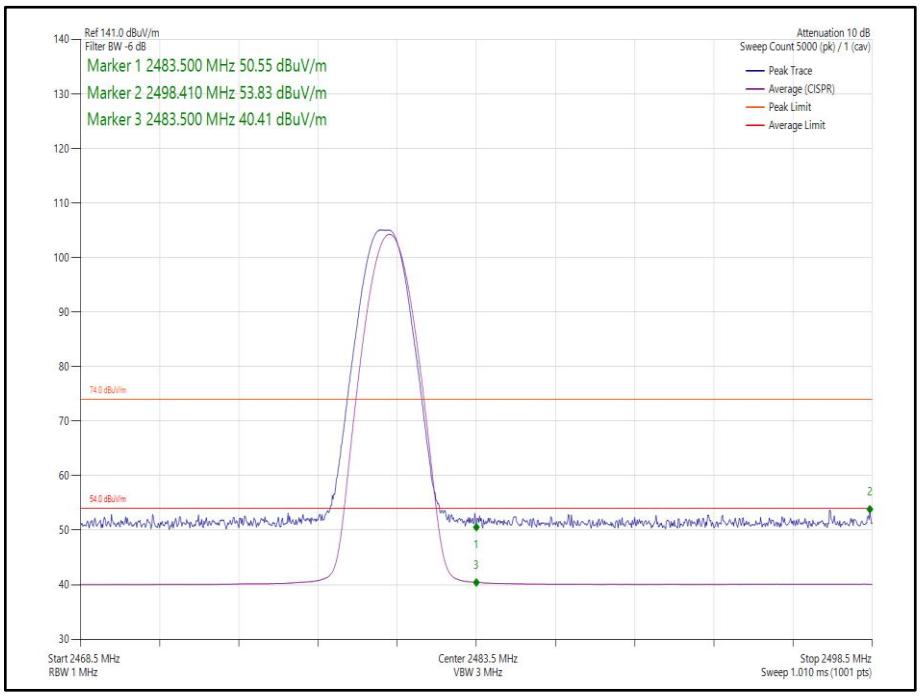

Figure 4 Core 0- Static - GFSK/DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

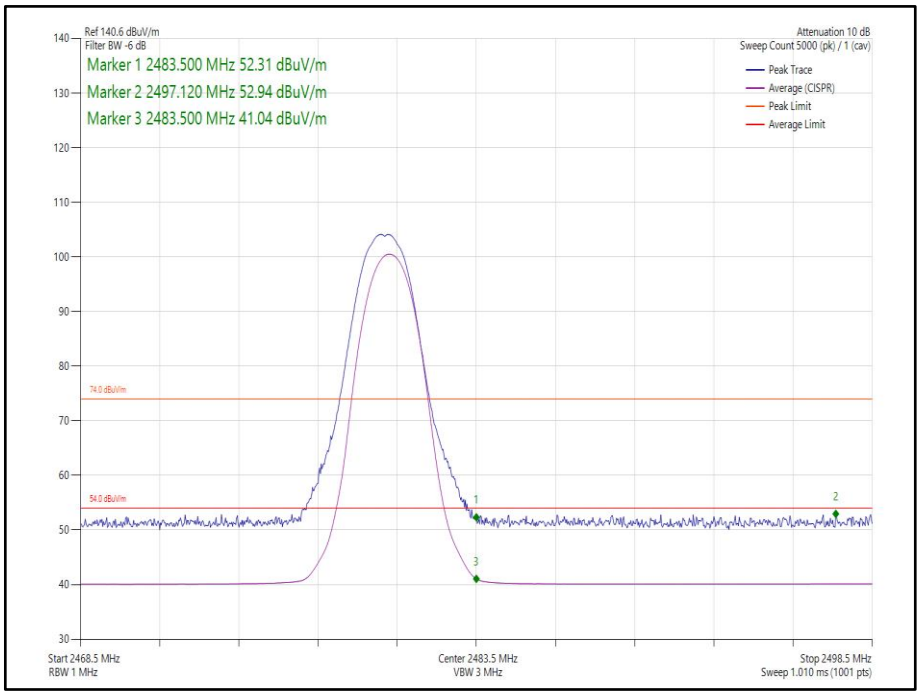

Figure 5 Core 0- Static - π/4 DQPSK/2DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

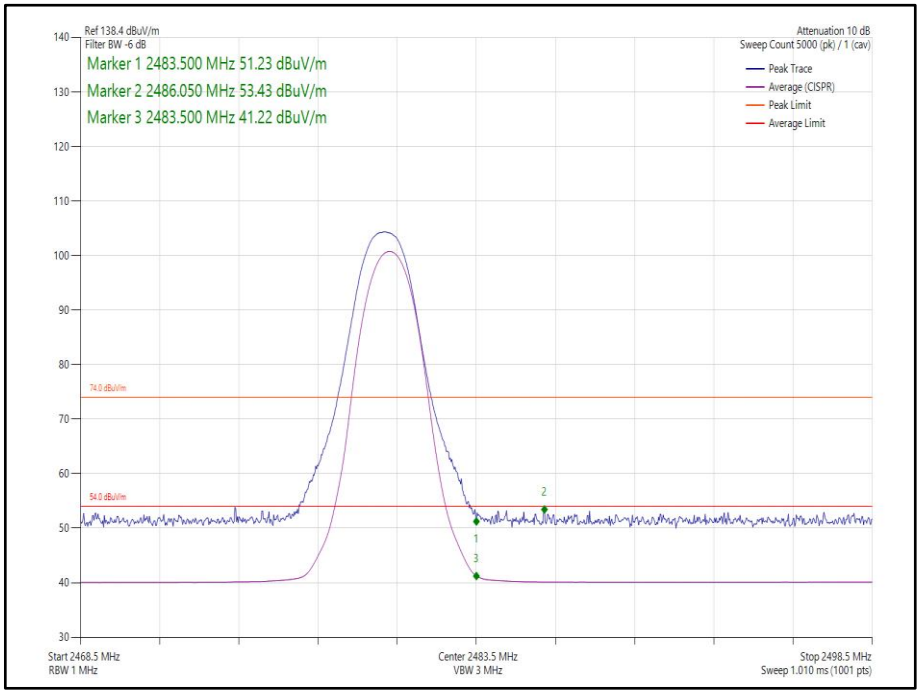

Figure 6 Core 0- Static - 8-DPSK/3DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

2.4 GHz Bluetooth (FHSS)

ePA

Mode	Modulation	Core	Packet Type	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
Static	GFSK	0	DH5	2402	2390.0	54.29	40.12
Static	π/4 DQPSK	0	2DH5	2402	2390.0	54.58	40.07
Static	8-DPSK	0	3DH5	2402	2390.0	54.29	40.14
Static	GFSK	0	DH5	2480	2483.5	53.81	41.37
Static	π/4 DQPSK	0	2DH5	2480	2483.5	53.76	41.29
Static	8-DPSK	0	3DH5	2480	2483.5	54.14	41.77

Table 7 - Restricted Band Edge Results

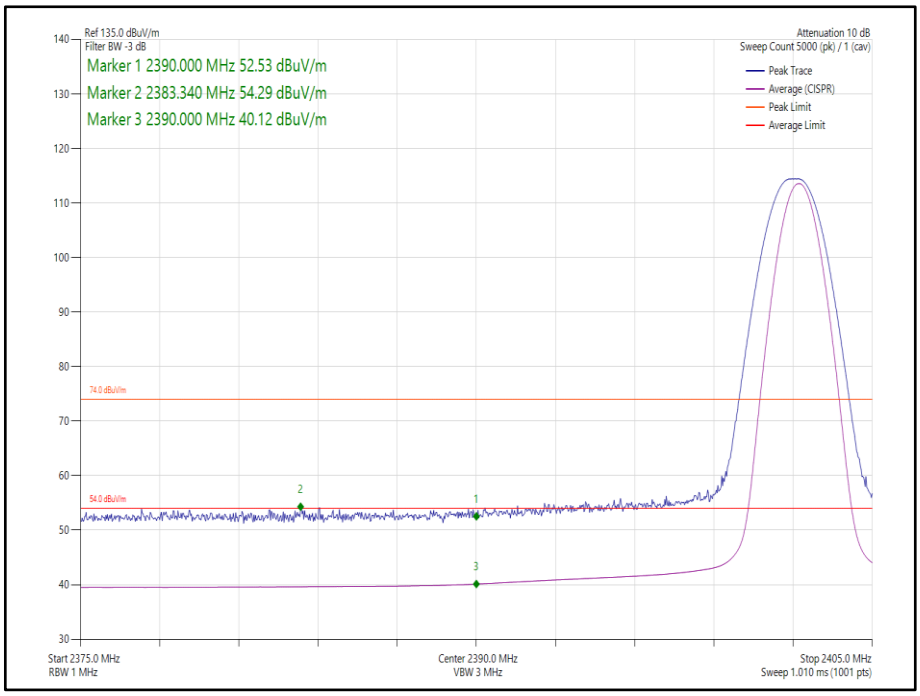

Figure 7 Core 0- Static - GFSK/DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

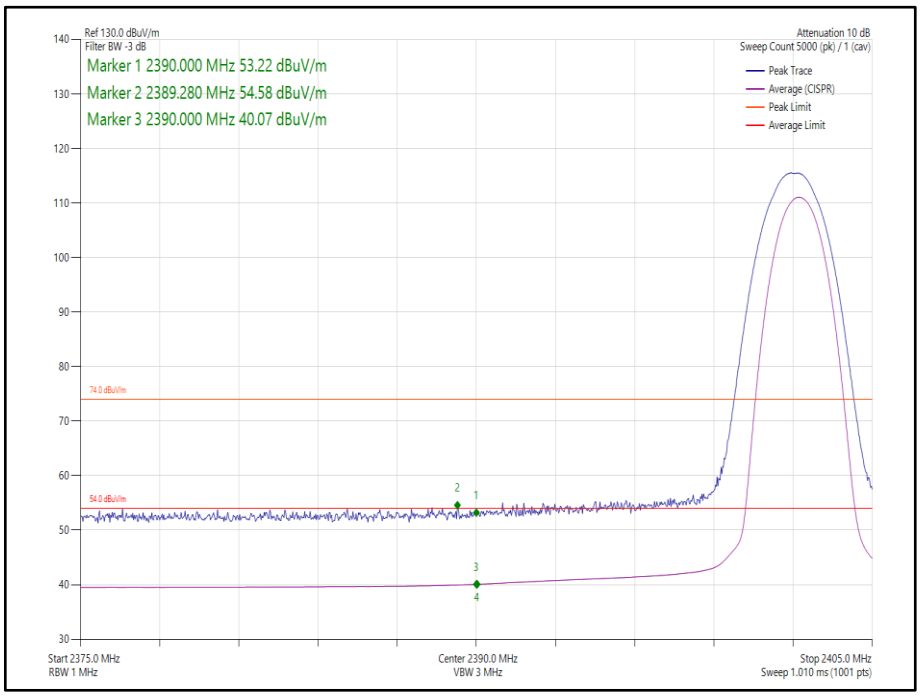

Figure 8 - Static Core 0- π/4 DQPSK/2DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

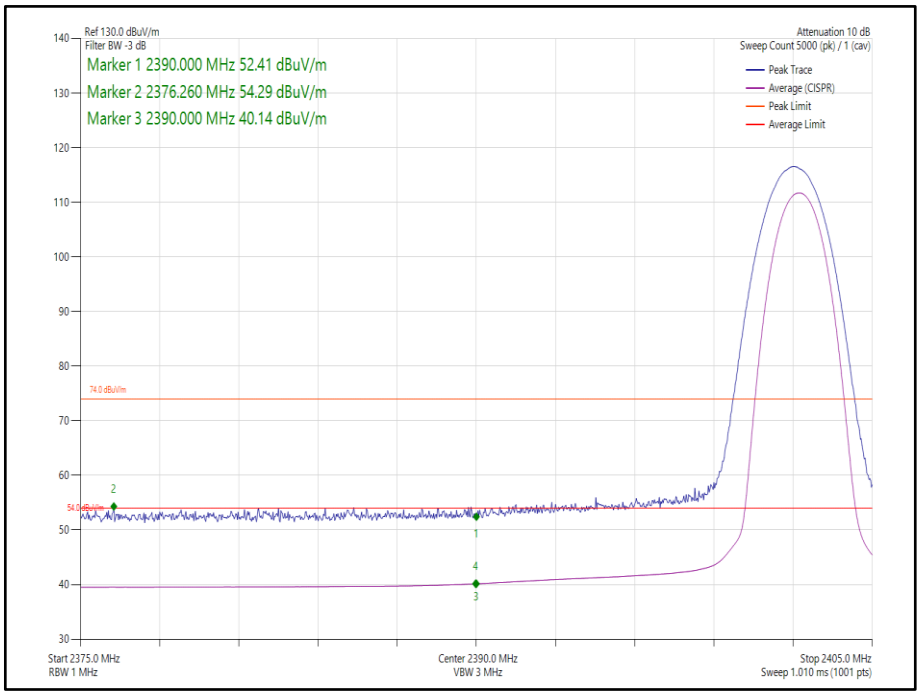

Figure 9 Core 0- Static - 8-DPSK/3DH5 - 2402 MHz Band Edge Frequency 2390.0 MHz

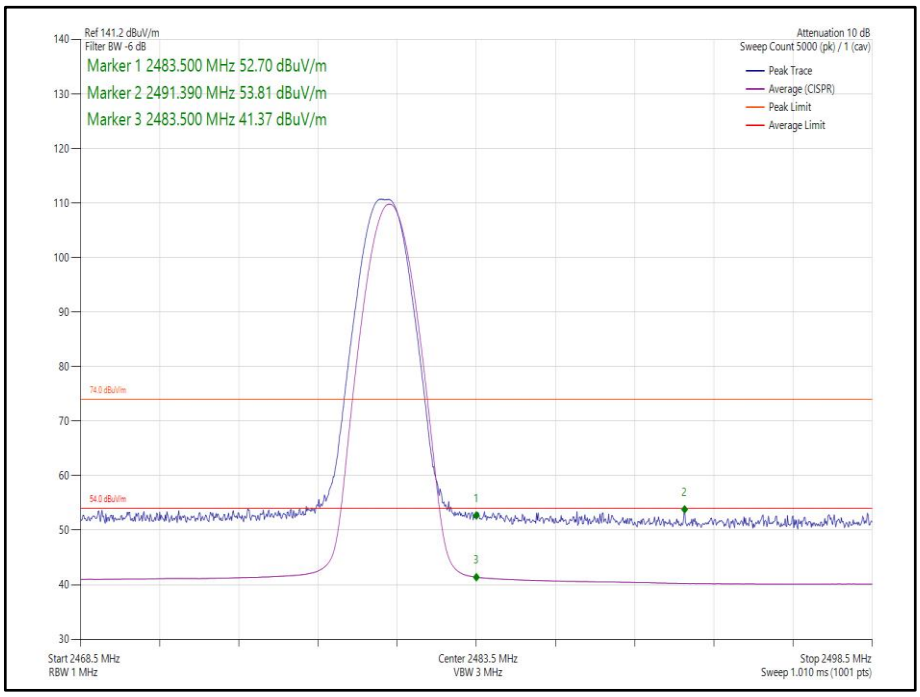

Figure 10 Core 0- Static - GFSK/DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

