

FCC and ISED Test Report

Apple Inc

Model: A2337

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: BCGA2337

IC: 579C-A2337

COMMERCIAL-IN-CONFIDENCE

Document 75949395-10 Issue 01



Add value.
Inspire trust.

SIGNATURE

NAME	JOB TITLE	RESPONSIBLE FOR	ISSUE DATE
Ryan Henley	Sales Manager	Authorised Signatory	26 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	26 October 2020	
Testing	Liang Tian	26 October 2020	
Testing	Aasim Butt	26 October 2020	
Testing	Connor Lee	26 October 2020	
Testing	Jaiyanth Balendrarajah	26 October 2020	
Testing	Faisal Malyar	26 October 2020	
Testing	Ahmad Javid	26 October 2020	
Testing	Malik Mohammad	26 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.



DISCLAIMER AND COPYRIGHT

This non-binding report has been prepared by TÜV SÜD with all reasonable skill and care. The document is confidential to the potential Client and TÜV SÜD. No part of this document may be reproduced without the prior written approval of TÜV SÜD. © 2020 TÜV SÜD. This report relates only to the actual item/items tested.

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).

TÜV SÜD
is a trading name of TÜV SÜD Ltd
Registered in Scotland at East Kilbride,
Glasgow G75 0QF, United Kingdom
Registered number: SC215164

TÜV SÜD Ltd is a
TÜV SÜD Group Company

Phone: +44 (0) 1489 558100
Fax: +44 (0) 1489 558101
www.tuv-sud.co.uk

TÜV SÜD
Octagon House
Concorde Way
Fareham
Hampshire PO15 5RL
United Kingdom



Contents

1 Report Summary2

1.1 Report Modification Record.....2

1.2 Introduction.....2

1.3 Brief Summary of Results3

1.4 Product Information4

1.5 Deviations from the Standard.....5

1.6 EUT Modification Record5

1.7 Test Location.....5

2 Test Details6

2.1 Emission Bandwidth.....6

2.2 Maximum Conducted Output Power56

2.3 Authorised Band Edges62

2.4 Restricted Band Edges85

2.5 Spurious Radiated Emissions117

2.6 Power Spectral Density.....150

3 Measurement Uncertainty156



1 Report Summary

1.1 Report Modification Record

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

Issue	Description of Change	Date of Issue
1	First Issue	26 October 2020

Table 1

1.2 Introduction

Applicant	Apple Inc
Manufacturer	Apple Inc
Model Number(s)	A2337
Serial Number(s)	C02D200EQ9MQ and C02D1009Q9MQ
Hardware Version(s)	REV 1.0
Software Version(s)	20A523220f
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	0540196335
Date	29-June-2020
Date of Receipt of EUT	03-August-2020 and 18-August-2020
Start of Test	03-August-2020
Finish of Test	15-September-2020
Name of Engineer(s)	Mehadi Choudhury, Liang Tian, Aasim Butt, Connor Lee, Jaiyanth Balendrarajah, Faisal Malyar, Ahmad Javid and Malik Mohammad
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 devices 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.

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)
- BT Core 1 – SISO (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	3.22	1.0
BT Core 1	2400 to 2480	4.03	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: A2337, Serial Number: C02D1009Q9MQ			
0	As supplied by the customer	Not Applicable	Not Applicable
Model: A2337, Serial Number: C02D200EQ9MQ			
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	Liang Tian, Aasim Butt, Connor Lee and Jaiyanth Balendrarajah	UKAS
Restricted Band Edges	Liang Tian, Aasim Butt, Connor Lee and Jaiyanth Balendrarajah	UKAS
Spurious Radiated Emissions	Faisal Malyar, Ahmad Javid, Jaiyanth Balendrarajah and Malik Mohammad	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

A2337, S/N: C02D1009Q9MQ - Modification State 0

2.1.3 Date of Test

15-September-2020

2.1.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 11.8.2.

2.1.5 Environmental Conditions

Ambient Temperature	22.9 - 25.2 °C
Relative Humidity	52.9 - 57.8 %



2.1.6 Test Results

2.4 GHz Bluetooth Low Energy (DTS)

iPA

Antenna Port Configuration: SISO

Modulation: $\pi/4$ DQPSK (HDR4)

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

Table 6 - 6 dB Bandwidth Results

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

Table 7 - 99% Bandwidth Results

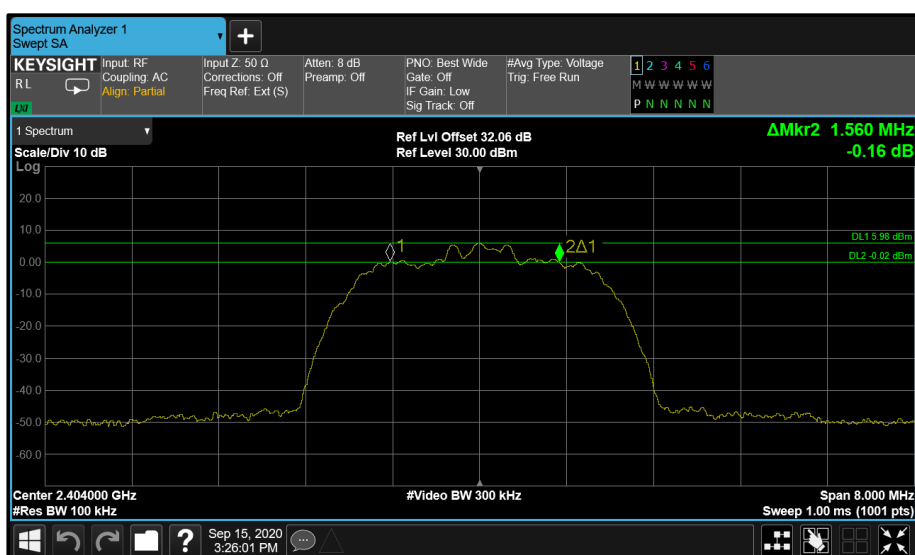


Figure 1 - Core 1 HDR4 2404 MHz (CH2)

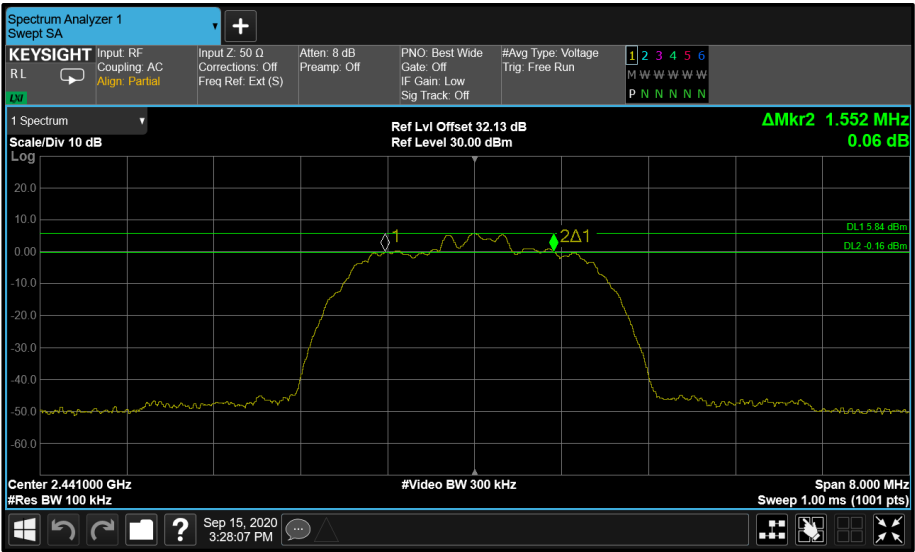


Figure 2 - Core 1 HDR4 2441 MHz (CH39)

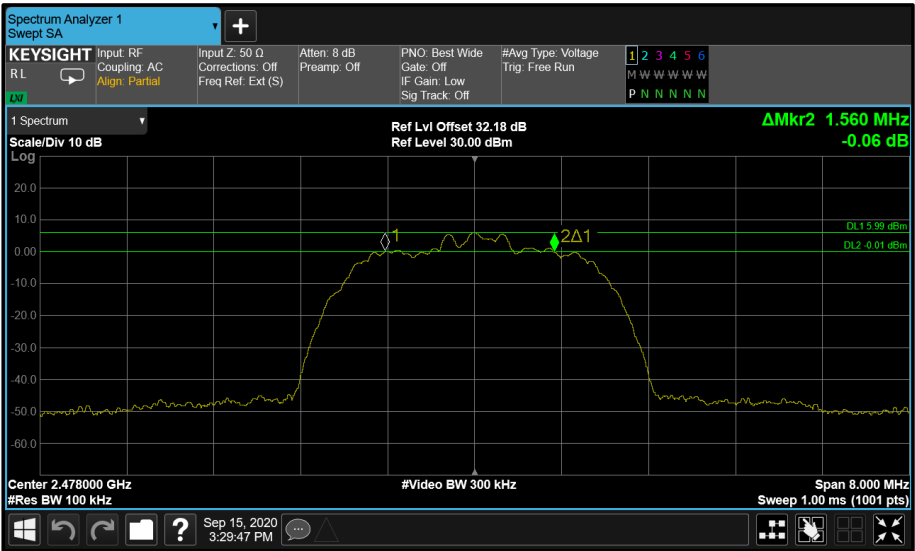


Figure 3 - Core 1 HDR4 2478 MHz (CH76)



Modulation: $\pi/4$ DQPSK (HDR8)

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

Table 8 - 6 dB Bandwidth Results

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

Table 9 - 99% Bandwidth Results

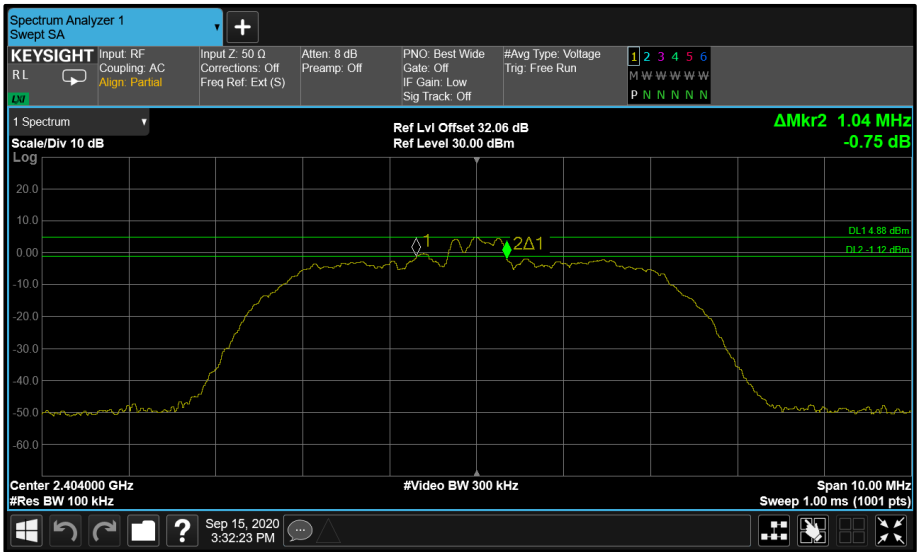


Figure 4 - Core 1 HDR8 2404 MHz (CH2)

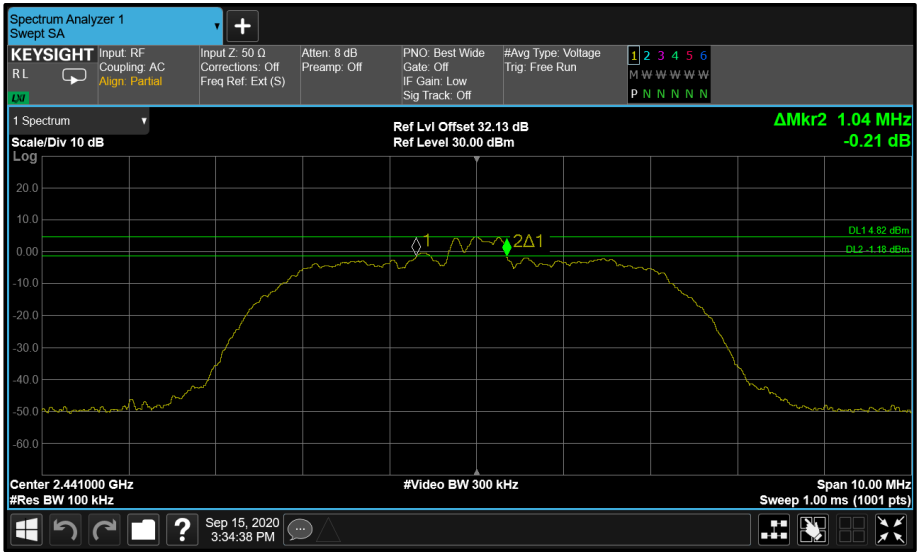


Figure 5 - Core 1 HDR8 2441 MHz (CH39)

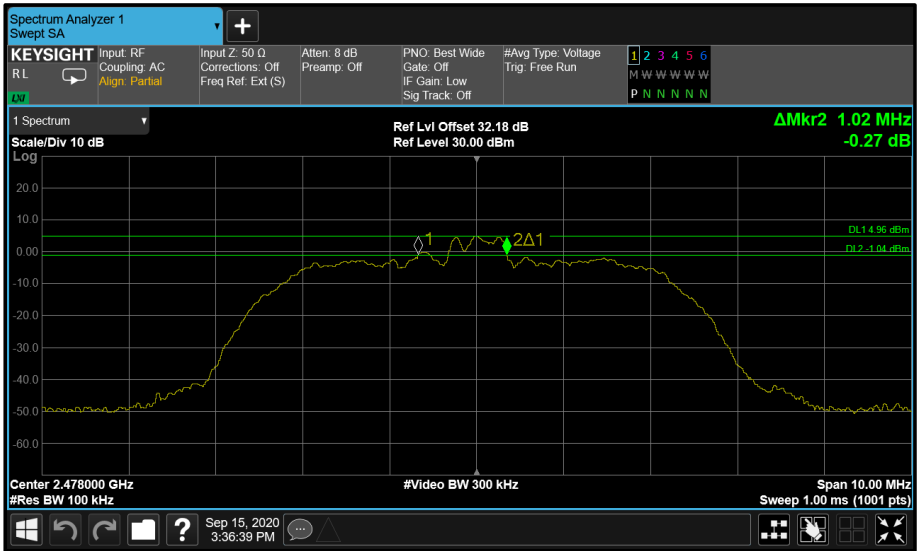


Figure 6 - Core 1 HDR8 2478 MHz (CH76)

Modulation: GFSK (LE 1M)

Test Frequency (MHz)	6 dB Bandwidth (MHz)
	Port(s)
	Core 1
2402	0.692
2440	0.692
2480	0.696

Table 10 - 6 dB Bandwidth Results

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

Table 11 - 99% Bandwidth Results

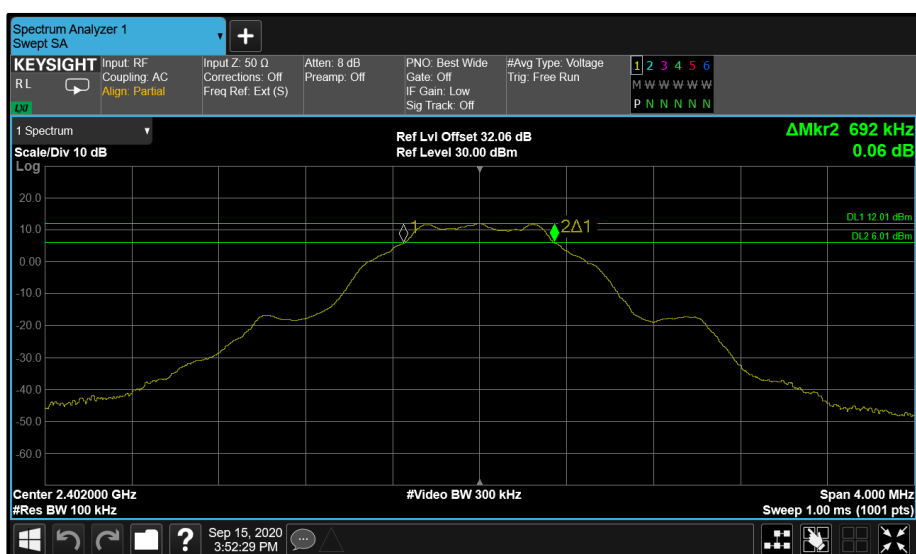


Figure 7 - Core 1 LE 1M 2402 MHz (CH0)

