FCC and ISED Test Report

Apple Inc
Model: A2338

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

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

FCC ID: BCGA2338 IC: 579C-A2338

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Document 75948987-10 Issue 01

SIGNATURE			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Neil Rousell	Senior Engineer	Authorised Signatory	22 October 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, 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	Mehadi Choudhury	22 October 2020	
Testing	Aasim Butt	22 October 2020	
Testing	Connor Lee	22 October 2020	
Testing	Liang Tian	22 October 2020	

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: 2019, ISED RSS-247: Issue 2 (02-2017) and ISED RSS-GEN: Issue 5 (04-2018) + A1 (03-2019) for the tests detailed in section 1.3.

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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	22 October 2020

Table 1

1.2 Introduction

Applicant	Apple Inc
Manufacturer	Apple Inc
Model Number(s)	A2338
Serial Number(s)	C02CX02PQC36 and C02CX02JQC36
Hardware Version(s)	REV 1.0
Software Version(s)	20W112771j
Number of Samples Tested	2
Test Specification/Issue/Date	FCC 47 CFR Part 15C: 2019 ISED RSS-247: Issue 2 (02-2017) ISED RSS-GEN: Issue 5 (04-2018) + A1 (03-2019)
Order Number Date	0540201117 05-May-2020
Date of Receipt of EUT	17-July-2020 and 17-August-2020
Start of Test	04-August-2020
Finish of Test	15-September-2020
Name of Engineer(s)	Mehadi Choudhury, Aasim Butt, Connor Lee and Liang Tian
Related Document(s)	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 Low Energy (DTS)						
-	15.203	-	-	Antenna Requirement	N/T	The device complies with the provisions of this section, as it uses a permanently attached antenna
2.1	15.247 (a)(2)	5.2	6.7	Emission Bandwidth	Pass	
2.2	15.247 (b)	5.4	6.12	Maximum Conducted Output Power	Pass	
2.3	15.247 (d)	5.5	-	Authorised Band Edges	Pass	
2.4	15.205	-	8.10	Restricted Band Edges	Pass	
2.5	15.247 (d) and 15.205	5.5	6.13	Spurious Radiated Emissions	Pass	
2.6	15.247 (e)	5.2	6.12	Power Spectral Density	Pass	

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/ax capabilities in the 2.4 GHz and 5 GHz bands.

1.4.2 Test Set-up

For conducted tests, a conducted test point was provided by the manufacturer via a 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 Core with the highest antenna gain as Core 0 and Core 1 are identical but with unequal antenna gains. Radiated tests were performed on all Cores. The EUT supports TxBF on Core 0 + Core 1 only.

Bluetooth LE + HDR was assessed as a DTS system. The EUT supports Bluetooth on the following mode of operations across it's antenna ports:

- BT Core 0 – SISO (iPA and ePA), TxBF (iPA and ePA)
- BT Core 1 – SISO (iPA and ePA), TxBF (iPA and ePA)
- BT Core 0 + BT Core 1 - 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 a static channel selected within the test script.

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

1.4.3 Antenna Gain Table (2.4GHz Bluetooth)

Antenna Port	Frequency Range (MHz)	Peak Gain (dBi)	Conducted Cable Loss (dB)
BT Core 0	2400 to 2480	0.57	1.0
BT Core 1	2400 to 2480	1.18	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: A2338, Serial Number: C02CX02JQC36			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: A2338, Serial Number: C02CX02PQC36			
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 Low Energy (DTS)		
Maximum Conducted Output Power	Mehadi Choudhury	UKAS
Power Spectral Density	Mehadi Choudhury	UKAS
Emission Bandwidth	Mehadi Choudhury	UKAS
Authorised Band Edges	Aasim Butt, Connor Lee and Liang Tian	UKAS
Restricted Band Edges	Aasim Butt, Connor Lee and Liang Tian	UKAS
Spurious Radiated Emissions	Aasim Butt, Connor Lee and Liang Tian	UKAS

Table 5

Office Address:

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

2 Test Details

2.1 Emission Bandwidth

2.1.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(2)
ISED RSS-247, Clause 5.2
ISED RSS-GEN, Clause 6.7

2.1.2 Equipment Under Test and Modification State

A2338, S/N: C02CX02JQC36 - Modification State 0

2.1.3 Date of Test

11-September-2020

2.1.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 11.8.1

2.1.5 Environmental Conditions

Ambient Temperature	21.5 - 25.9 °C
Relative Humidity	46.0 - 52.9 %

2.1.6 Test Results

2.4 GHz Bluetooth Low Energy (DTS)

iPA

Antenna Port Configuration: SISO

Modulation: π/4 DQPSK (HDR4)

Test Frequency (MHz)	6 dB Bandwidth (MHz)
	Port(s)
	Core 1
2404	1.864
2441	1.560
2478	1.560

Table 6 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)
	Port(s)
	Core 1
2404	2.360
2441	2.344
2478	2.344

Table 7 - 99% Bandwidth Results

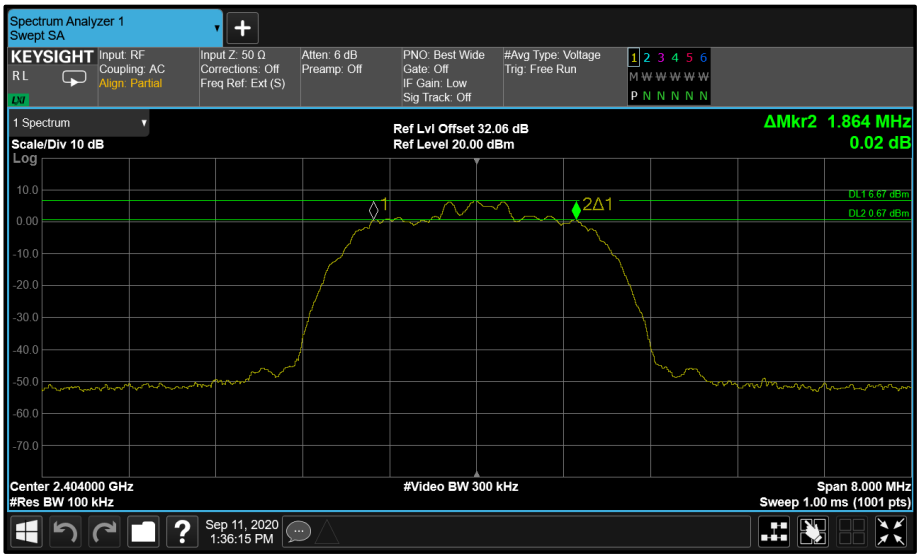

Figure 1 - Core 1 HDR4 2404 MHz (CH2)

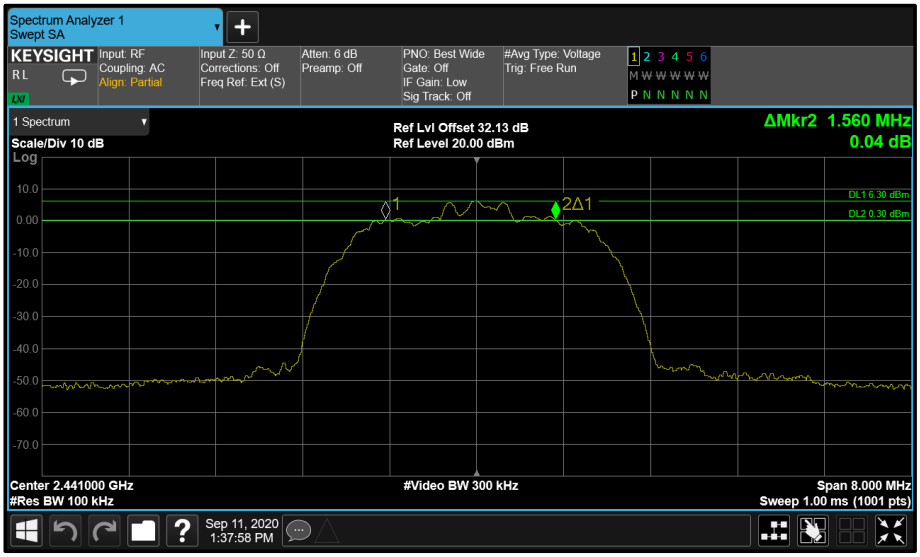

Figure 2 - Core 1 HDR4 2441 MHz (CH39)

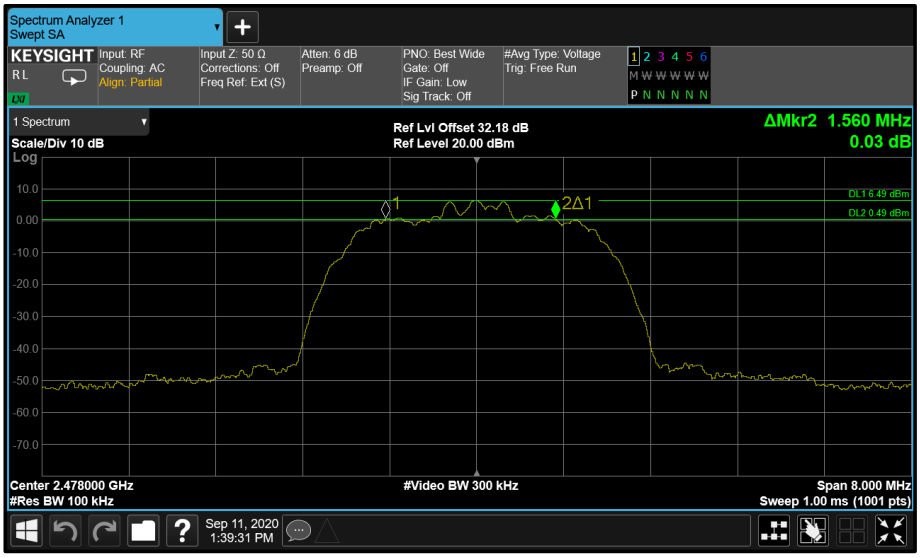

Figure 3 - Core 1 HDR4 2478 MHz (CH76)

Modulation: π/4 DQPSK (HDR8)

Test Frequency (MHz)	6 dB Bandwidth (MHz)
	Port(s)
	Core 1
2404	1.030
2441	1.030
2478	1.040

Table 8 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)
	Port(s)
	Core 1
2404	4.550
2441	4.550
2478	4.550

Table 9 - 99% Bandwidth Results

Figure 4 - Core 1 HDR8 2404 MHz (CH2)

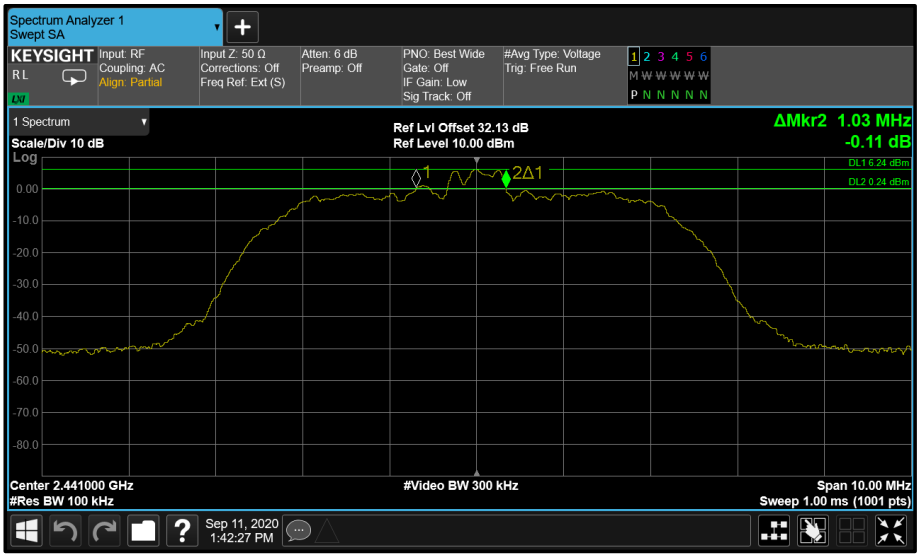

Figure 5 - Core 1 HDR8 2441 MHz (CH39)

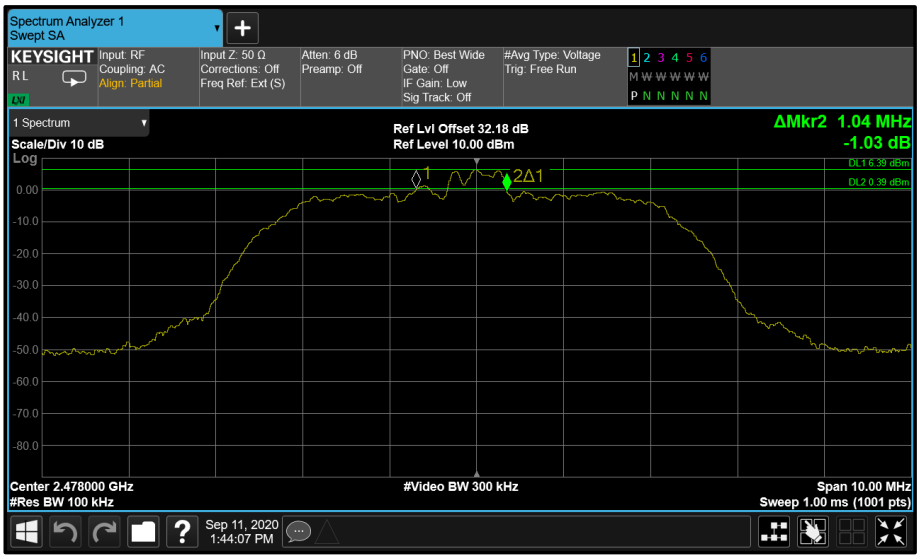

Figure 6 - Core 1 HDR8 2478 MHz (CH76)

Modulation: GFSK (LE 1M)

Test Frequency (MHz)	6 dB Bandwidth (MHz)
	Port(s)
	Core 1
2402	0.688
2440	0.692
2480	0.692

Table 10 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)
	Port(s)
	Core 1
2402	1.080
2440	1.080
2480	1.080

Table 11 - 99% Bandwidth Results

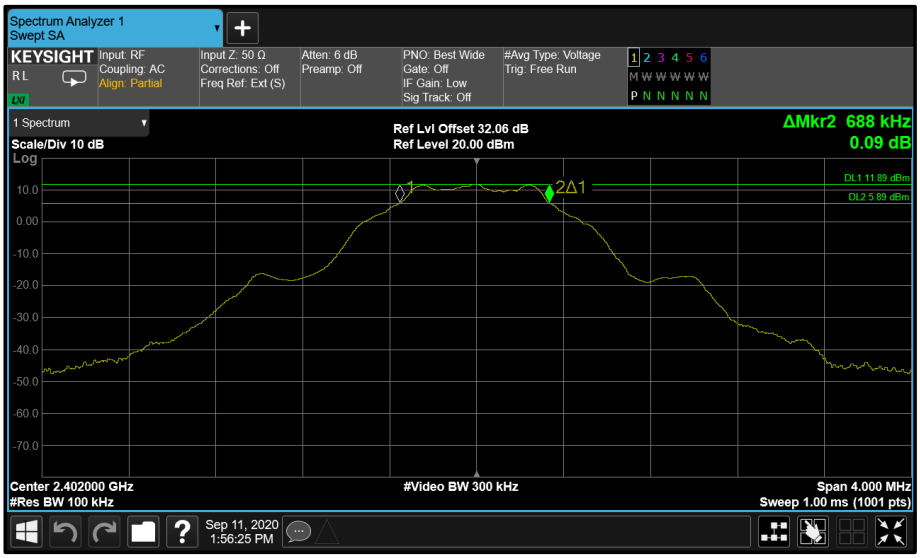

Figure 7 - Core 1 LE 1M 2402 MHz (CH0)

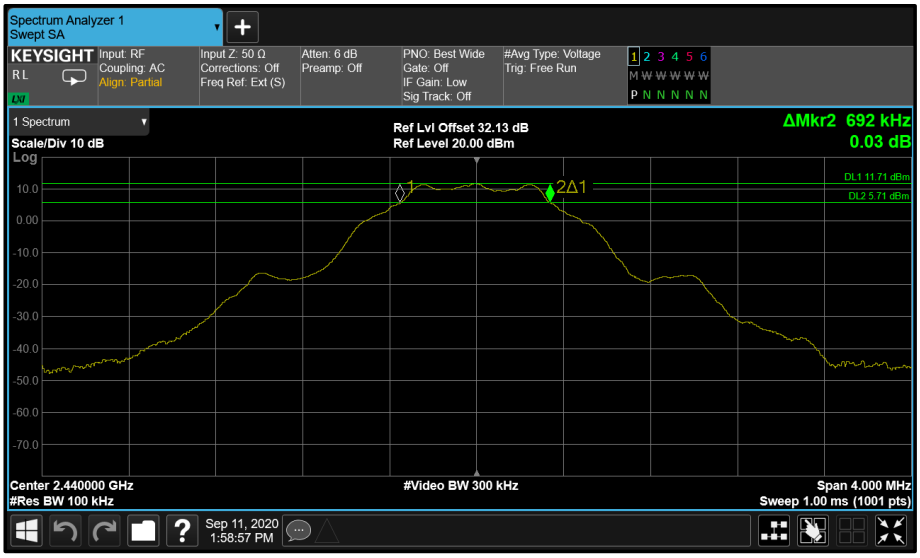

Figure 8 - Core 1 LE 1M 2440 MHz (CH19)

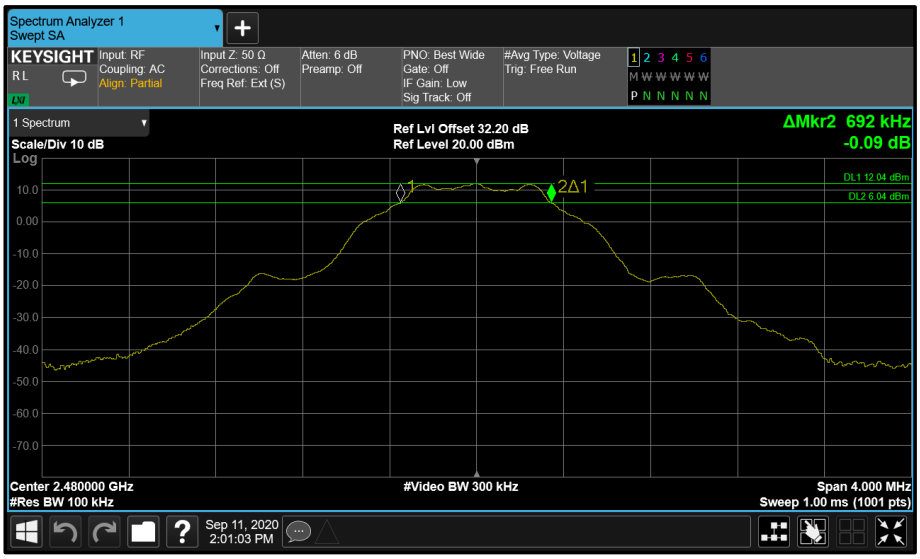

Figure 9 - Core 1 LE 1M 2480 MHz (CH39)

Modulation: GFSK (LE 2M)

Test Frequency (MHz)	6 dB Bandwidth (MHz)
	Port(s)
	Core 1
2402	1.224
2440	1.224
2480	1.232

Table 12 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)
	Port(s)
	Core 1
2402	2.088
2440	2.080
2480	2.080

Table 13 - 99% Bandwidth Results

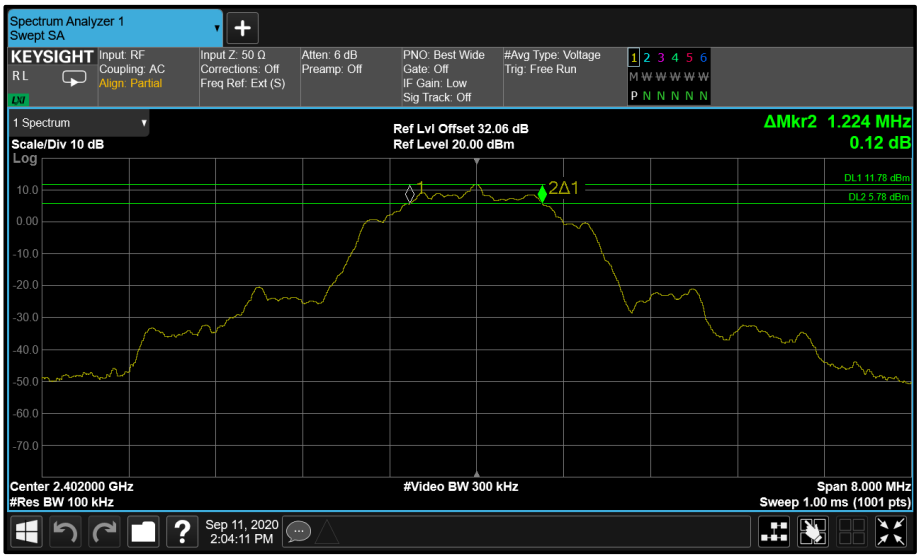

Figure 10 - Core 1 LE 2M 2402 MHz (CH0)

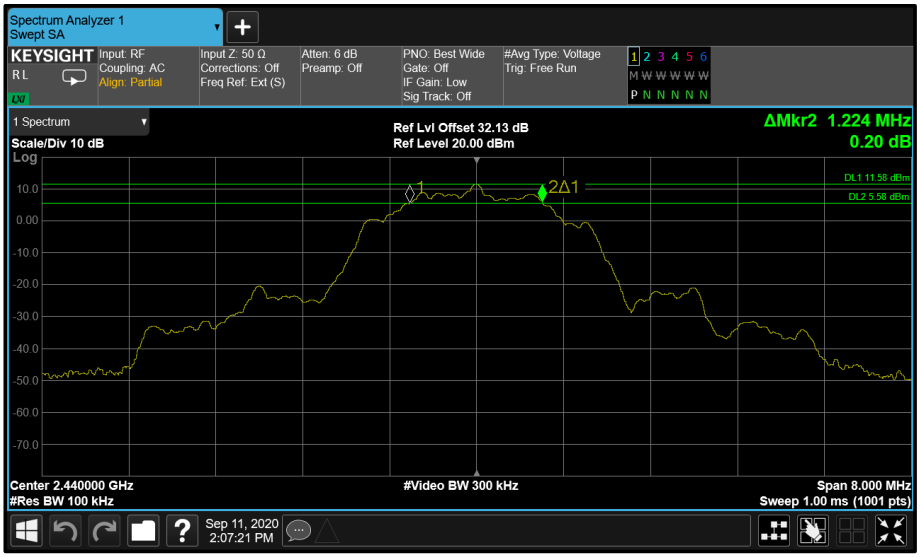

Figure 11 - Core 1 LE 2M 2440 MHz (CH19)