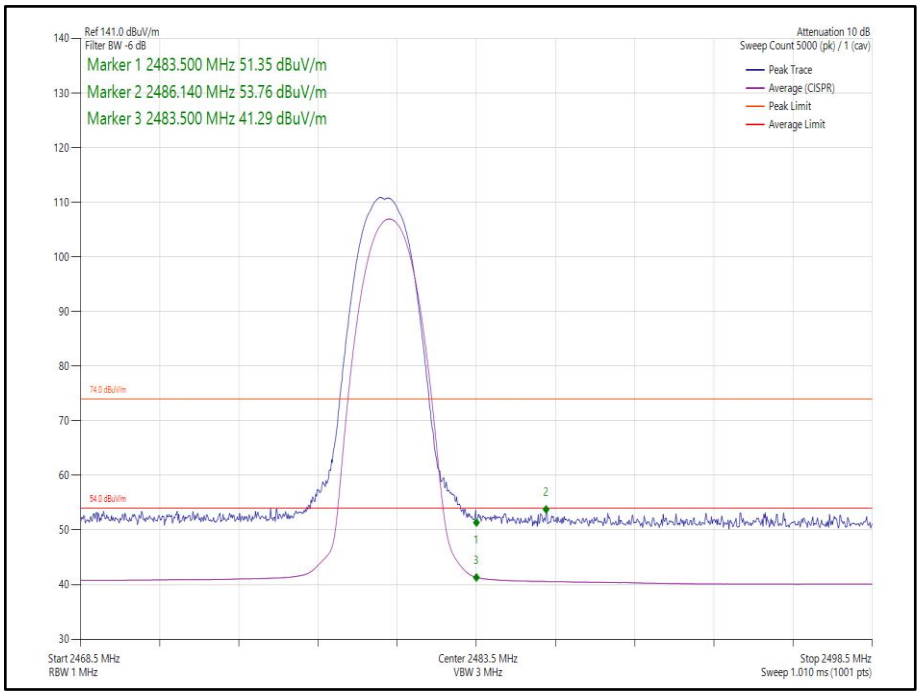

Figure 11 Core 0- Static - π/4 DQPSK/2DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

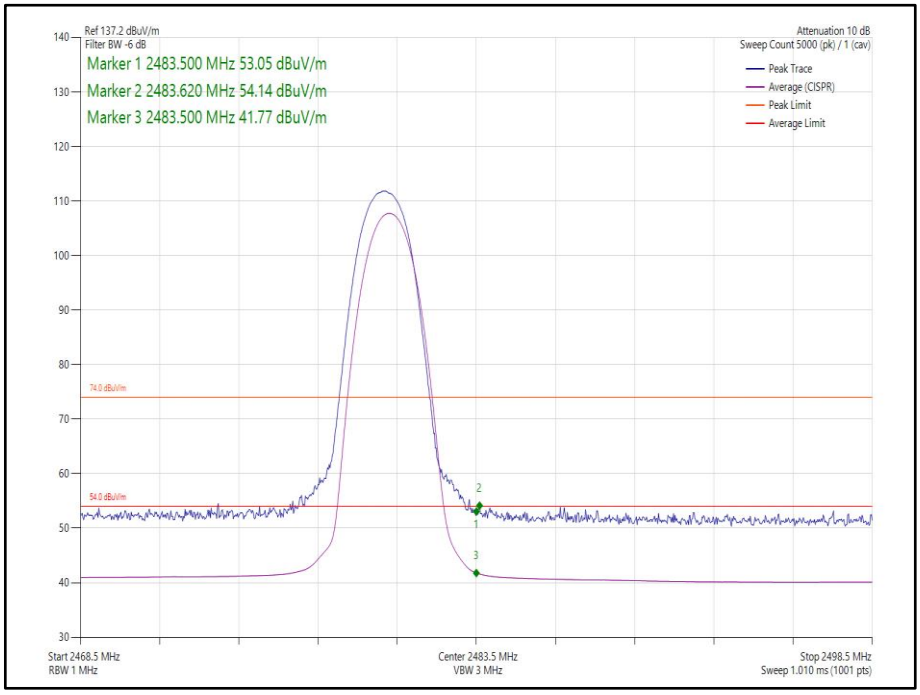

Figure 12 Core 0- Static - 8-DPSK/3DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

2.4 GHz Bluetooth (FHSS)

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Mode	Modulation	Core	Packet Type	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
Static	GFSK	2	DH5	2402	2390.0	54.63	39.70
Static	π/4 DQPSK	2	2DH5	2402	2390.0	54.20	39.73
Static	8-DPSK	2	3DH5	2402	2390.0	54.47	39.73
Static	GFSK	2	DH5	2480	2483.5	53.28	40.59
Static	π/4 DQPSK	2	2DH5	2480	2483.5	53.20	40.42
Static	8-DPSK	2	3DH5	2480	2483.5	52.84	40.44

Table 8 - Restricted Band Edge Results

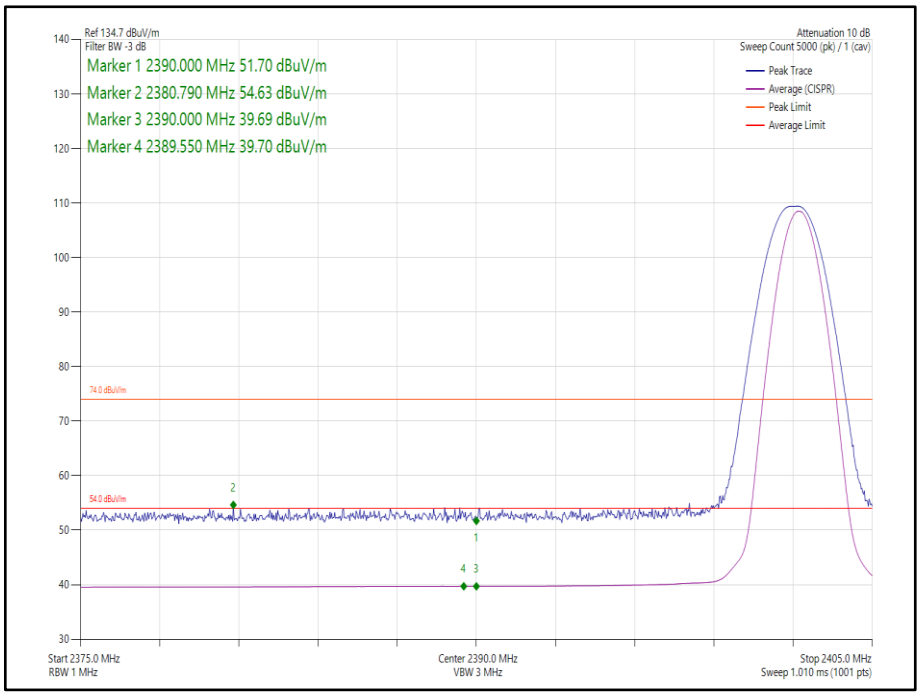

Figure 13 Core 2- Static - GFSK/DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

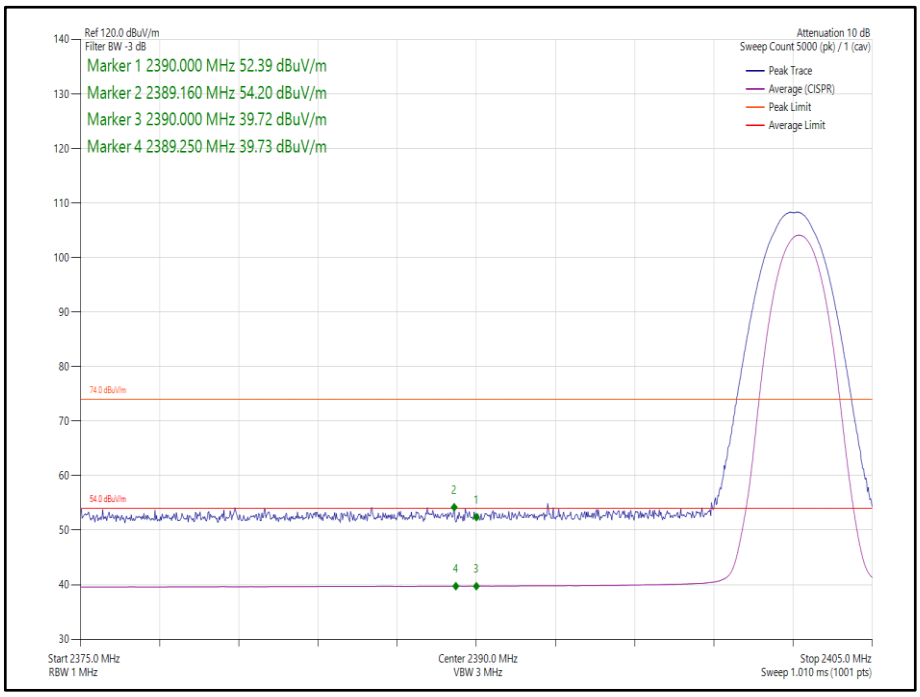

Figure 14 Core 2- Static - π/4 DQPSK/2DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

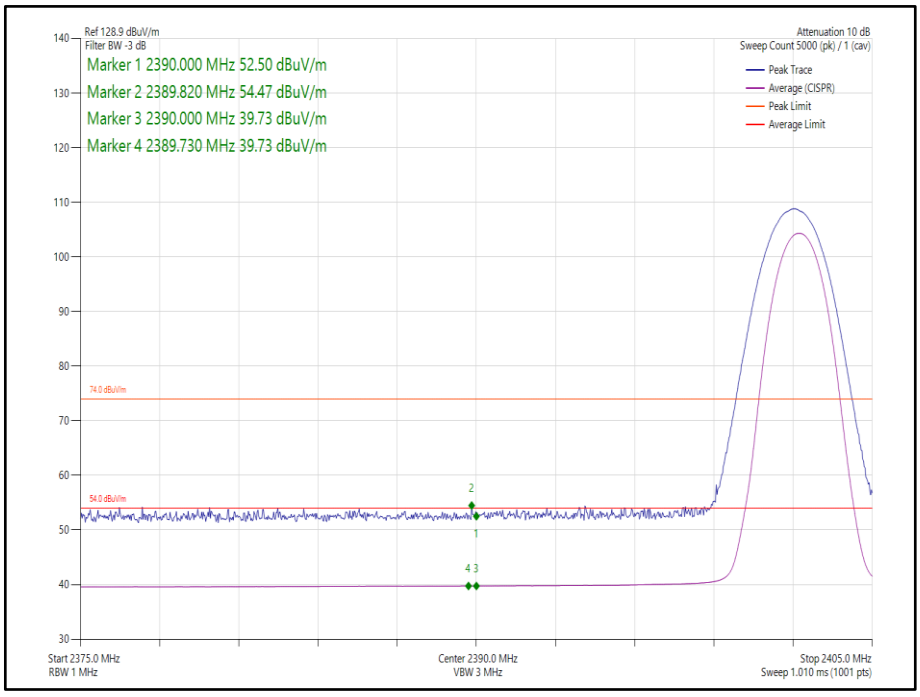

Figure 15 Core 2- Static - 8-DPSK/3DH5 - 2402 MHz Band Edge Frequency 2390.0 MHz

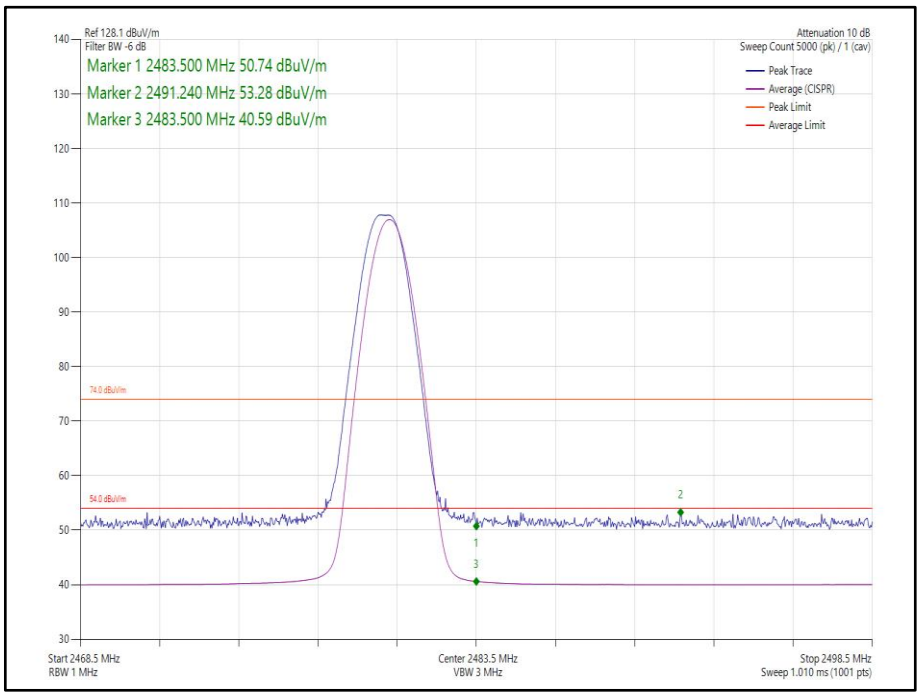

Figure 16 Core 2- Static - GFSK/DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