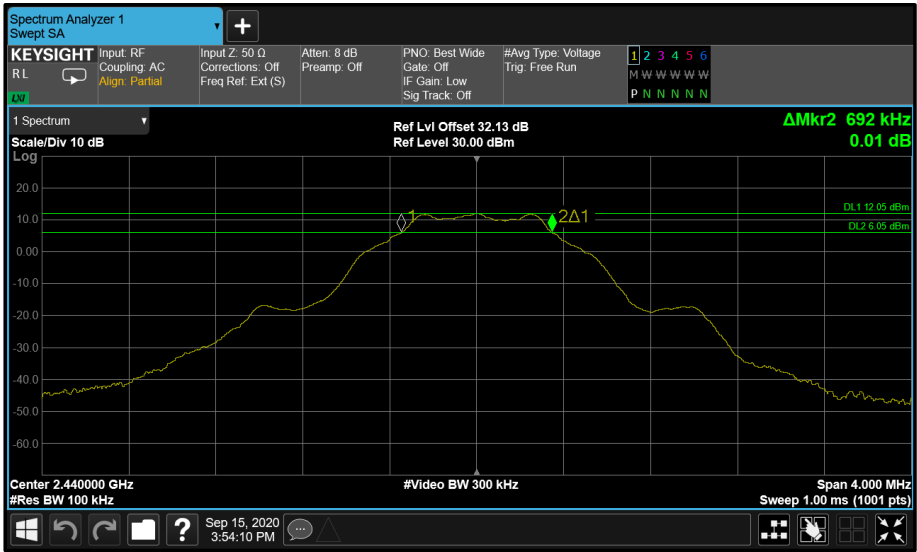


Figure 8 - Core 1 LE 1M 2440 MHz (CH19)

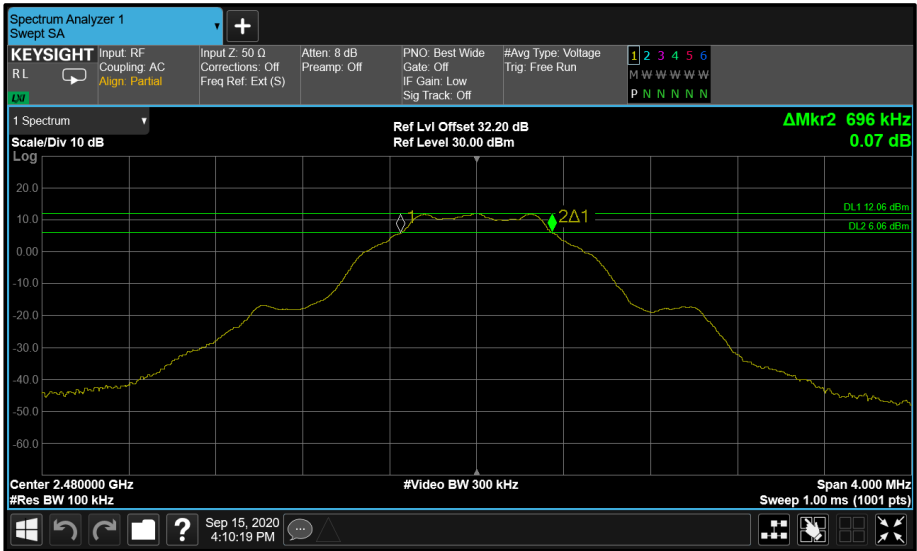


Figure 9 - Core 1 LE 1M 2480 MHz (CH39)

Modulation: GFSK (LE 2M)

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

Table 12 - 6 dB Bandwidth Results

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

Table 13 - 99% Bandwidth Results

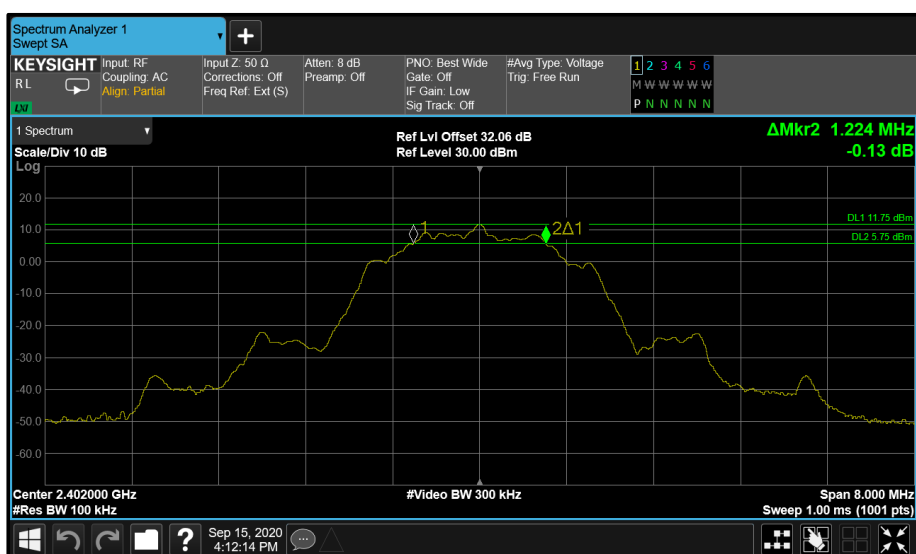


Figure 10 - Core 1 LE 2M 2402 MHz (CH0)

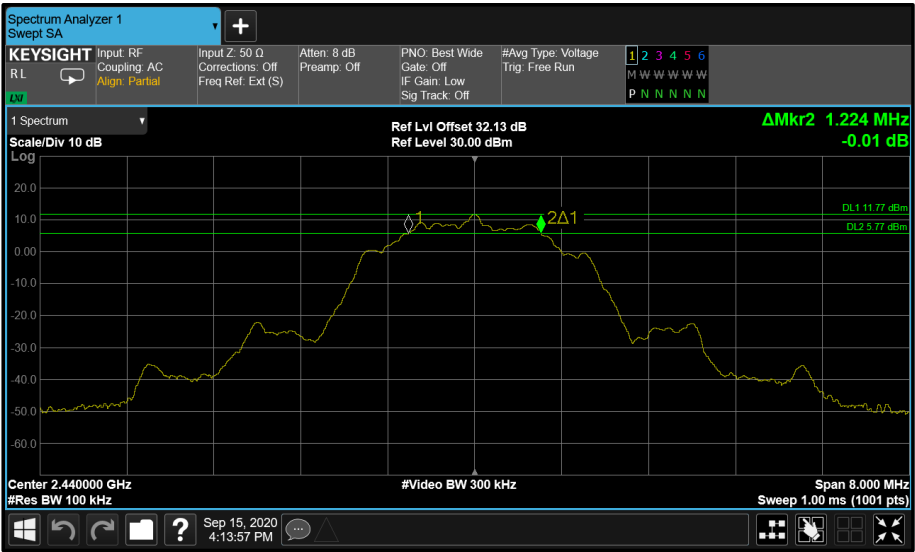


Figure 11 - Core 1 LE 2M 2440 MHz (CH19)

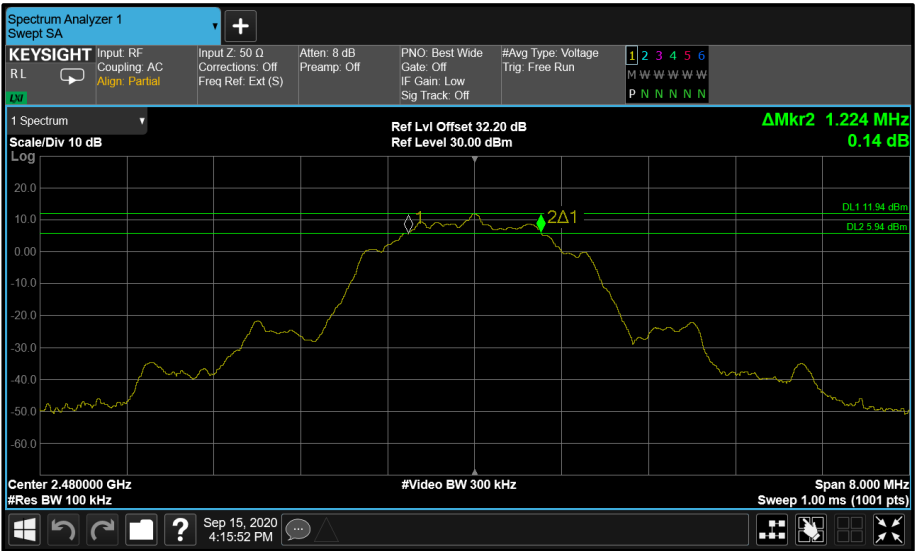


Figure 12 - Core 1 LE 2M 2480 MHz (CH39)



Antenna Port Configuration: Beamforming

Modulation: $\pi/4$ DQPSK (HDR4)

Test Frequency (MHz)	6 dB Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2404	1.544	1.552
2441	1.568	1.560
2478	1.568	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	2.344	2.344
2478	2.352	2.344

Table 15 - 99% Bandwidth Results

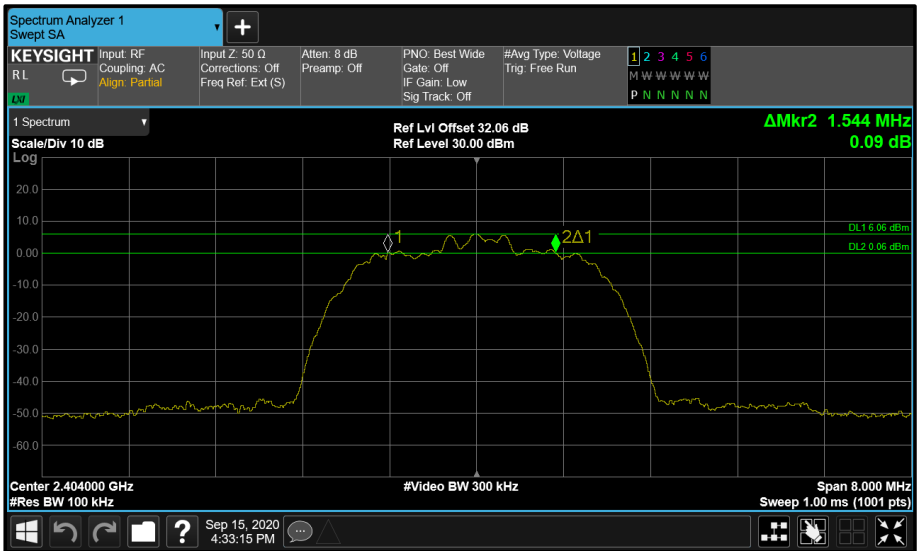


Figure 13 - Core 1 HDR4 2404 MHz (CH2)

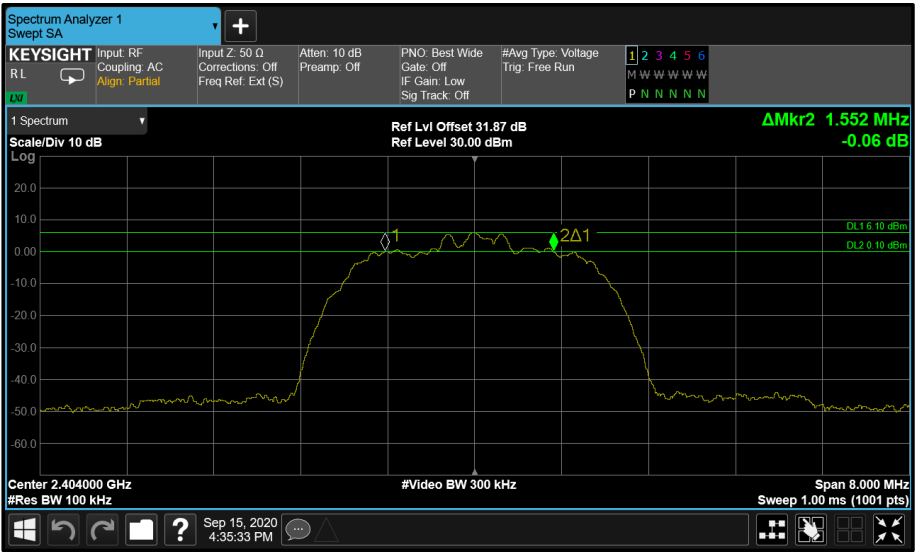


Figure 14 - Core 0 HDR4 2404 MHz (CH2)

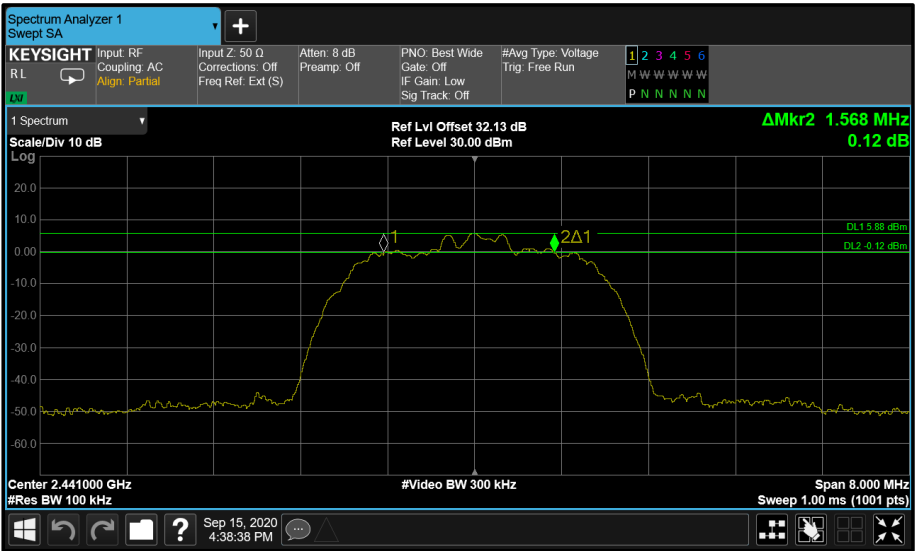


Figure 15 - Core 1 HDR4 2441 MHz (CH39)

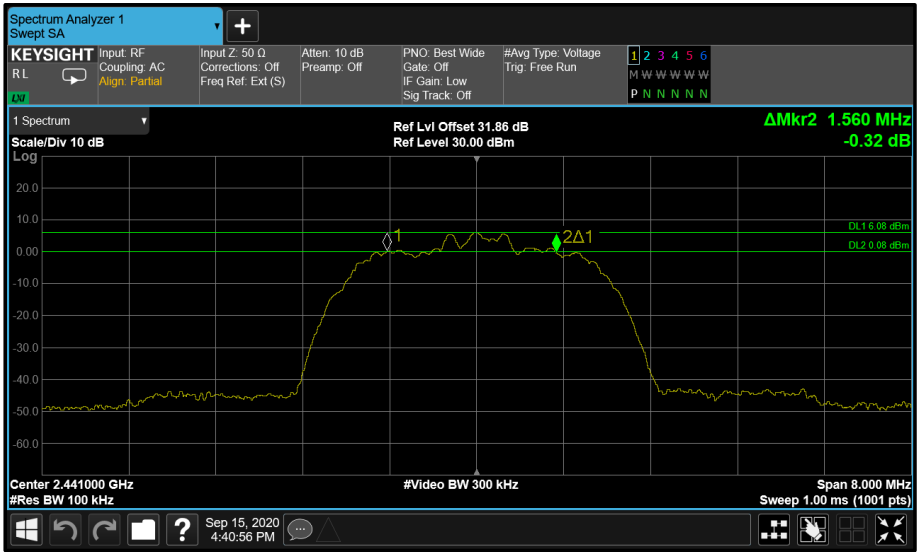


Figure 16 - Core 0 HDR4 2441 MHz (CH39)