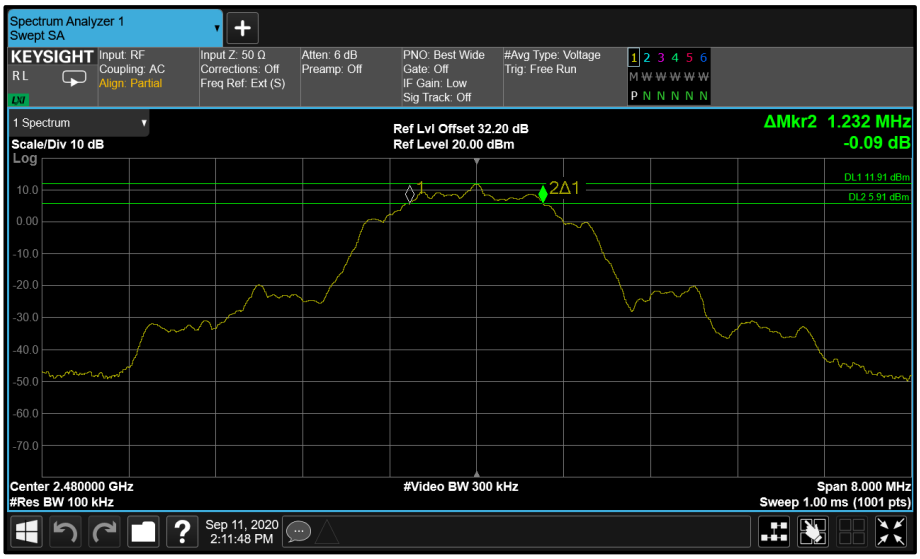

Figure 12 - Core 1 LE 2M 2480 MHz (CH39)

Antenna Port Configuration: Beamforming

Modulation: π/4 DQPSK (HDR4)

Test Frequency (MHz)	6 dB Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2404	1.488	1.552
2441	1.488	1.552
2478	1.552	1.560

Table 14 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2404	2.344	2.344
2441	2.352	2.336
2478	2.344	2.344

Table 15 - 99% Bandwidth Results

Figure 13 - Core 1 HDR4 2404 MHz (CH2)

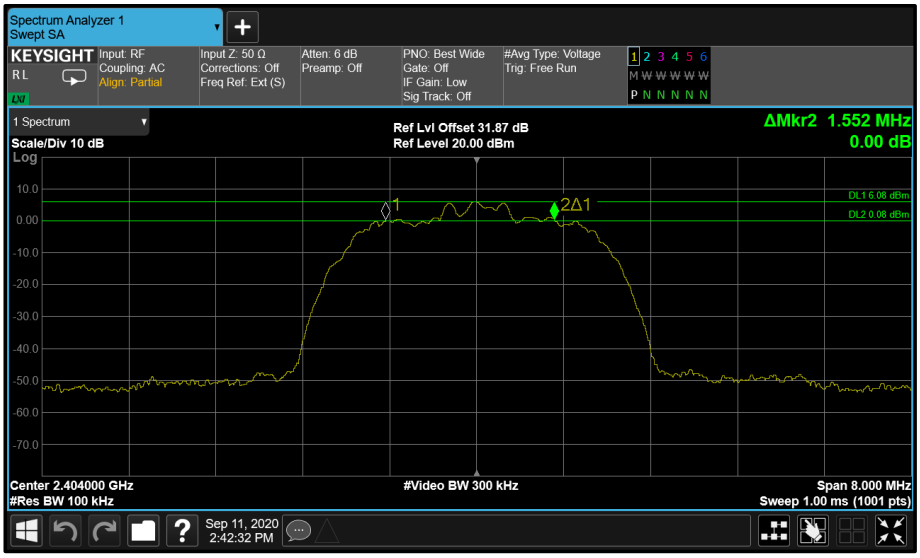

Figure 14 - Core 0 HDR4 2404 MHz (CH2)

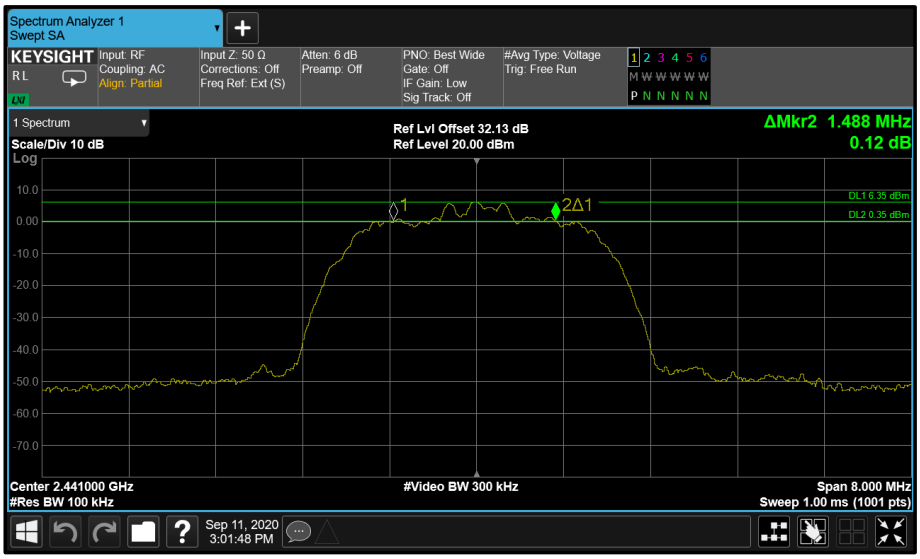

Figure 15 - Core 1 HDR4 2441 MHz (CH39)

Figure 16 - Core 0 HDR4 2441 MHz (CH39)

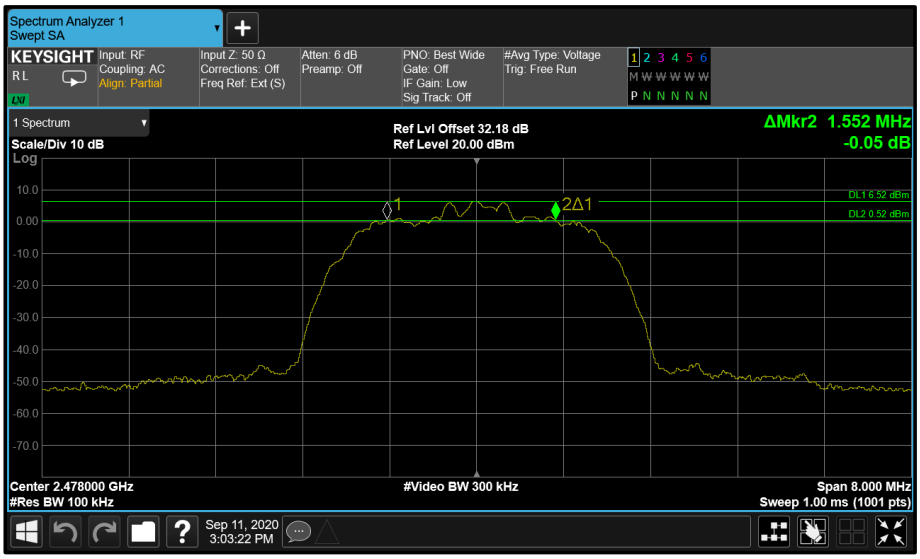

Figure 17 - Core 1 HDR4 2478 MHz (CH76)

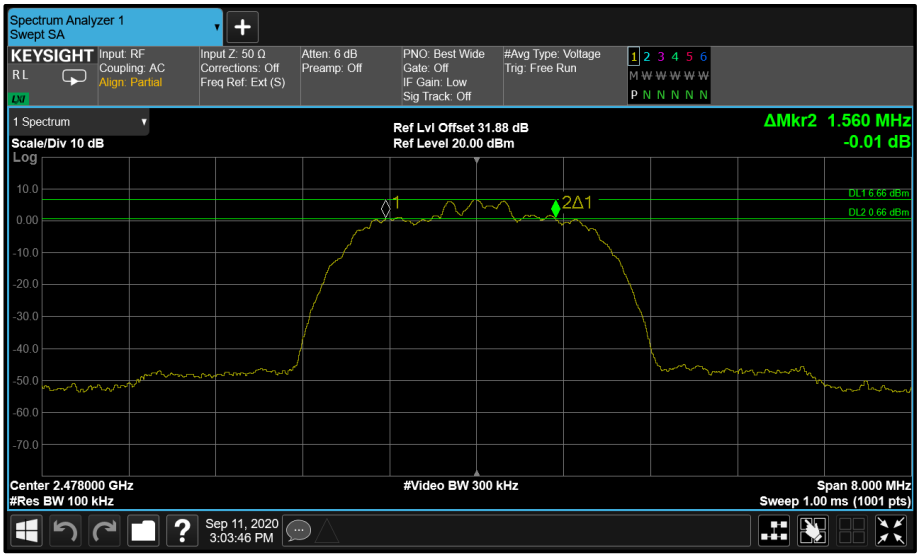

Figure 18 - Core 0 HDR4 2478 MHz (CH76)

Modulation: π/4 DQPSK (HDR8)

Test Frequency (MHz)	6 dB Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2404	1.030	1.020
2441	1.030	1.040
2478	1.030	1.030

Table 16 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2404	4.550	4.550
2441	4.550	4.550
2478	4.550	4.550

Table 17 - 99% Bandwidth Results

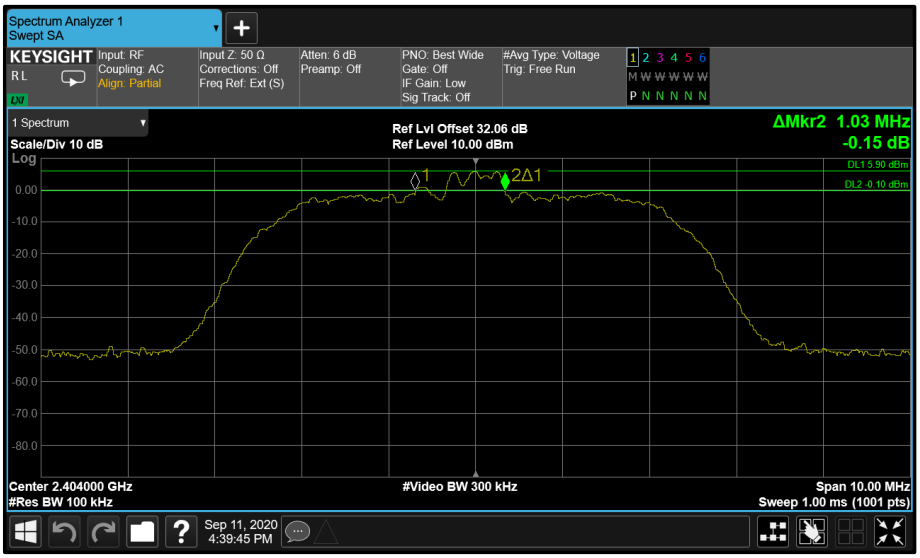

Figure 19 - Core 1 HDR8 2404 MHz (CH2)

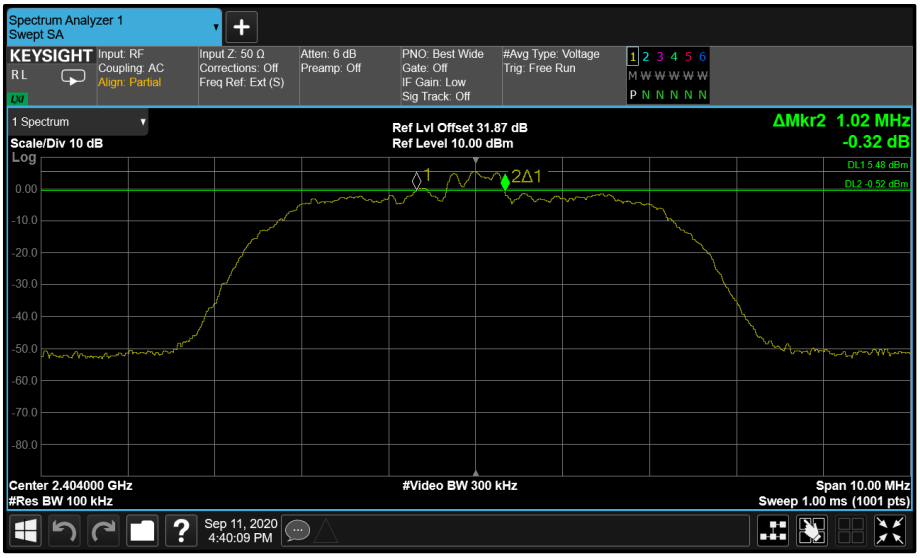

Figure 20 - Core 0 HDR8 2404 MHz (CH2)

Figure 21 - Core 1 HDR8 2441 MHz (CH39)

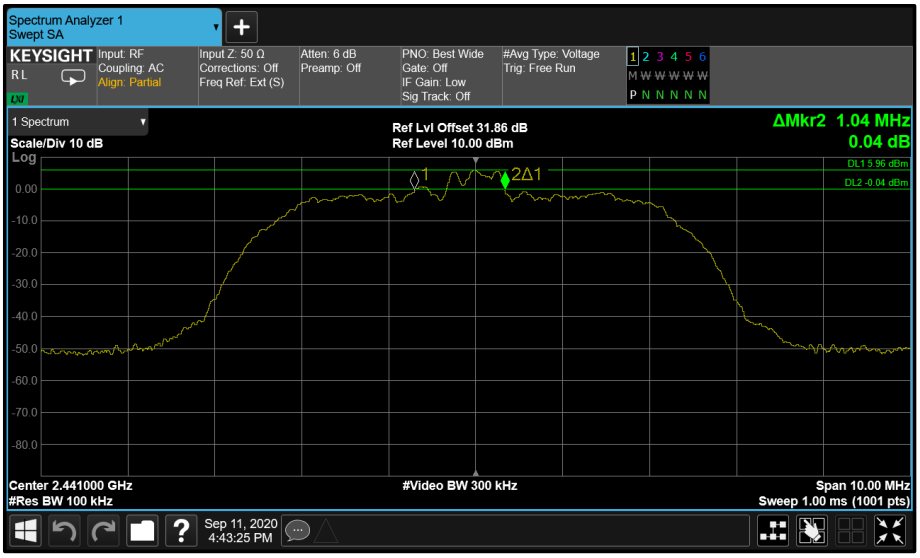

Figure 22 - Core 0 HDR8 2441 MHz (CH39)

Figure 23 - Core 1 HDR8 2478 MHz (CH76)

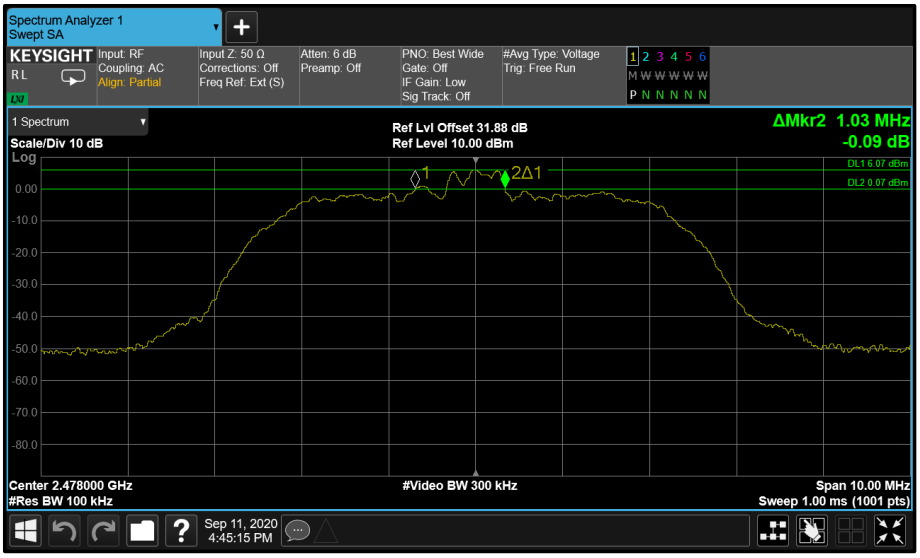

Figure 24 - Core 0 HDR8 2478 MHz (CH76)

Modulation: GFSK (LE 1M)

Test Frequency (MHz)	6 dB Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2402	0.688	0.688
2440	0.692	0.692
2480	0.692	0.692

Table 18 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2402	1.076	1.076
2440	1.080	1.076
2480	1.080	1.076

Table 19 - 99% Bandwidth Results

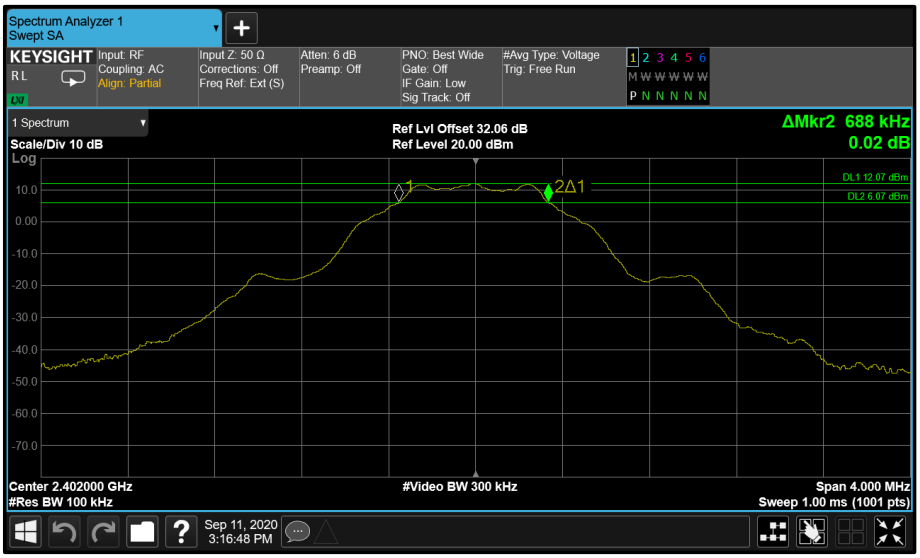

Figure 25 - Core 1 LE 1M 2402 MHz (CH0)

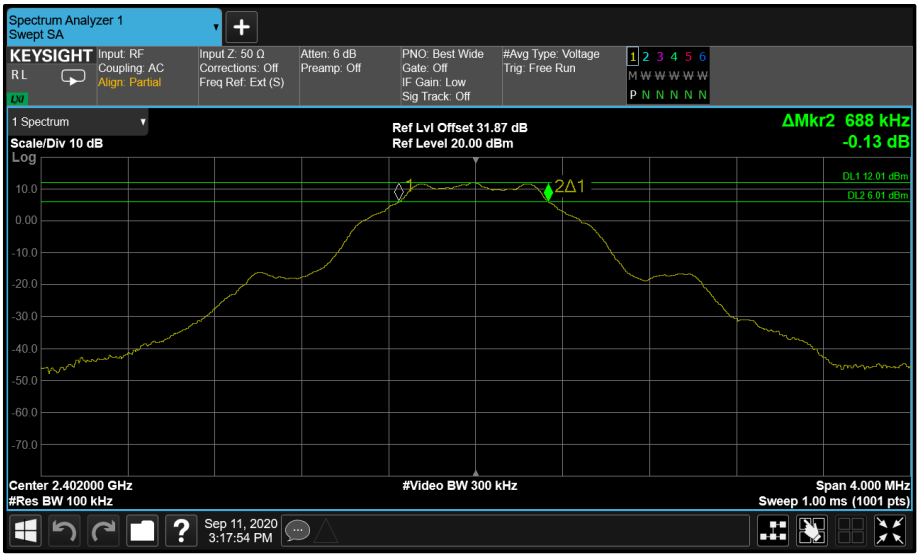

Figure 26 - Core 0 LE 1M 2402 MHz (CH0)

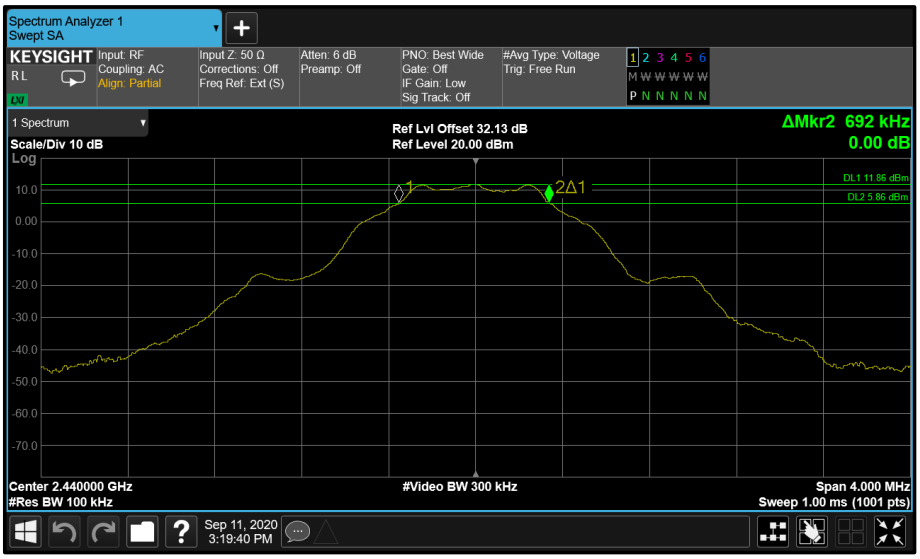

Figure 27 - Core 1 LE 1M 2440 MHz (CH19)

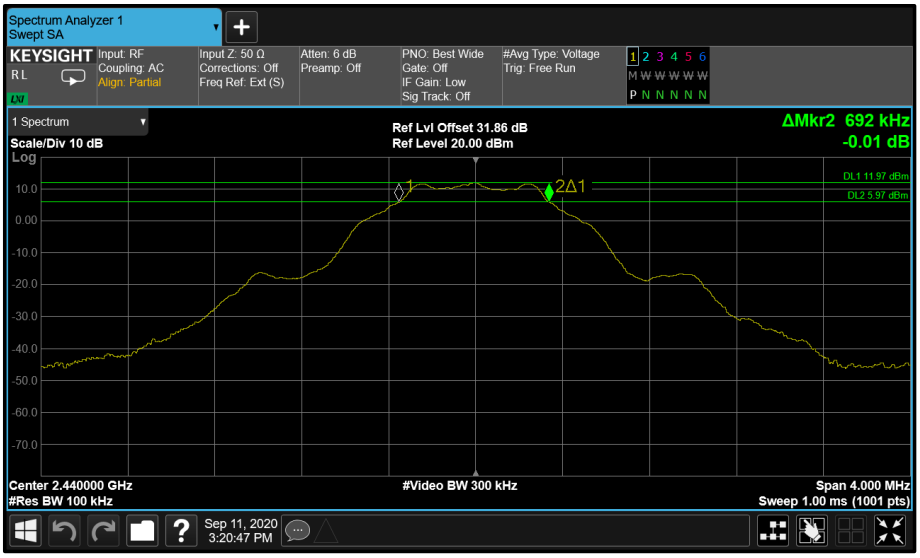

Figure 28 - Core 0 LE 1M 2440 MHz (CH19)