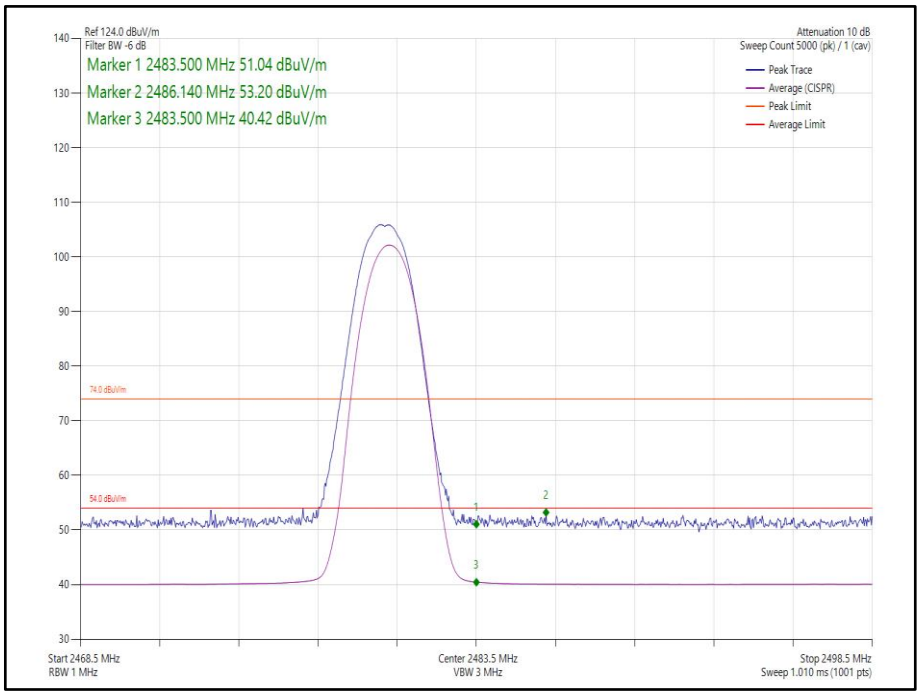

Figure 17 Core 2- Static - π/4 DQPSK/2DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

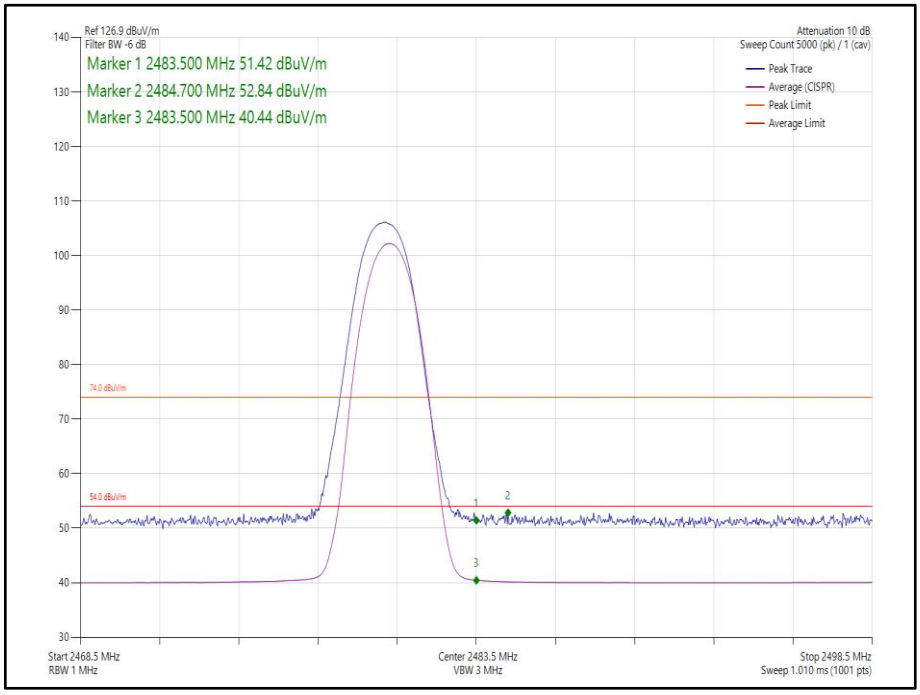

Figure 18 Core 2- Static - 8-DPSK/3DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

2.4 GHz Bluetooth (FHSS)

iPA

Mode	Modulation	Core	Packet Type	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
Static	GFSK	0-1	DH5	2402	2390.0	54.30	39.72
Static	π/4 DQPSK	0-1	2DH5	2402	2390.0	54.42	39.76
Static	8-DPSK	0-1	3DH5	2402	2390.0	54.70	39.77
Static	GFSK	0-1	DH5	2480	2483.5	53.15	40.49
Static	π/4 DQPSK	0-1	2DH5	2480	2483.5	53.17	40.56
Static	8-DPSK	0-1	3DH5	2480	2483.5	52.97	40.56

Table 9 - Restricted Band Edge Results

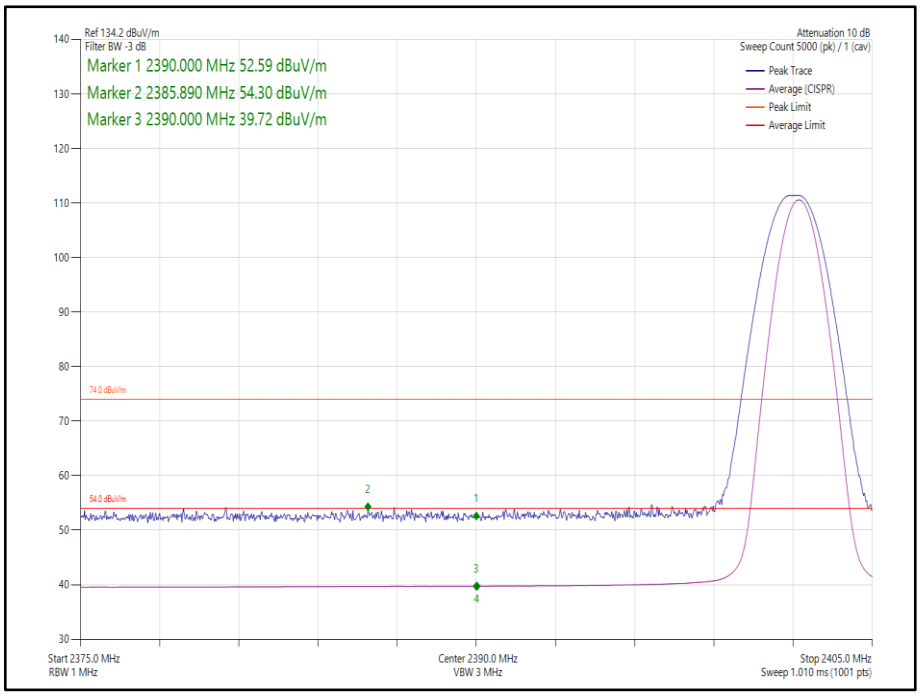

Figure 19 Core 0-1- Static - GFSK/DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

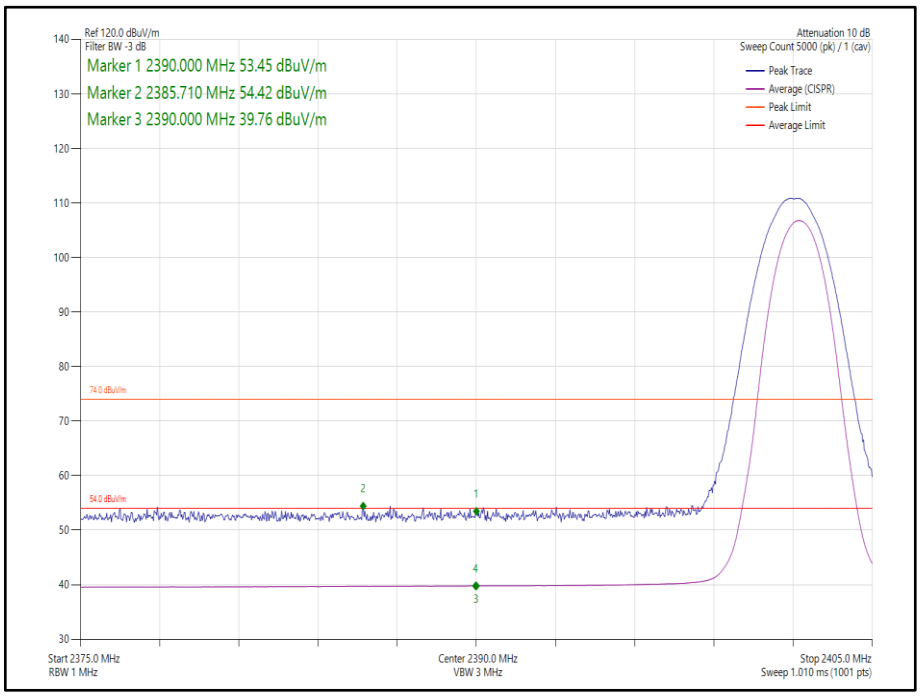

Figure 20 - Static Core 0-1- π/4 DQPSK/2DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

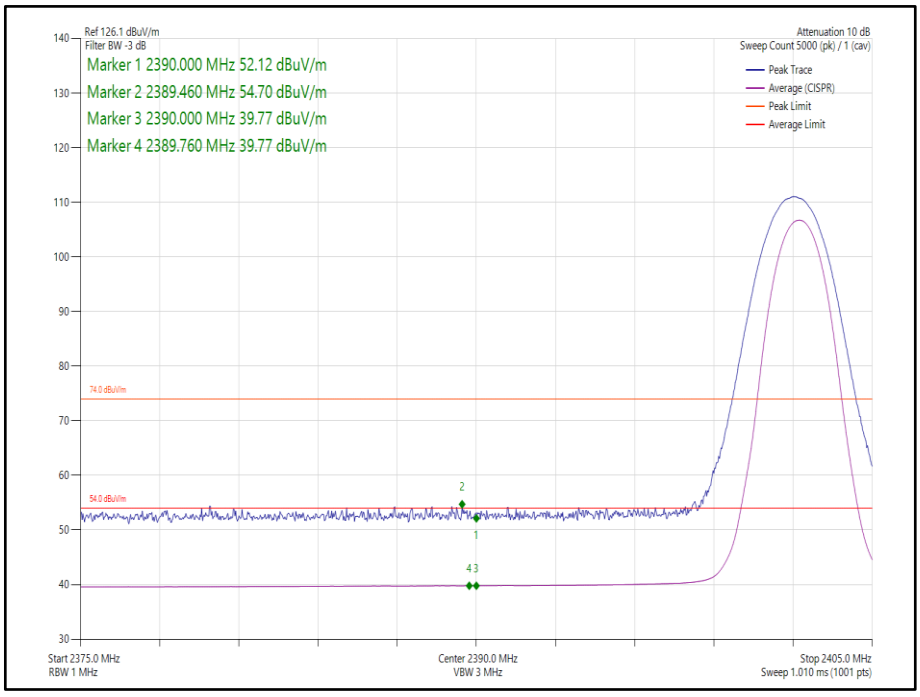

Figure 21 - Static Core 0-1- 8-DPSK/3DH5 - 2402 MHz Band Edge Frequency 2390.0 MHz

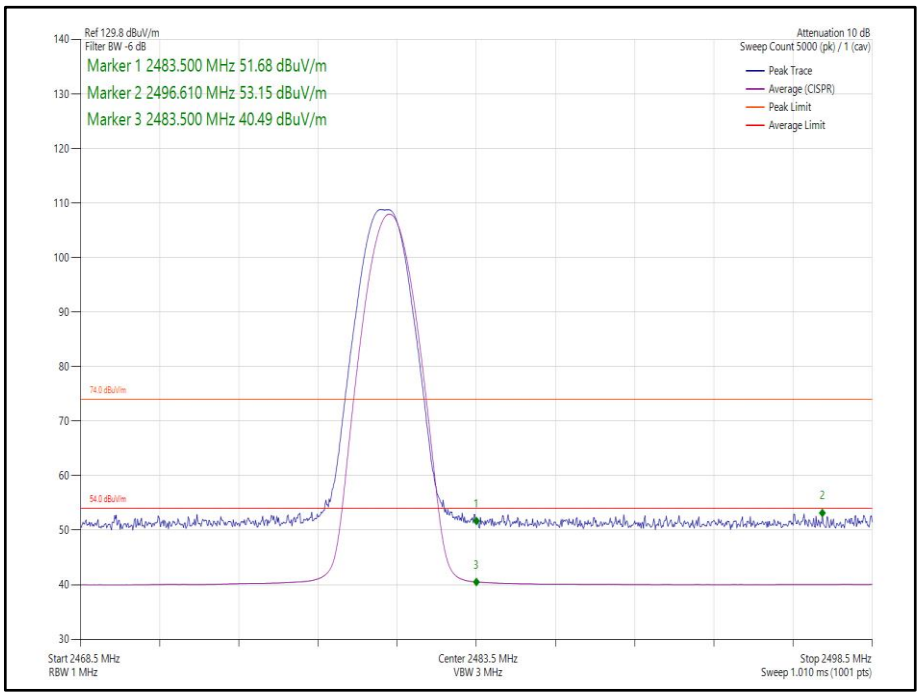

Figure 22 - Static Core 0-1- GFSK/DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