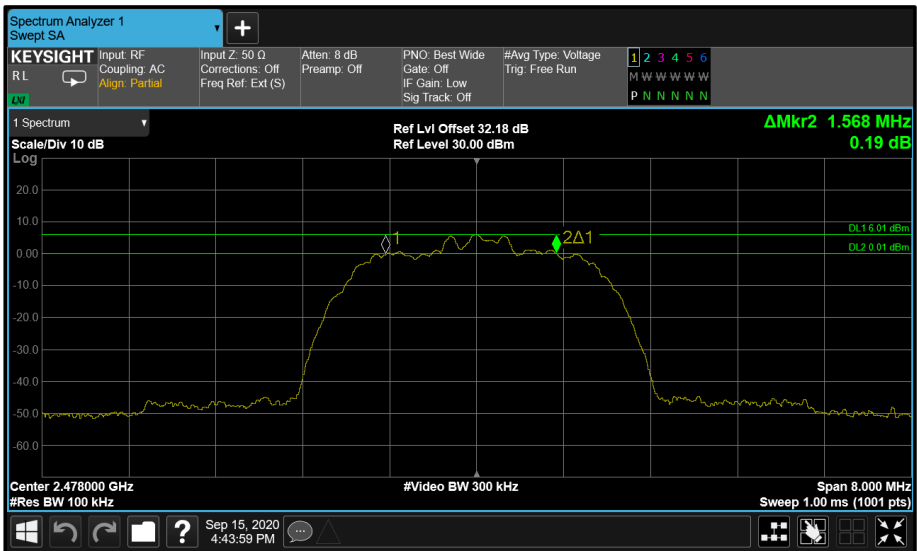


Figure 17 - Core 1 HDR4 2478 MHz (CH76)

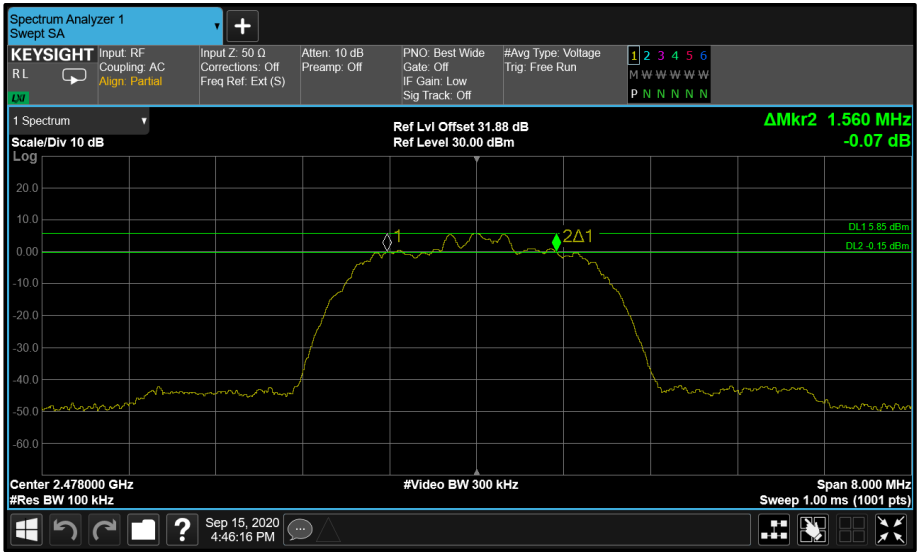


Figure 18 - Core 0 HDR4 2478 MHz (CH76)

Modulation: $\pi/4$ DQPSK (HDR8)

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

Table 16 - 6 dB Bandwidth Results

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

Table 17 - 99% Bandwidth Results

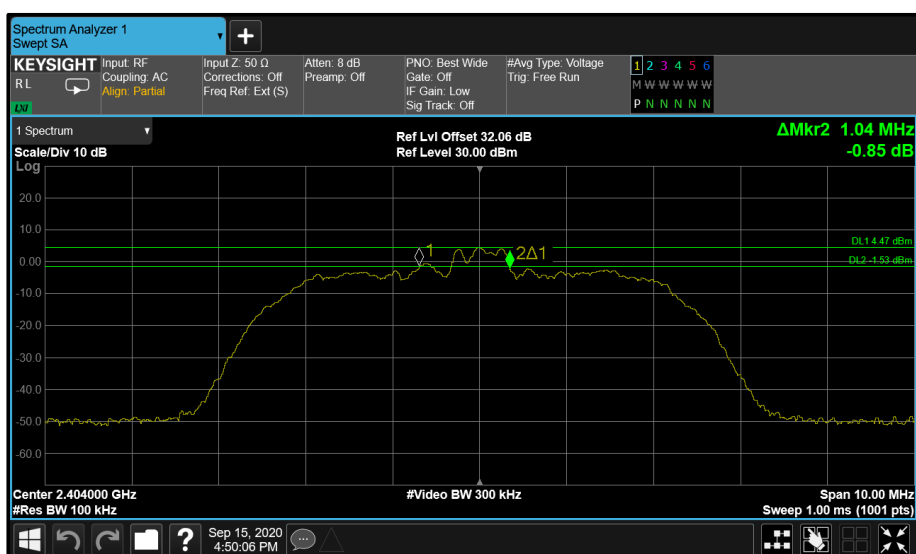


Figure 19 - Core 1 HDR8 2404 MHz (CH2)

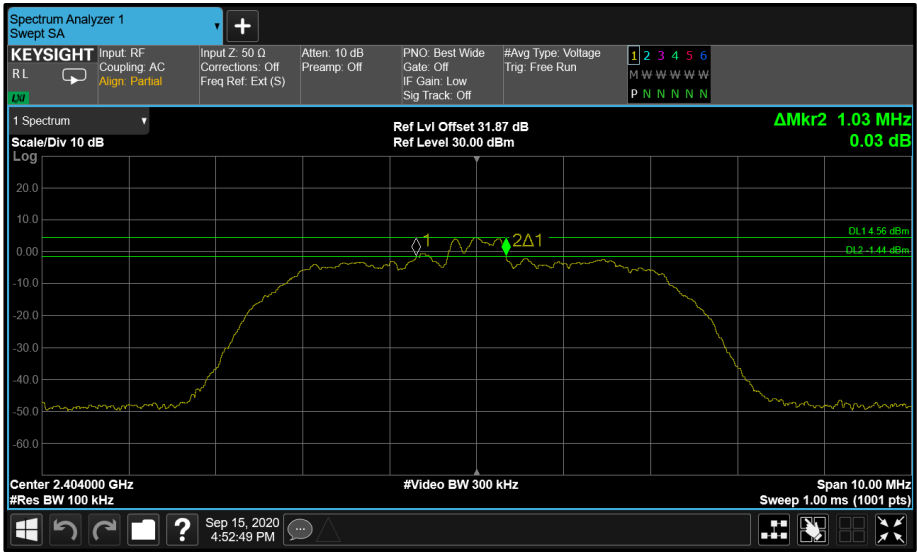


Figure 20 - Core 0 HDR8 2404 MHz (CH2)

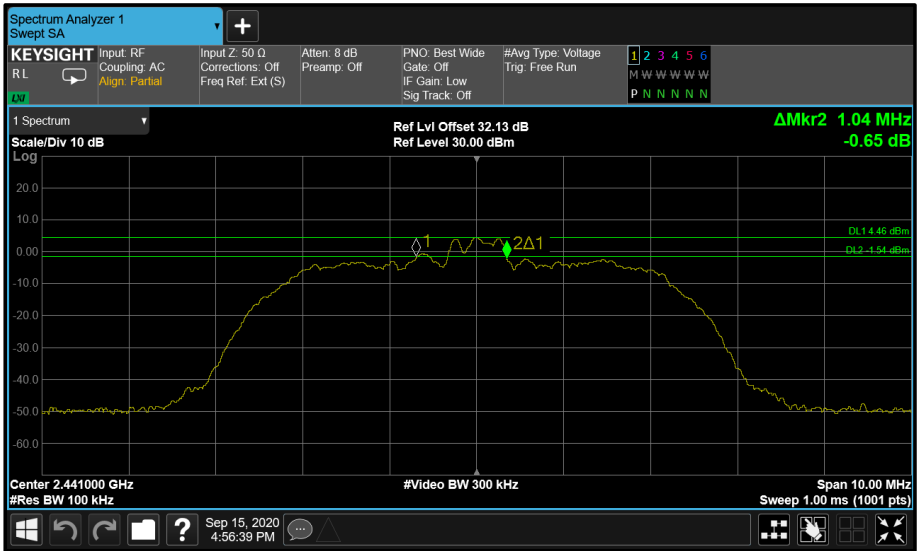
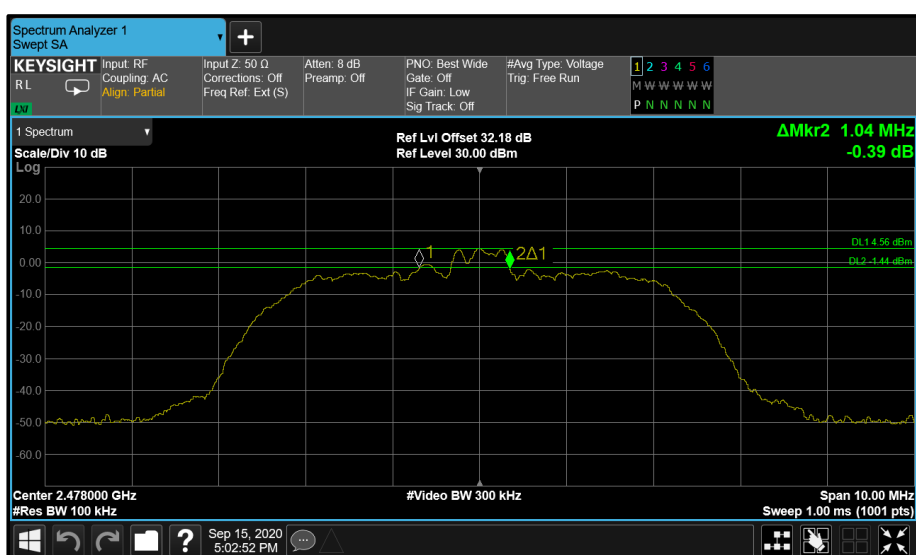
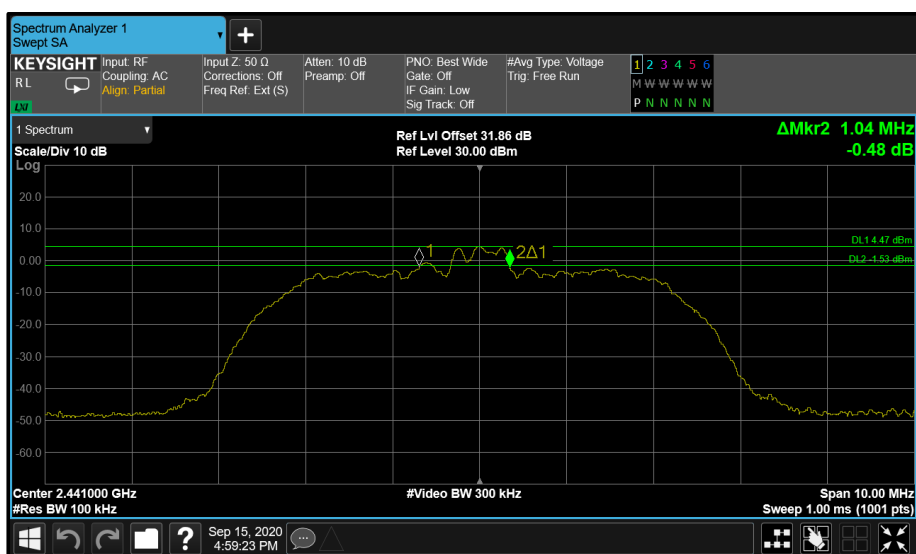


Figure 21 - Core 1 HDR8 2441 MHz (CH39)



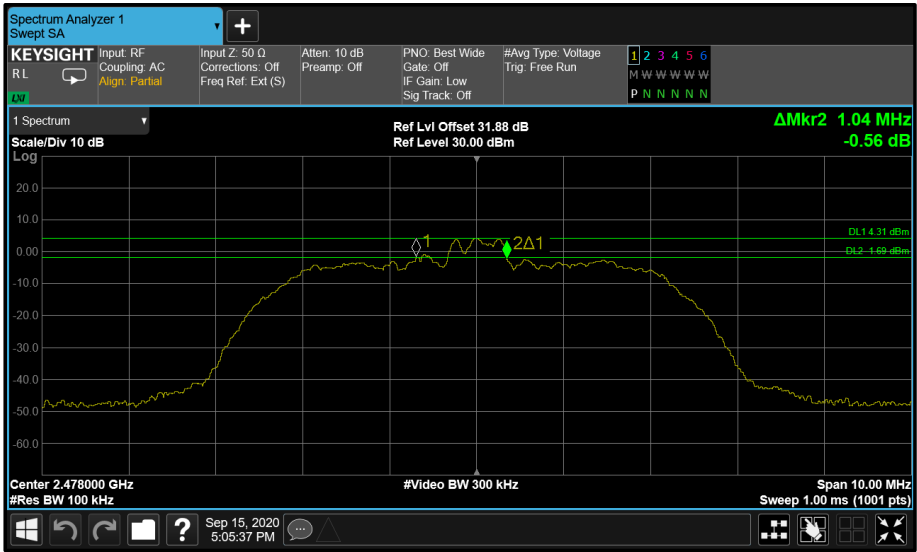


Figure 24 - Core 0 HDR8 2478 MHz (CH76)

Modulation: GFSK (LE 1M)

Test Frequency (MHz)	6 dB Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2402	0.692	0.692
2440	0.692	0.696
2480	0.696	0.708

Table 18 - 6 dB Bandwidth Results

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

Table 19 - 99% Bandwidth Results

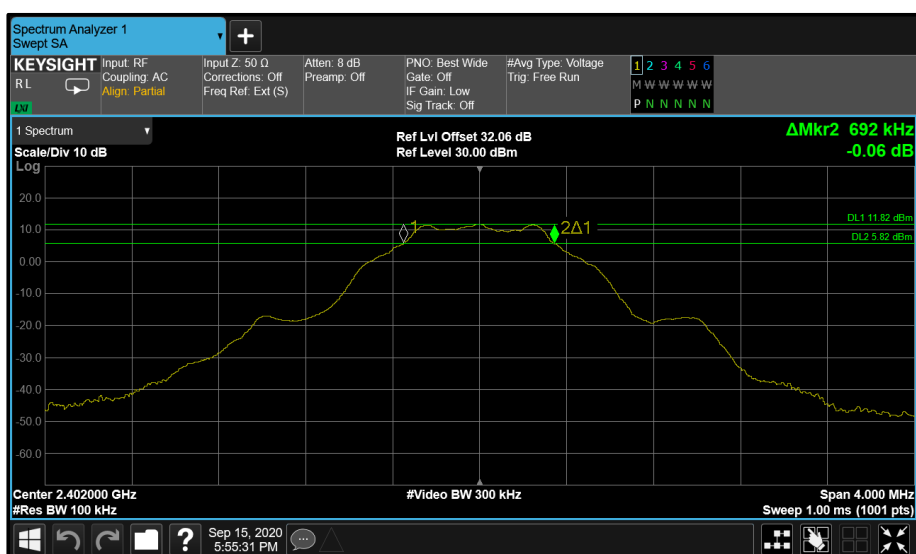


Figure 25 - Core 1 LE 1M 2402 MHz (CH0)

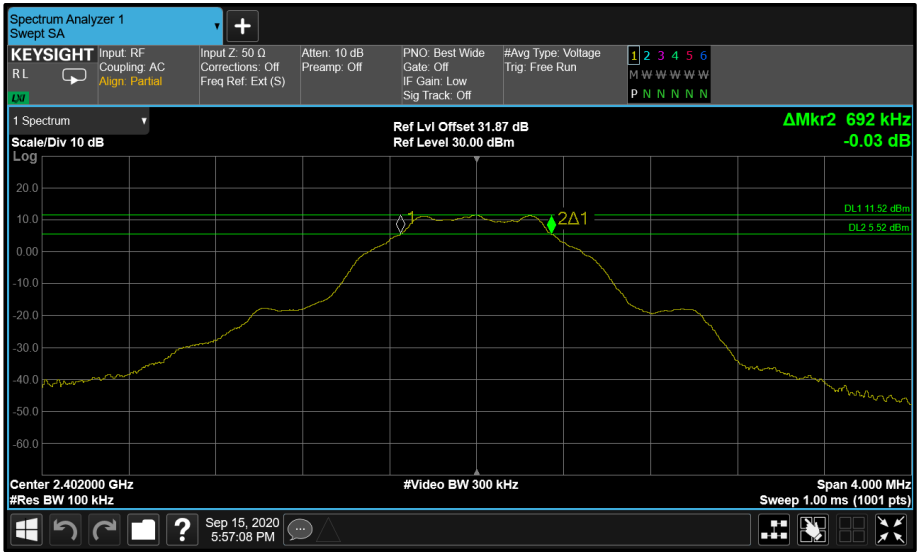


Figure 26 - Core 0 LE 1M 2402 MHz (CH0)