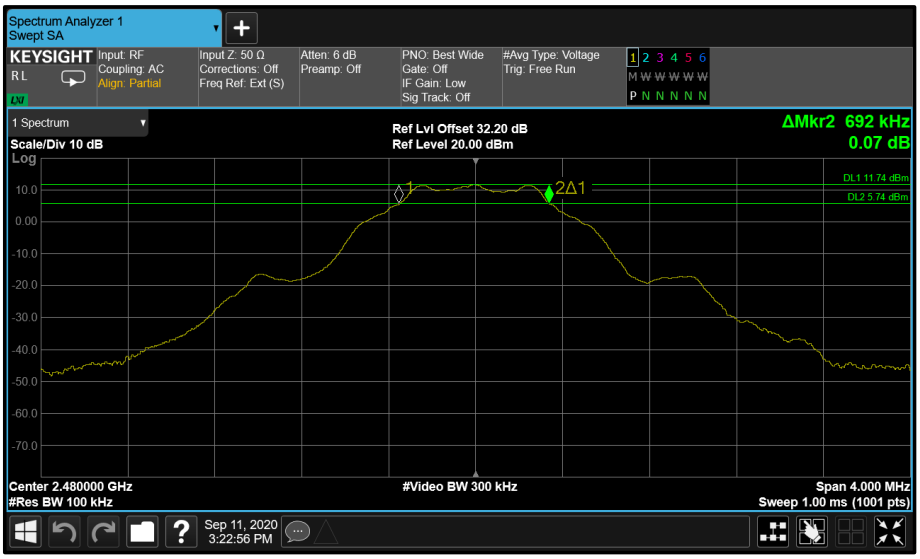

Figure 29 - Core 1 LE 1M 2480 MHz (CH39)

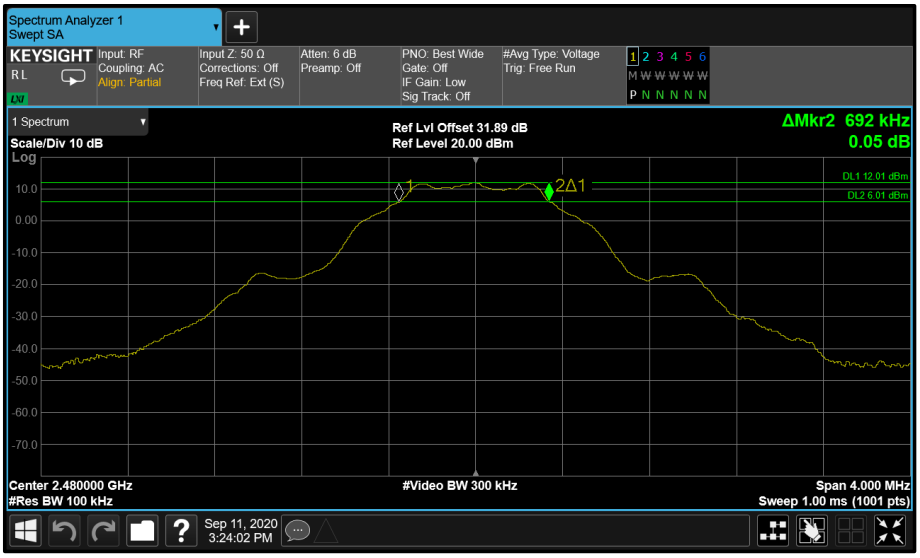

Figure 30 - Core 0 LE 1M 2480 MHz (CH39)

Modulation: GFSK (LE 2M)

Test Frequency (MHz)	6 dB Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2402	1.224	1.216
2440	1.224	1.216
2480	1.224	1.216

Table 20 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2402	2.088	2.072
2440	2.080	2.080
2480	2.080	2.080

Table 21 - 99% Bandwidth Results

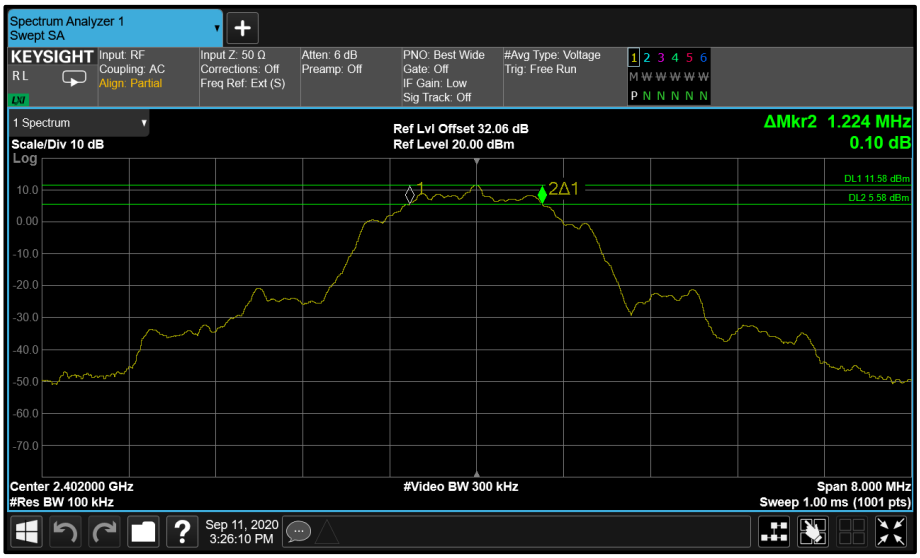

Figure 31 - Core 1 LE 2M 2402 MHz (CH0)

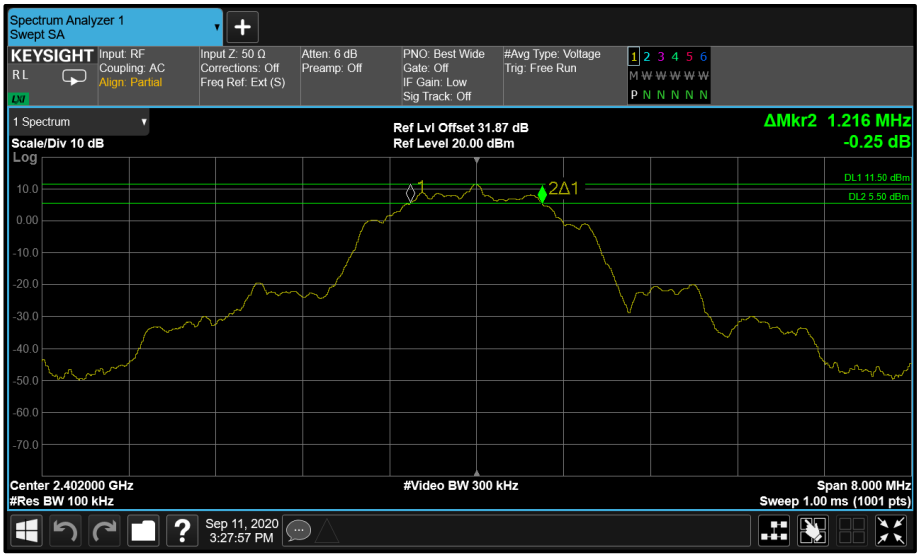

Figure 32 - Core 0 LE 2M 2402 MHz (CH0)

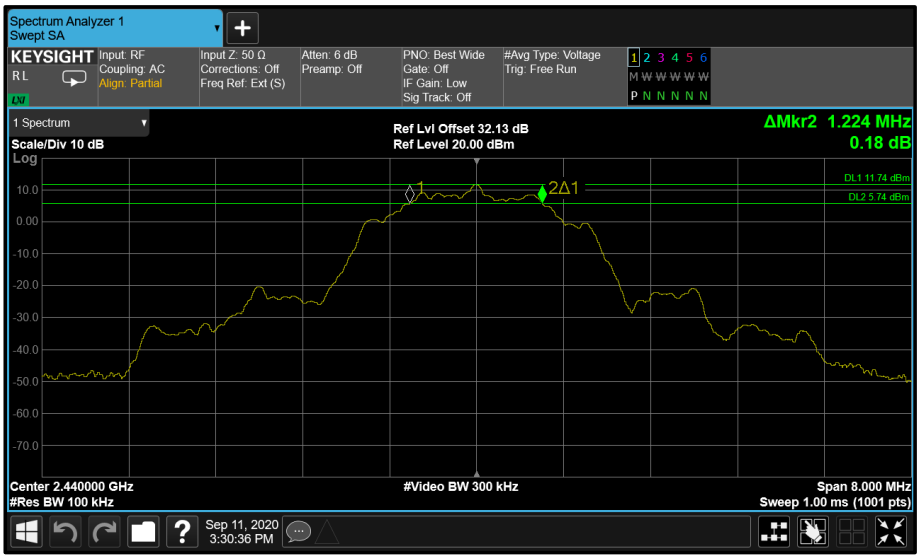

Figure 33 - Core 1 LE 2M 2440 MHz (CH19)

Figure 34 - Core 0 LE 2M 2440 MHz (CH19)

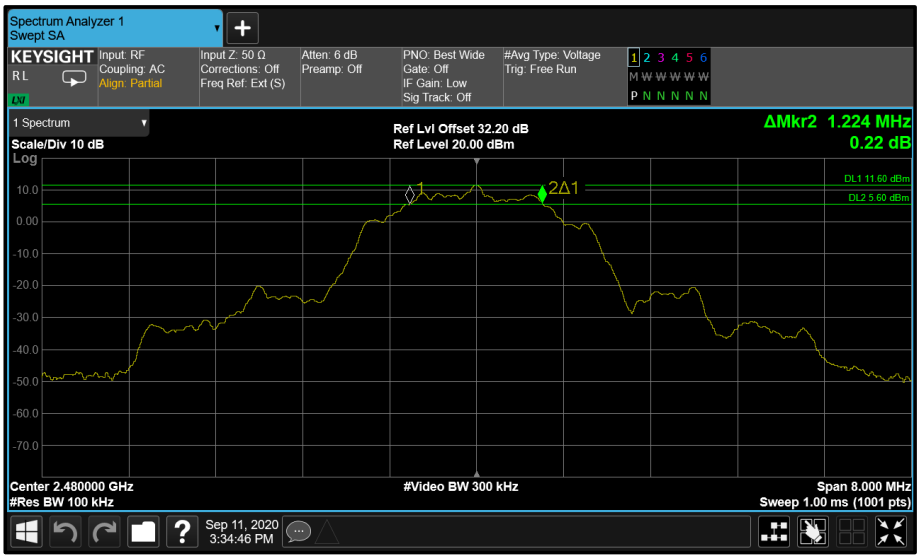

Figure 35 - Core 1 LE 2M 2480 MHz (CH39)

Figure 36 - Core 0 LE 2M 2480 MHz (CH39)

ePA

Antenna Port Configuration: SISO

Modulation: π/4 DQPSK (HDR4)

Test Frequency (MHz)	6 dB Bandwidth (MHz)
	Port(s)
	Core 1
2404	1.568
2441	1.552
2478	1.560

Table 22 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)
	Port(s)
	Core 1
2404	2.360
2441	2.352
2478	2.352

Table 23 - 99% Bandwidth Results

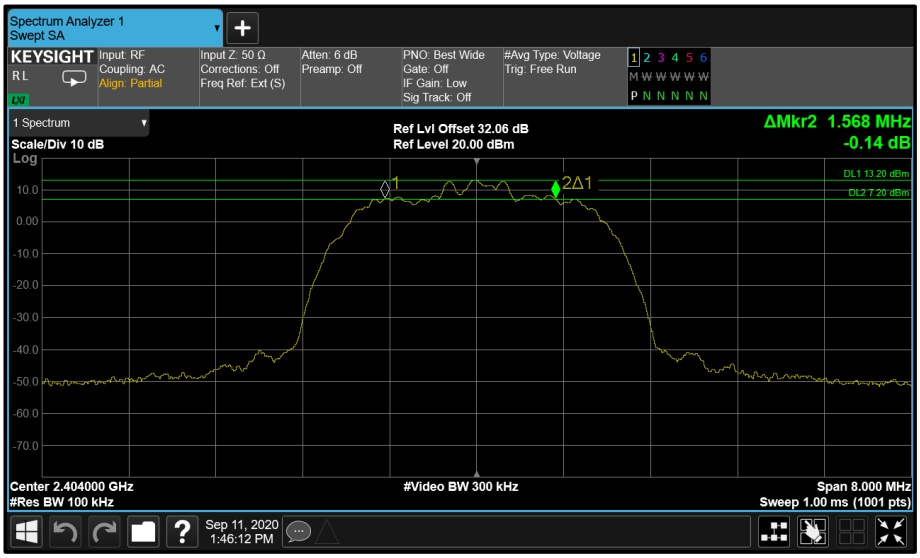

Figure 37 - Core 1 HDR4 2404 MHz (CH2)

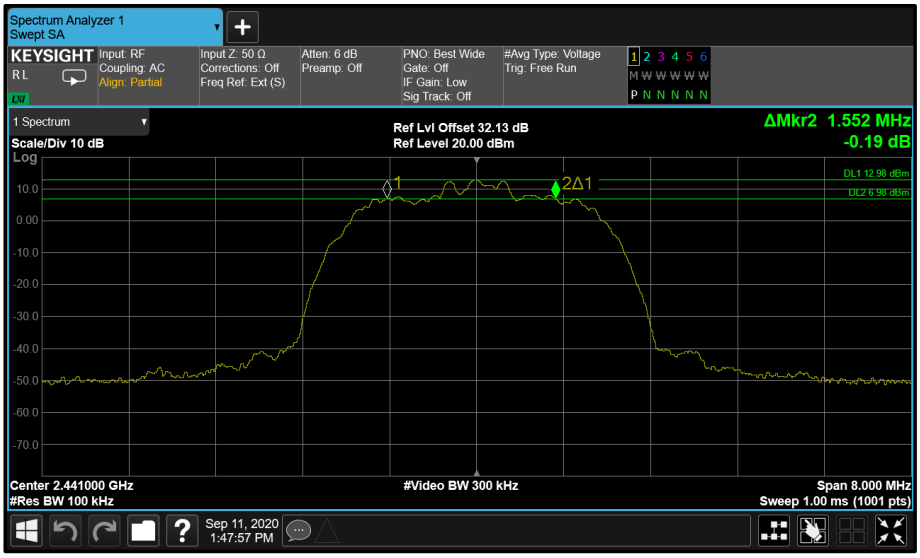

Figure 38 - Core 1 HDR4 2441 MHz (CH39)

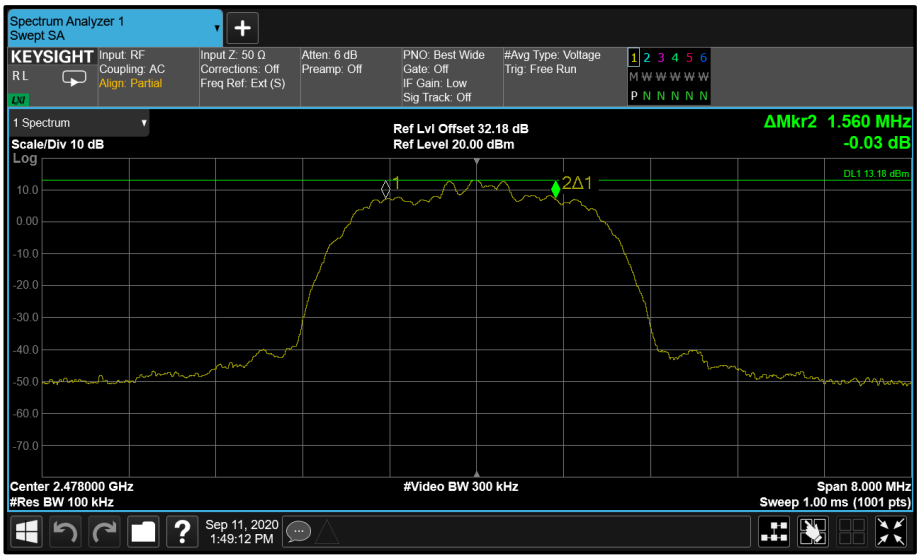

Figure 39 - Core 1 HDR4 2478 MHz (CH76)

Modulation: π/4 DQPSK (HDR8)

Test Frequency (MHz)	6 dB Bandwidth (MHz)
	Port(s)
	Core 1
2404	1.030
2441	1.030
2478	1.030

Table 24 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)
	Port(s)
	Core 1
2404	4.560
2441	4.550
2478	4.560

Table 25 - 99% Bandwidth Results

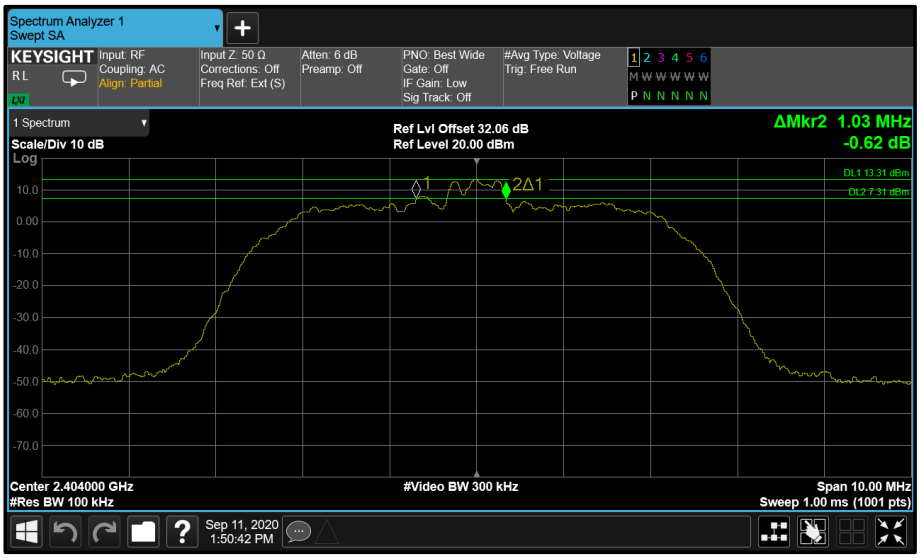

Figure 40 - Core 1 HDR8 2404 MHz (CH2)

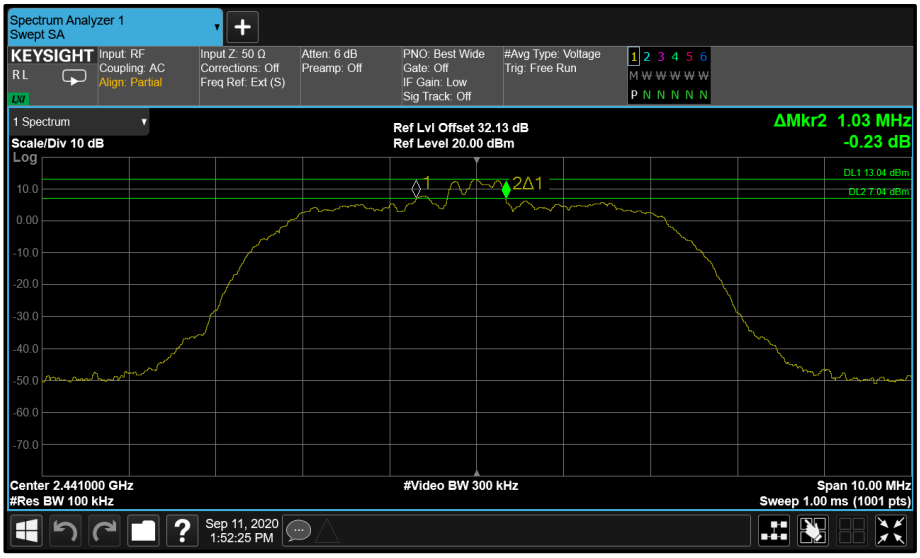

Figure 41 - Core 1 HDR8 2441 MHz (CH39)

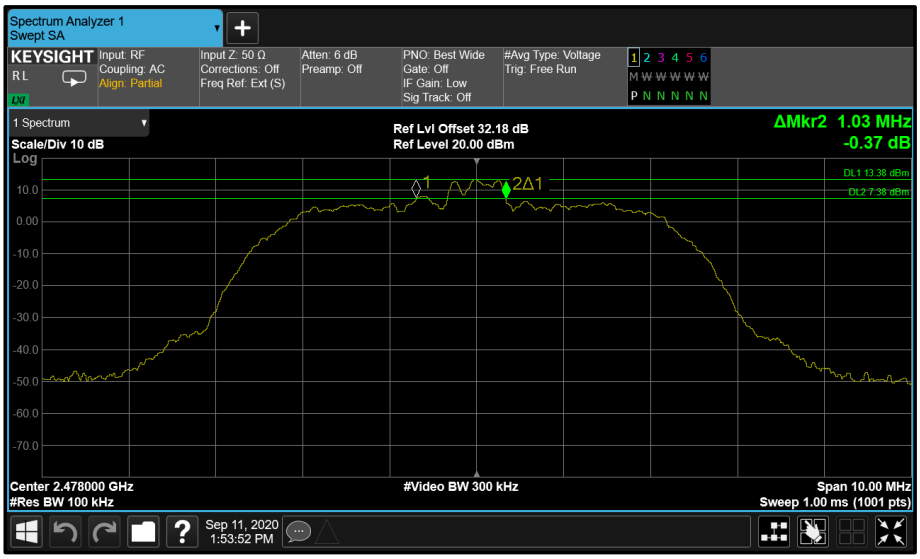

Figure 42 - Core 1 HDR8 2478 MHz (CH76)

Modulation: GFSK (LE1M)

Test Frequency (MHz)	6 dB Bandwidth (MHz)
	Port(s)
	Core 1
2402	0.680
2440	0.680
2480	0.680

Table 26 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)
	Port(s)
	Core 1
2402	1.088
2440	1.092
2480	1.088

Table 27 - 99% Bandwidth Results

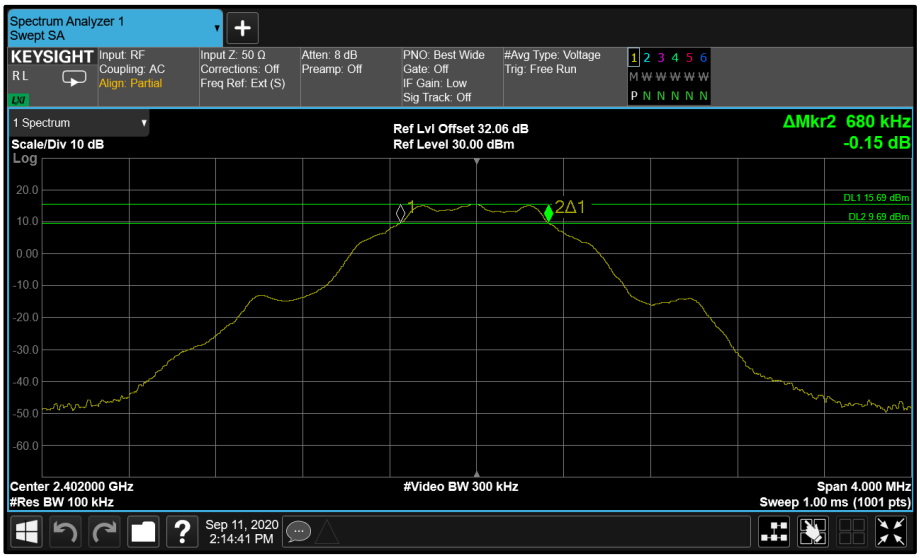

Figure 43 - Core 1 LE 1M 2402 MHz (CH0)