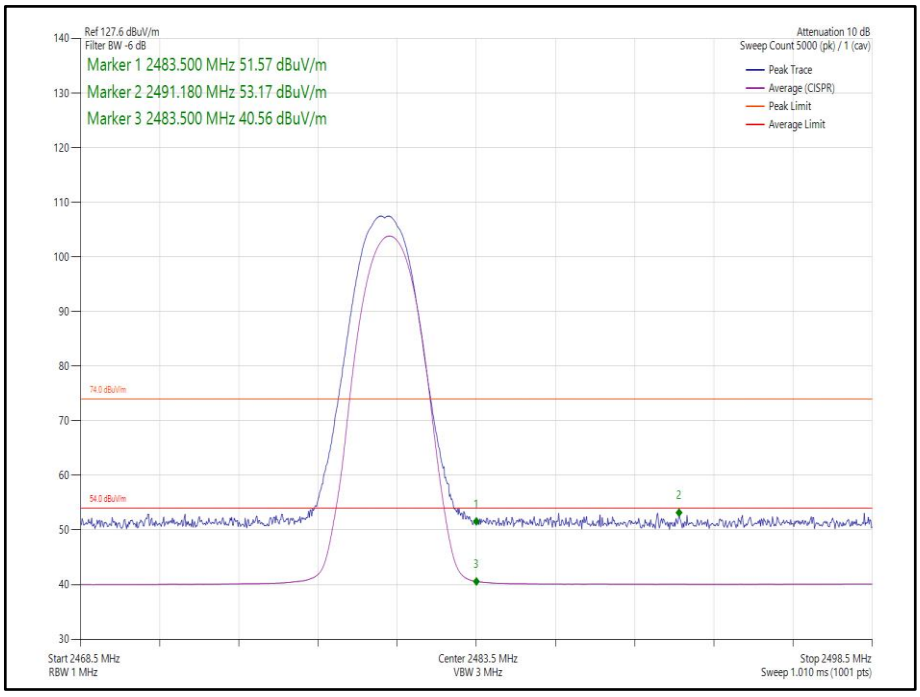

Figure 23 - Static Core 0-1- π/4 DQPSK/2DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

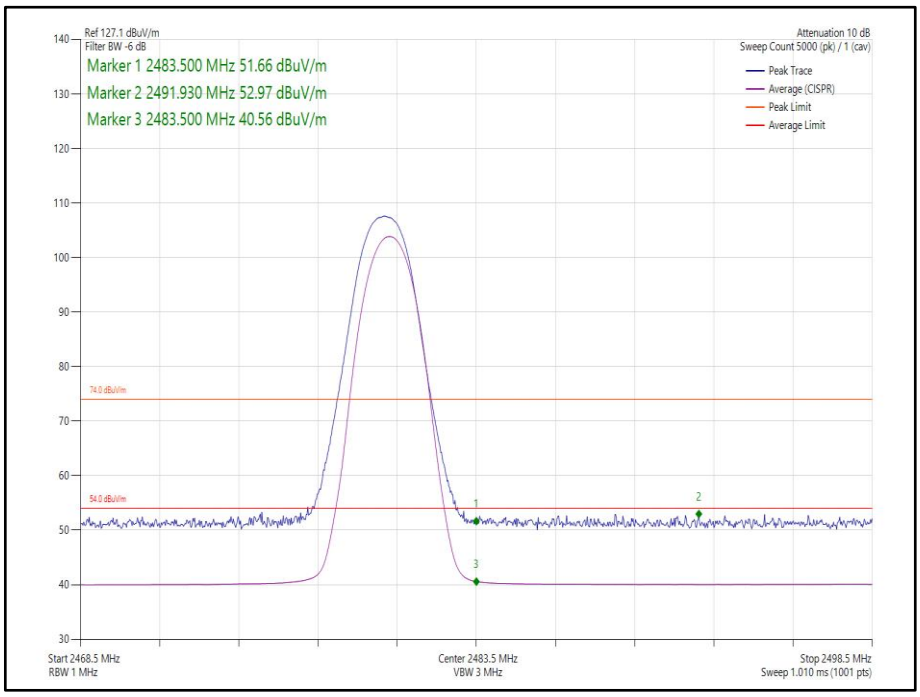

Figure 24 Core 0-1- Static - 8-DPSK/3DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

2.4 GHz Bluetooth (FHSS)

ePA

Mode	Modulation	Core	Packet Type	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
Static	GFSK	0-1	DH5	2402	2390.0	55.05	40.12
Static	π/4 DQPSK	0-1	2DH5	2402	2390.0	54.27	40.10
Static	8-DPSK	0-1	3DH5	2402	2390.0	54.70	40.18
Static	GFSK	0-1	DH5	2480	2483.5	54.78	41.64
Static	π/4 DQPSK	0-1	2DH5	2480	2483.5	54.60	42.18
Static	8-DPSK	0-1	3DH5	2480	2483.5	54.78	42.45

Table 10 - Restricted Band Edge Results

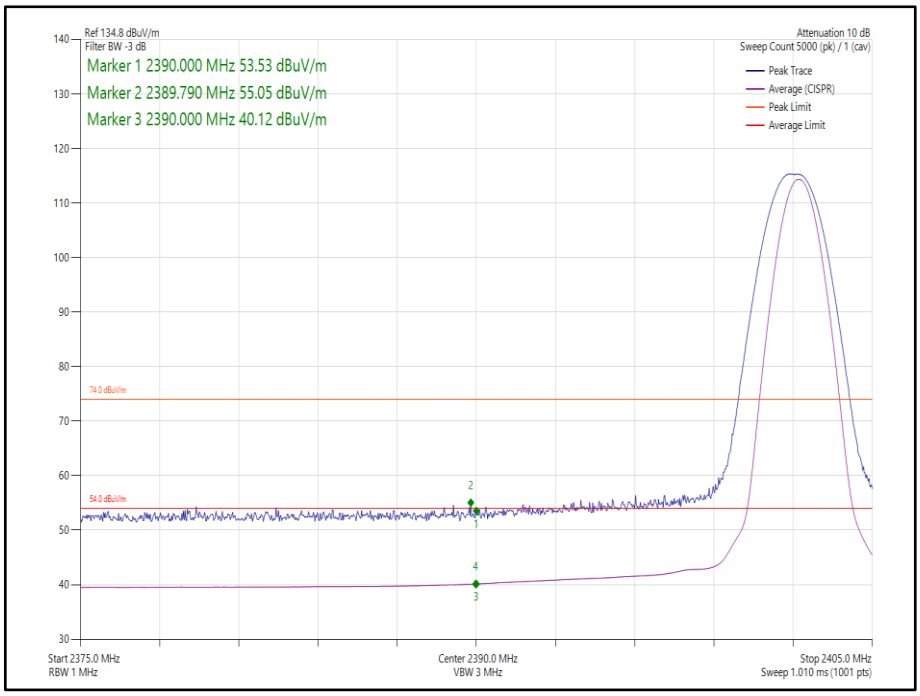

Figure 25 Core 0-1- Static - GFSK/DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

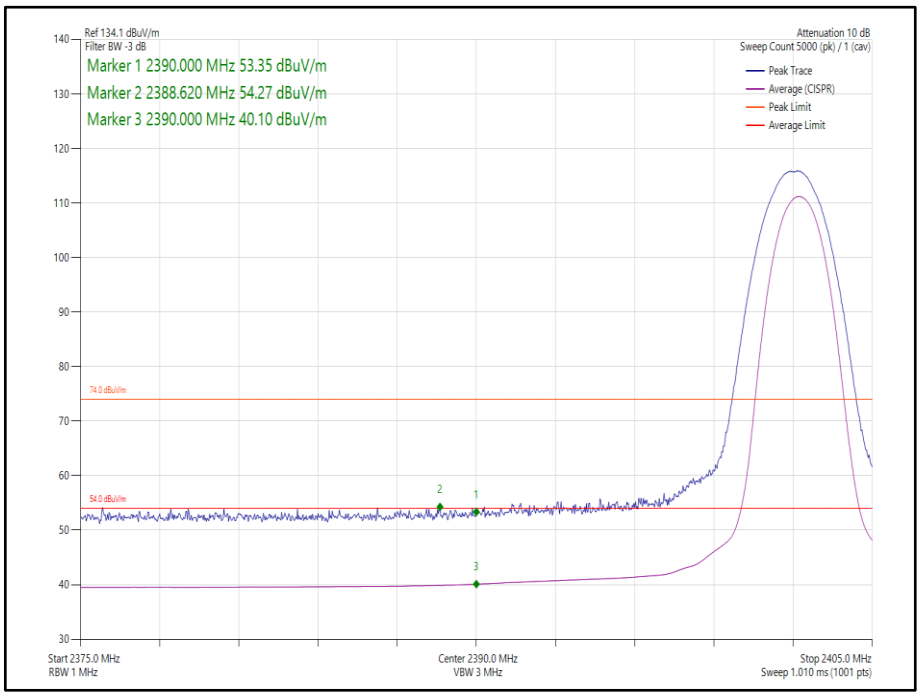

Figure 26 - Static Core 0-1- π/4 DQPSK/2DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

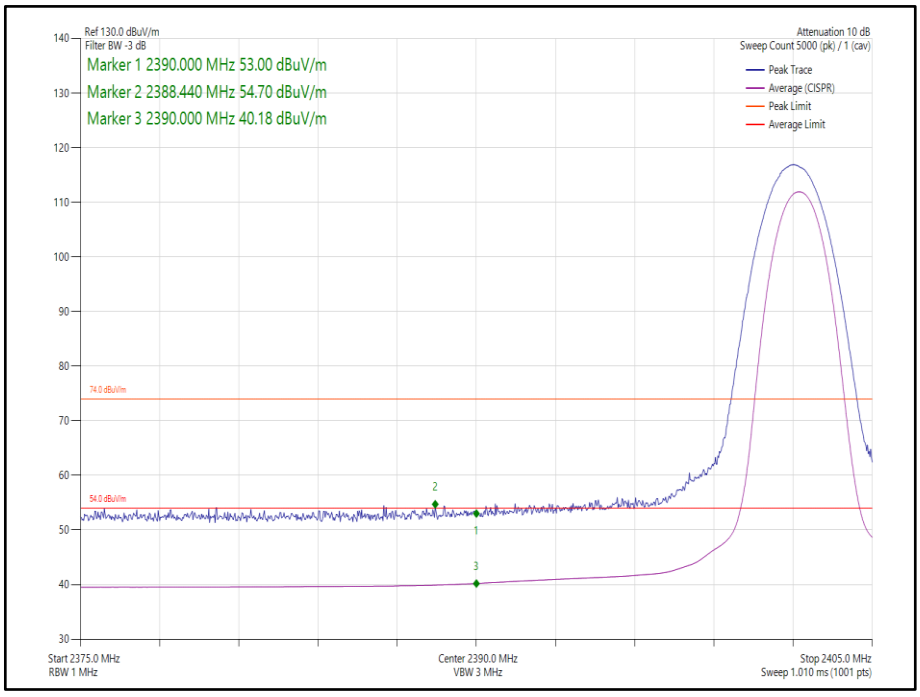

Figure 27 - Static Core 0-1- 8-DPSK/3DH5 - 2402 MHz Band Edge Frequency 2390.0 MHz

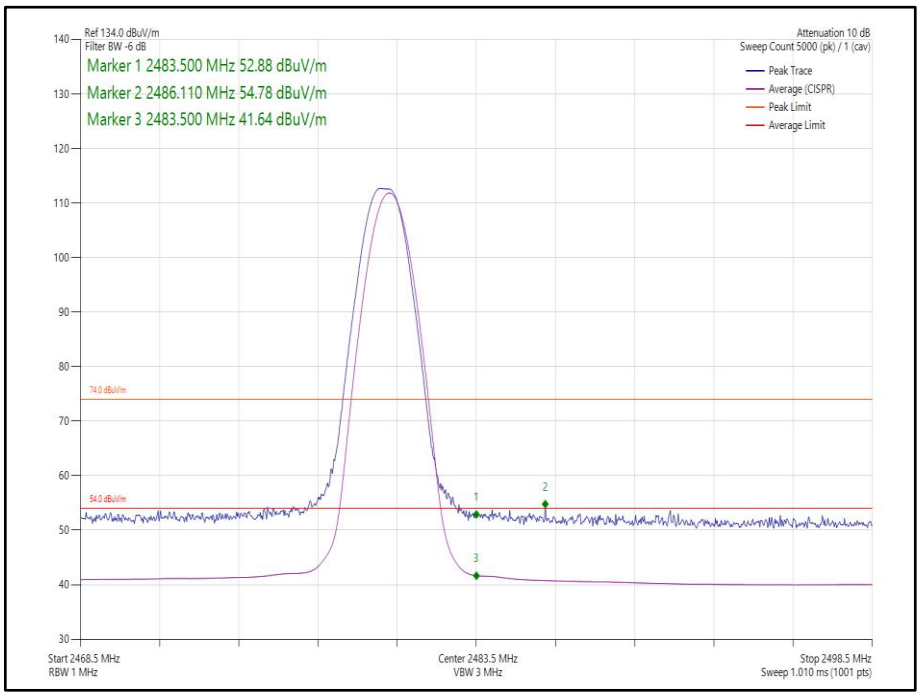

Figure 28 - Static Core 0-1- GFSK/DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