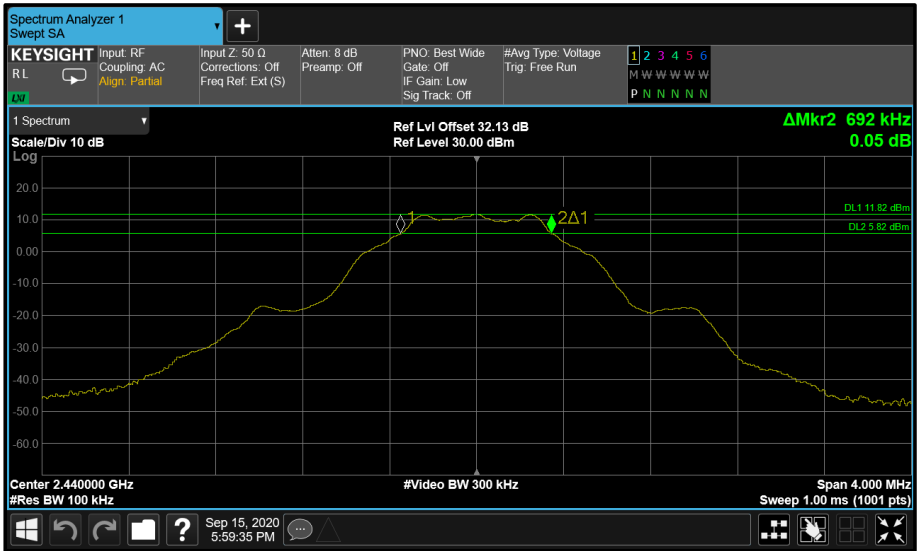


Figure 27 - Core 1 LE 1M 2440 MHz (CH19)

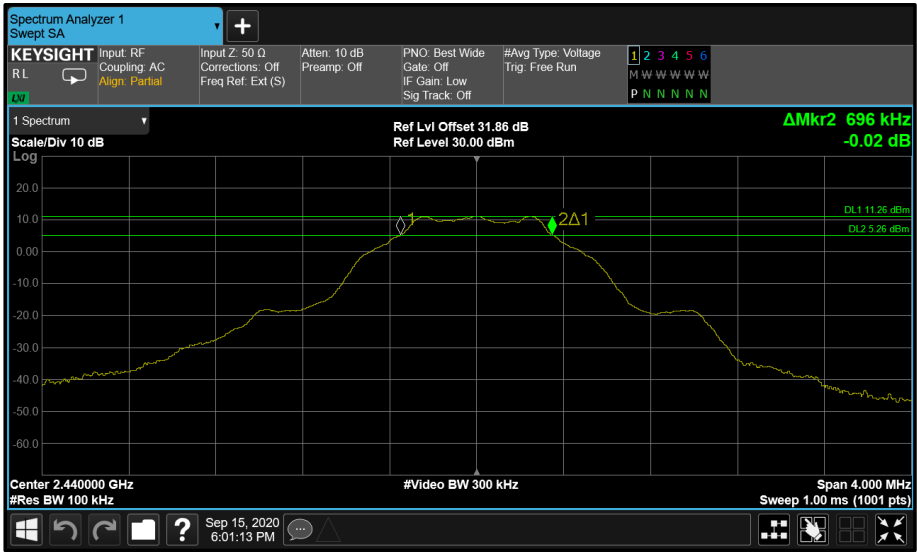


Figure 28 - Core 0 LE 1M 2440 MHz (CH19)

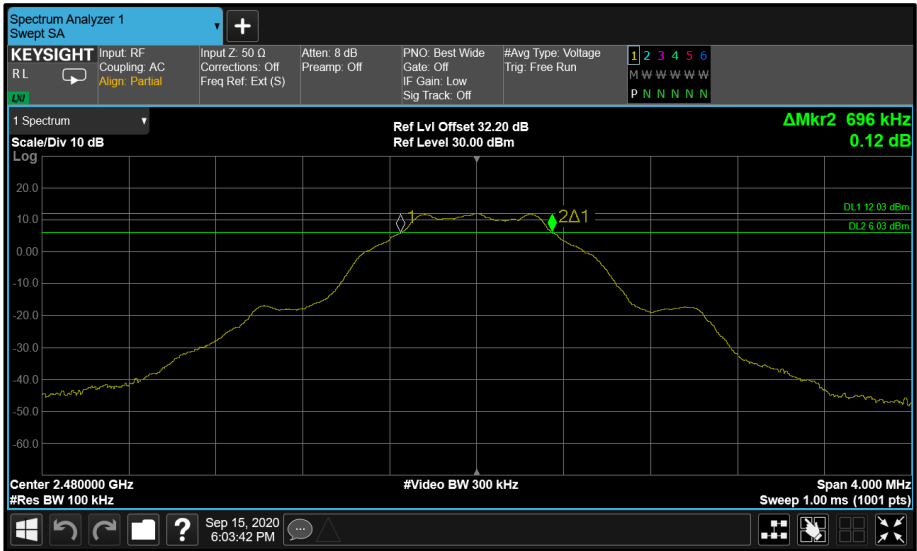


Figure 29 - Core 1 LE 1M 2480 MHz (CH39)

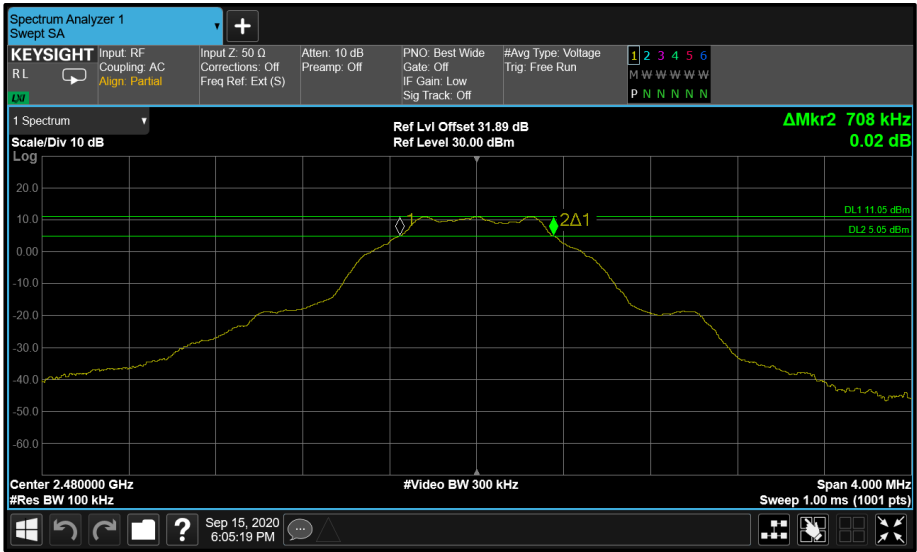


Figure 30 - Core 0 LE 1M 2480 MHz (CH39)

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

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

Spectrum Analyzer 1
Swept SA

KEYSIGHT Input: RF
R.L. Coupling: AC
Align: Partial

Input Z: 50 Ω
Corrections: Off
Freq Ref: Ext (S)

Atten: 8 dB
Preamp: Off

PNO: Best Wide
Gate: Off
IF Gain: Low
Sig Track: Off

#Avg Type: Voltage
Trig: Free Run

1 2 3 4 5 6
M W W W W W
P N N N N N

1 Spectrum
Scale/Div 10 dB
Log

Ref Lvl Offset 32.06 dB
Ref Level 30.00 dBm

$\Delta\text{Mkr}2$ 1.224 MHz
-0.07 dB

2Δ1

DL1 11.78 dBm
DL2 5.78 dBm

Center 2.402000 GHz
#Res BW 100 kHz

#Video BW 300 kHz

Span 6.000 MHz
Sweep 1.00 ms (1001 pts)

Page 27 of 156

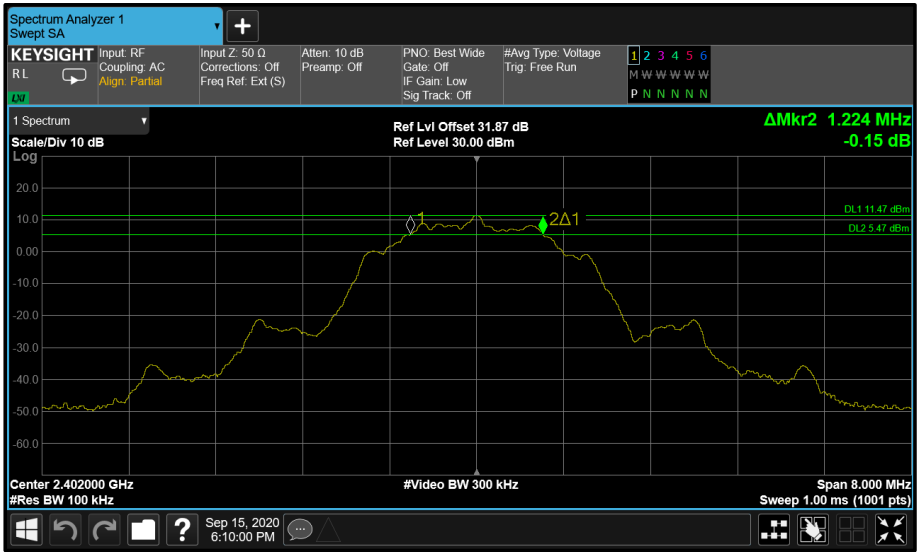


Figure 32 - Core 0 LE 2M 2402 MHz (CH0)

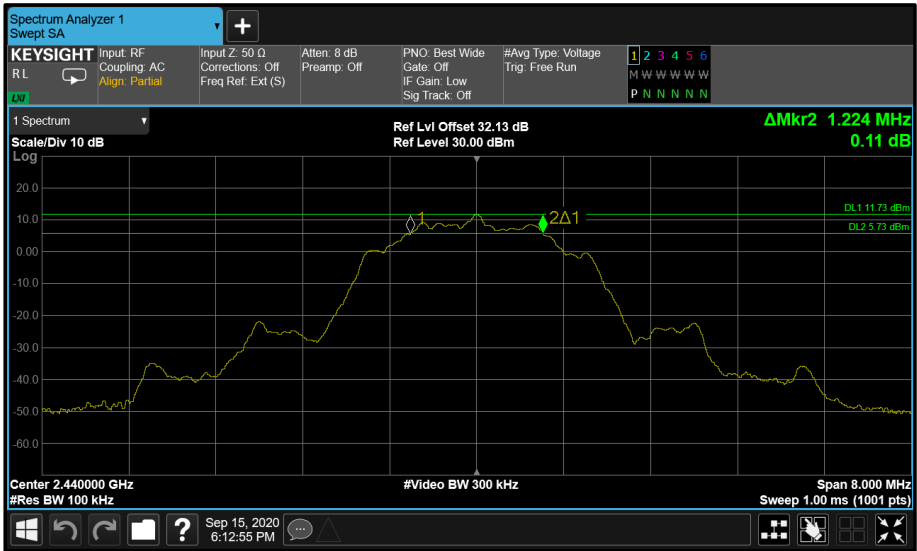


Figure 33 - Core 1 LE 2M 2440 MHz (CH19)

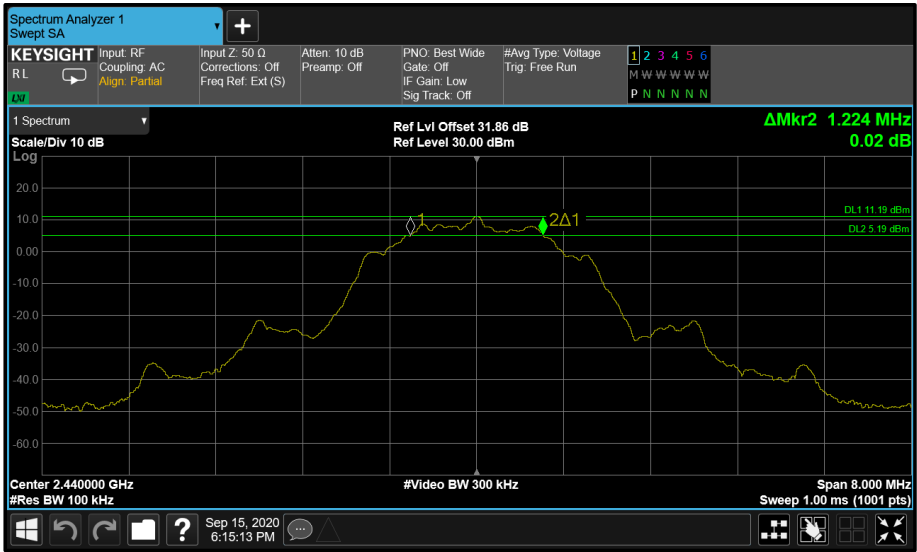


Figure 34 - Core 0 LE 2M 2440 MHz (CH19)

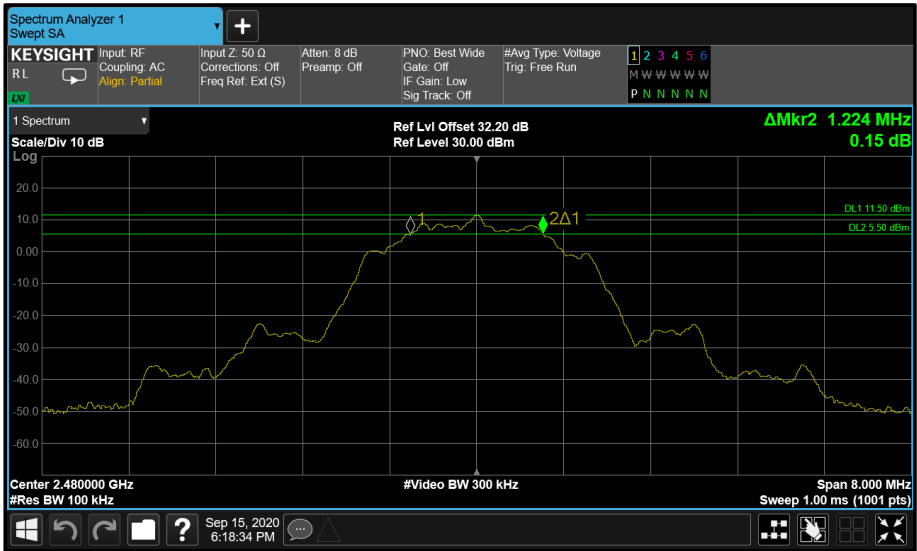


Figure 35 - Core 1 LE 2M 2480 MHz (CH39)

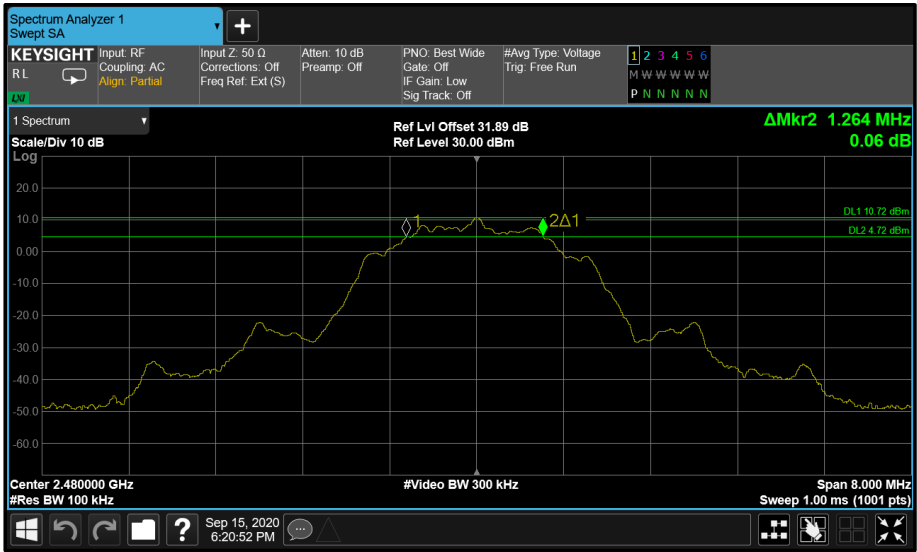


Figure 36 - Core 0 LE 2M 2480 MHz (CH39)



ePA

Antenna Port Configuration: SISO

Modulation: $\pi/4$ DQPSK (HDR4)

Test Frequency (MHz)	6 dB Bandwidth (MHz)
	Port(s)
	Core 1
2404	1.560
2441	1.560
2478	1.760