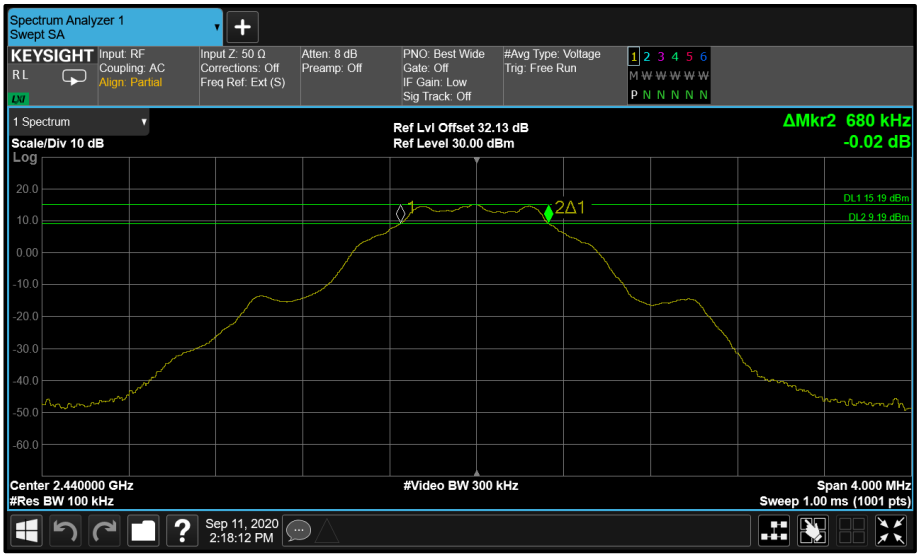

Figure 44 - Core 1 LE 1M 2440 MHz (CH19)

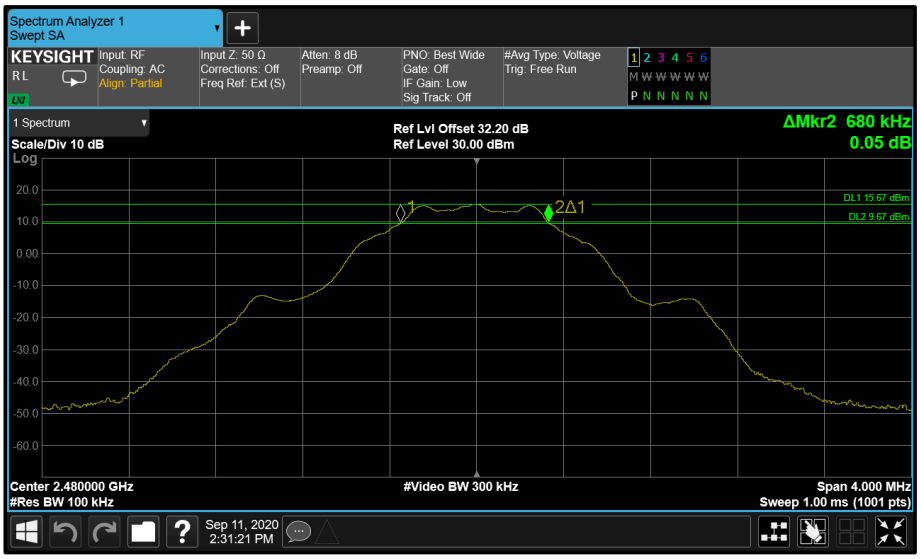

Figure 45 - Core 1 LE 1M 2480 MHz (CH39)

Modulation: GFSK (LE2M)

Test Frequency (MHz)	6 dB Bandwidth (MHz)
	Port(s)
	Core 1
2402	1.224
2440	1.224
2480	1.224

Table 28 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)
	Port(s)
	Core 1
2402	2.088
2440	2.088
2480	2.096

Table 29 - 99% Bandwidth Results

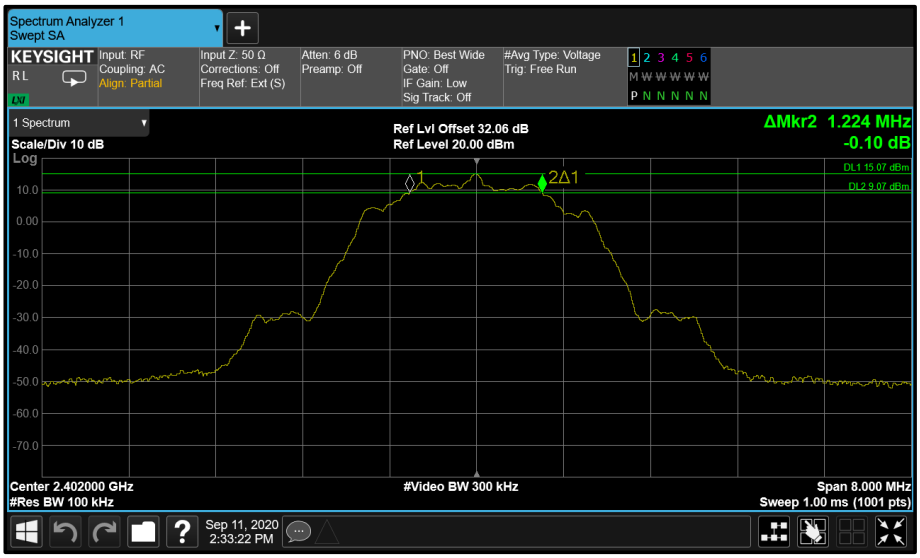

Figure 46 - Core 1 LE 2M 2402 MHz (CH0)

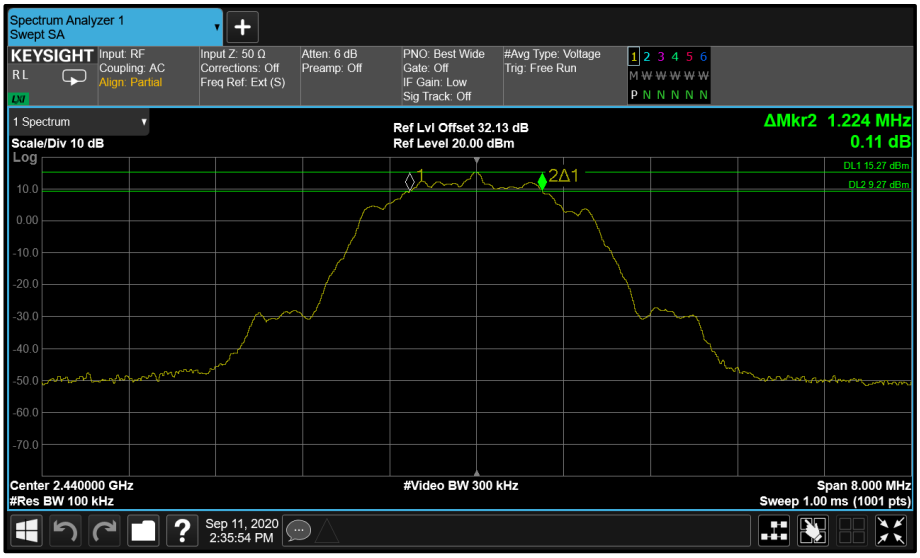

Figure 47 - Core 1 LE 2M 2440 MHz (CH19)

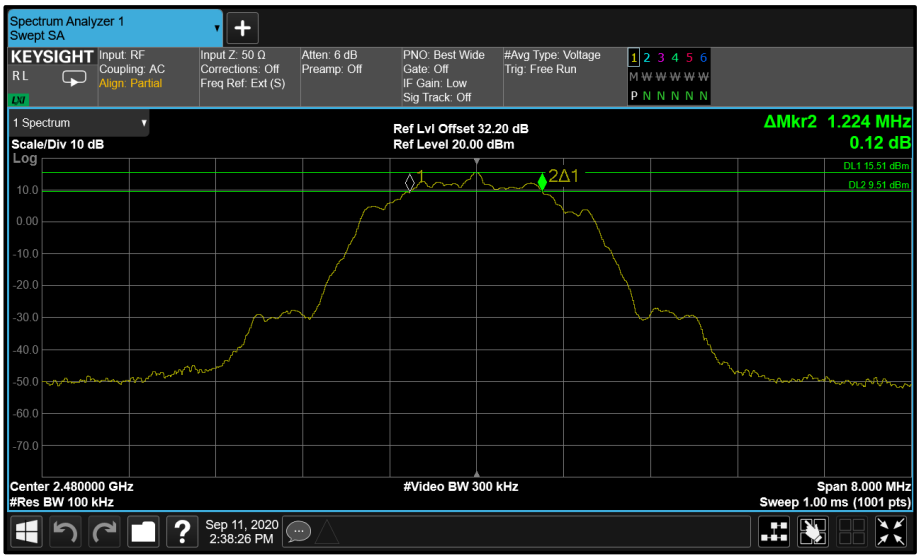

Figure 48 - Core 1 LE 2M 2480 MHz (CH39)

Antenna Port Configuration: Beamforming

Modulation: π/4 DQPSK (HDR4)

Test Frequency (MHz)	6 dB Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2404	1.560	1.560
2441	1.560	1.568
2478	1.560	1.560

Table 30 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2404	2.352	2.352
2441	2.352	2.360
2478	2.360	2.352

Table 31 - 99% Bandwidth Results

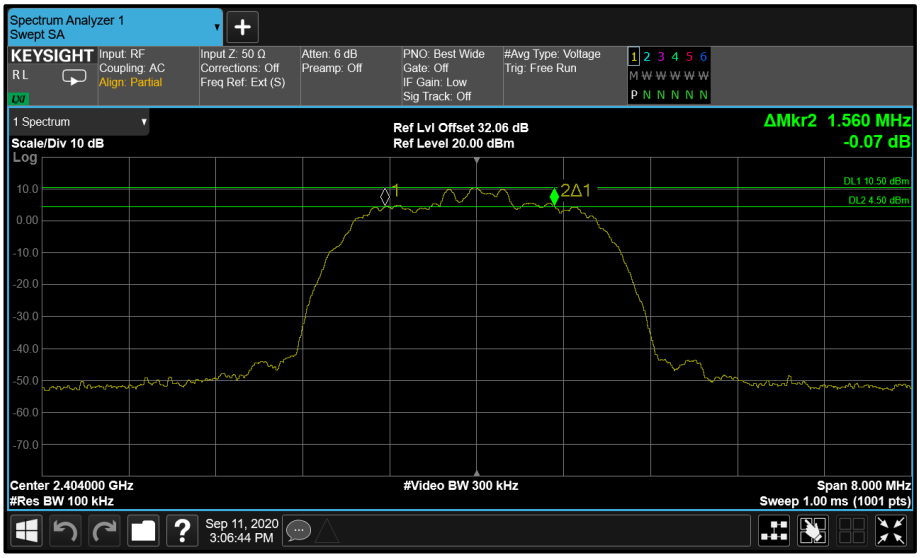

Figure 49 - Core 1 HDR4 2404 MHz (CH2)

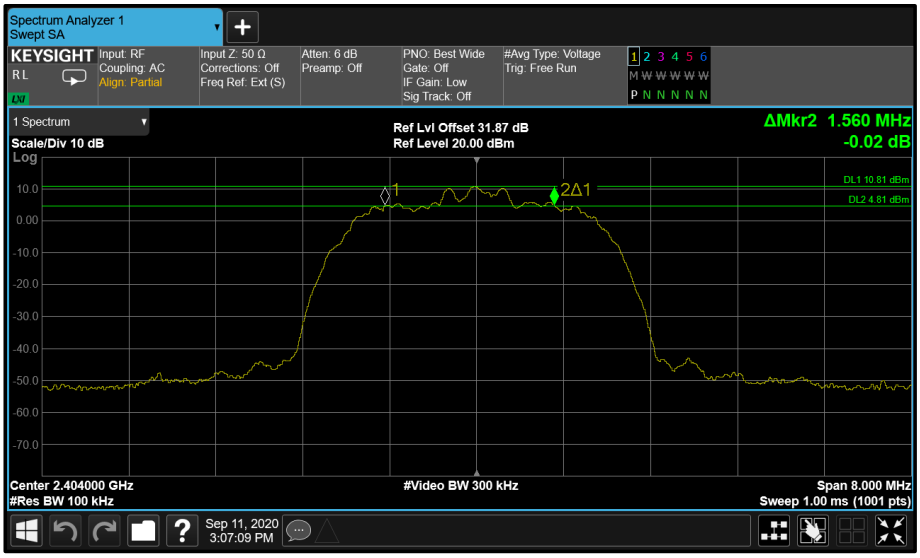

Figure 50 - Core 0 HDR4 2404 MHz (CH2)

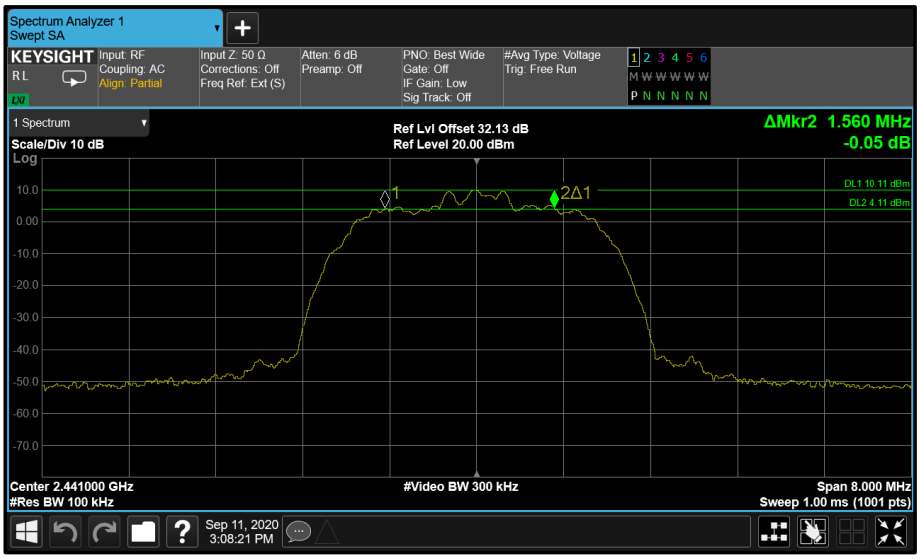

Figure 51 - Core 1 HDR4 2441 MHz (CH39)

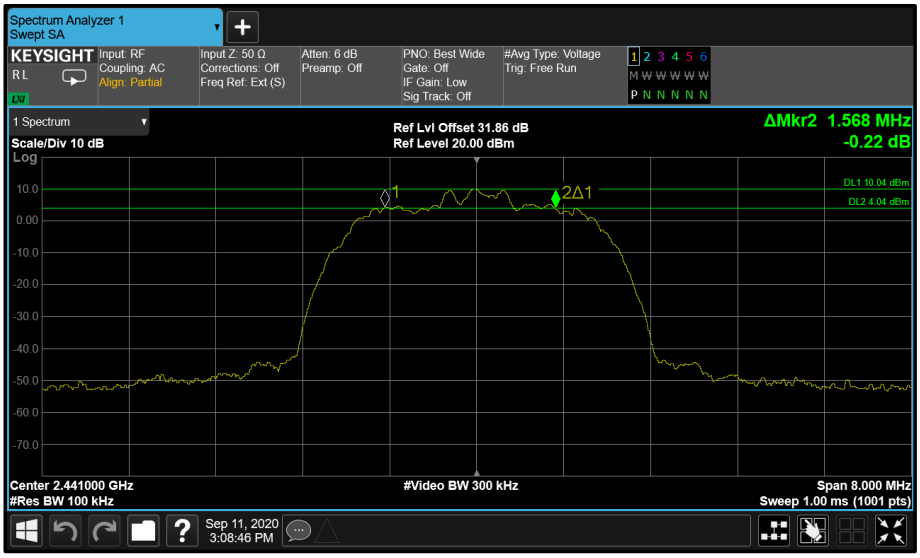

Figure 52 - Core 0 HDR4 2441 MHz (CH39)

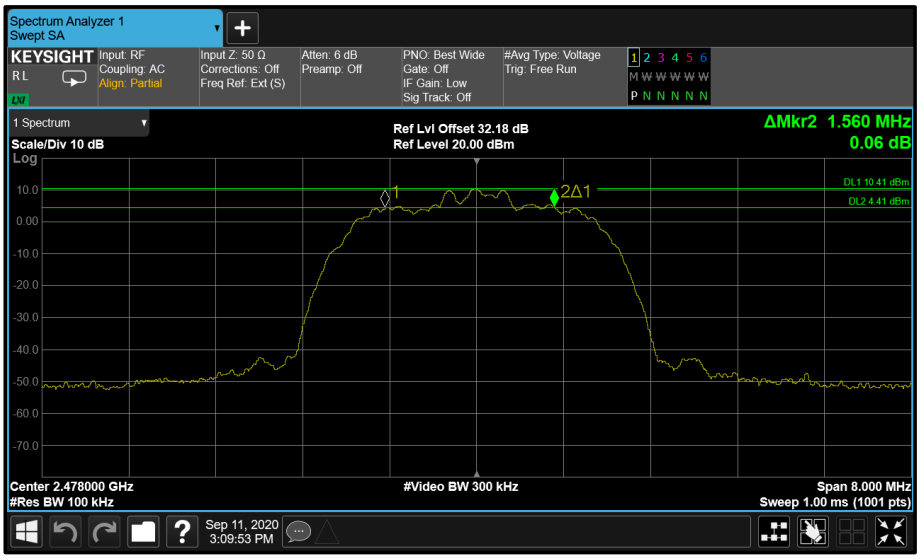

Figure 53 - Core 1 HDR4 2478 MHz (CH76)

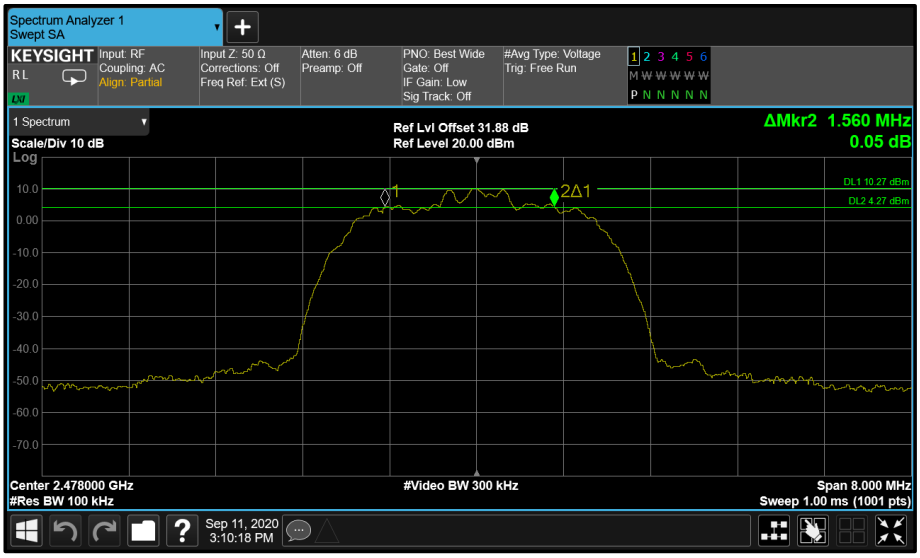

Figure 54 - Core 0 HDR4 2478 MHz (CH76)

Modulation: π/4 DQPSK (HDR8)

Test Frequency (MHz)	6 dB Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2404	1.050	1.030
2441	1.020	1.030
2478	1.030	1.030

Table 32 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2404	4.570	4.560
2441	4.550	4.550
2478	4.550	4.550

Table 33 - 99% Bandwidth Results

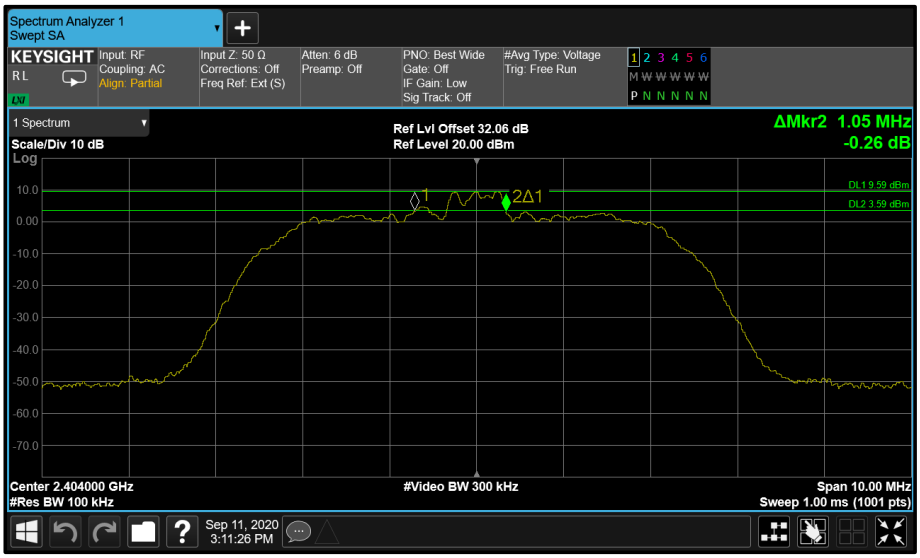

Figure 55 - Core 1 HDR8 2404 MHz (CH2)

Figure 56 - Core 0 HDR8 2404 MHz (CH2)

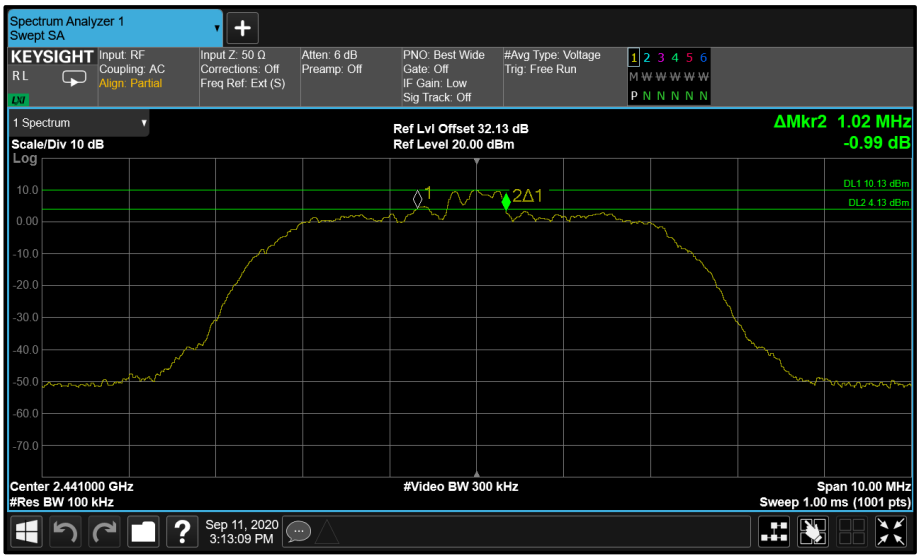

Figure 57 - Core 1 HDR8 2441 MHz (CH39)

Figure 58 - Core 0 HDR8 2441 MHz (CH39)