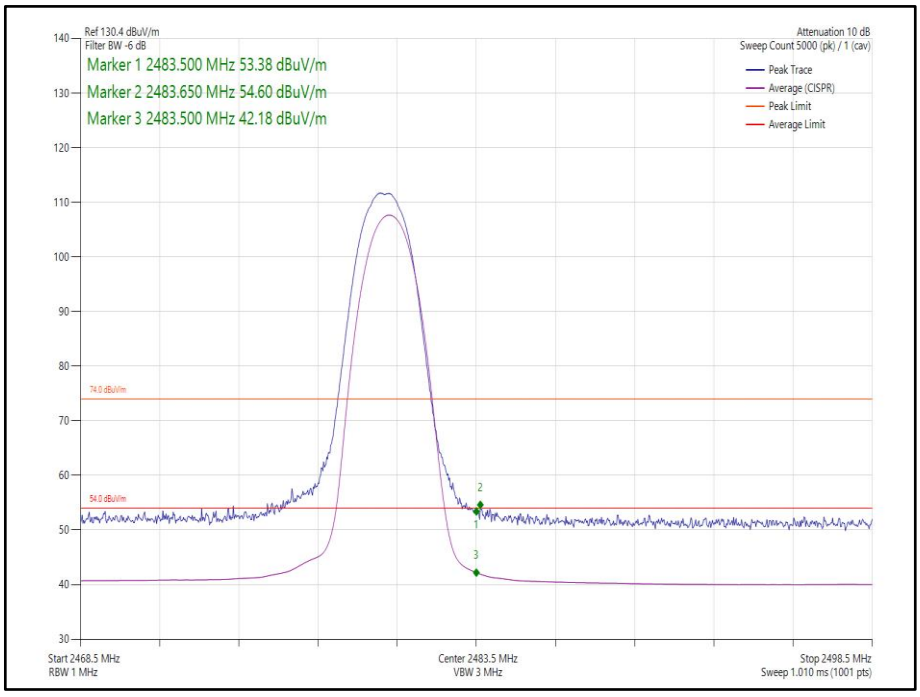

Figure 29 - Static Core 0-1- π/4 DQPSK/2DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

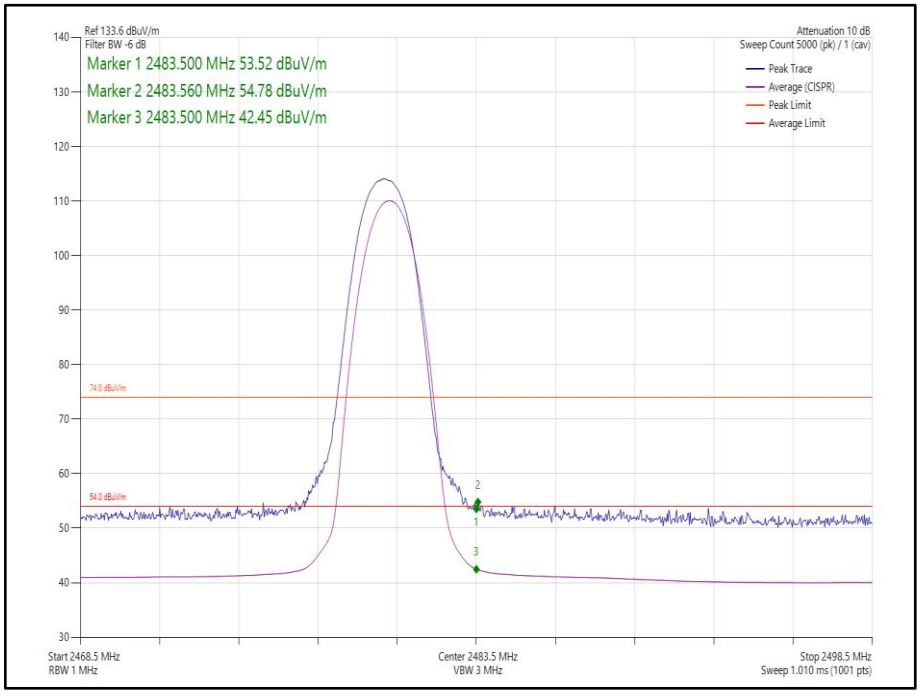

Figure 30 - Static Core 0-1- 8-DPSK/3DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

FCC 47 CFR Part 15, Limit Clause 15.209

Frequency (MHz)	Field Strength (µV/m at 3 m)
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

Table 11

ISED RSS-GEN, Limit Clause 8.9

Frequency (MHz)	Field Strength (µV/m at 3 m)
30 to 88	100
88 to 216	150
216 to 960	200
Above 960*	500

Table 12

*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.

2.1.7 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 Expires
Multimeter	Iso-tech	IDM101	2421	12	28-Oct-2021
EMI Test Receiver	Rohde & Schwarz	ESW44	5084	12	08-Mar-2022
Emissions Software	TUV SUD	EmX V2.1.11	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
Horn Antenna (1-10GHz)	Schwarzbeck	BBHA 9120 B	5215	12	01-Apr-2022
2m SMA Cable	Junkosha	MWX221-02000AMSAMS/A	5518	12	09-Apr-2022
8m N Type Cable	Junkosha	MWX221-08000NMSNMS/B	5522	12	24-Mar-2022
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB 40	5604	12	22-Sep-2022

Table 13

TU - Traceability Unscheduled

2.2 Frequency Hopping Systems - Average Time of Occupancy

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

A2615, S/N: H617C20363 - Modification State 0

2.2.3 Date of Test

15-December-2021 to 16-December-2021

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	22.6 - 23.5 °C
Relative Humidity	31.7 - 44.3 %

2.2.6 Test Results

2.4 GHz Bluetooth - FHSS

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247 (a)(1)(iii) RSS-247 5.1 d)	Test Method(s):	C63.10 7.8.4
Additional Reference(s):	-		

DUT Configuration			
Mode:	ePA GFSK (DH5)	Duty Cycle (%):	76.7
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (Core 0)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	Time of Occupancy			Limit (ms)
	Dwell Time (ms)	Number of Transmissions	Time of Occupancy (ms)	
2402	2.888	101	291.7	400.0

Table 14 - Time of Occupancy Results

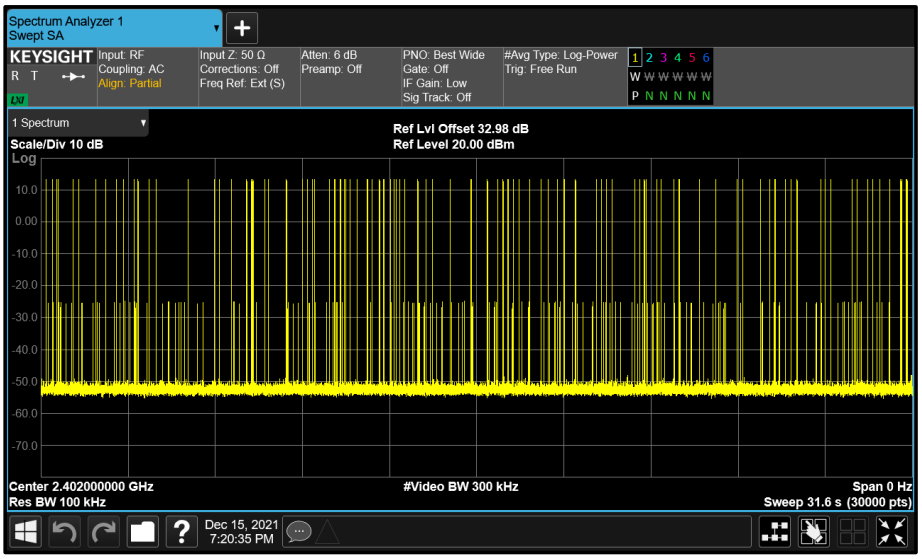

Figure 31 - GFSK - 2402 MHz Accumulated Transmit Time

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247 (a)(1)(iii) RSS-247 5.1 d)	Test Method(s):	C63.10 7.8.4
Additional Reference(s):	-		

DUT Configuration			
Mode:	ePA GFSK (DH5)	Duty Cycle (%):	76.7
Antenna Configuration:	Beamforming	DCCF (dB):	-
Active Port(s):	A+B (Core 0 + Core 1)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	Time of Occupancy			Limit (ms)
	Dwell Time (ms)	Number of Transmissions	Time of Occupancy (ms)	
2402	2.888	107	309.0	400.0

Table 15 - Time of Occupancy Results

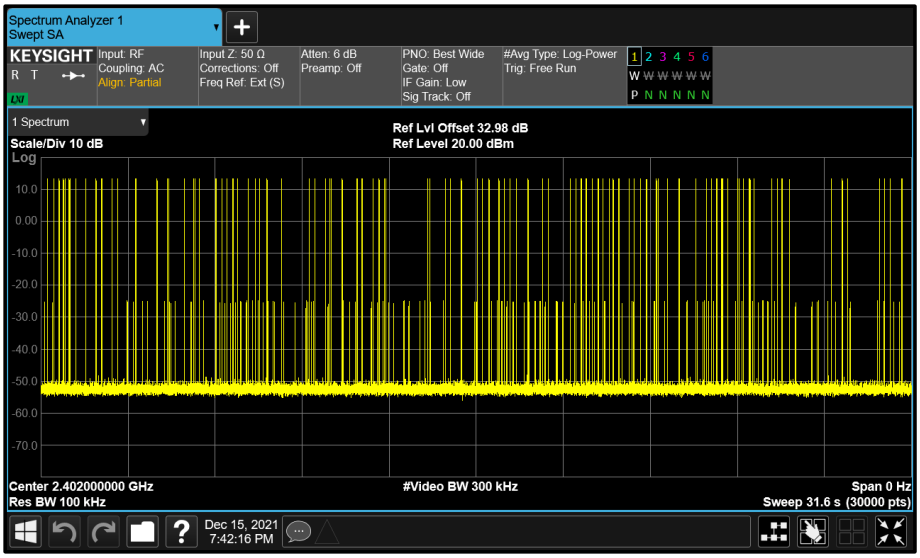

Figure 32 - GFSK - 2402 MHz Accumulated Transmit Time

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247 (a)(1)(iii) RSS-247 5.1 d)	Test Method(s):	C63.10 7.8.4
Additional Reference(s):	-		

DUT Configuration			
Mode:	iPA GFSK (DH5)	Duty Cycle (%):	76.7
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (Core 0)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	Time of Occupancy			Limit (ms)
	Dwell Time (ms)	Number of Transmissions	Time of Occupancy (ms)	
2402	2.888	108	311.9	400.0

Table 16 - Time of Occupancy Results

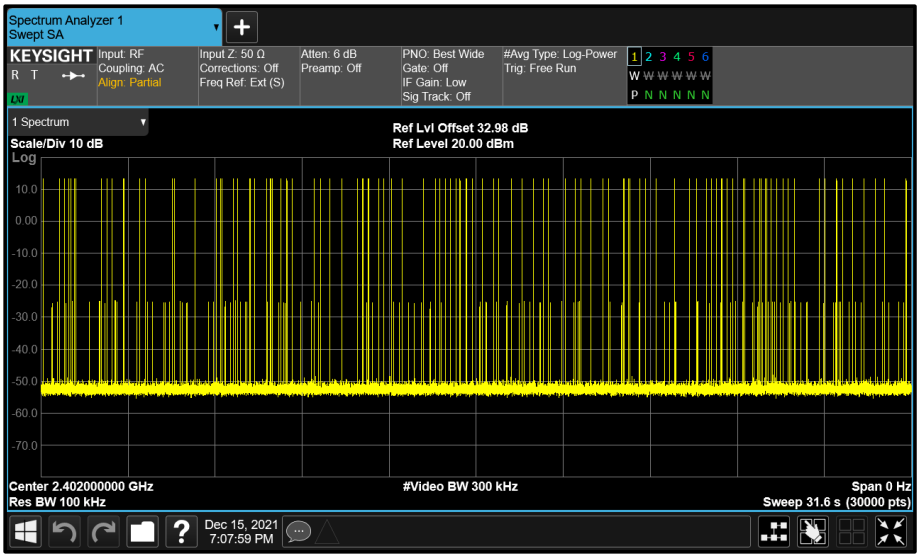

Figure 33 - GFSK - 2402 MHz Accumulated Transmit Time

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247 (a)(1)(iii) RSS-247 5.1 d)	Test Method(s):	C63.10 7.8.4
Additional Reference(s):	-		

DUT Configuration			
Mode:	iPA GFSK (DH5)	Duty Cycle (%):	76.7
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	C (Core 2)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	Time of Occupancy			Limit (ms)
	Dwell Time (ms)	Number of Transmissions	Time of Occupancy (ms)	
2402	2.888	112	323.5	400.0