Table 22 - 6 dB Bandwidth Results

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

Table 23 - 99% Bandwidth Results

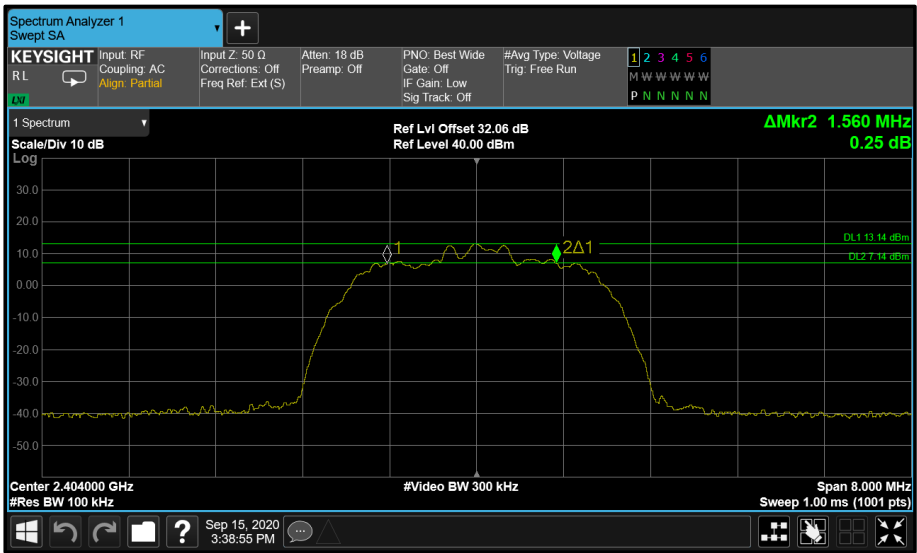


Figure 37 - Core 1 HDR4 2404 MHz (CH2)

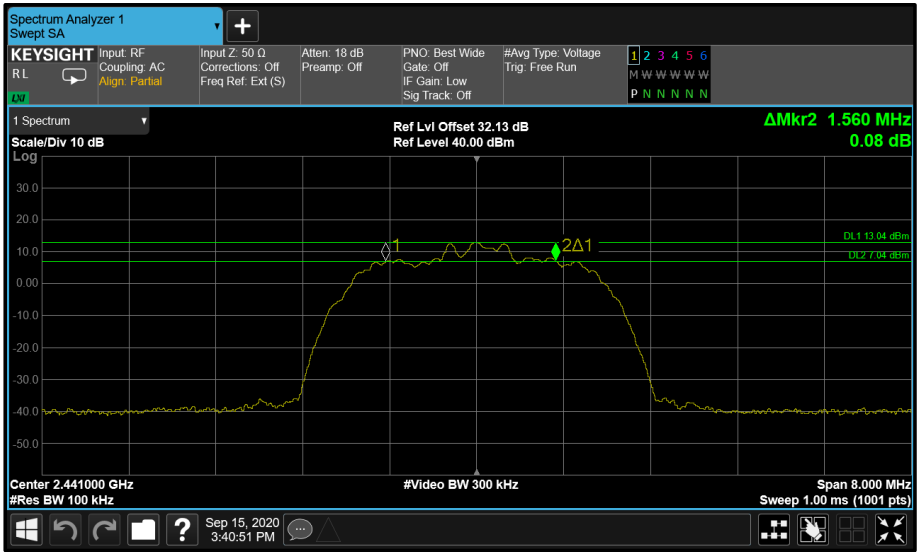


Figure 38 - Core 1 HDR4 2441 MHz (CH39)

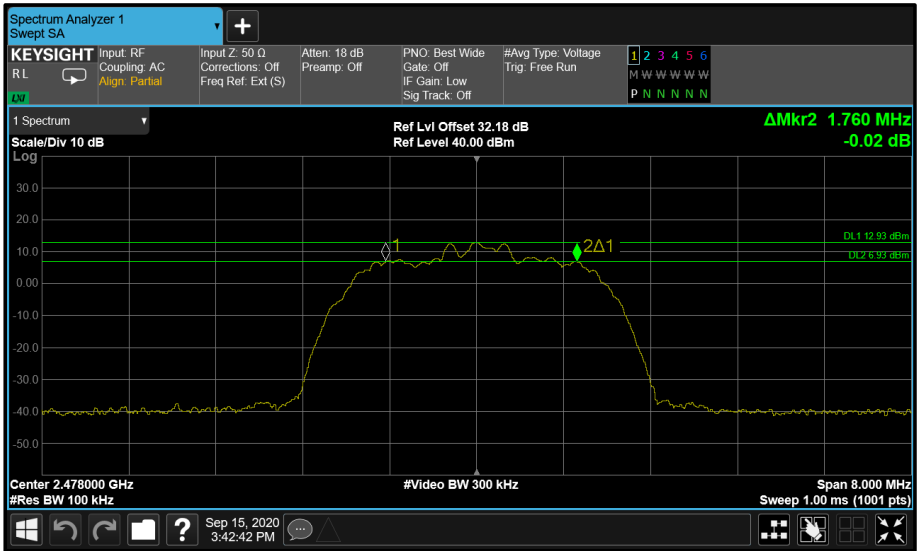


Figure 39 - Core 1 HDR4 2478 MHz (CH76)



Modulation: $\pi/4$ DQPSK (HDR8)

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

Table 24 - 6 dB Bandwidth Results

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

Table 25 - 99% Bandwidth Results

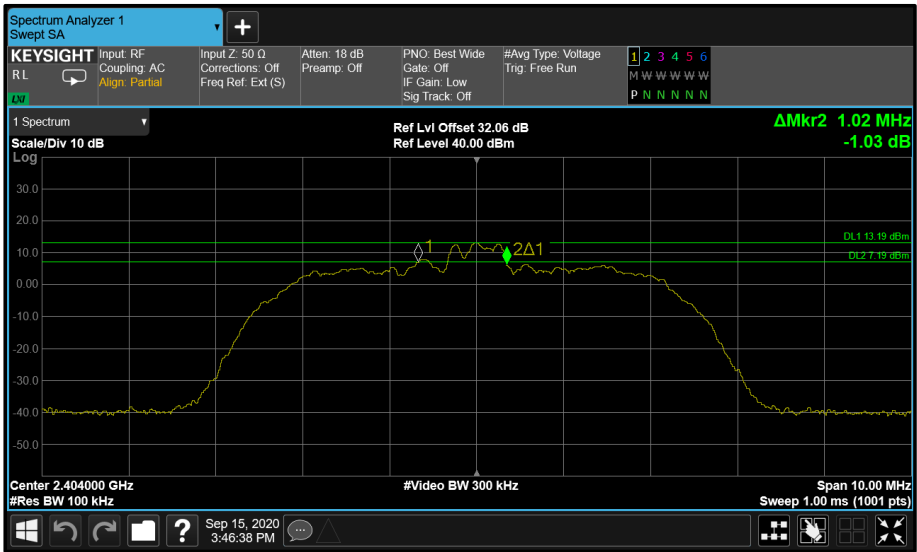


Figure 40 - Core 1 HDR8 2404 MHz (CH2)

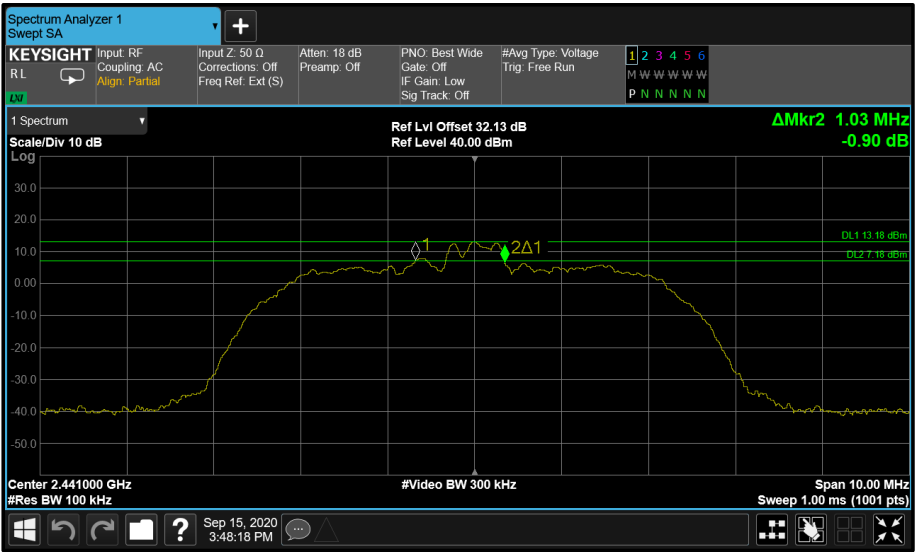


Figure 41 - Core 1 HDR8 2441 MHz (CH39)

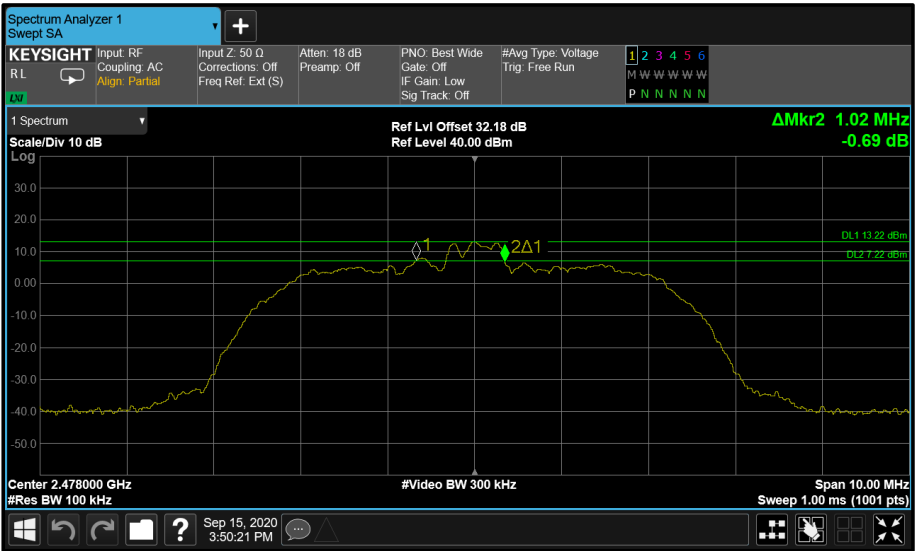


Figure 42 - Core 1 HDR8 2478 MHz (CH76)

Modulation: GFSK (LE 1M)

Test Frequency (MHz)	6 dB Bandwidth (MHz)
	Port(s)
	Core 1
2402	0.692
2440	0.692
2480	0.696

Table 26 - 6 dB Bandwidth Results

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

Table 27 - 99% Bandwidth Results

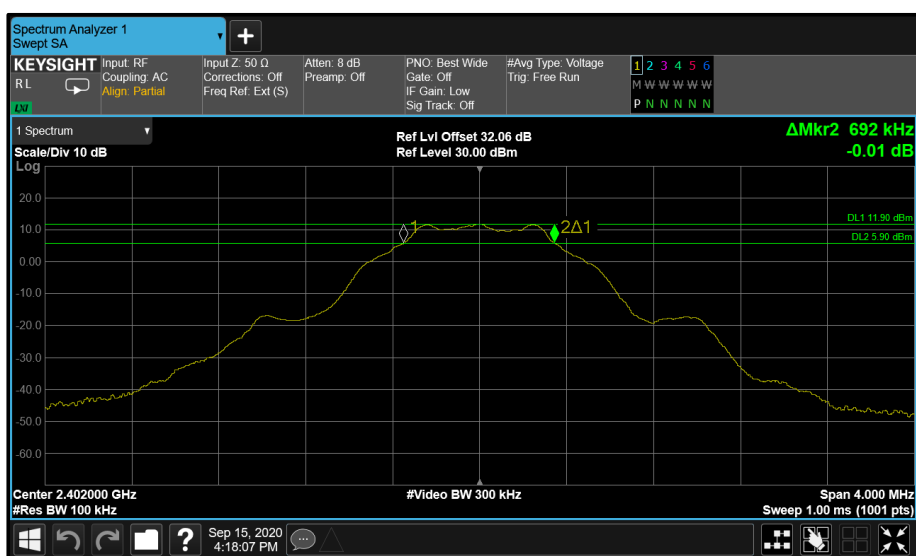


Figure 43 - Core 1 LE 1M 2402 MHz (CH0)

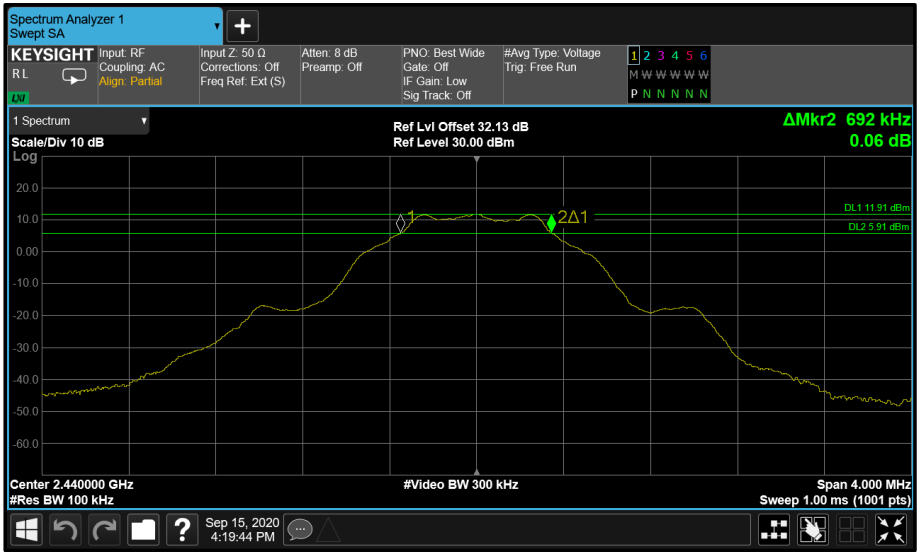


Figure 44 - Core 1 LE 1M 2440 MHz (CH19)

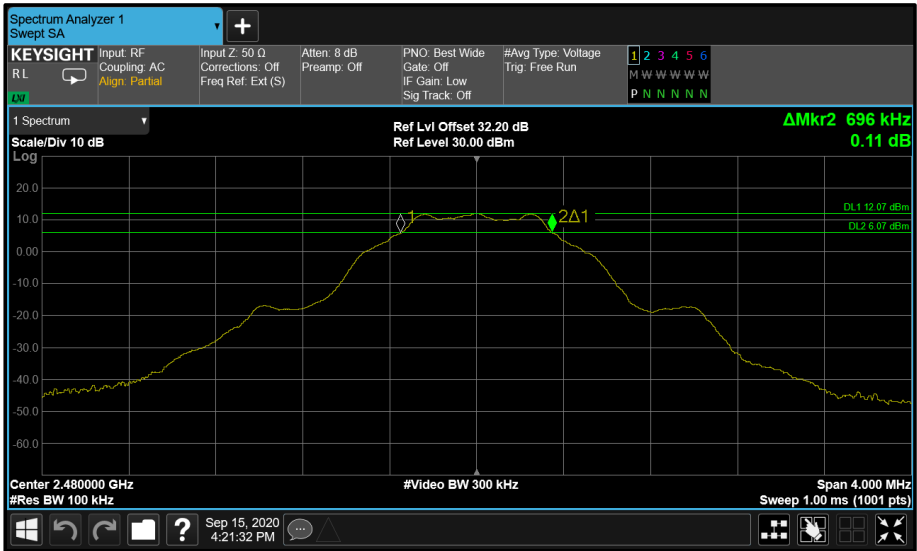


Figure 45 - Core 1 LE 1M 2480 MHz (CH39)



Modulation: GFSK (LE 2M)

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	2.072
2440	2.080
2480	2.080