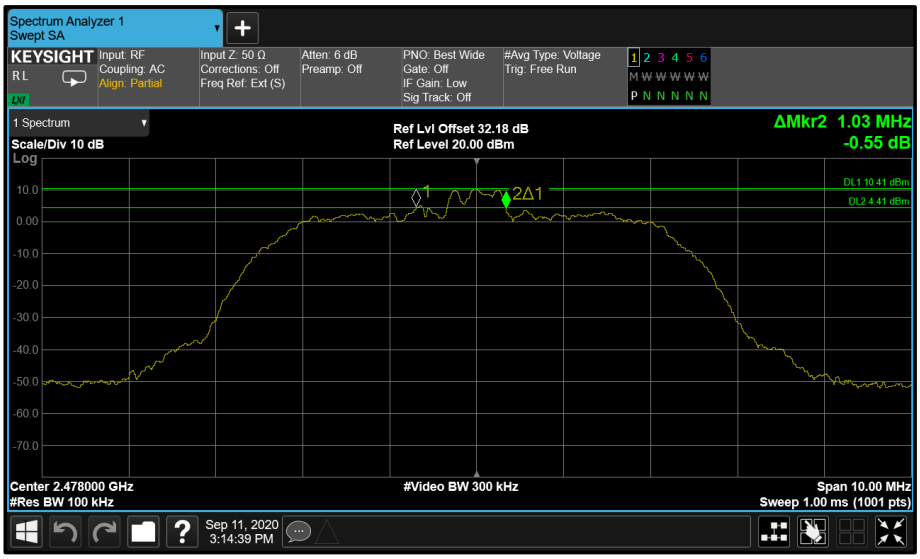

Figure 59 - Core 1 HDR8 2478 MHz (CH76)

Figure 60 - Core 0 HDR8 2478 MHz (CH76)

Modulation: GFSK (LE1M)

Test Frequency (MHz)	6 dB Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2402	0.700	0.700
2440	0.704	0.704
2480	0.708	0.712

Table 34 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2402	1.072	1.068
2440	1.072	1.072
2480	1.076	1.076

Table 35 - 99% Bandwidth Results

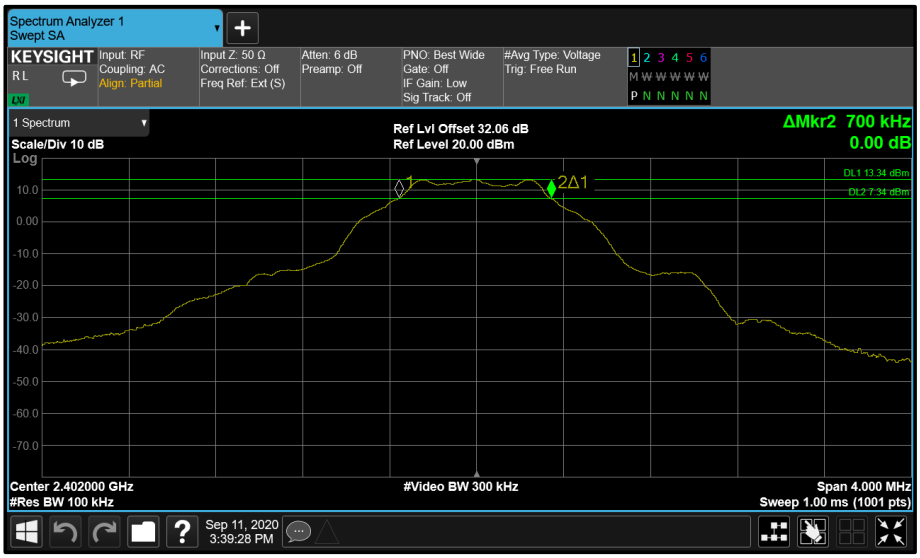

Figure 61 - Core 1 LE 1M 2402 MHz (CH0)

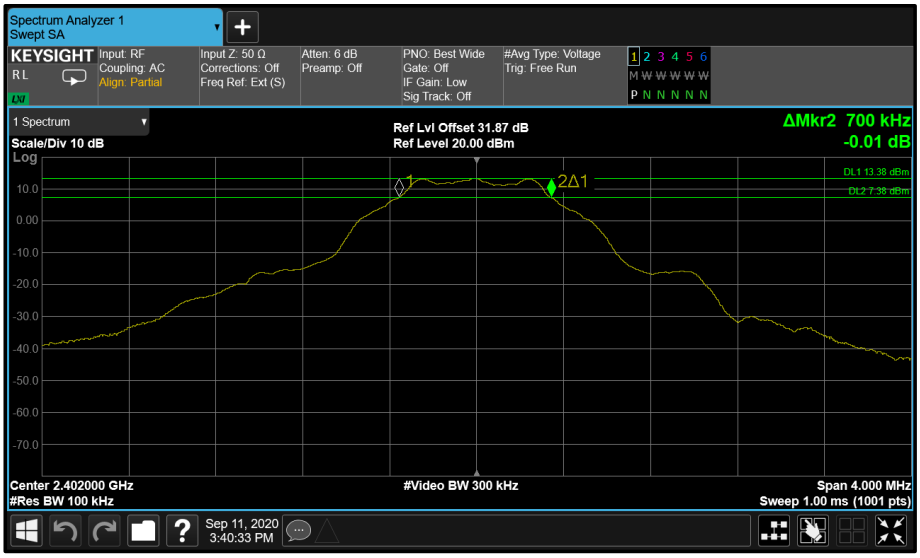

Figure 62 - Core 0 LE 1M 2402 MHz (CH0)

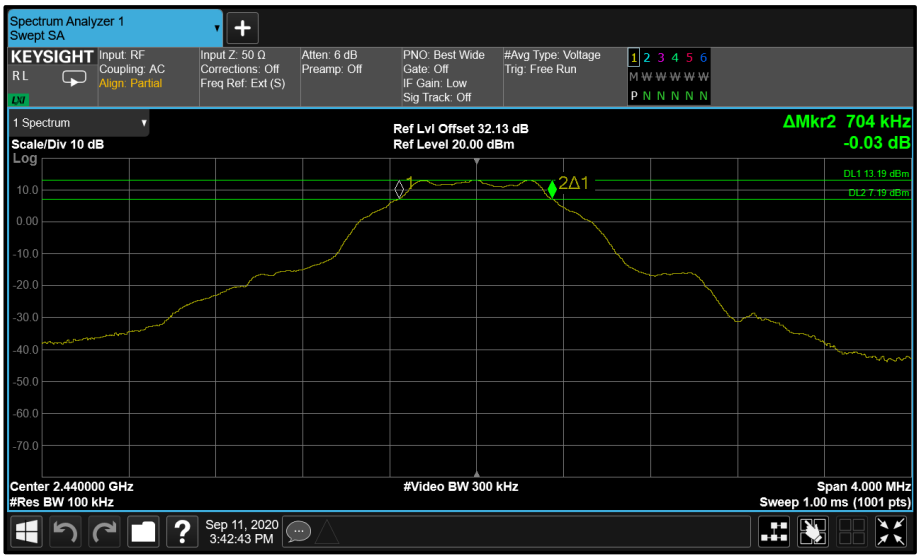

Figure 63 - Core 1 LE 1M 2440 MHz (CH19)

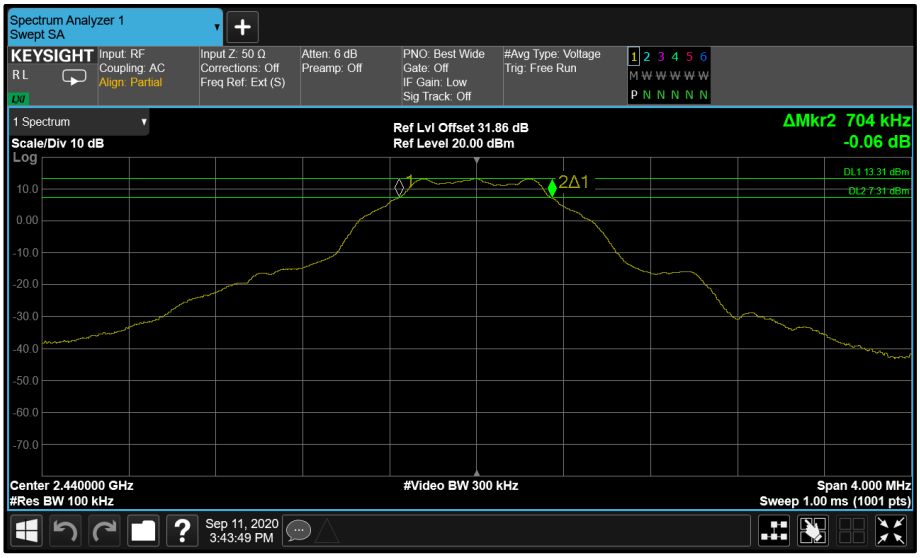

Figure 64 - Core 0 LE 1M 2440 MHz (CH19)

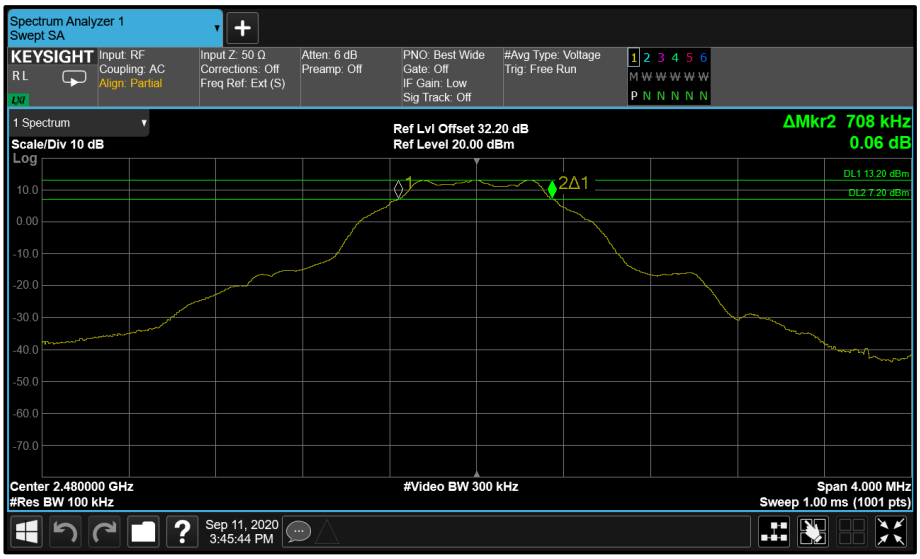

Figure 65 - Core 1 LE 1M 2480 MHz (CH39)

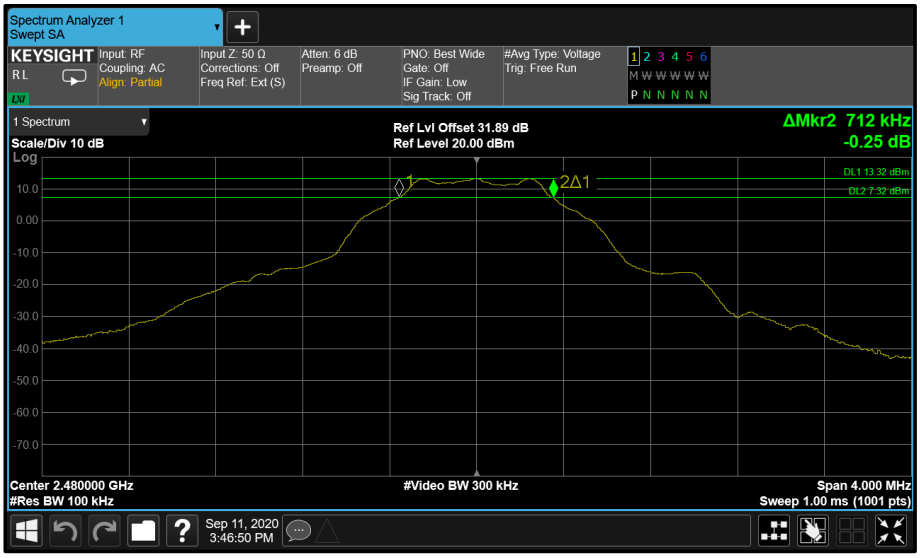

Figure 66 - Core 0 LE 1M 2480 MHz (CH39)

Modulation: GFSK (LE 2M)

Test Frequency (MHz)	6 dB Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2402	1.224	1.224
2440	1.264	1.224
2480	1.272	1.224

Table 36 - 6 dB Bandwidth Results

Test Frequency (MHz)	99% Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2402	2.080	2.072
2440	2.088	2.080
2480	2.088	2.088

Table 37 - 99% Bandwidth Results

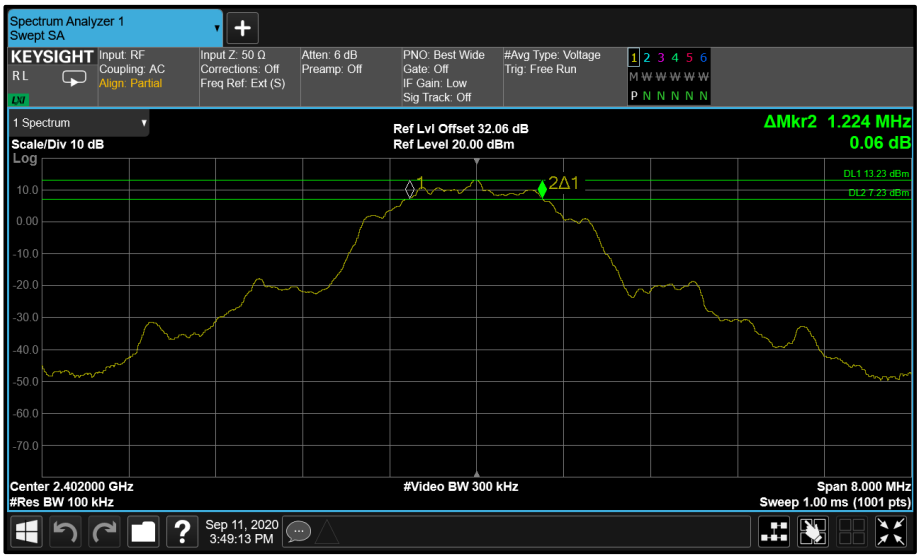

Figure 67 - Core 1 LE 2M 2402 MHz (CH0)

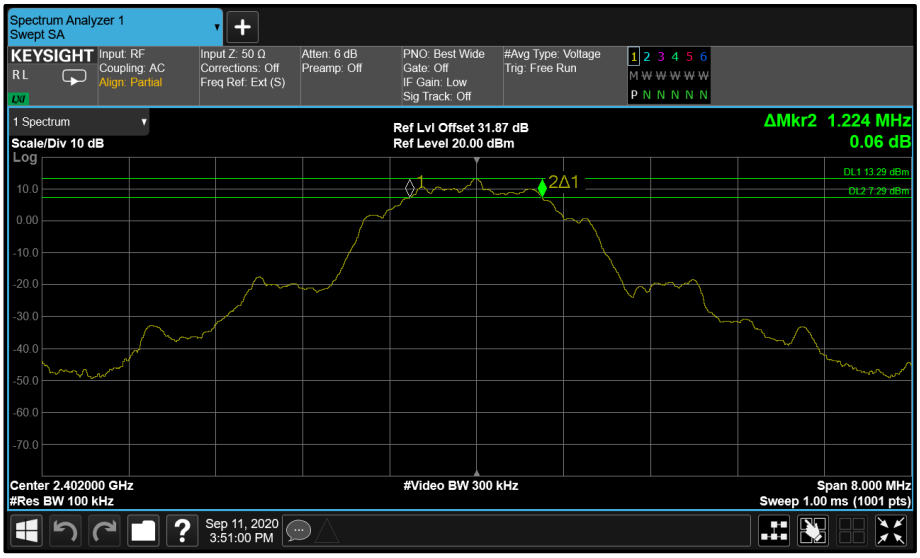

Figure 68 - Core 0 LE 2M 2402 MHz (CH0)

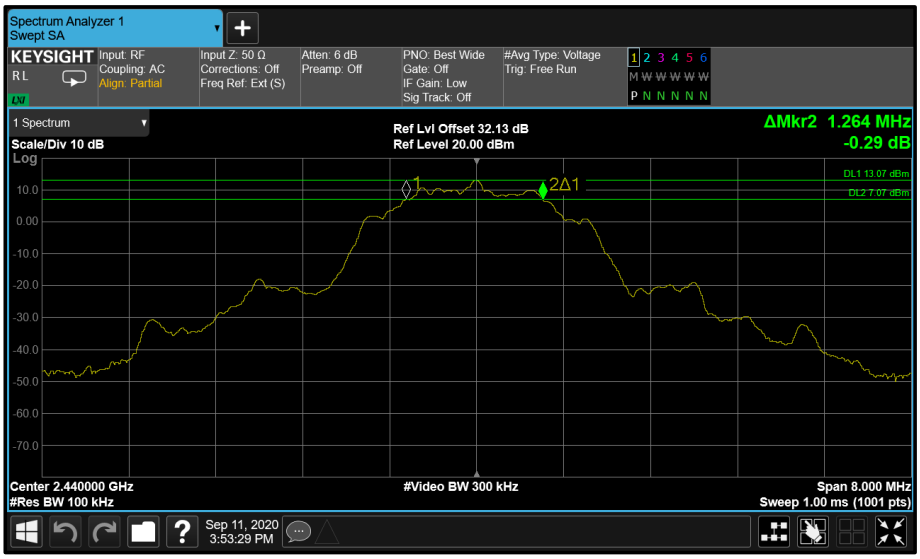

Figure 69 - Core 1 LE 2M 2440 MHz (CH19)

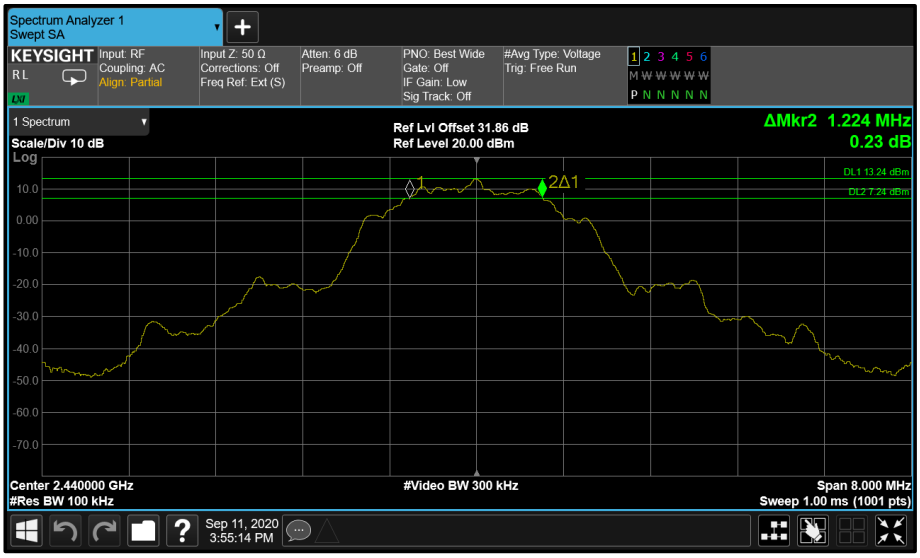

Figure 70 - Core 0 LE 2M 2440 MHz (CH19)

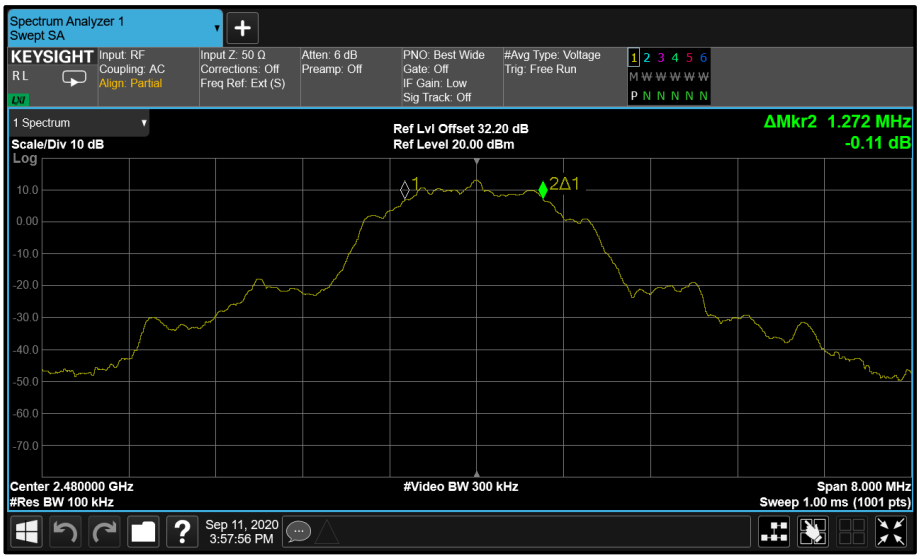

Figure 71 - Core 1 LE 2M 2480 MHz (CH39)

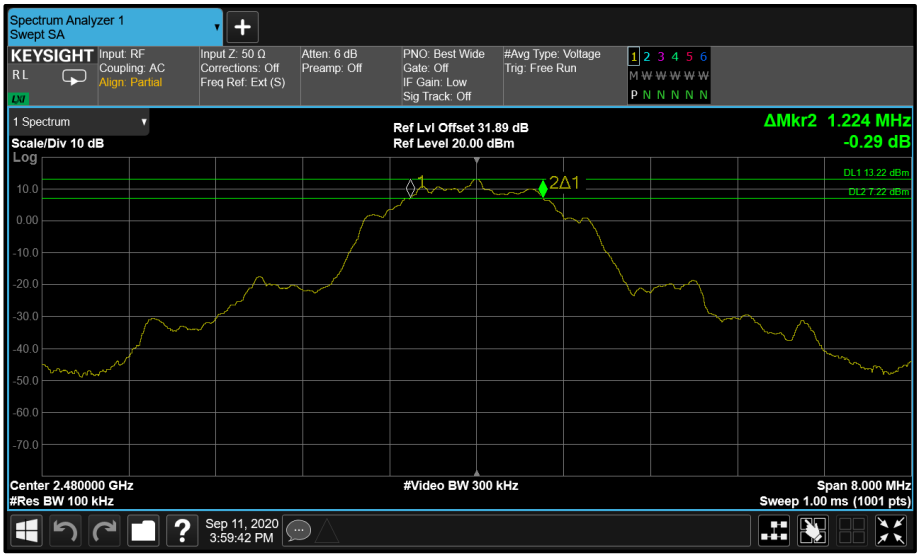

Figure 72 - Core 0 LE 2M 2480 MHz (CH39)

FCC 47 CFR Part 15, Limit Clause 15.247(a)(2) and ISEDC RSS-247, Clause 5.2(a)

The minimum 6 dB Bandwidth shall be at least 500 kHz.

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
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	08-Nov-2020
Multimeter	Iso-tech	IDM101	2424	12	12-Dec-2020
Hygrometer	Rotronic	I-1000	3220	12	25-Sep-2020
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	08-Nov-2020
AC Programmable Power Supply	iTech	IT7324	5225	-	O/P Mon
MXA Signal Analyser	Keysight Technologies	N9020B	5528	24	04-Mar-2022
Signal Commissioning Unit	TUV SUD	SCU001	5546	12	15-Apr-2021

Table 38

O/P Mon – Output Monitored using calibrated equipment

2.2 Maximum Conducted Output Power

2.2.1 Specification Reference

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

2.2.2 Equipment Under Test and Modification State

A2338, S/N: C02CX02JQC36 - Modification State 0

2.2.3 Date of Test

11-September-2020

2.2.4 Test Method

This test was performed in accordance with ANSI C63.10 clause 11.9.2.3.2 Method AVGPM-G.