Table 17 - Time of Occupancy Results

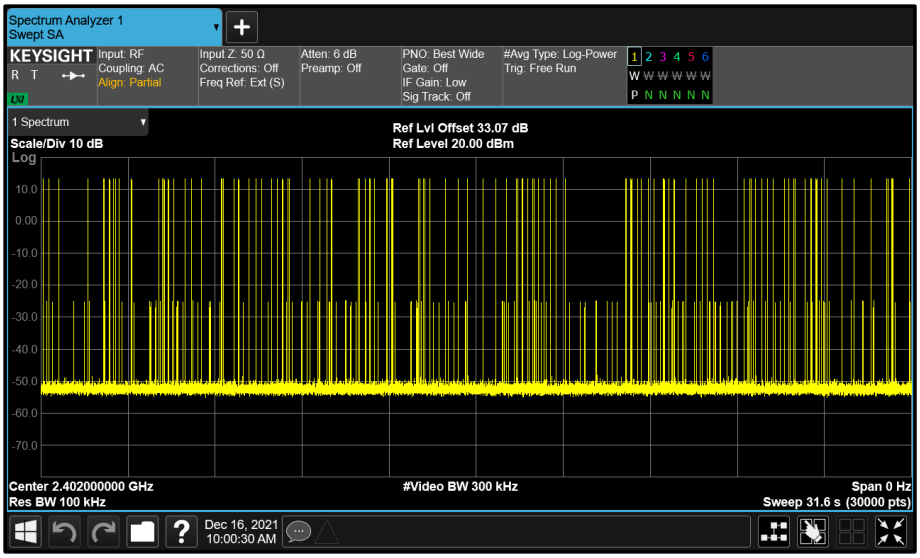

Figure 34 - GFSK - 2402 MHz Accumulated Transmit Time

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247 (a)(1)(iii) RSS-247 5.1 d)	Test Method(s):	C63.10 7.8.4
Additional Reference(s):	-		

DUT Configuration			
Mode:	iPA GFSK (DH5)	Duty Cycle (%):	76.7
Antenna Configuration:	Beamforming	DCCF (dB):	-
Active Port(s):	A+B (Core 0 + Core 1)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	Time of Occupancy			Limit (ms)
	Dwell Time (ms)	Number of Transmissions	Time of Occupancy (ms)	
2402	2.888	106	306.1	400.0

Table 18 - Time of Occupancy Results

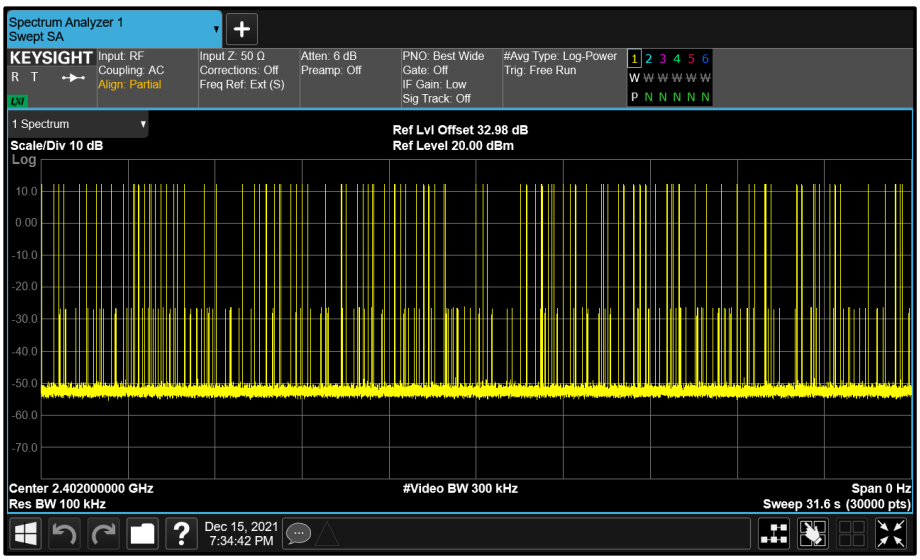

Figure 35 - GFSK - 2402 MHz Accumulated Transmit Time

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 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Expires
Multimeter	Fluke	79 Series II	3057	12	23-Aug-2022
Hygrometer	Rotronic	I-1000	3220	12	05-Nov-2022
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	03-Jan-2022
AC Programmable Power Supply	iTech	IT7324	5226	-	O/P Mon
MXA Signal Analyser	Keysight Technologies	N9020B	5528	24	04-Mar-2022
Signal Commissioning Unit	TUV SUD	SCU002	5759	12	30-Jun-2022

Table 19

O/P Mon – Output Monitored using calibrated equipment

2.3 Frequency Hopping Systems - Channel Separation

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

A2615, S/N: H617C20363 - Modification State 0

2.3.3 Date of Test

15-December-2021

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	22.6 - 23.5 °C
Relative Humidity	31.7 - 44.3 %

2.3.6 Test Results

2.4 GHz Bluetooth - FHSS

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	ePA GFSK (DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (Core 0)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	0.959	2441.024	2442.024	1.000	≥639.2

Table 20 - Carrier Frequency Separation Results

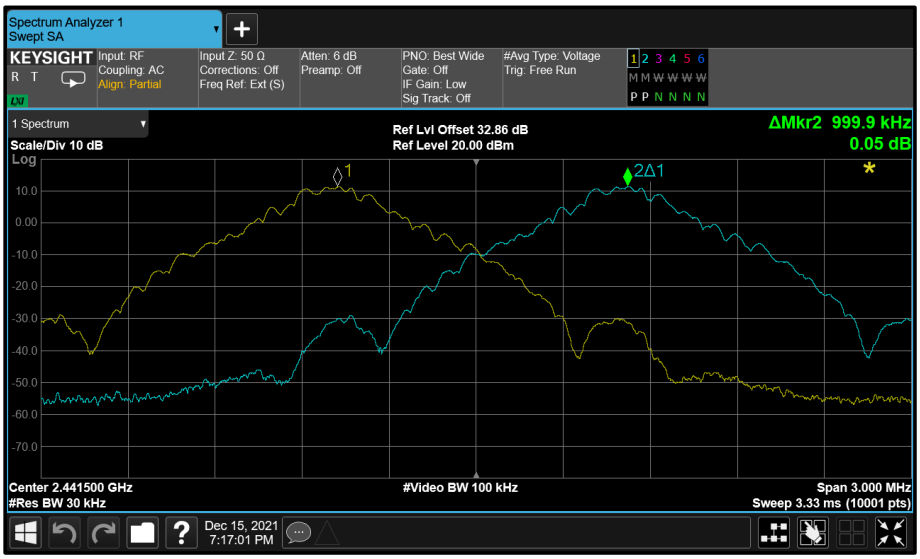

Figure 36 - GFSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	ePA π/4 DQPSK (2-DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (Core 0)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	1.387	2441.009	2442.010	1.001	≥924.5

Table 21 - Carrier Frequency Separation Results

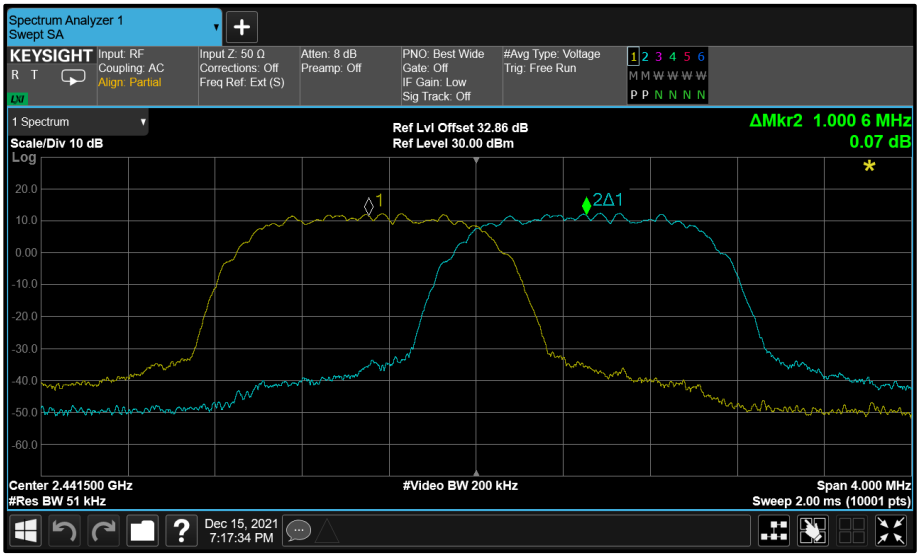

Figure 37 - π/4 DQPSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	ePA 8-DPSK (3-DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (Core 0)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	1.368	2441.005	2442.004	0.999	≥912.3

Table 22 - Carrier Frequency Separation Results

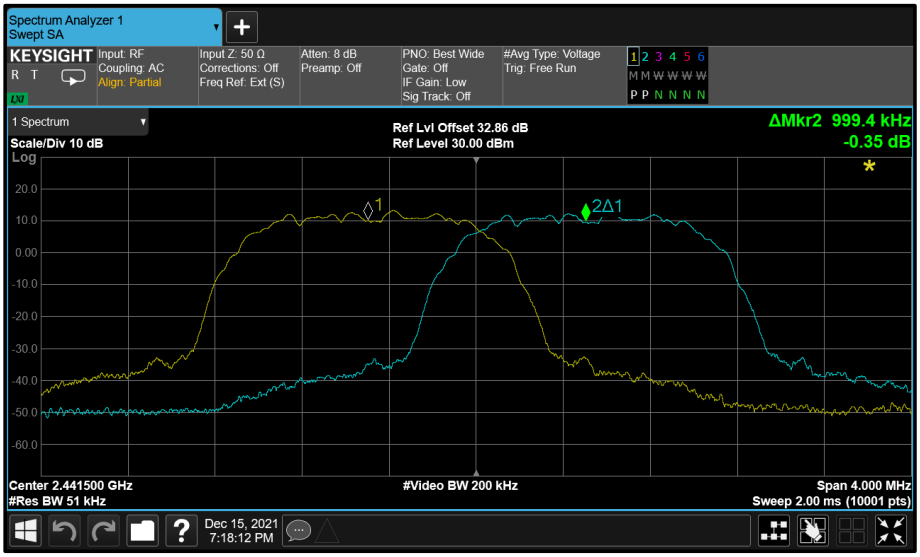

Figure 38 - 8-DPSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	ePA GFSK (DH5)	Duty Cycle (%):	-
Antenna Configuration:	Beamforming	DCCF (dB):	-
Active Port(s):	A+B (Core 0 + Core 1)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	0.956	2441.023	2442.023	1.000	≥637.4

Table 23 - Carrier Frequency Separation Results

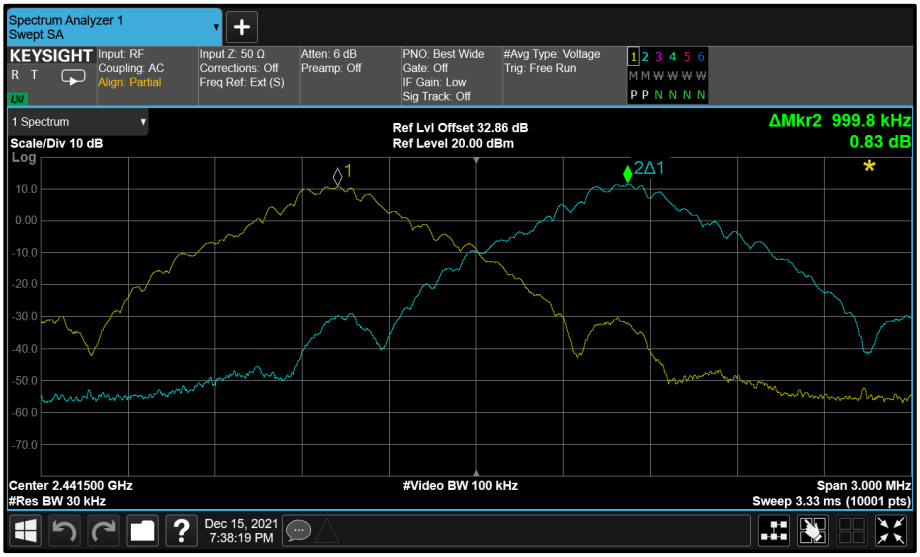

Figure 39 - GFSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	ePA π/4 DQPSK (2-DH5)	Duty Cycle (%):	-
Antenna Configuration:	Beamforming	DCCF (dB):	-
Active Port(s):	A+B (Core 0 + Core 1)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	1.387	2441.008	2442.007	0.999	≥924.8

Table 24 - Carrier Frequency Separation Results

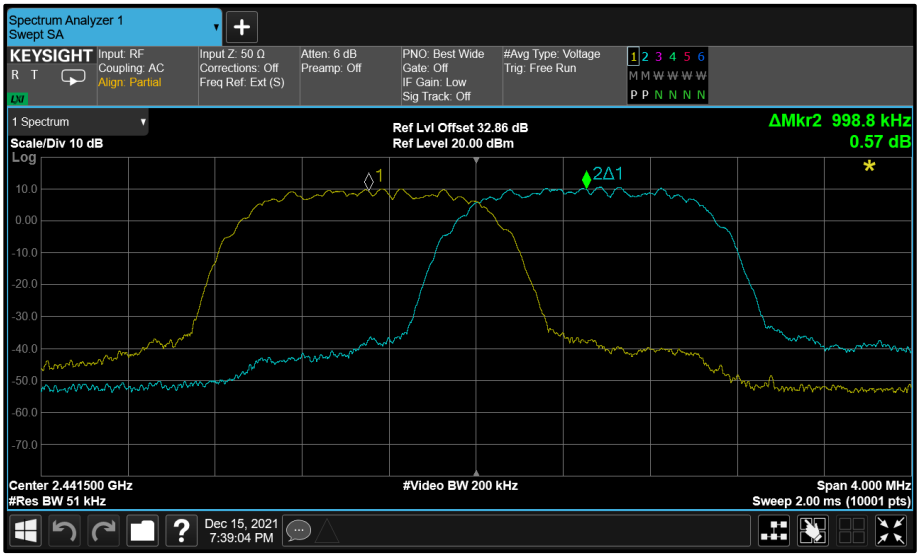

Figure 40 - π/4 DQPSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	ePA 8-DPSK (3-DH5)	Duty Cycle (%):	-
Antenna Configuration:	Beamforming	DCCF (dB):	-
Active Port(s):	A+B (Core 0 + Core 1)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	1.371	2441.002	2442.003	1.001	≥913.9