Table 29 - 99% Bandwidth Results

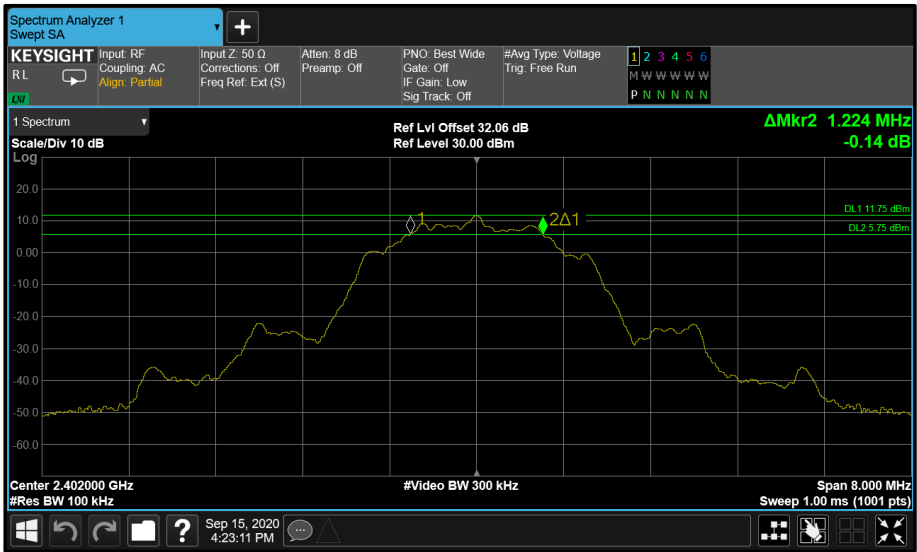


Figure 46 - Core 1 LE 2M 2402 MHz (CH0)

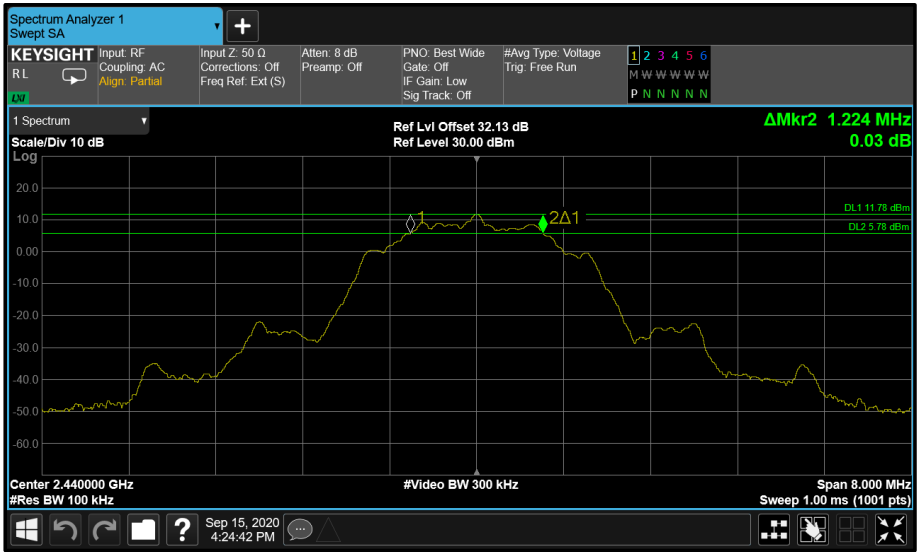


Figure 47 - Core 1 LE 2M 2440 MHz (CH19)

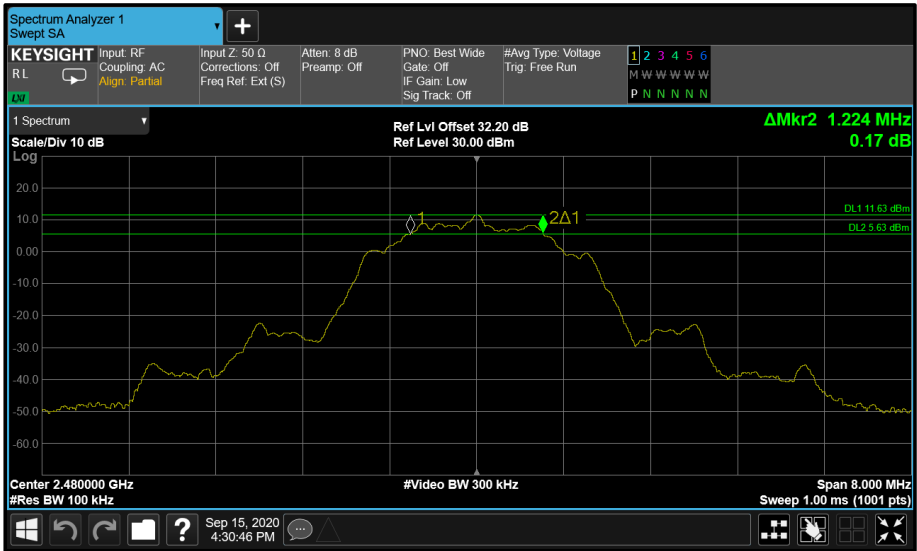


Figure 48 - Core 1 LE 2M 2480 MHz (CH39)



Antenna Port Configuration: Beamforming

Modulation: $\pi/4$ DQPSK (HDR4)

Test Frequency (MHz)	6 dB Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2404	1.752	1.560
2441	1.552	1.568
2478	1.752	1.568

Table 30 - 6 dB Bandwidth Results

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

Table 31 - 99% Bandwidth Results

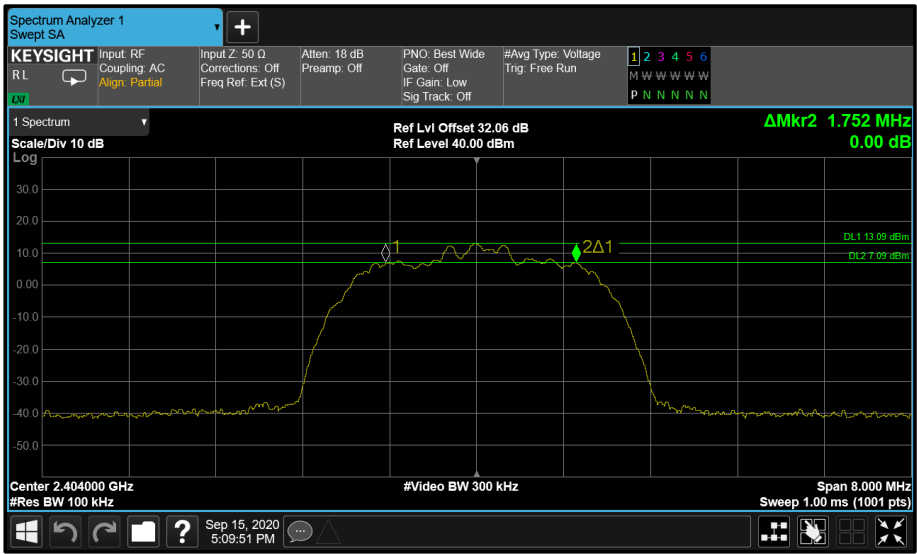


Figure 49 - Core 1 HDR4 2404 MHz (CH2)

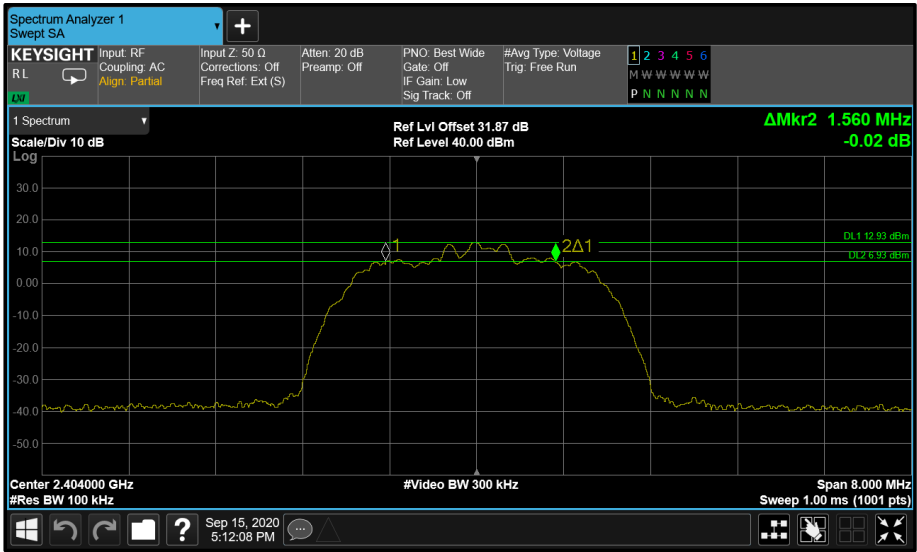


Figure 50 - Core 0 HDR4 2404 MHz (CH2)

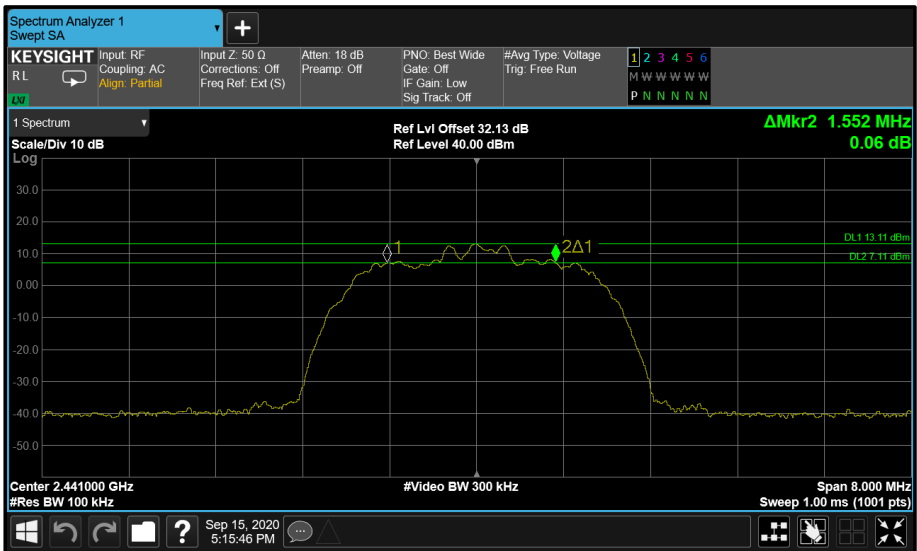


Figure 51 - Core 1 HDR4 2441 MHz (CH39)

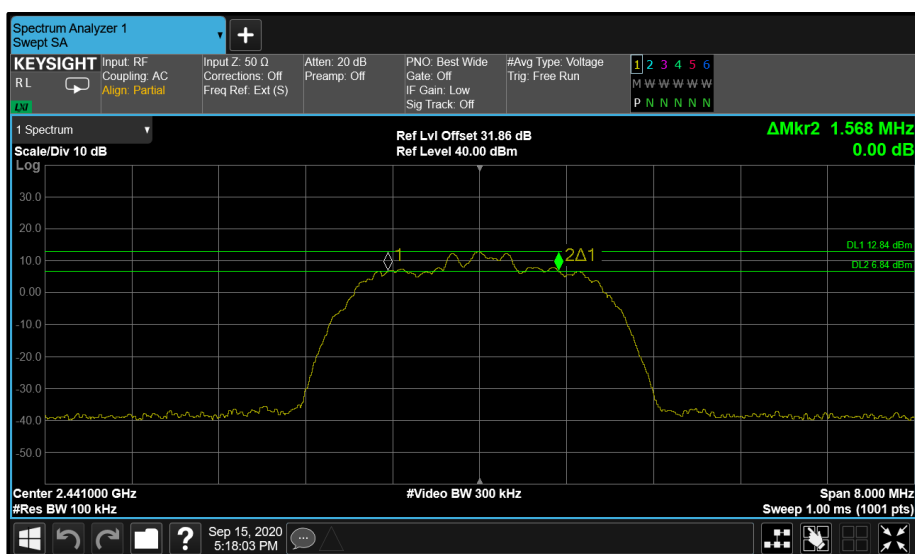


Figure 52 - Core 0 HDR4 2441 MHz (CH39)

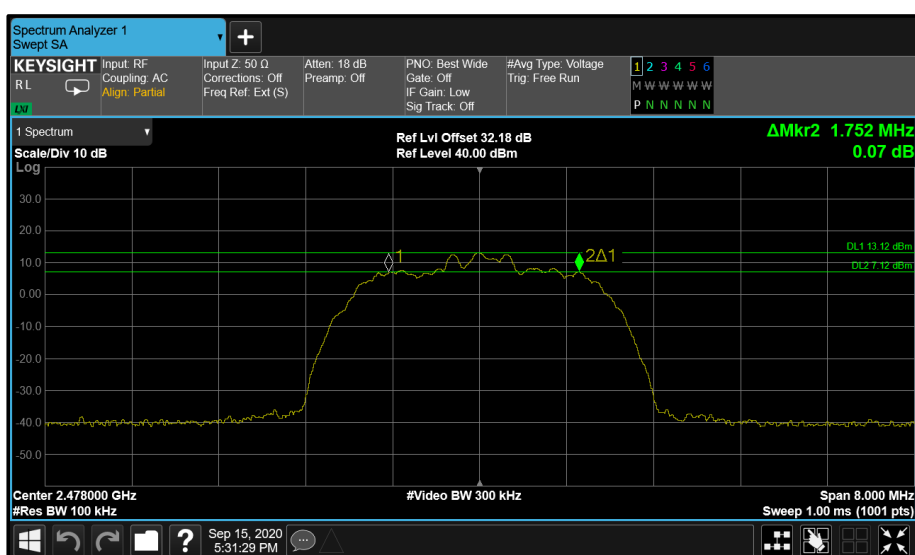


Figure 53 - Core 1 HDR4 2478 MHz (CH76)

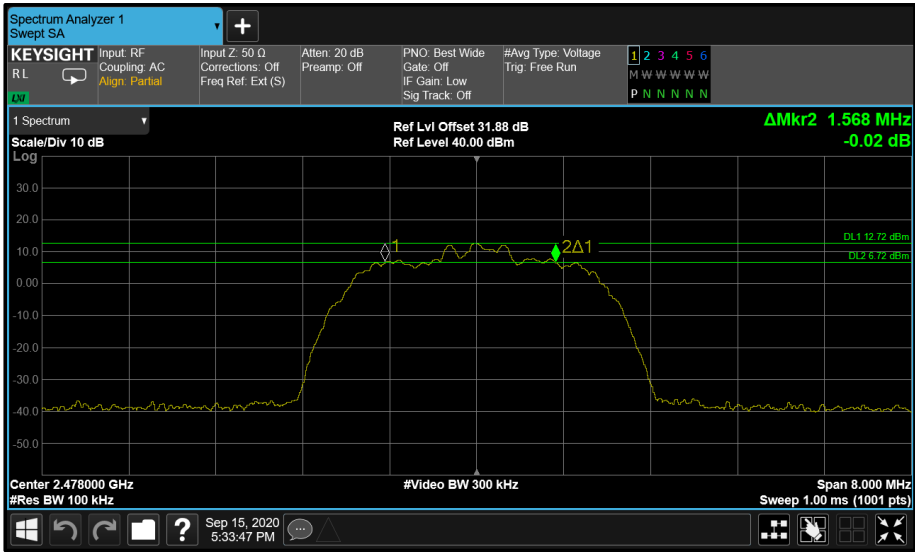


Figure 54 - Core 0 HDR4 2478 MHz (CH76)



Modulation: $\pi/4$ DQPSK (HDR8)

Test Frequency (MHz)	6 dB Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2404	1.020	1.030
2441	1.010	1.030
2478	1.010	1.020