Both EUT antennas are less than 6 dBi (0.57 dBi and 1.18 dBi for Cores 0 & 1 respectively). This means for non-TxBF modes, the 1 Watt FCC conducted limit does not need to be reduced, and the ISED 1 Watt (30 dBm) conducted limit is more stringent than the 4 Watt (36 dBm) EIRP limit. The conducted non-TxBF results presented below can therefore be directly compared to the 1 Watt (30 dBm) limit to show compliance.

For TxBF the combined powers were calculated using the measure and sum method. Both the power per chain and the antenna gains differed, therefore directional antenna gain was calculated using the worst-case highest antenna gain, two transmit chains and a single correlated spacial stream as per the first formula in KDB 662911 D01 section e) (ii), with N_{SS} = 1 and $G_{ANT\ MAX}$ of 1.18 dBi. This resulted in a directional gain of 4.18 dBi. Since the directional gain is still less than 6 dBi, this results in TxBF conducted results also being directly comparable to the most stringent conducted limit of 1 Watt (30 dBm) for both FCC and ISED.

2.2.5 Environmental Conditions

Ambient Temperature	21.5 °C
Relative Humidity	46.0 %

2.2.6 Test Results

2.4 GHz Bluetooth Low Energy (DTS)

iPA

Antenna Port Configuration: SISO

Modulation: π/4 DQPSK (HDR4)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)	
	Average Power	Peak Power
	Core 1	Core 1
2404	6.5	9.2
2441	6.1	8.9
2478	6.1	8.9

Table 39 - Maximum Conducted Output Power Results

Modulation: π/4 DQPSK (HDR8)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)	
	Average Power	Peak Power
	Core 1	Core 1
2404	6.2	9.6
2441	6.0	9.4
2478	6.1	9.5

Table 40 - Maximum Conducted Output Power Results

Modulation: GFSK (LE 1M)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)	
	Average Power	Peak Power
	Core 1	Core 1
2402	12.3	13.1
2440	12.1	12.9
2480	12.3	13.0

Table 41 - Maximum Conducted Output Power Results

Modulation: GFSK (LE 2M)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)	
	Average Power	Peak Power
	Core 1	Core 1
2402	12.4	13.4
2440	12.2	13.2
2480	12.4	13.3

Table 42 - Maximum Conducted Output Power Results

Antenna Port Configuration: Beamforming

Modulation: π/4 DQPSK (HDR4)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					
	Average Power			Peak Power		
	Core 1	Core 0	∑	Core 1	Core 0	∑
2404	6.2	5.7	9.0	8.9	8.4	11.7
2441	6.1	5.7	8.9	8.8	8.5	11.7
2478	6.1	6.3	9.2	8.9	9.0	12.0

Table 43 - Maximum Conducted Output Power Results

Modulation: π/4 DQPSK (HDR8)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					
	Average Power			Peak Power		
	Core 1	Core 0	∑	Core 1	Core 0	∑
2404	5.9	5.3	8.6	9.3	8.7	12.0
2441	6.1	5.7	8.9	9.4	9.1	12.3
2478	5.7	5.8	8.8	9.1	9.1	12.1

Table 44 - Maximum Conducted Output Power Results

Modulation: GFSK (LE 1M)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					
	Average Power			Peak Power		
	Core 1	Core 0	∑	Core 1	Core 0	∑
2402	12.4	12.3	15.4	13.2	13.1	16.2
2440	12.2	12.3	15.3	13.0	13.1	16.1
2480	12.0	12.3	15.2	12.8	13.1	16.0

Table 45 - Maximum Conducted Output Power Results

Modulation: GFSK (LE 2M)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					
	Average Power			Peak Power		
	Core 1	Core 0	∑	Core 1	Core 0	∑
2402	12.2	12.0	15.1	13.2	13.1	16.2
2440	12.4	12.4	15.4	13.3	13.4	16.4
2480	12.1	12.4	15.3	13.1	13.2	16.2

Table 46 - Maximum Conducted Output Power Results

ePA

Antenna Port Configuration: SISO

Modulation: π/4 DQPSK (HDR4)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)	
	Average Power	Peak Power
	Core 1	Core 1
2404	12.9	15.7
2441	12.7	15.5
2478	12.8	15.6

Table 47 - Maximum Conducted Output Power Results

Modulation: π/4 DQPSK (HDR8)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)	
	Average Power	Peak Power
	Core 1	Core 1
2404	12.9	16.3
2441	12.7	16.1
2478	12.8	16.2

Table 48 - Maximum Conducted Output Power Results

Modulation: GFSK (LE 1M)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)	
	Average Power	Peak Power
	Core 1	Core 1
2402	15.8	17.0
2440	15.3	16.5
2480	15.7	16.9

Table 49 - Maximum Conducted Output Power Results

Modulation: GFSK (LE 2M)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)	
	Average Power	Peak Power
	Core 1	Core 1
2402	15.6	16.8
2440	15.8	17.0
2480	15.9	17.1

Table 50 - Maximum Conducted Output Power Results

Antenna Port Configuration: Beamforming

Modulation: π/4 DQPSK (HDR4)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					
	Average Power			Peak Power		
	Core 1	Core 0	∑	Core 1	Core 0	∑
2404	9.3	9.5	12.4	12.0	12.3	15.2
2441	9.8	9.9	12.9	12.5	12.6	15.6
2478	9.7	9.7	12.7	12.4	12.4	15.4

Table 51 - Maximum Conducted Output Power Results

Modulation: π/4 DQPSK (HDR8)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					
	Average Power			Peak Power		
	Core 1	Core 0	∑	Core 1	Core 0	∑
2404	9.7	10.0	12.9	13.1	13.3	16.2
2441	9.7	9.8	12.7	13.1	13.2	16.2
2478	9.9	10.0	13.0	13.3	13.4	16.4

Table 52 - Maximum Conducted Output Power Results

Modulation: GFSK (LE 1M)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					
	Average Power			Peak Power		
	Core 1	Core 0	∑	Core 1	Core 0	∑
2402	13.9	13.9	16.9	14.4	14.4	17.4
2440	13.8	13.9	16.9	14.3	14.4	17.4
2480	13.7	13.8	16.8	14.2	14.3	17.3

Table 53 - Maximum Conducted Output Power Results

Modulation: GFSK (LE 2M)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					
	Average Power			Peak Power		
	Core 1	Core 0	∑	Core 1	Core 0	∑
2402	14.0	13.9	17.0	14.6	14.5	17.6
2440	13.8	13.9	16.9	14.4	14.5	17.5
2480	13.8	13.8	16.8	14.3	14.3	17.3

Table 54 - Maximum Conducted Output Power Results

FCC 47 CFR Part 15, Limit Clause 15.247 (b)(3)

For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 Watt.

ISED RSS-247, Limit Clause 5.4 (b)

For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e) of the specification.

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
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	08-Nov-2020
Multimeter	Iso-tech	IDM101	2424	12	12-Dec-2020
Hygrometer	Rotronic	I-1000	3220	12	25-Sep-2020
Frequency Standard	Spectracom	SecureSync 1200-0408-0601	4393	6	08-Nov-2020
USB Power Sensor	Boonton	RTP5006	5184	12	09-Jan-2021
USB Power Sensor	Boonton	RTP5006	5186	12	28-Nov-2020
AC Programmable Power Supply	iTech	IT7324	5225	-	O/P Mon
Signal Commissioning Unit	TUV SUD	SCU001	5546	12	15-Apr-2021

Table 55

O/P Mon – Output Monitored using calibrated equipment

2.3 Authorised Band Edges

2.3.1 Specification Reference

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

2.3.2 Equipment Under Test and Modification State

A2338, S/N: C02CX02PQC36 - Modification State 0

2.3.3 Date of Test

04-August-2020 to 08-September-2020

2.3.4 Test Method

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

2.3.5 Environmental Conditions

Ambient Temperature	20.9-23.5 °C
Relative Humidity	34.4-60.1 %

2.3.6 Test Results

2.4 GHz Bluetooth Low Energy (DTS)

LE1M

iPA

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	0	2402	2400.0	-58.77

Table 56 - Authorised Band Edge Results

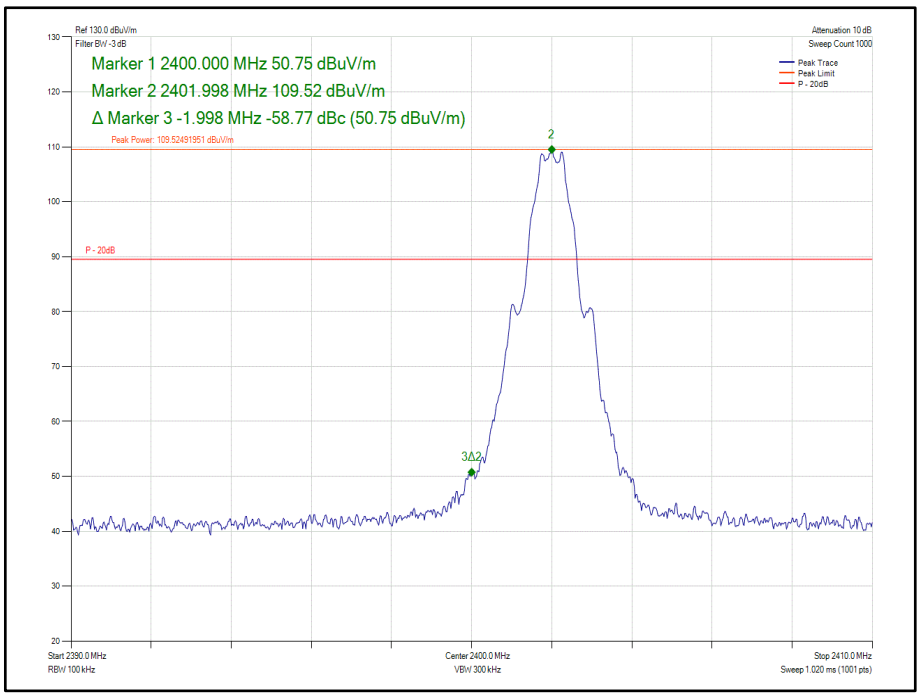

Figure 73 - Core 0 - GFSK/DH1- 2402 MHz – Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	1	2402	2400.0	-52.45

Table 57 - Authorised Band Edge Results

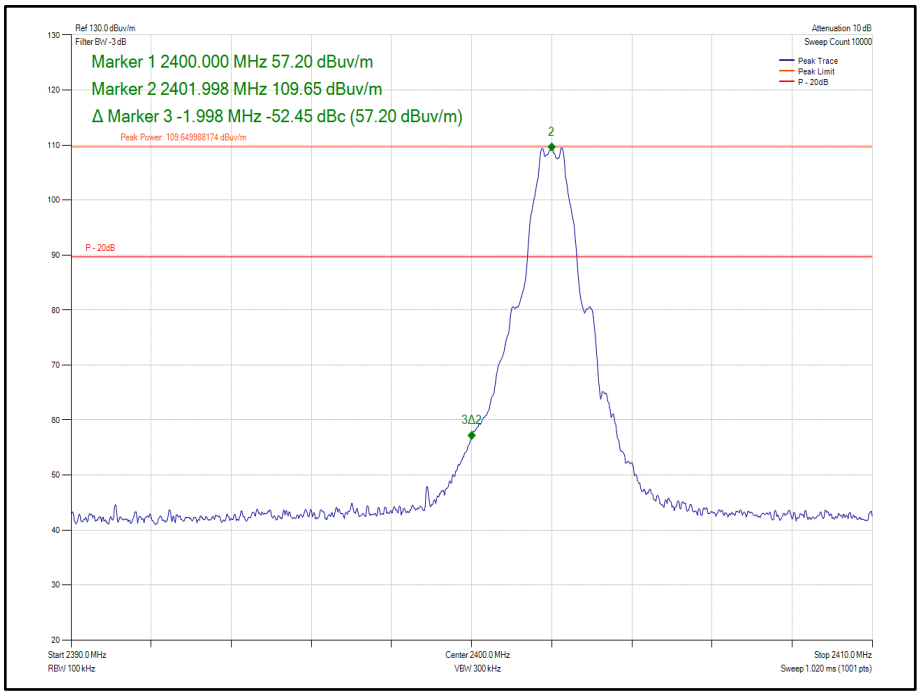

Figure 74 - Core 1 - GFSK/DH1- 2402 MHz – Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	0-1	2402	2400.0	-55.07

Table 58 - Authorised Band Edge Results

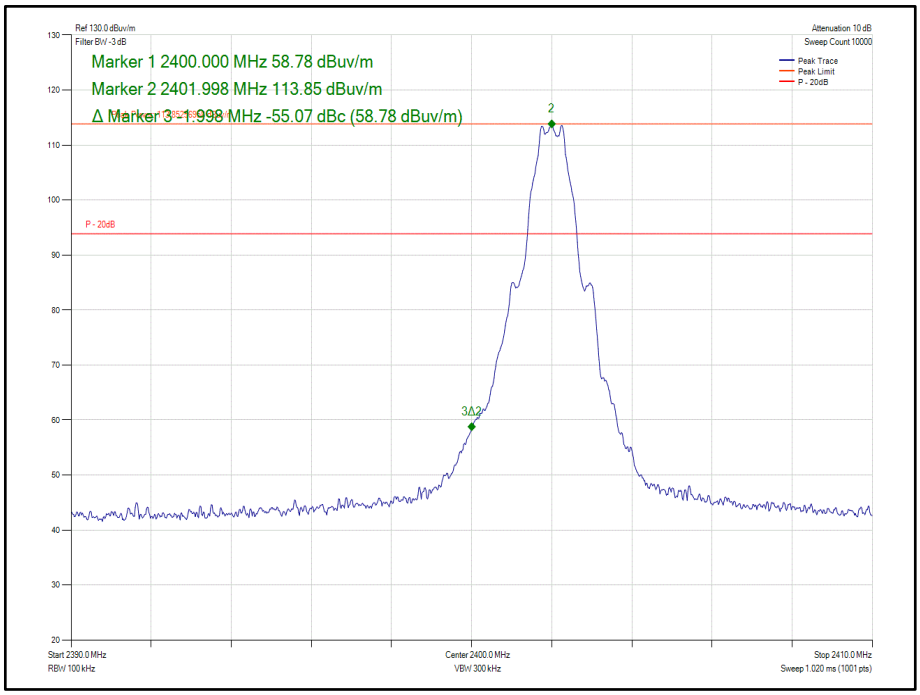

Figure 75 - Core 0-1 GFSK/DH1- 2402 MHz – Band Edge Frequency 2400.0 MHz

ePA

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	0	2402	2400.0	-65.27

Table 59 - Authorised Band Edge Results

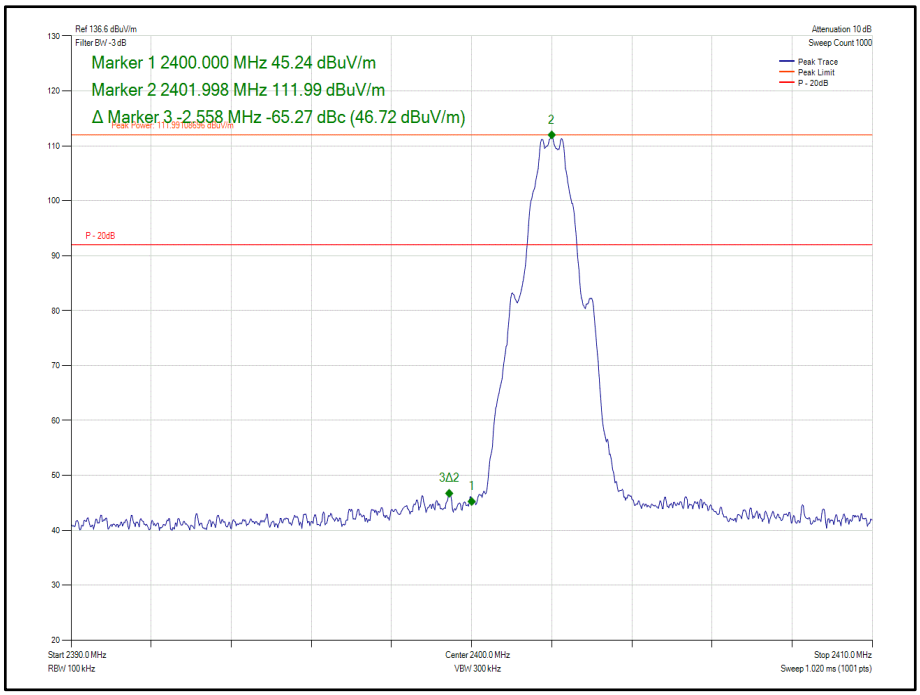

Figure 76 - Core 0 - GFSK/DH1- 2402 MHz – Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	1	2402	2400.0	-52.39

Table 60 - Authorised Band Edge Results

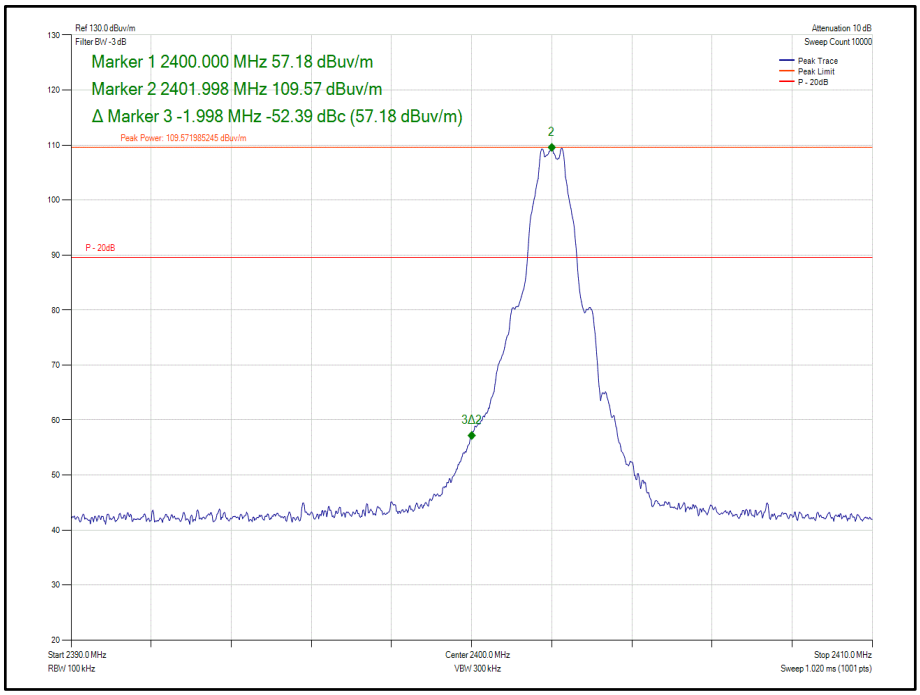

Figure 77 - Core 1 - GFSK/DH1- 2402 MHz – Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	0-1	2402	2400.0	-54.77

Table 61 - Authorised Band Edge Results

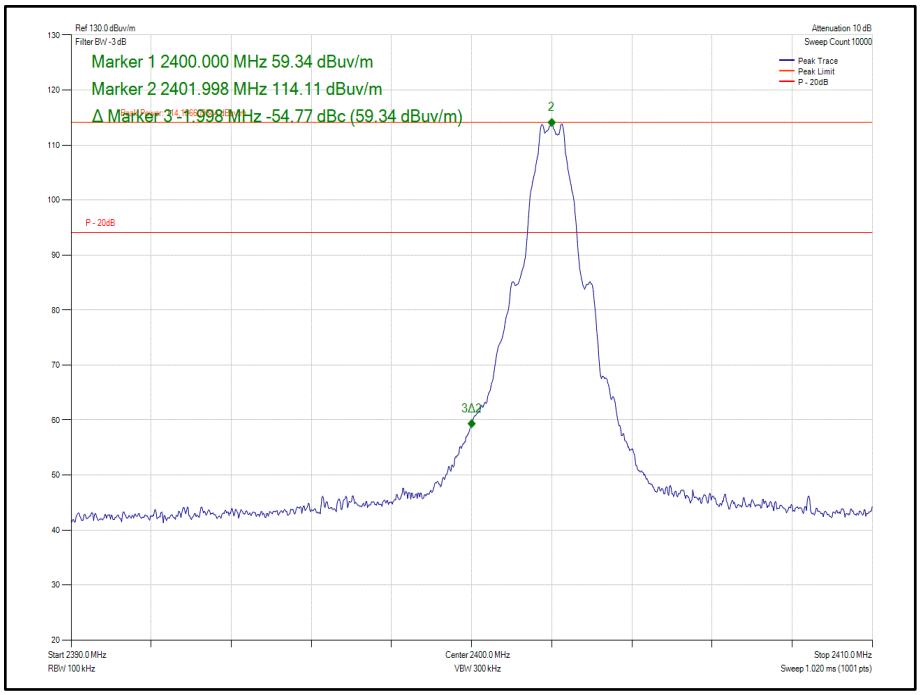

Figure 78 - Core 0-1 GFSK/DH1- 2402 MHz – Band Edge Frequency 2400.0 MHz

LE2M

iPA

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	0	2402	2400.0	-32.04

Table 62 - Authorised Band Edge Results

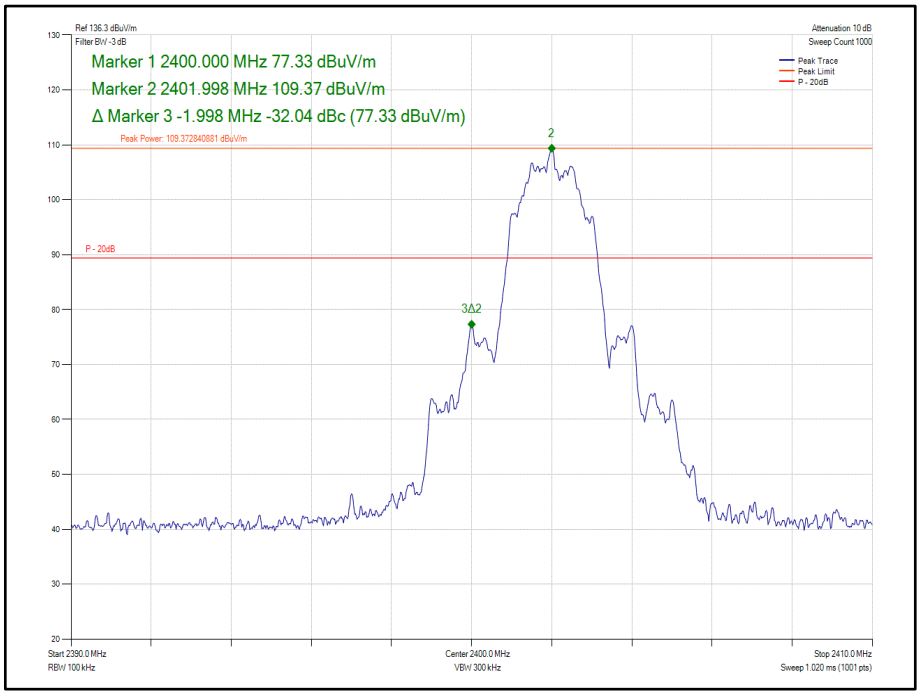

Figure 79 - Core 0 - GFSK/DH1- 2402 MHz – Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	1	2402	2400.0	-31.37