Table 25 - Carrier Frequency Separation Results

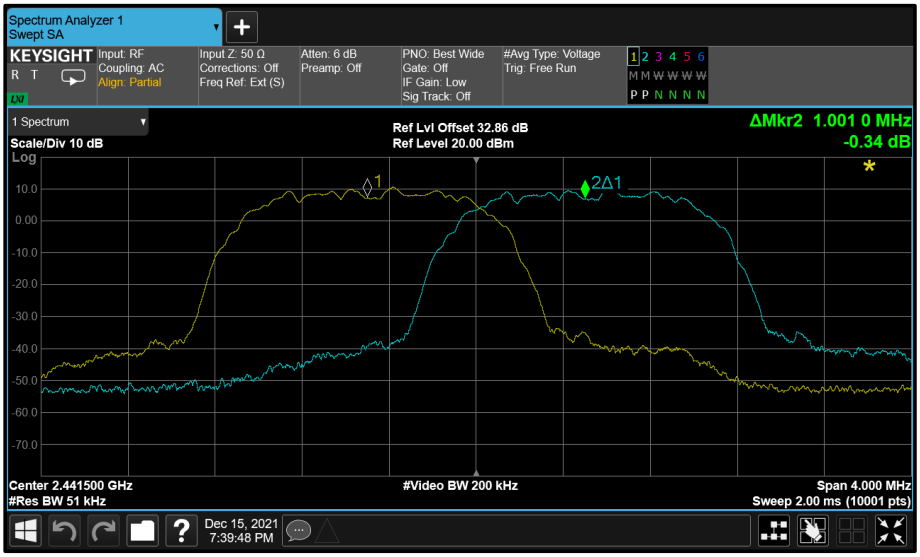

Figure 41 - 8-DPSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	iPA GFSK (DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (Core 0)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	0.958	2441.024	2442.024	1.000	≥638.4

Table 26 - Carrier Frequency Separation Results

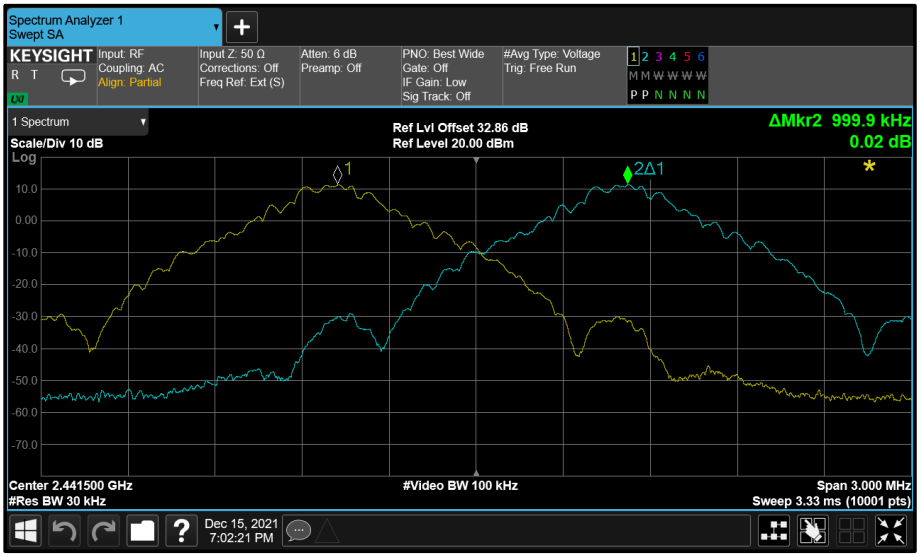

Figure 42 - GFSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	iPA π/4 DQPSK (2-DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (Core 0)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	1.391	2441.011	2442.010	0.999	≥927.5

Table 27 - Carrier Frequency Separation Results

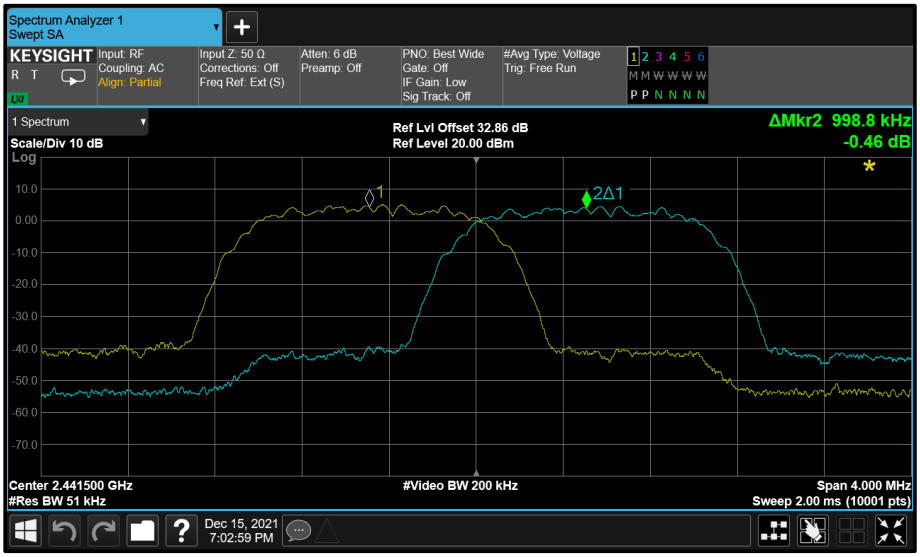

Figure 43 - π/4 DQPSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	iPA 8-DPSK (3-DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (Core 0)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	1.374	2441.002	2442.002	1.000	≥916.3

Table 28 - Carrier Frequency Separation Results

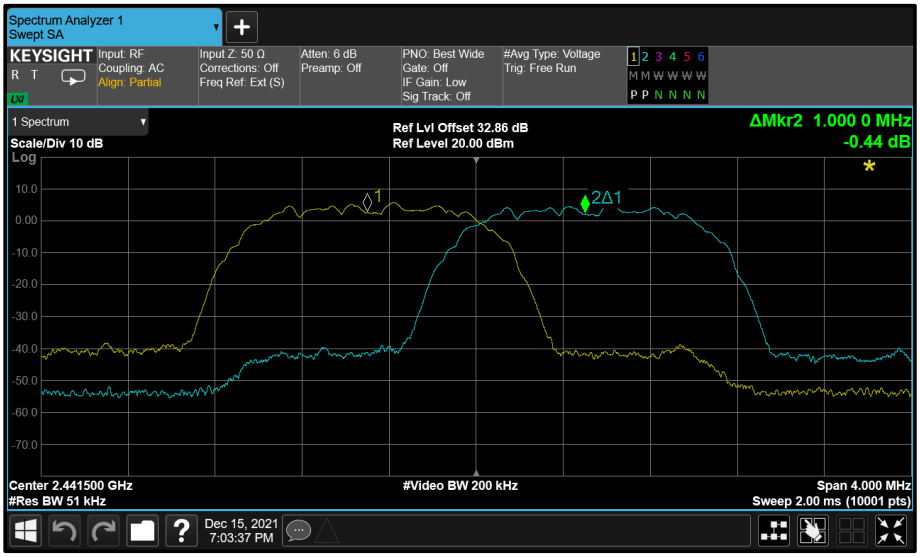

Figure 44 - 8-DPSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	iPA GFSK (DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	C (Core 2)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	0.957	2441.024	2442.023	0.999	≥638.2

Table 29 - Carrier Frequency Separation Results

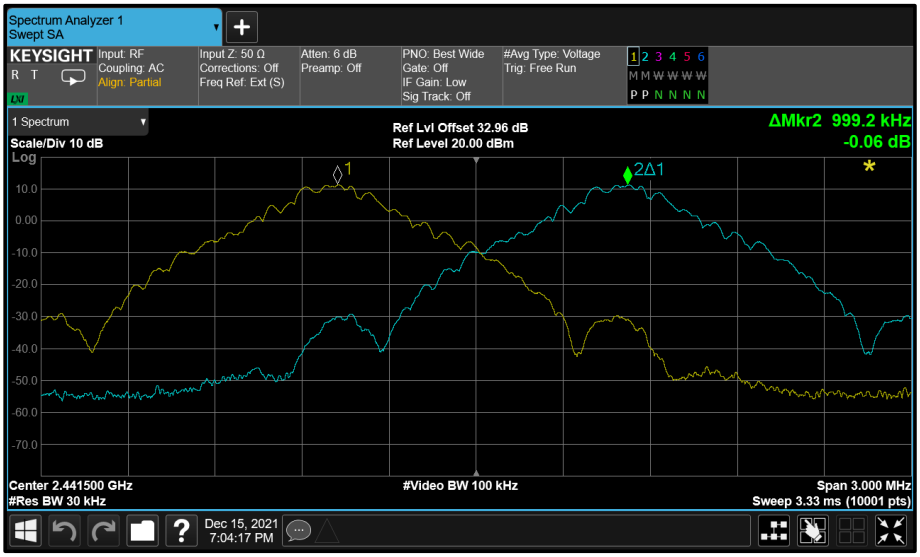

Figure 45 - GFSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	iPA π/4 DQPSK (2-DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	C (Core 2)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	1.393	2441.011	2442.011	1.000	≥928.5

Table 30 - Carrier Frequency Separation Results

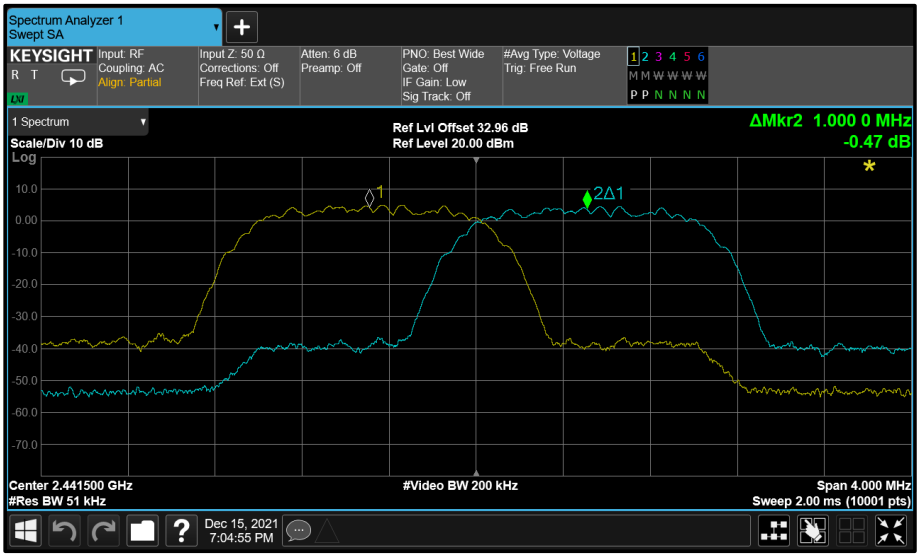

Figure 46 - π/4 DQPSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	iPA 8-DPSK (3-DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	C (Core 2)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	1.376	2441.002	2442.002	1.000	≥917.3

Table 31 - Carrier Frequency Separation Results

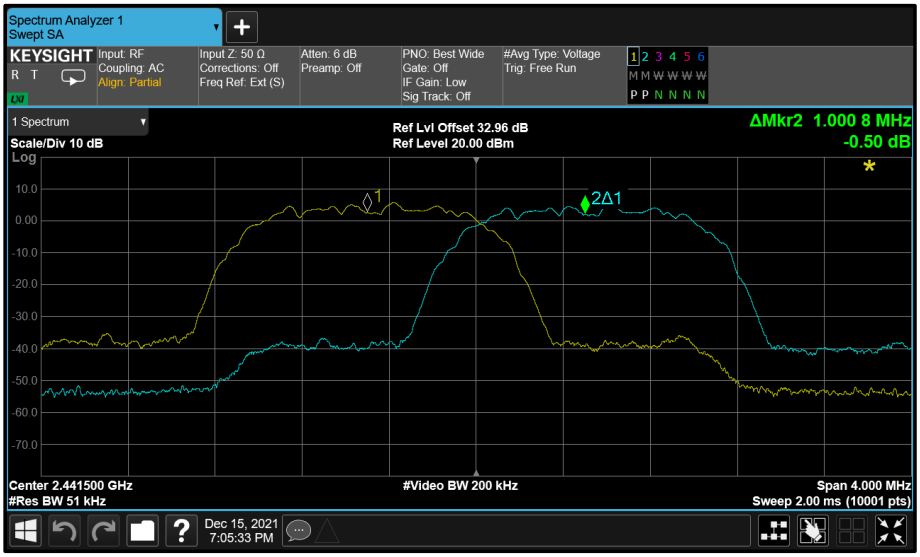

Figure 47 - 8-DPSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	iPA GFSK (DH5)	Duty Cycle (%):	-
Antenna Configuration:	Beamforming	DCCF (dB):	-
Active Port(s):	A+B (Core 0 + Core 1)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	0.958	2441.024	2442.024	1.000	≥638.4