Table 32 - 6 dB Bandwidth Results

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

Table 33 - 99% Bandwidth Results

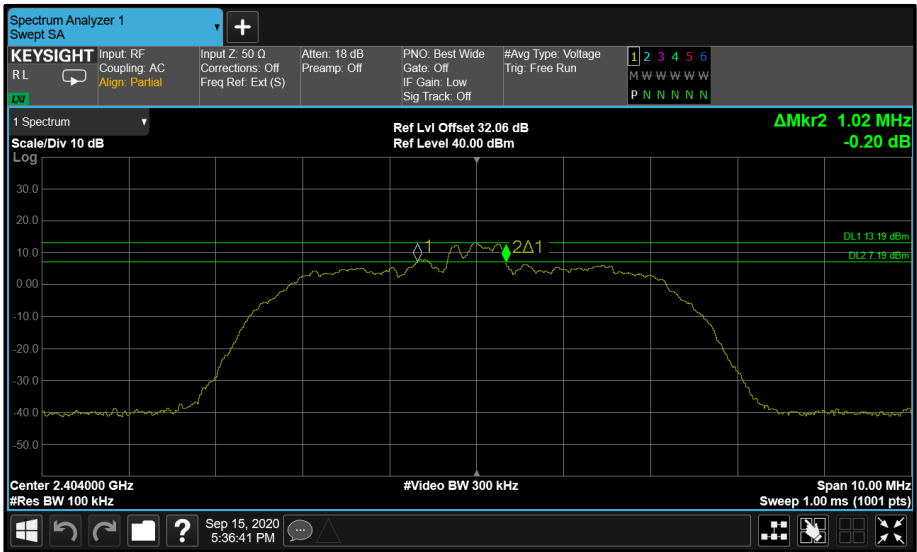
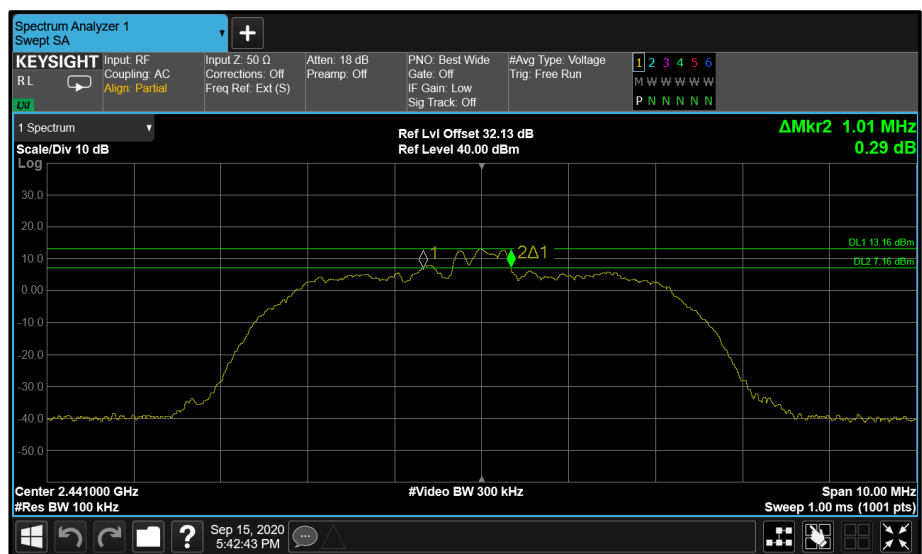
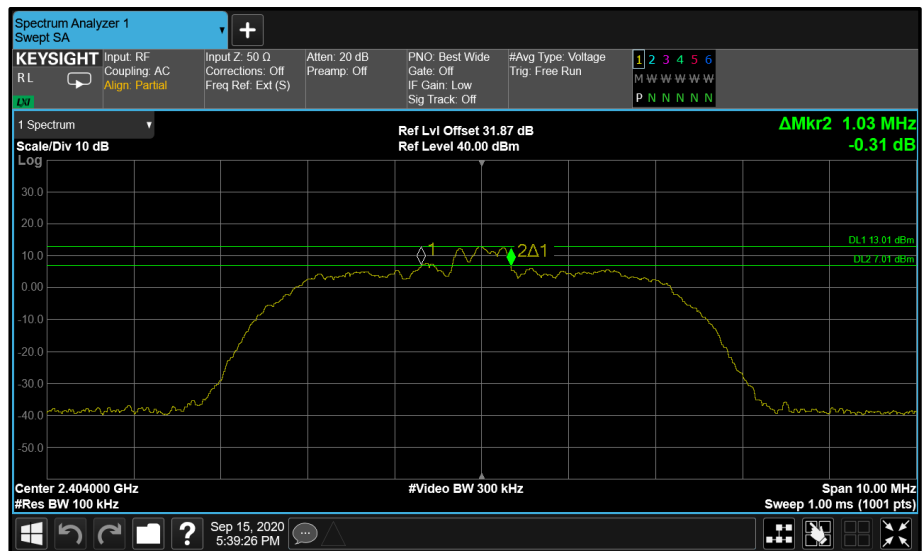


Figure 55 - Core 1 HDR8 2404 MHz (CH2)



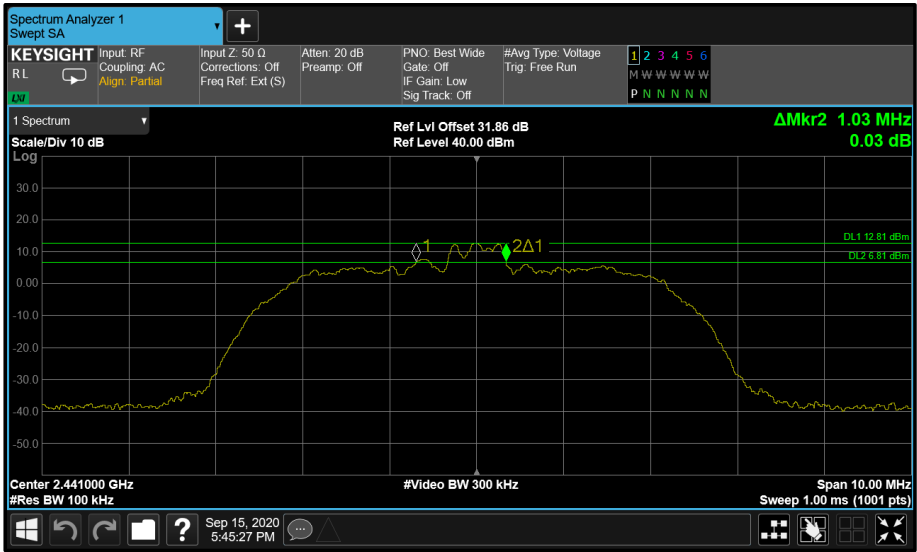


Figure 58 - Core 0 HDR8 2441 MHz (CH39)

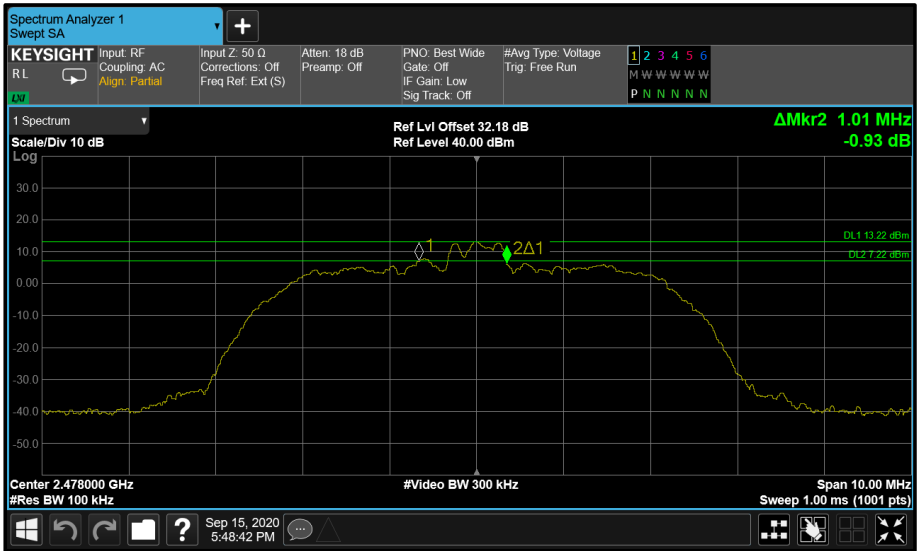


Figure 59 - Core 1 HDR8 2478 MHz (CH76)

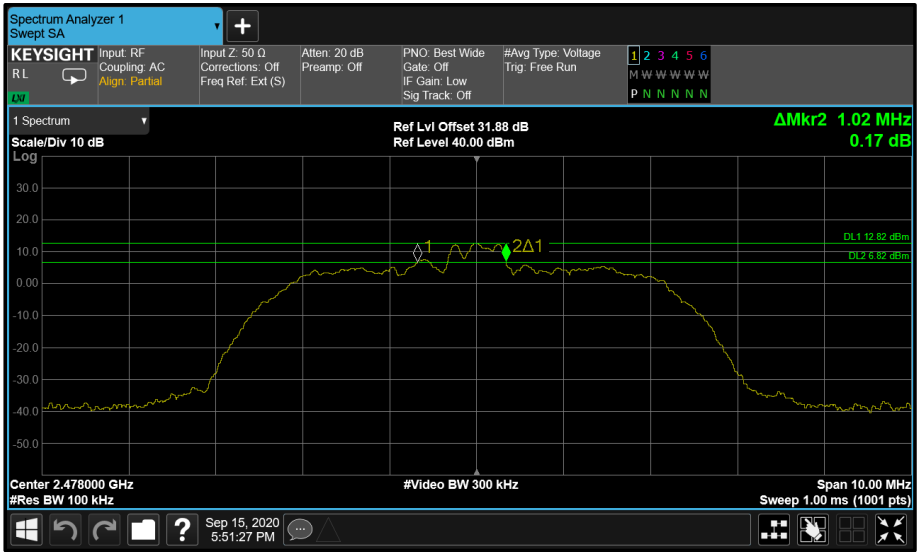


Figure 60 - Core 0 HDR8 2478 MHz (CH76)



Modulation: GFSK (LE 1M)

Test Frequency (MHz)	6 dB Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2402	0.692	0.692
2440	0.692	0.700
2480	0.692	0.708

Table 34 - 6 dB Bandwidth Results

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

Table 35 - 99% Bandwidth Results

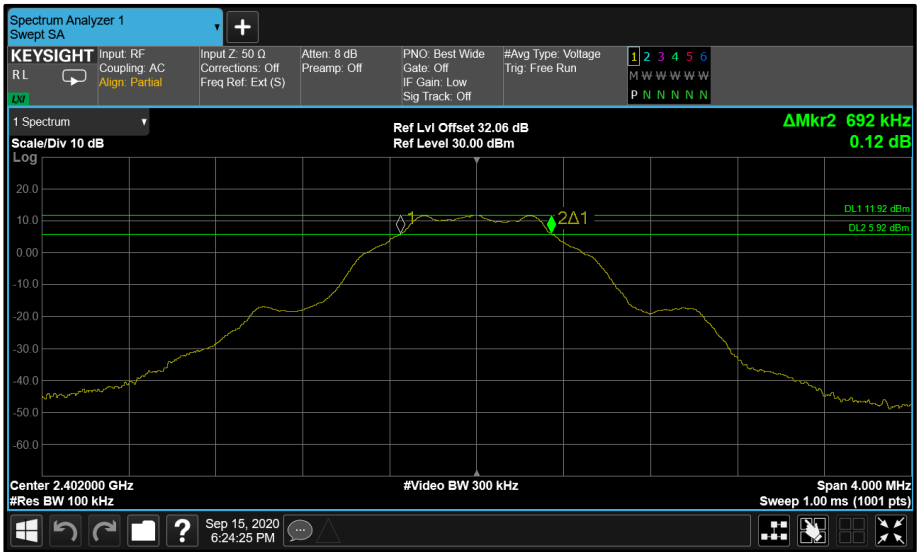
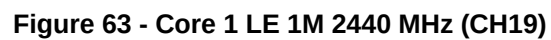


Figure 61 - Core 1 LE 1M 2402 MHz (CH0)



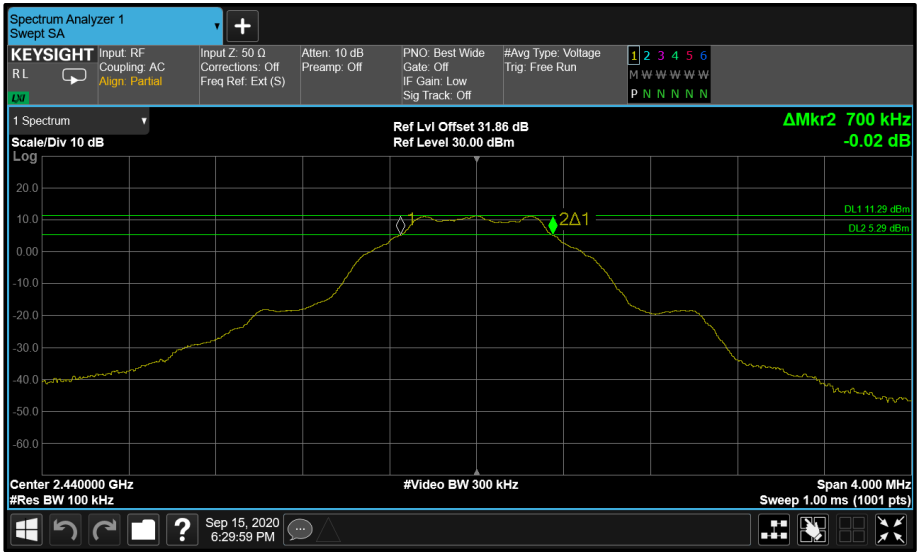


Figure 64 - Core 0 LE 1M 2440 MHz (CH19)

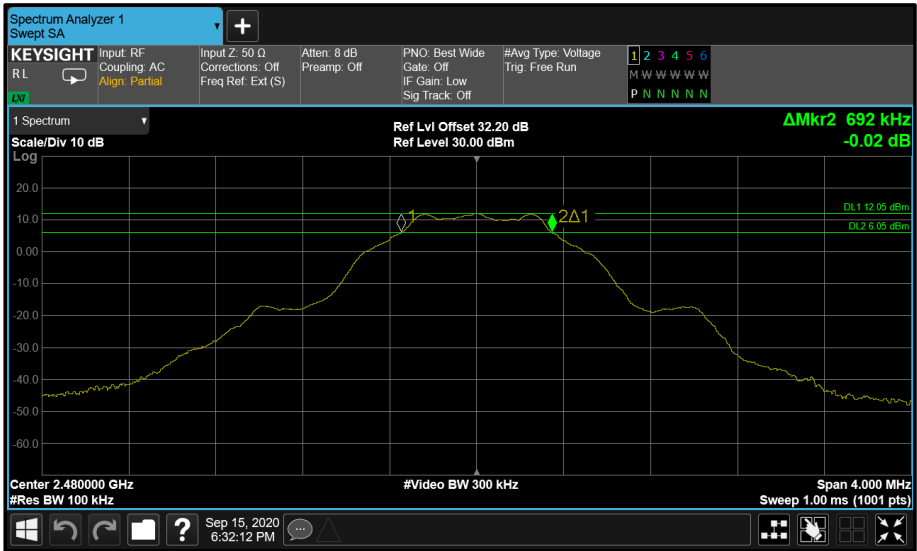


Figure 65 - Core 1 LE 1M 2480 MHz (CH39)

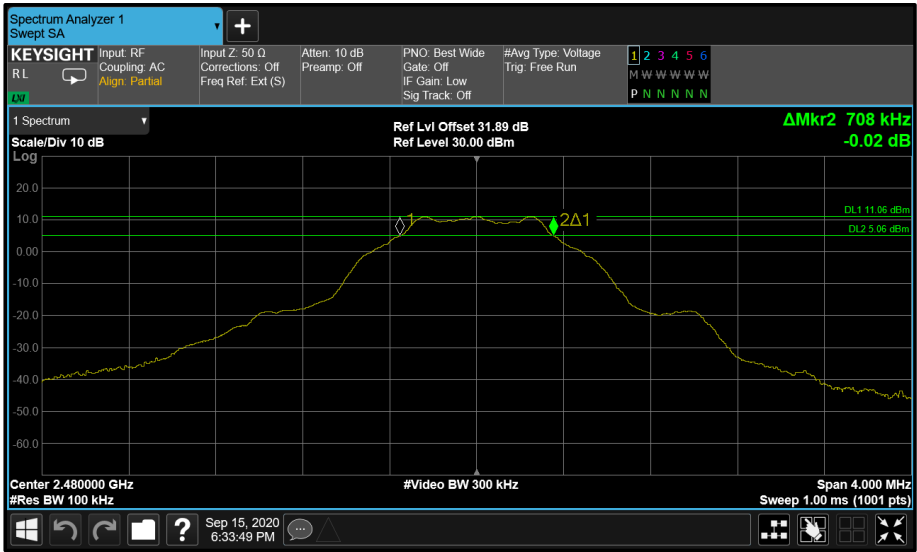


Figure 66 - Core 0 LE 1M 2480 MHz (CH39)

Test Frequency (MHz)	6 dB Bandwidth (MHz)	
	Port(s)	
	Core 1	Core 0
2402	1.224	1.224
2440	1.224	1.224
2480	1.224	1.256

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

Spectrum Analyzer 1
 Keysight R.L. Input Z: 50 Ω Coupling: AC Attenuation: 8 dB PNO: Best Wide #Avg Type: Voltage
 Align: Partial Corrections: Off Freq Ref: Ext (S) Gate: Off IF Gain: Low Trig: Free Run
 LVL M W W W W W P N N N N N