Table 63 - Authorised Band Edge Results

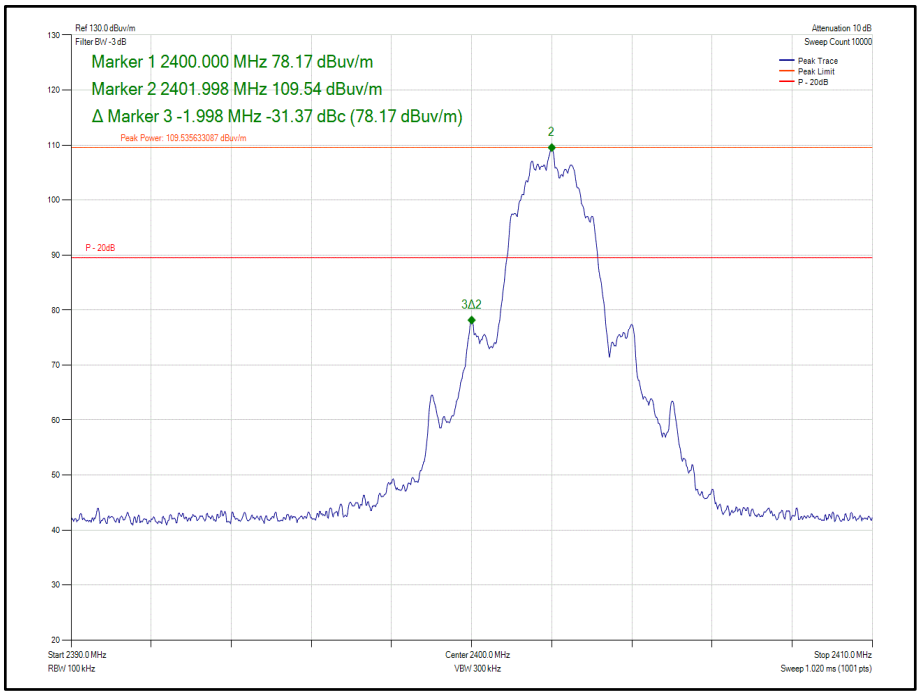

Figure 80 - Core 1 - GFSK/DH1- 2402 MHz – Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	0-1	2402	2400.0	-31.85

Table 64 - Authorised Band Edge Results

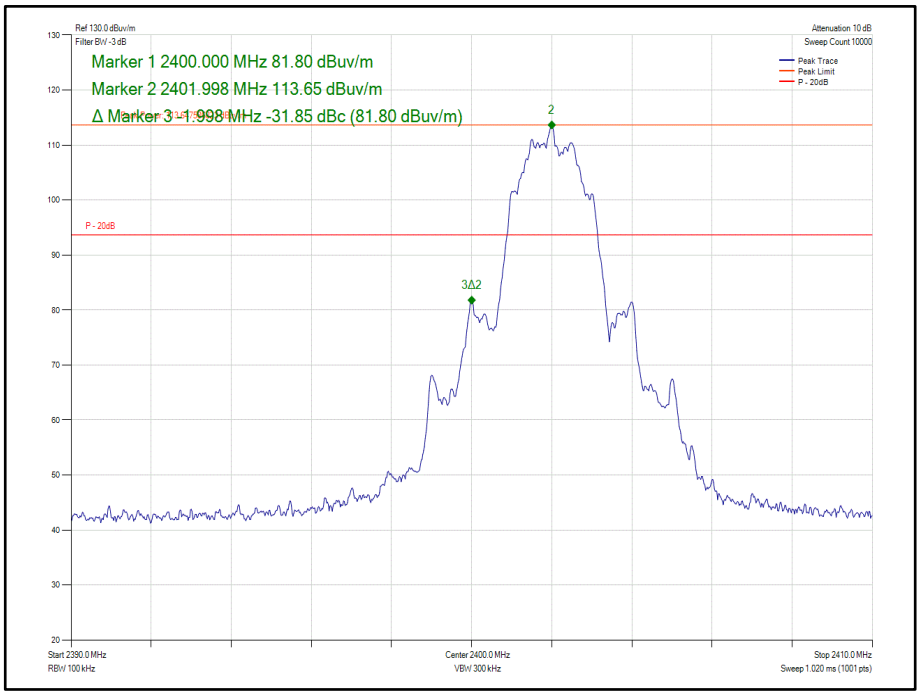

Figure 81 - Core 0-1 - GFSK/DH1- 2402 MHz – Band Edge Frequency 2400.0 MHz

ePA

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	0	2402	2400.0	-31.90

Table 65 - Authorised Band Edge Results

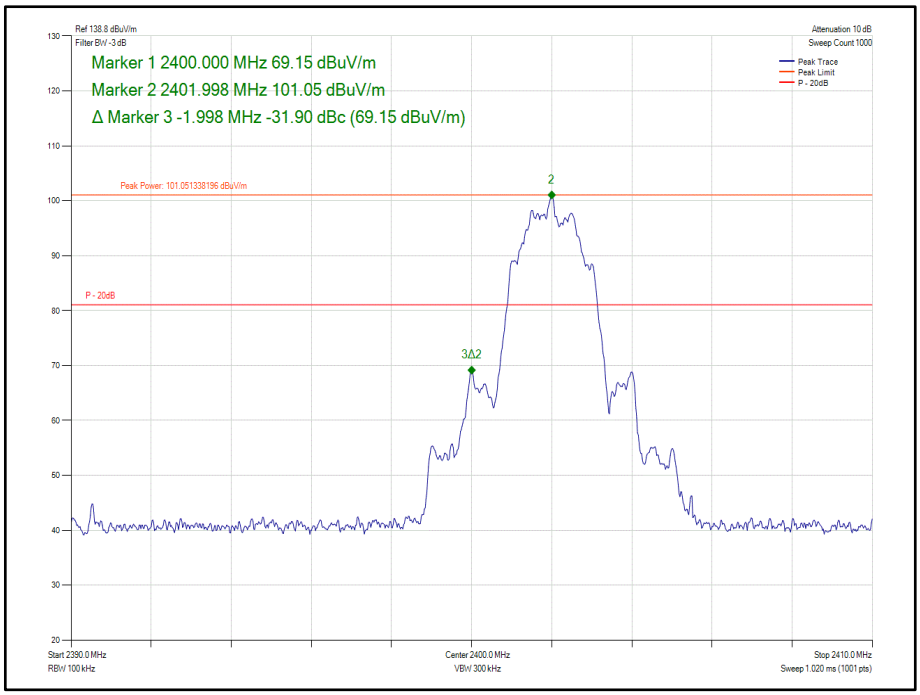

Figure 82 - Core 0 - GFSK/DH1- 2402 MHz – Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	1	2402	2400.0	-31.30

Table 66 - Authorised Band Edge Results

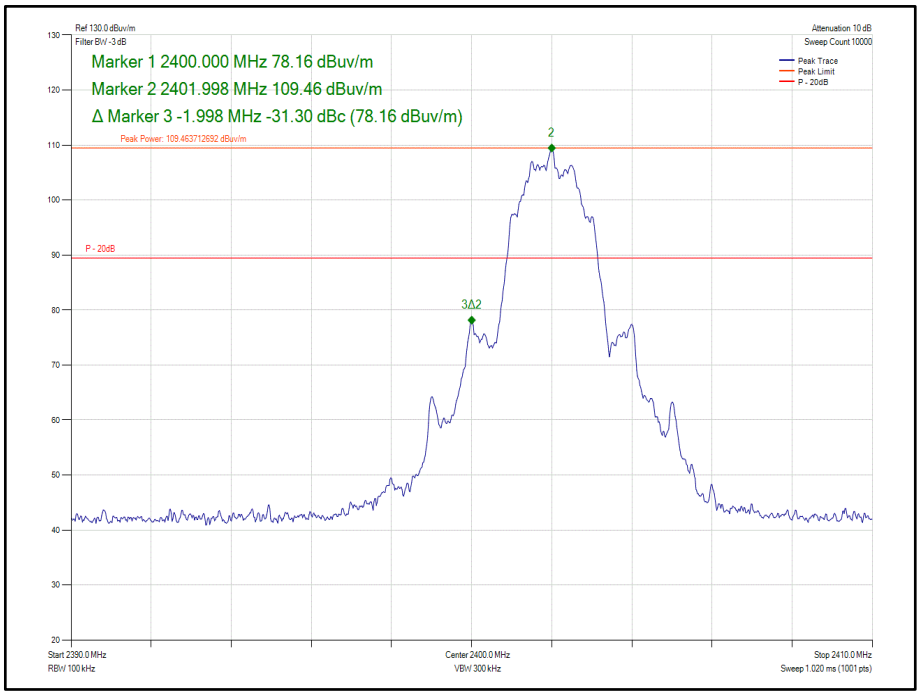

Figure 83 - Core 1 - GFSK/DH1- 2402 MHz – Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	0-1	2402	2400.0	-31.71

Table 67 - Authorised Band Edge Results

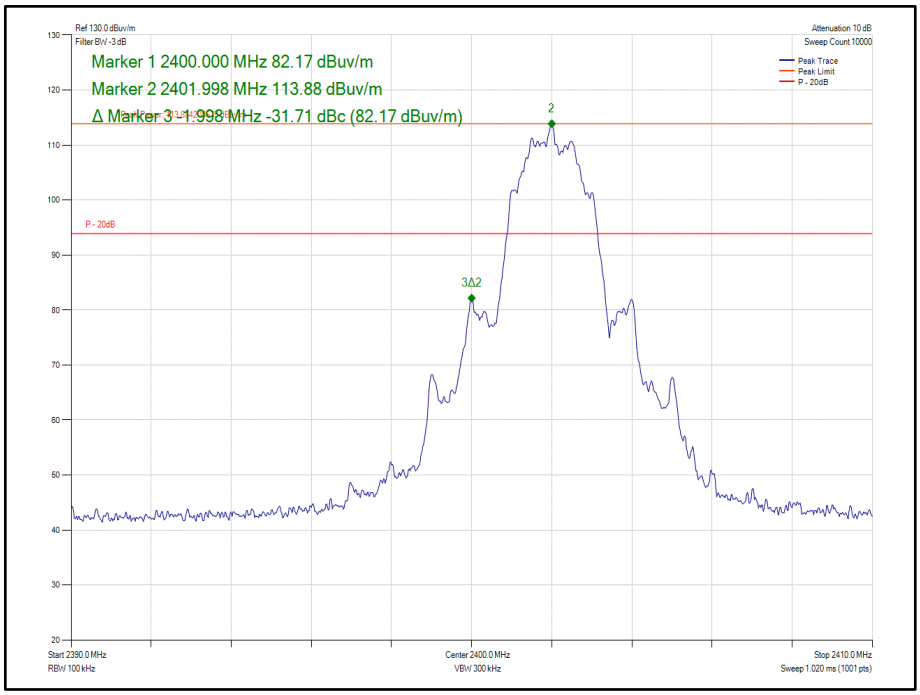

Figure 84 - Core 0-1 - GFSK/DH1- 2402 MHz – Band Edge Frequency 2400.0 MHz

HDR4

iPA

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
π/4 DQPSK	HDR4	0	2404	2400.0	-58.11

Table 68 - Authorised Band Edge Results

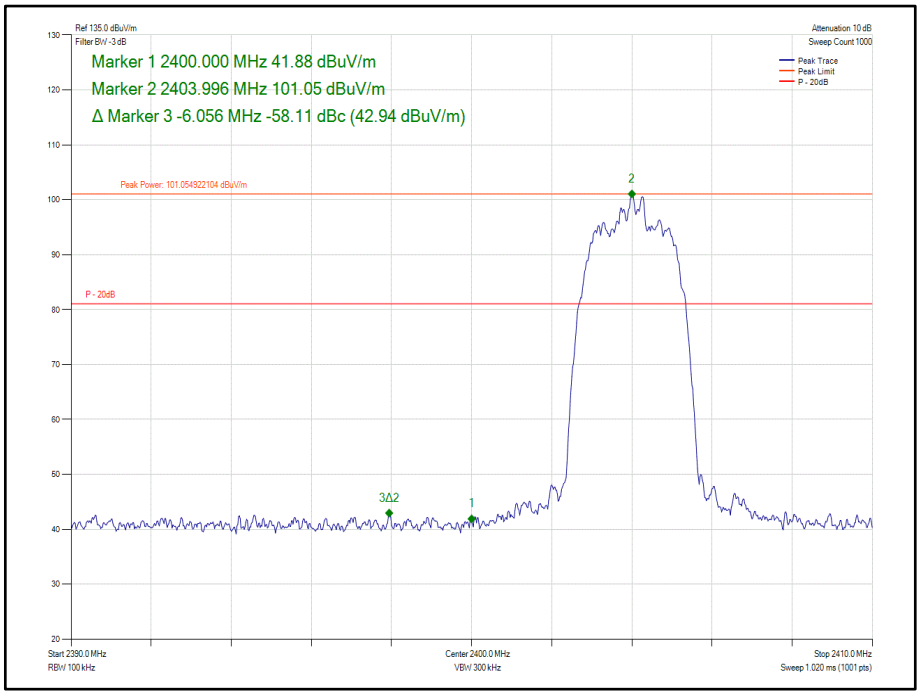

Figure 85 - Core 0 - π/4 DQPSK /HDR4 - 2404 MHz - Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
π/4 DQPSK	HDR4	1	2404	2400.0	-59.51

Table 69 - Authorised Band Edge Results

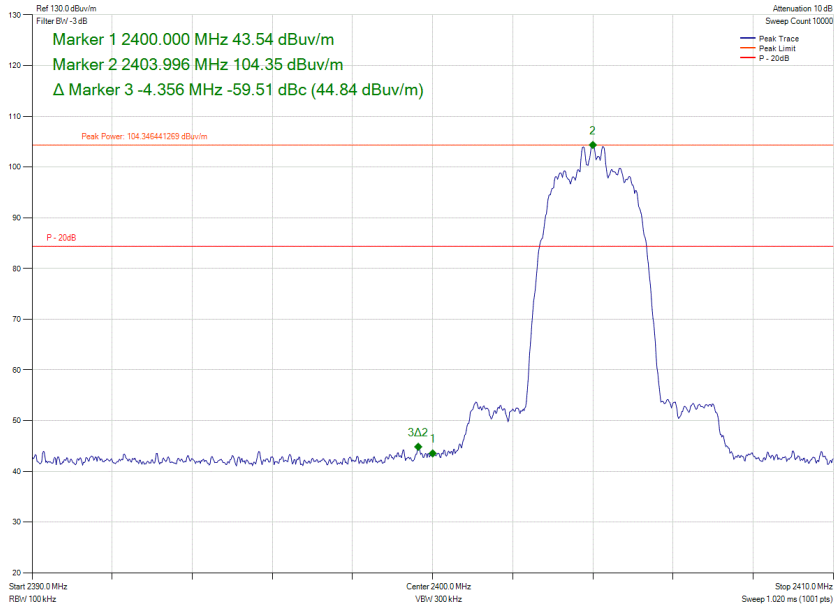

Figure 86 - Core 1 - π/4 DQPSK /HDR4 - 2404 MHz - Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
π/4 DQPSK	HDR4	0-1	2404	2400.0	-63.22

Table 70 - Authorised Band Edge Results

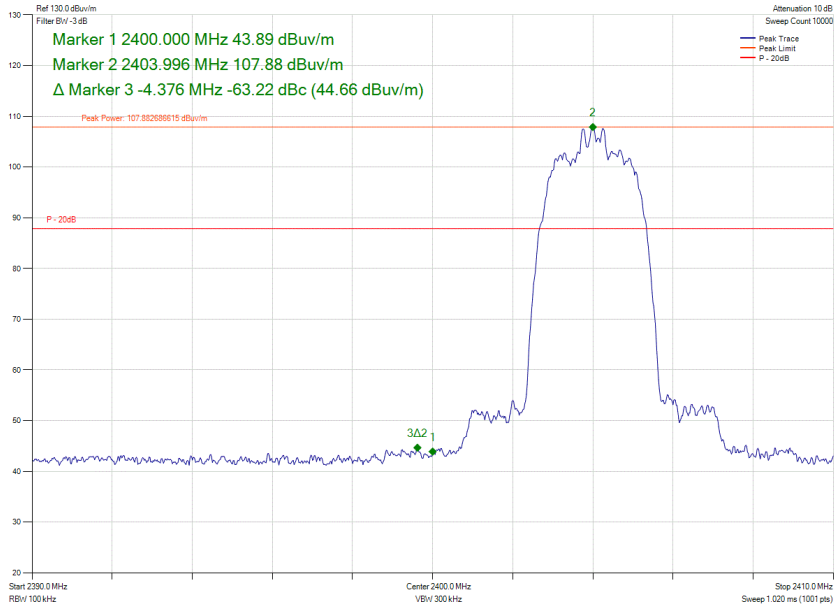

Figure 87 - Core 0-1 - π/4 DQPSK /HDR4 - 2404 MHz - Band Edge Frequency 2400.0 MHz

ePA

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
π/4 DQPSK	HDR4	0	2404	2400.0	-64.46

Table 71 - Authorised Band Edge Results

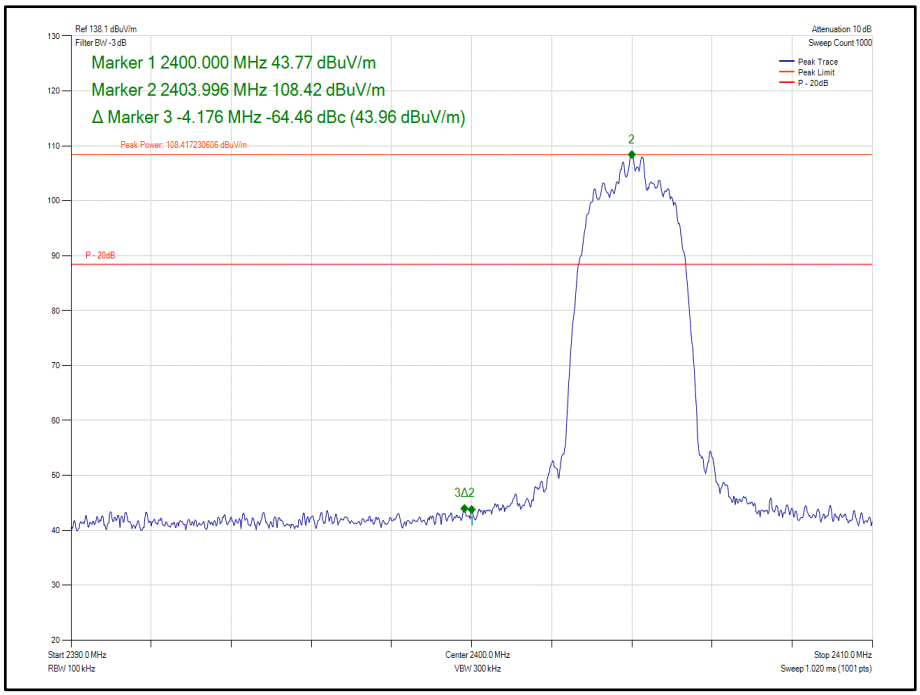

Figure 88 - Core 0 - π/4 DQPSK /HDR4- 2404 MHz – Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
π/4 DQPSK	HDR4	1	2404	2400.0	-63.07

Table 72 - Authorised Band Edge Results

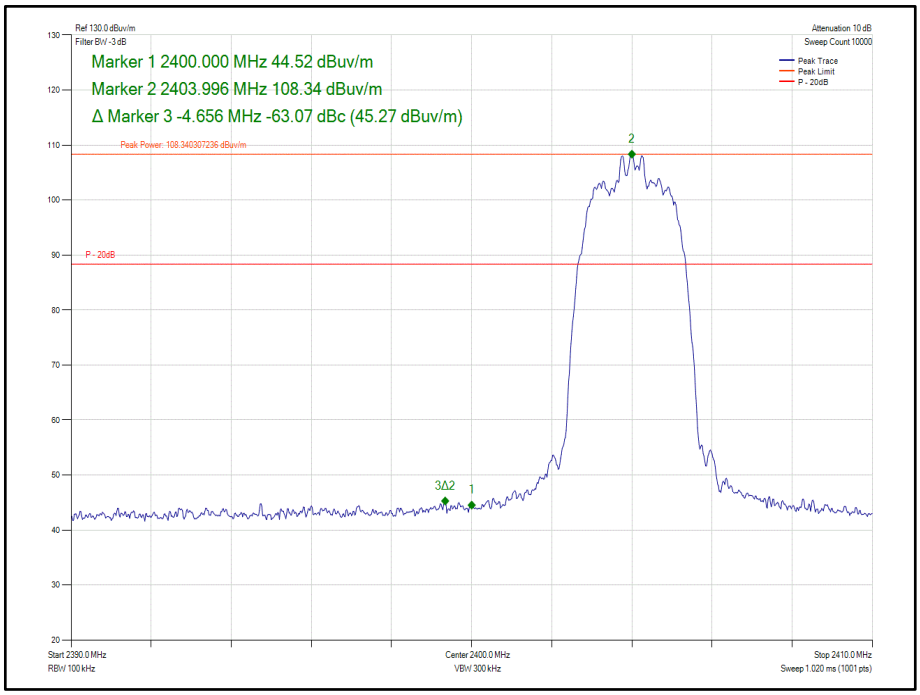

Figure 89 - Core 1 - π/4 DQPSK /HDR4- 2404 MHz – Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
π/4 DQPSK	HDR4	0-1	2404	2400.0	-66.92

Table 73 - Authorised Band Edge Results

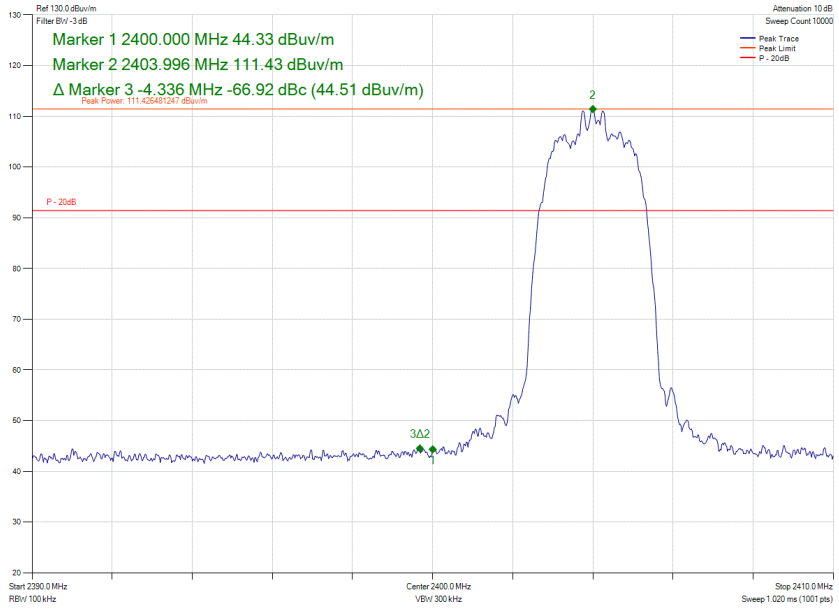

Figure 90 - Core 0-1 - π/4 DQPSK /HDR4 - 2404 MHz - Band Edge Frequency 2400.0 MHz