Table 32 - Carrier Frequency Separation Results

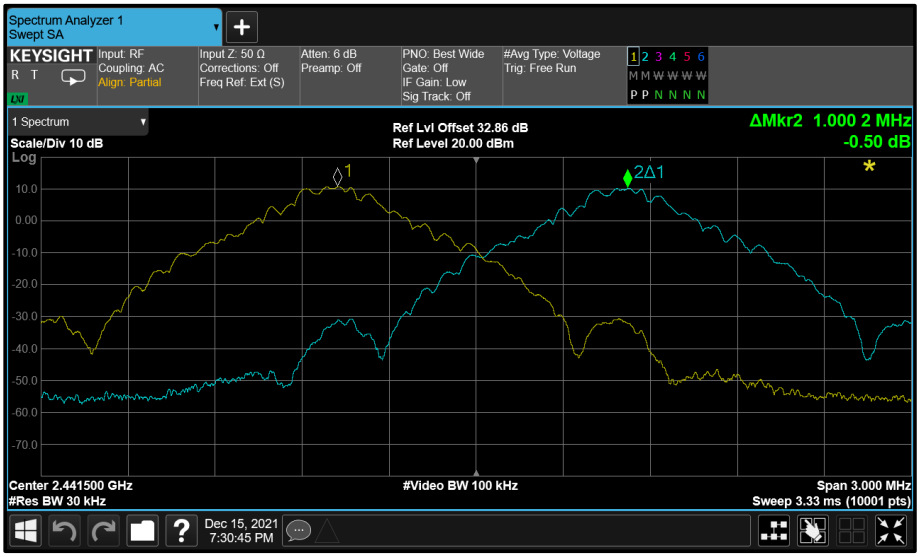

Figure 48 - GFSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	iPA π/4 DQPSK (2-DH5)	Duty Cycle (%):	-
Antenna Configuration:	Beamforming	DCCF (dB):	-
Active Port(s):	A+B (Core 0 + Core 1)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	1.388	2441.011	2442.010	0.999	≥925.6

Table 33 - Carrier Frequency Separation Results

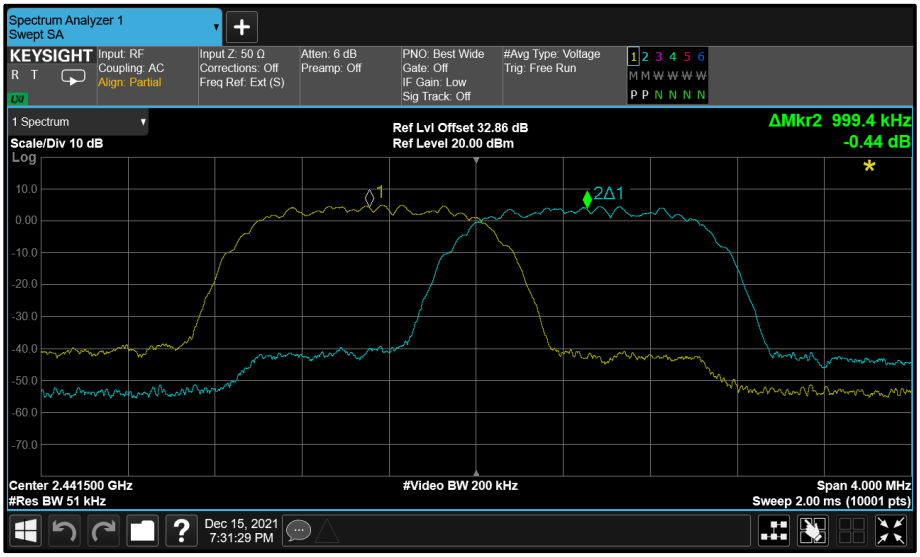

Figure 49 - π/4 DQPSK - 2441 MHz (CH39)

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1) RSS-247 5.1 b)	Test Method(s):	C63.10 7.8.2
Additional Reference(s):	-		

DUT Configuration			
Mode:	iPA 8-DPSK (3-DH5)	Duty Cycle (%):	-
Antenna Configuration:	Beamforming	DCCF (dB):	-
Active Port(s):	A+B (Core 0 + Core 1)	Peak Antenna Gain (dBi):	-

Test Frequency (MHz)	20 dB Bandwidth (MHz)	Carrier Frequency Separation (MHz)			Limit (kHz)
		F1C	F2C	FHS	
2441	1.376	2441.002	2442.003	1.001	≥917.3

Table 34 - Carrier Frequency Separation Results

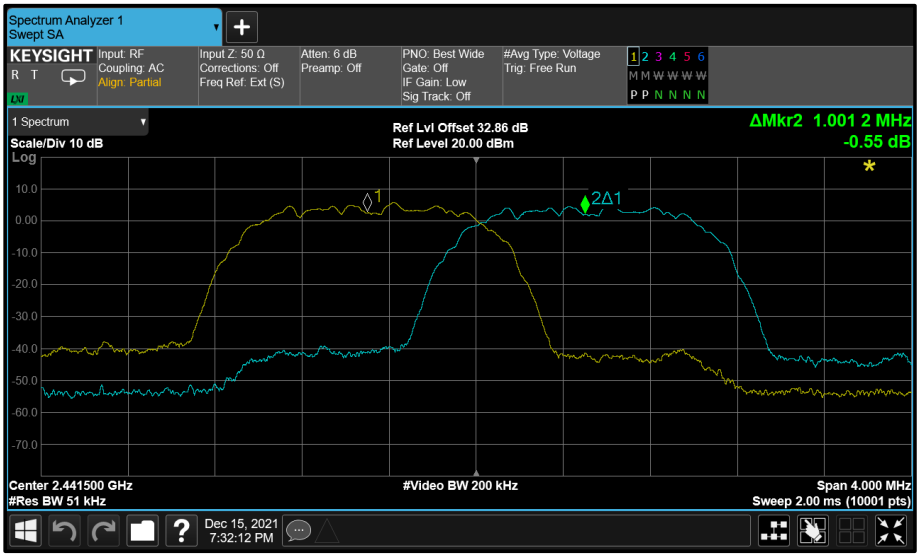

Figure 50 - 8-DPSK - 2441 MHz (CH39)

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.

2.3.7 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 Expires
Multimeter	Fluke	79 Series II	3057	12	23-Aug-2022
Hygrometer	Rotronic	I-1000	3220	12	05-Nov-2022
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	03-Jan-2022
AC Programmable Power Supply	iTech	IT7324	5226	-	O/P Mon
MXA Signal Analyser	Keysight Technologies	N9020B	5528	24	04-Mar-2022
Signal Commissioning Unit	TUV SUD	SCU002	5759	12	30-Jun-2022

Table 35

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)
ISED RSS-247, Clause 5.1

2.4.2 Equipment Under Test and Modification State

A2615, S/N: H617C20363 - Modification State 0

2.4.3 Date of Test

15-December-2021 to 16-December-2021

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	22.6 - 23.5 °C
Relative Humidity	31.7 - 44.3 %

2.4.6 Test Results

2.4 GHz Bluetooth - FHSS

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1)(iii) RSS-247 5.1 d)	Test Method(s):	C63.10 7.8.3
Additional Reference(s):	-		

DUT Configuration			
Mode:	ePA GFSK (DH5)	Duty Cycle (%):	-
Antenna Configuration:	SISO	DCCF (dB):	-
Active Port(s):	A (Core 0)	Peak Antenna Gain (dBi):	-

Number of Hopping Frequencies	Limit
79	≥15.0

Table 36 - Number of Hopping Frequencies Results

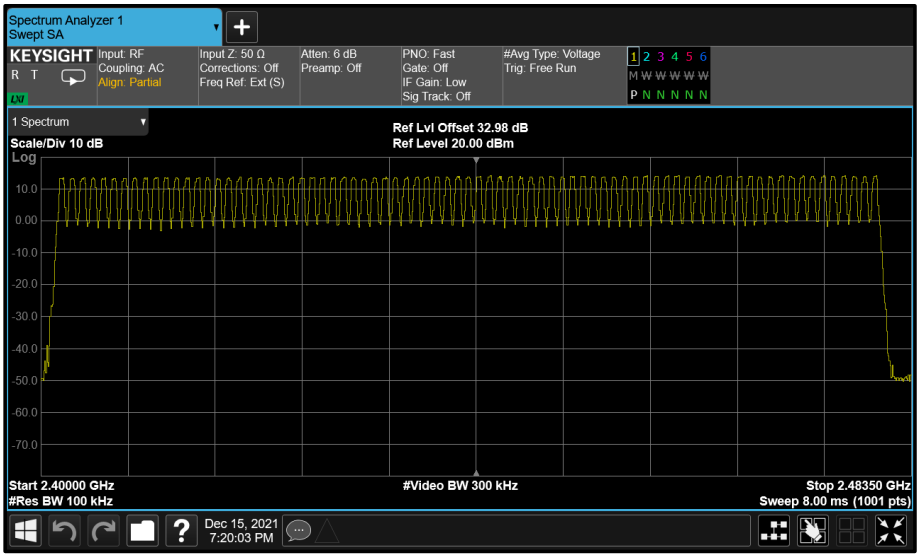

Figure 51 - GFSK (DH5) - Number of Hopping Channels

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1)(iii) RSS-247 5.1 d)	Test Method(s):	C63.10 7.8.3
Additional Reference(s):	-		

DUT Configuration			
Mode:	ePA GFSK (DH5)	Duty Cycle (%):	-
Antenna Configuration:	Beamforming	DCCF (dB):	-
Active Port(s):	A+B (Core 0 + Core 1)	Peak Antenna Gain (dBi):	-

Number of Hopping Frequencies	Limit
79	≥15.0

Table 37 - Number of Hopping Frequencies Results

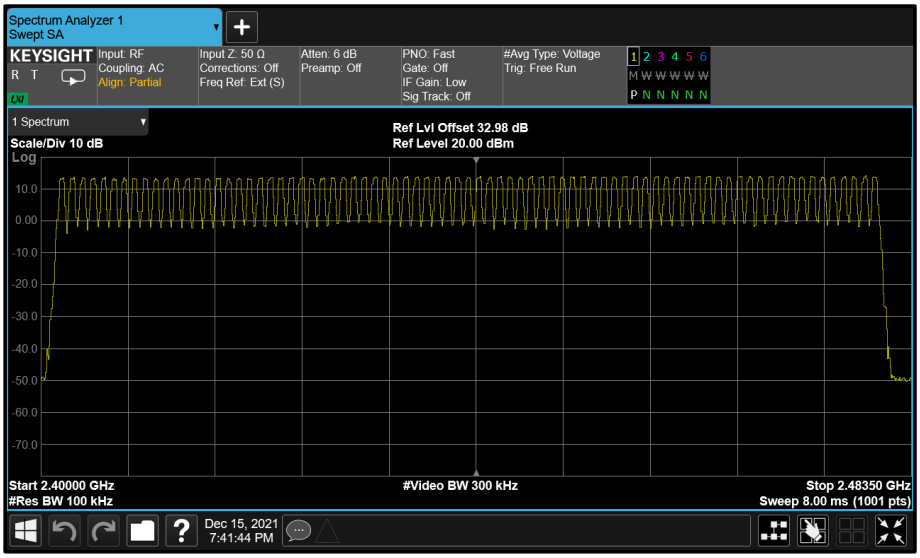

Figure 52 - GFSK (DH5) - Number of Hopping Channels

Test Configuration			
Frequency Range:	2400-2483.5 MHz	Band:	2.4 GHz
Limit Clause(s):	FCC 15.247(a)(1)(iii) RSS-247 5.1 d)	Test Method(s):	C63.10 7.8.3
Additional Reference(s):	-		

DUT Configuration			
Mode:	ePA π/4 DQPSK (2-DH5)	Duty Cycle (%):	-
Antenna Configuration:	Beamforming	DCCF (dB):	-
Active Port(s):	A+B (Core 0 + Core 1)	Peak Antenna Gain (dBi):	-

Number of Hopping Frequencies	Limit
79	≥15.0

Table 38 - Number of Hopping Frequencies Results

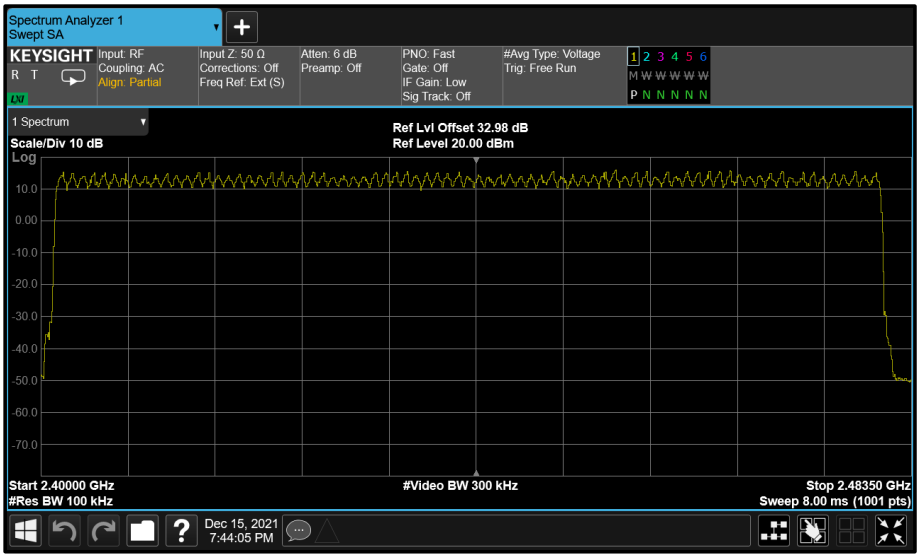

Figure 53 - π/4 DQPSK (2-DH5) - Number of Hopping Channels