HDR8

iPA

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
π/4 DQPSK	HDR8	0	2404	2400.0	-57.01

Table 74 - Authorised Band Edge Results

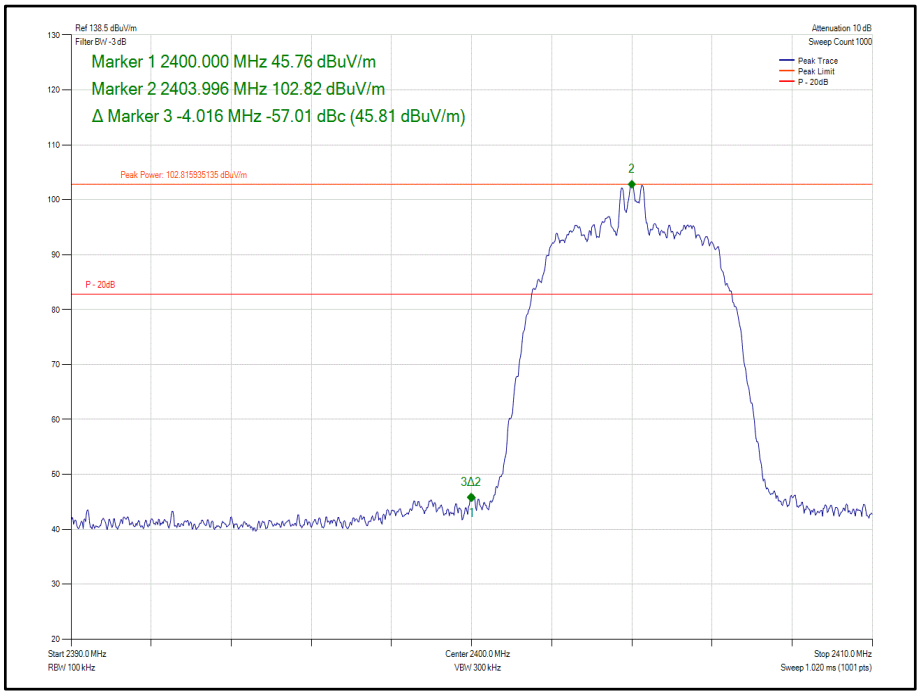

Figure 91 - Core 0 - π/4 DQPSK /HDR8 - 2404 MHz - Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
π/4 DQPSK	HDR8	1	2404	2400.0	-53.26

Table 75 - Authorised Band Edge Results

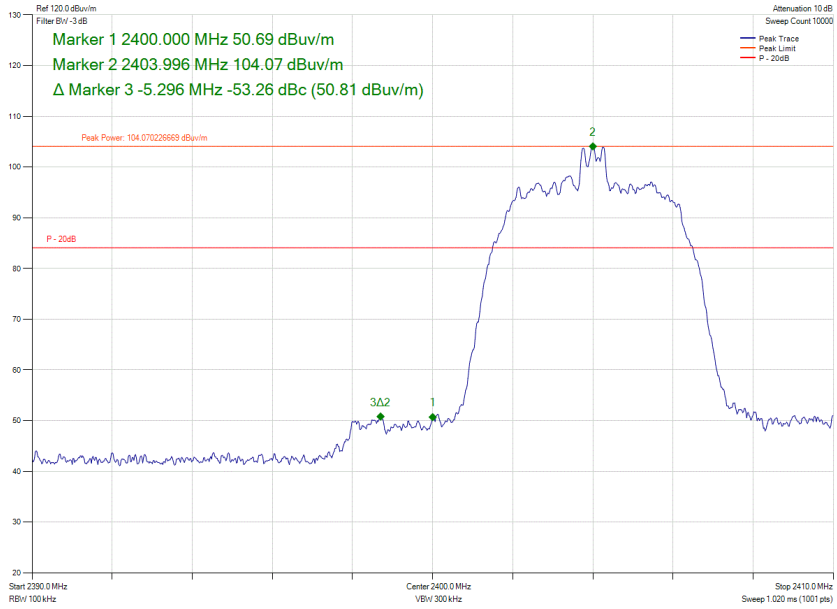

Figure 92 - Core 1 - π/4 DQPSK /HDR8 - 2404 MHz - Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
π/4 DQPSK	HDR8	0-1	2404	2400.0	-56.15

Table 76 - Authorised Band Edge Results

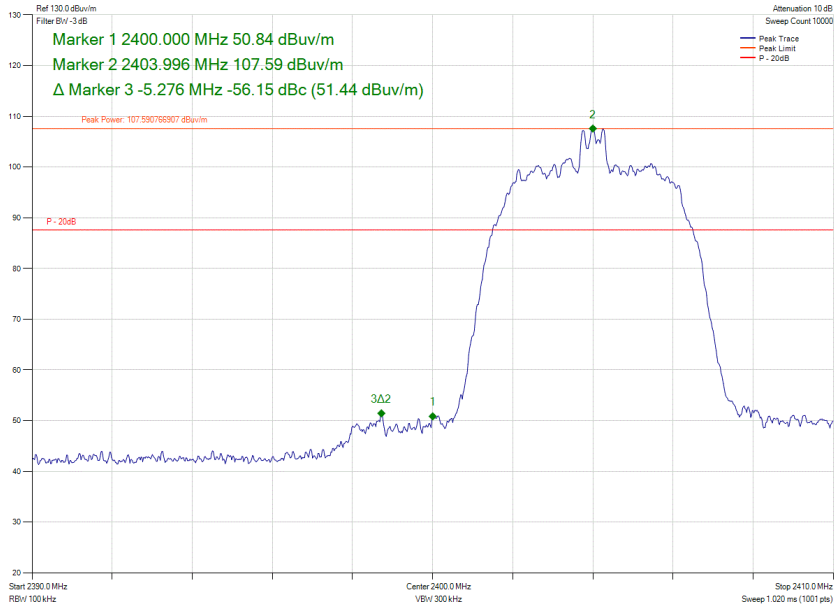

Figure 93 - Core 0-1 - π/4 DQPSK /HDR8 - 2404 MHz - Band Edge Frequency 2400.0 MHz

ePA

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
π/4 DQPSK	HDR8	0	2404	2400.0	-61.65

Table 77 - Authorised Band Edge Results

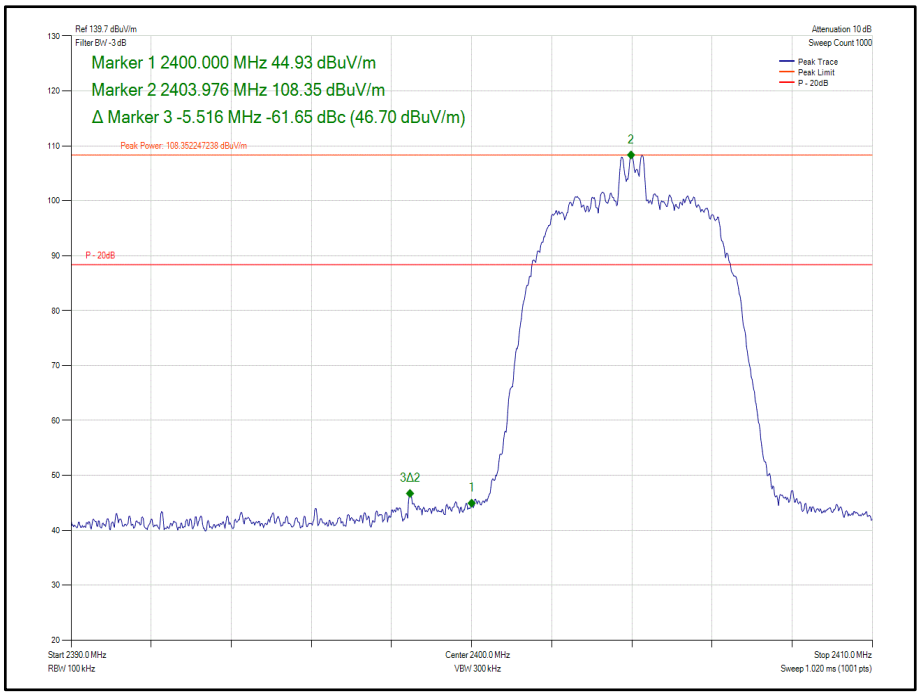

Figure 94 - Core 0 - π/4 DQPSK /HDR8- 2404 MHz – Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
π/4 DQPSK	HDR8	1	2404	2400.0	-61.22

Table 78 - Authorised Band Edge Results

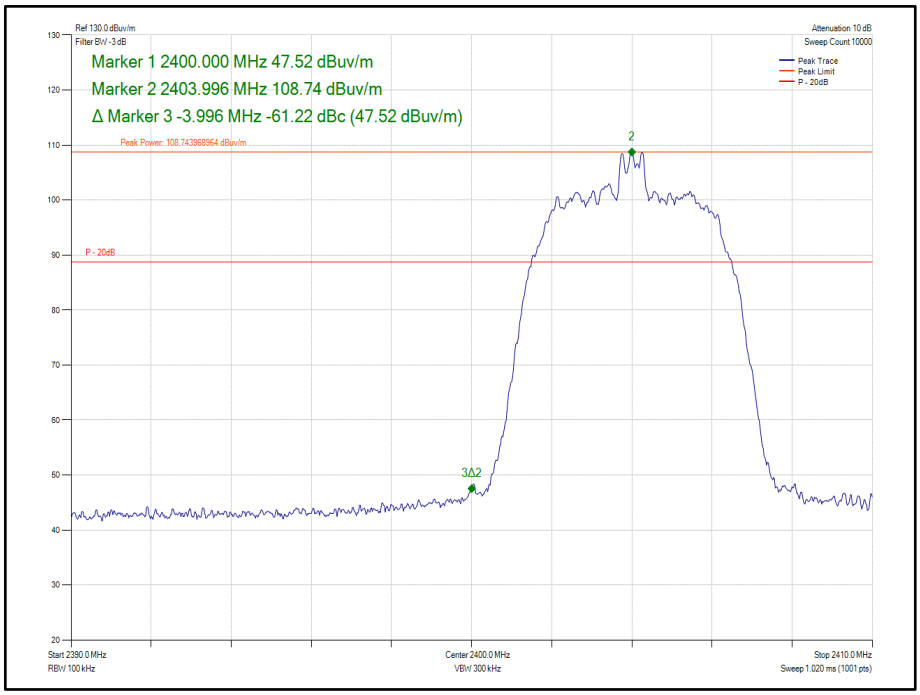

Figure 95 - Core 1 - π/4 DQPSK /HDR8- 2404 MHz – Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
π/4 DQPSK	HDR8	0-1	2404	2400.0	-66.92

Table 79 - Authorised Band Edge Results

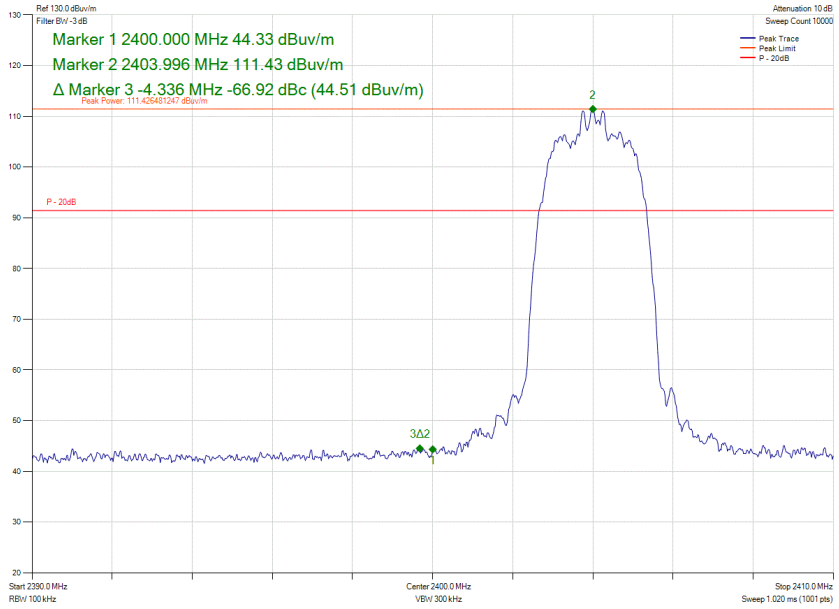

Figure 96 - Core 0-1 - π/4 DQPSK /HDR8 - 2404 MHz - Band Edge Frequency 2400.0 MHz

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

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

ISED RSS-247, Limit Clause 5.5

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

2.3.7 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
Multimeter	Iso-tech	IDM101	2419	12	28-Nov-2020
EMI Test Receiver	Rohde & Schwarz	ESW44	5084	12	28-Nov-2020
EmX Emissions Software	TUV SUD	EmX	5125	-	Software
Screened Room (11)	Rainford	Rainforf	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	10-Mar-2021
Thermo-Hygro-Barometer	PCE Instruments	PCE-THB-40	5475	12	17-Mar-2021
Attenuator 5W 10dB DC-18GHz	Aaren	AT40A-4041-D18-10	5494	12	14-Apr-2021
2m SMA Cable	Junkosha	MWX221-02000AMSAMS/A	5518	12	01-Apr-2021
8m N Type Cable	Junkosha	MWX221-08000NMSNMS/B	5522	12	24-Mar-2021

Table 80

TU - Traceability Unscheduled

2.4 Restricted Band Edges

2.4.1 Specification Reference

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

2.4.2 Equipment Under Test and Modification State

A2338, S/N: C02CX02PQC36 - Modification State 0

2.4.3 Date of Test

04-August-2020 to 08-September-2020

2.4.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 6.10.5 and 11.12.1.

Plots for average measurements were taken in accordance with ANSI C63.10, clause 11.12.2.5.2.

2.4.5 Environmental Conditions

Ambient Temperature	20.9-23.5 °C
Relative Humidity	34.4-60.1 %

2.4.6 Test Results

2.4 GHz Bluetooth Low Energy (DTS)

LE1M

iPA

Modulation	Tx Frequency (MHz)	Core	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
GFSK/DH1	2402	0	2390.0	54.24	41.95
GFSK/DH1	2480	0	2483.5	54.11	42.07

Table 81 - Restricted Band Edge Results

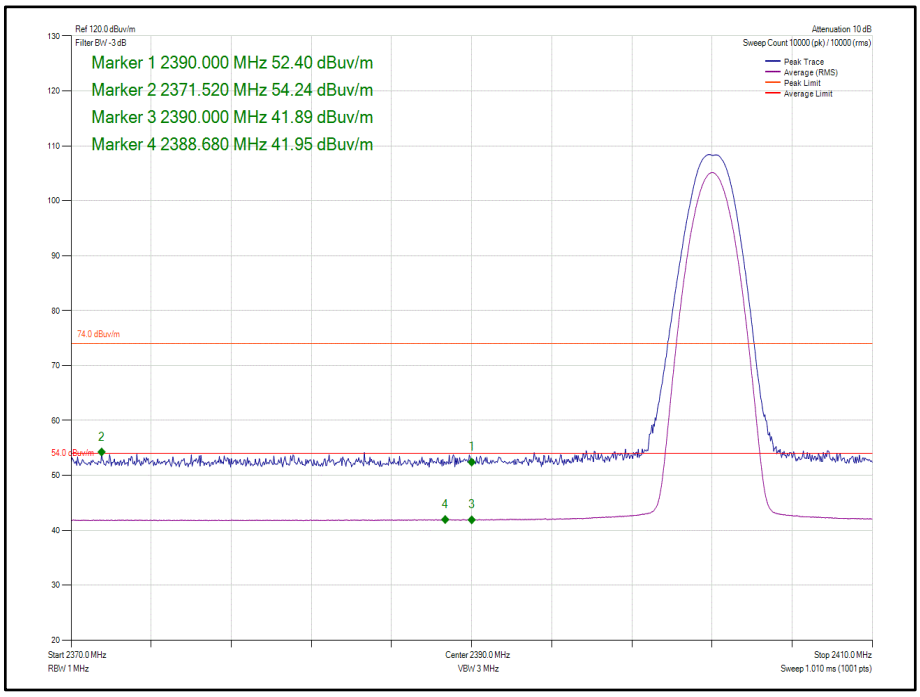

Figure 97 – Core 0 - GFSK/DH1 - 2402 MHz - Band Edge Frequency 2390.0 MHz

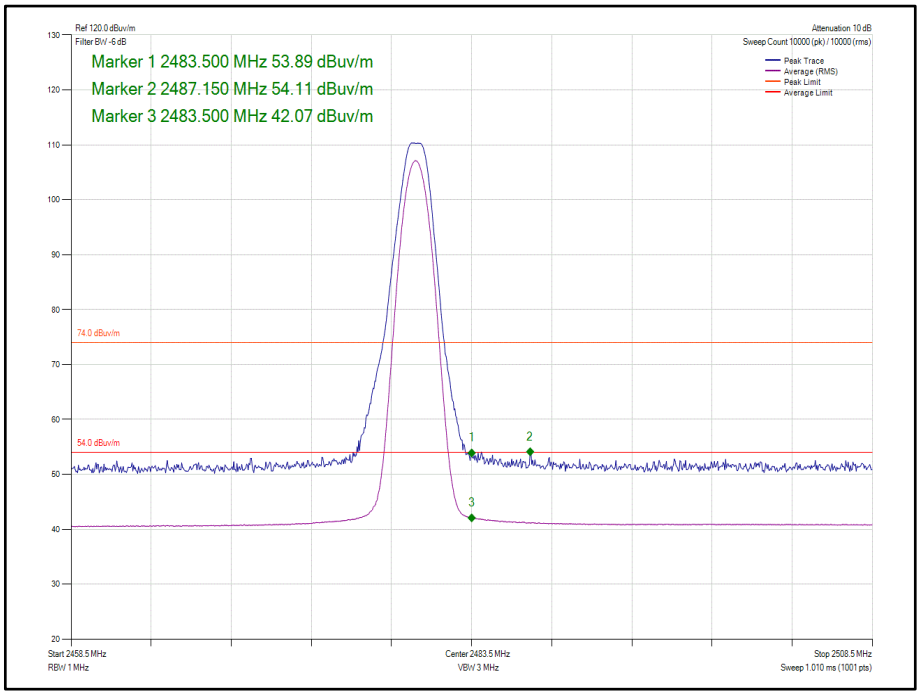

Figure 98 – Core 0 - GFSK/DH1 - 2480 MHz - Band Edge Frequency 2483.5 MHz

Modulation	Tx Frequency (MHz)	Core	Band Edge Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
GFSK/DH1	2402	1	2390.0	54.33	42.04
GFSK/DH1	2480	1	2483.5	54.75	42.47

Table 82 - Restricted Band Edge Results

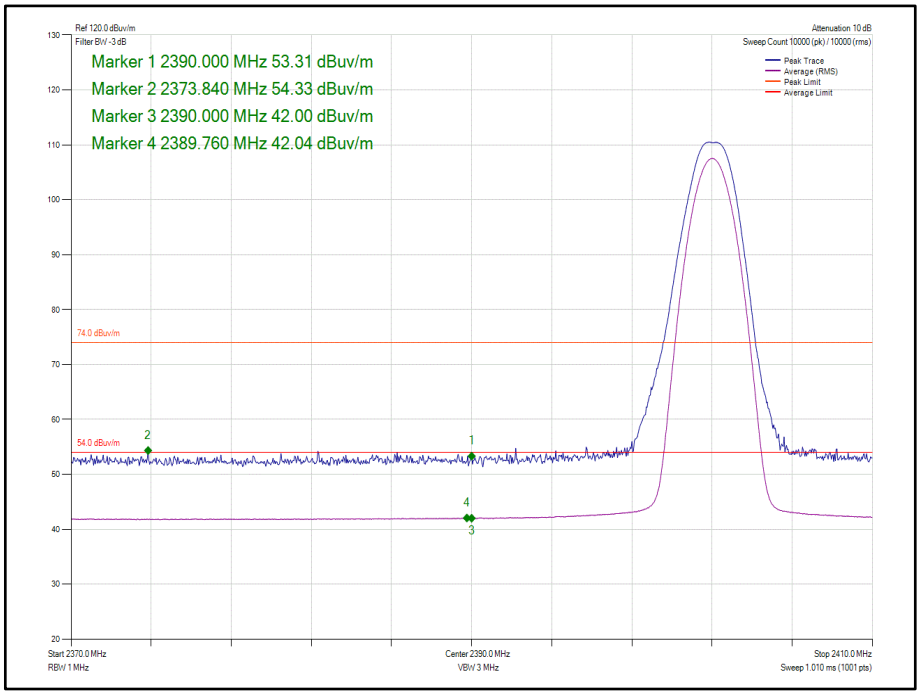

Figure 99 – Core 1 - GFSK/DH1 - 2402 MHz - Band Edge Frequency 2390.0 MHz

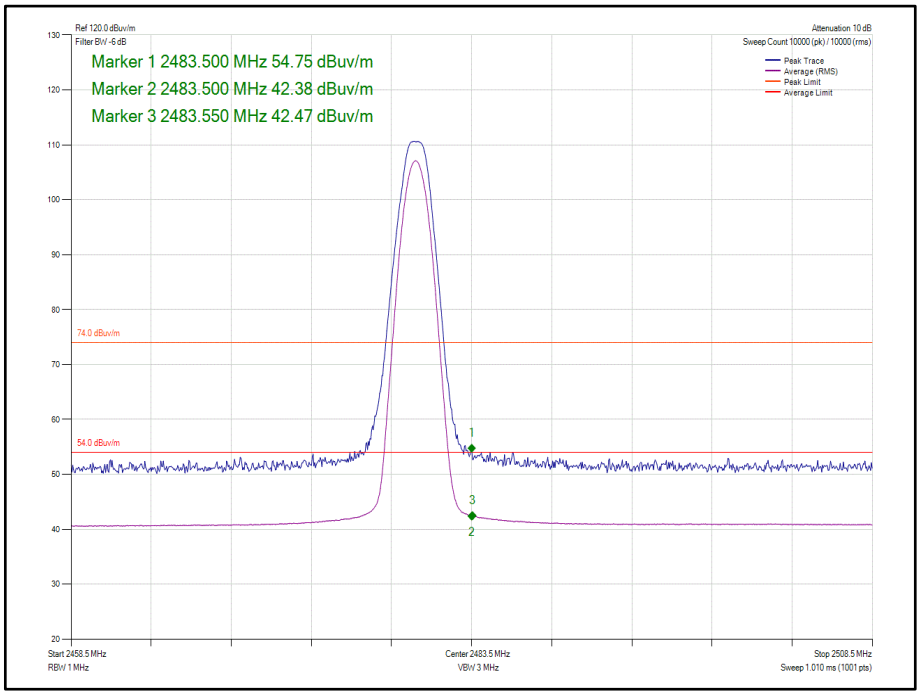

Figure 100 – Core 1 - GFSK/DH1 - 2480 MHz - Band Edge Frequency 2483.5 MHz