1 Spectrum
 Scale/Div 10 dB Ref Lvl Offset 32.06 dB Δ Mkr2 1.224 MHz
 Log Ref Level 30.00 dBm -0.11 dB

DL1 11.41 dBm
 DL2 5.41 dBm

Center 2.402000 GHz #Video BW 300 kHz Span 6.000 MHz
 Res BW 100 kHz Sweep 1.00 ms (1001 pts)

Page 51 of 156

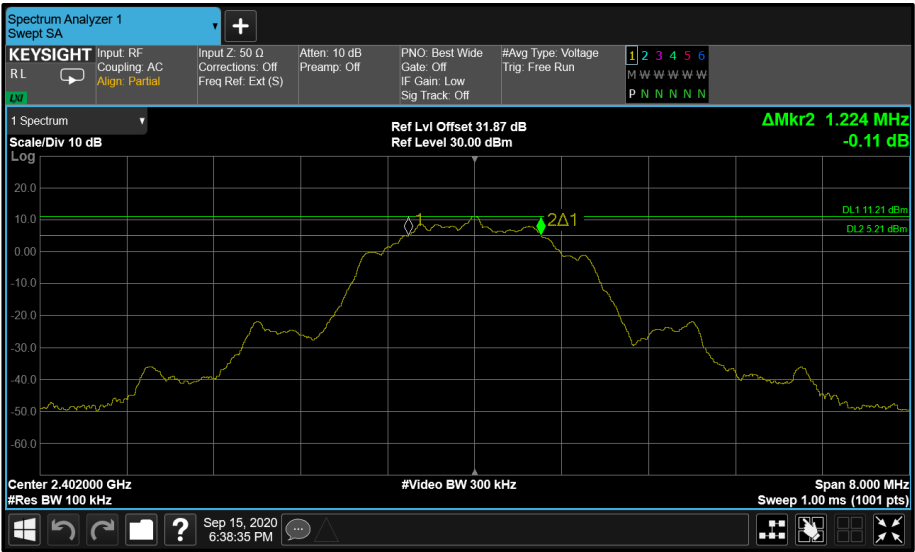


Figure 68 - Core 0 LE 2M 2402 MHz (CH0)

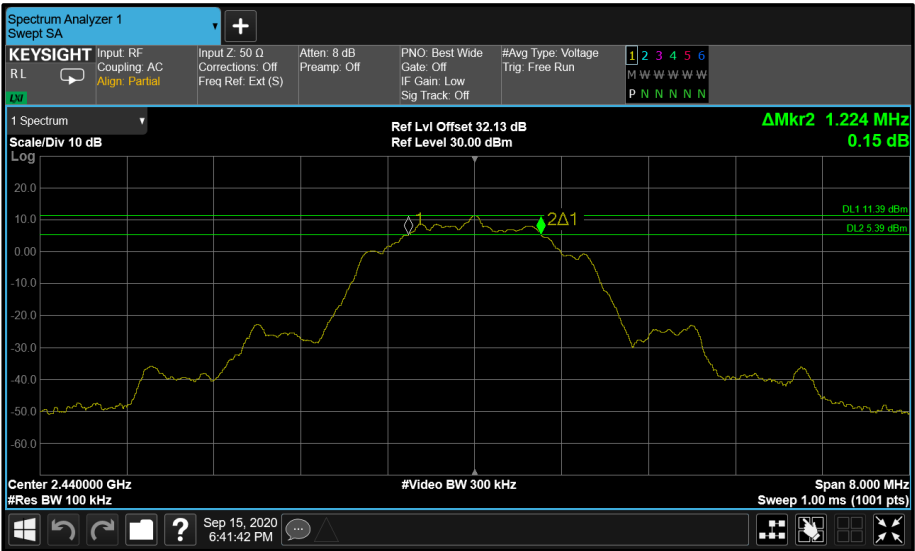


Figure 69 - Core 1 LE 2M 2440 MHz (CH19)

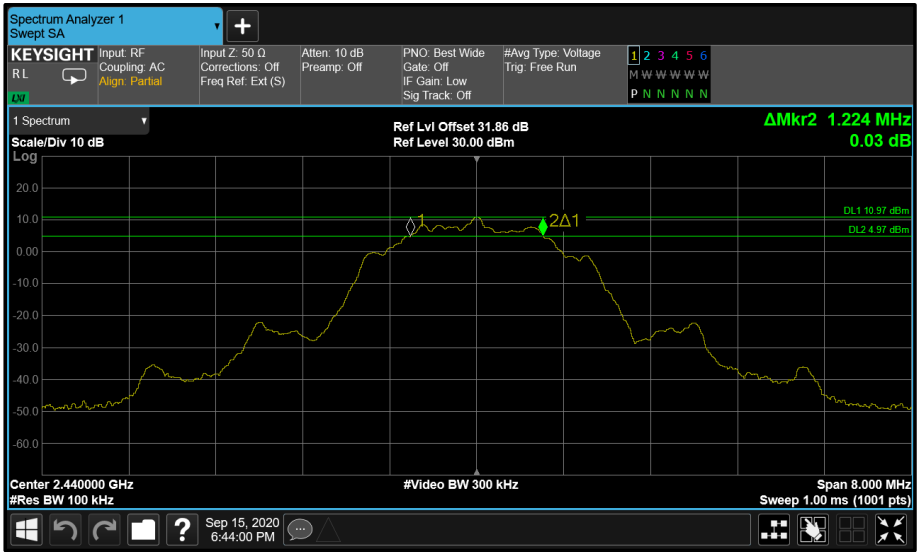


Figure 70 - Core 0 LE 2M 2440 MHz (CH19)

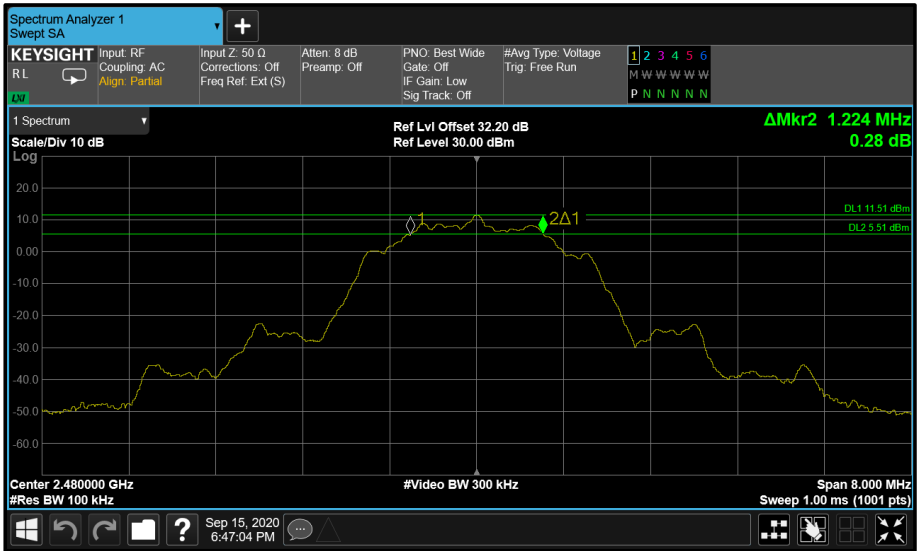


Figure 71 - Core 1 LE 2M 2480 MHz (CH39)

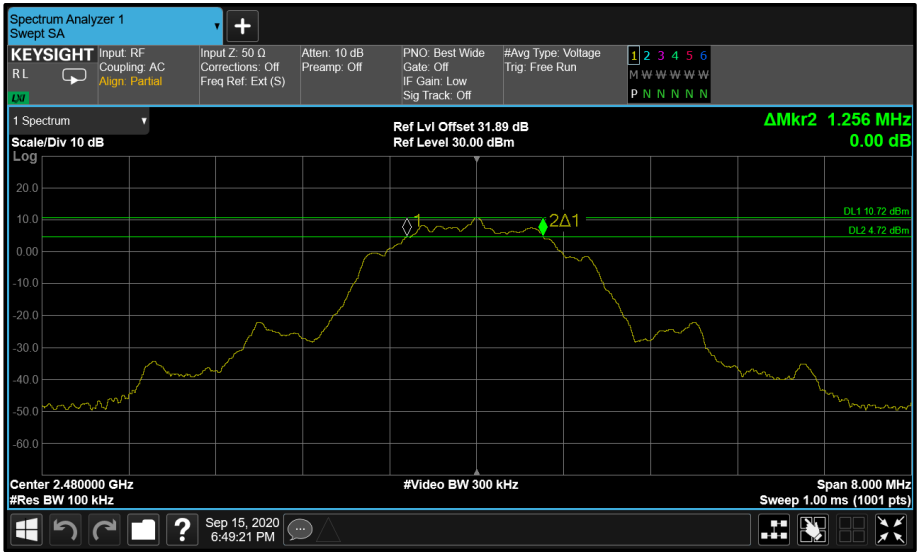


Figure 72 - Core 0 LE 2M 2480 MHz (CH39)

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

A2337, S/N: C02D1009Q9MQ - Modification State 0

2.2.3 Date of Test

15-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 (3.22 dBi and 4.03 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 spatial stream as per the first formula in KDB 662911 D01 v02r01 section e) (ii) with $N_{SS} = 1$ and $G_{ANT MAX}$ of 4.03 dBi. This resulted in a directional gain of 7.03 dBi. This results in:

- the 1 Watt (30 dBm) FCC conducted limit for a maximum of 6 dBi antenna gain being reduced by 1.03 dB to 29.0 dBm.
- the 4 Watt (36 dBm) ISED EIRP limit minus 7.03 dBi directional gain, also resulting in an equivalent conducted limit of 29.0 dBm.

2.2.5 Environmental Conditions

Ambient Temperature	22.9 - 25.2 °C
Relative Humidity	52.9 - 57.8 %



2.2.6 Test Results

2.4 GHz Bluetooth Low Energy (DTS)

iPA

Antenna Port Configuration: SISO

Modulation: $\pi/4$ DQPSK (HDR4)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)	
	Average Power	Peak Power
	Core 1	Core 1
2404	5.6	8.4
2441	5.6	8.3
2478	5.7	8.4

Table 39 - Maximum Conducted Output Power Results

Modulation: $\pi/4$ DQPSK (HDR8)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)	
	Average Power	Peak Power
	Core 1	Core 1
2404	4.7	8.1
2441	4.7	8.1
2478	4.7	8.1

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	12.5	13.2
2440	12.5	13.2
2480	12.4	13.1

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	13.3
2440	12.4	13.3
2480	12.5	13.3

Table 42 - Maximum Conducted Output Power Results



Antenna Port Configuration: Beamforming

Modulation: $\pi/4$ DQPSK (HDR4)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					
	Average Power			Peak Power		
	Core 1	Core 0	Σ	Core 1	Core 0	Σ
2404	5.7	5.8	8.8	8.5	8.5	11.5
2441	5.7	5.9	8.8	8.4	8.6	11.5
2478	5.8	5.7	8.8	8.5	8.3	11.4

Table 43 - Maximum Conducted Output Power Results

Modulation: $\pi/4$ DQPSK (HDR8)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					
	Average Power			Peak Power		
	Core 1	Core 0	Σ	Core 1	Core 0	Σ
2404	4.4	4.5	7.5	7.8	7.9	10.9
2441	4.4	4.4	7.5	7.8	7.8	10.8
2478	4.4	4.2	7.3	7.8	7.6	10.7

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	Σ	Core 1	Core 0	Σ
2402	12.3	12.1	15.2	13.0	12.7	15.9
2440	12.4	12.0	15.2	13.0	12.5	15.8
2480	12.5	11.8	15.2	13.2	12.2	15.7

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	Σ	Core 1	Core 0	Σ
2402	12.5	12.3	15.4	13.3	12.9	16.1
2440	12.5	12.1	15.3	13.3	12.6	16.0
2480	12.1	11.6	14.9	13.0	12.1	15.6

Table 46 - Maximum Conducted Output Power Results



ePA

Antenna Port Configuration: SISO

Modulation: $\pi/4$ DQPSK (HDR4)

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

Table 47 - Maximum Conducted Output Power Results

Modulation: $\pi/4$ DQPSK (HDR8)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)	
	Average Power	Peak Power
	Core 1	Core 1
2404	12.9	16.4
2441	12.9	16.4
2478	12.9	16.3

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	12.4	13.1
2440	12.4	13.1
2480	12.5	13.1

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	12.5	13.2
2440	12.5	13.3
2480	12.2	13.0

Table 50 - Maximum Conducted Output Power Results



Antenna Port Configuration: Beamforming

Modulation: $\pi/4$ DQPSK (HDR4)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					
	Average Power			Peak Power		
	Core 1	Core 0	Σ	Core 1	Core 0	Σ
2404	12.8	12.7	15.8	15.7	15.5	18.6
2441	13.0	12.8	15.9	15.8	15.6	18.7
2478	12.9	12.5	15.7	15.8	15.3	18.6

Table 51 - Maximum Conducted Output Power Results

Modulation: $\pi/4$ DQPSK (HDR8)

Test Frequency (MHz)	Maximum Conducted Output Power (dBm)					
	Average Power			Peak Power		
	Core 1	Core 0	Σ	Core 1	Core 0	Σ
2404	13.0	12.8	15.9	16.5	16.3	19.4
2441	12.9	12.7	15.8	16.4	16.1	19.3
2478	12.9	12.6	15.8	16.4	16.0	19.2

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	Σ	Core 1	Core 0	Σ
2402	12.5	12.3	15.4	13.2	12.9	16.1
2440	12.4	12.0	15.2	13.1	12.5	15.8
2480	12.5	11.8	15.2	13.2	12.2	15.7

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	Σ	Core 1	Core 0	Σ
2402	12.1	12.1	15.1	13.0	12.7	15.9
2440	12.1	11.8	15.0	13.0	12.4	15.7
2480	12.1	11.6	14.9	13.0	12.1	15.6

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 DTSSs 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

A2337, S/N: C02D200EQ9MQ - Modification State 0

2.3.3 Date of Test

03-August-2020 to 22-August-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 20.7-23.2 °C
Relative Humidity 48.1-56.8 %

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	-53.95

Table 56 - Authorised Band Edge Results

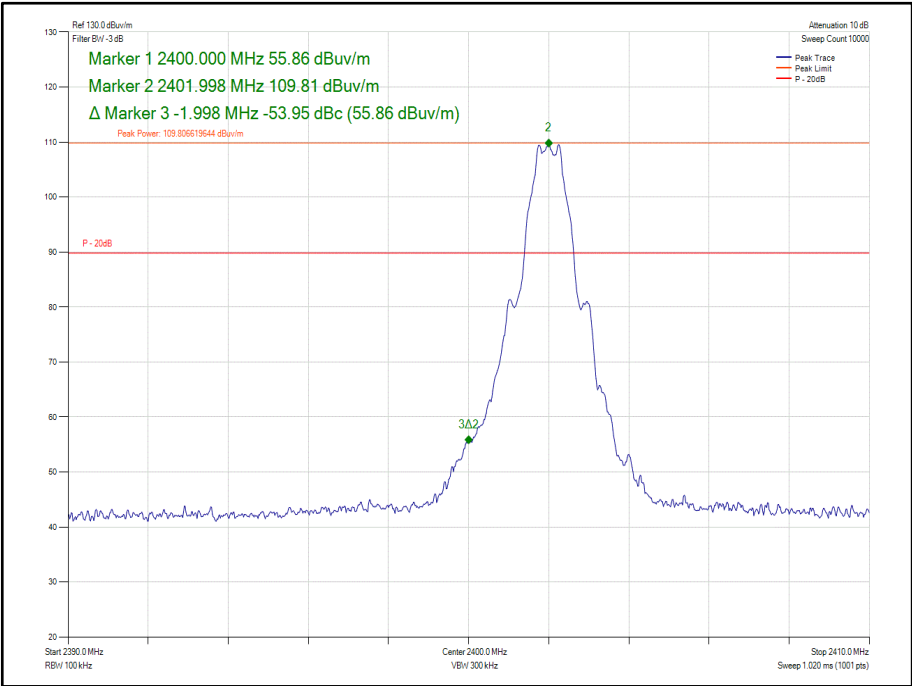


Figure 73 - Core 0 - GFSK / DH1- 2402 MHz – Band Edge Frequency 2400.0 MHz



Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	1	2402	2400.0	-57.59

Table 57 - Authorised Band Edge Results

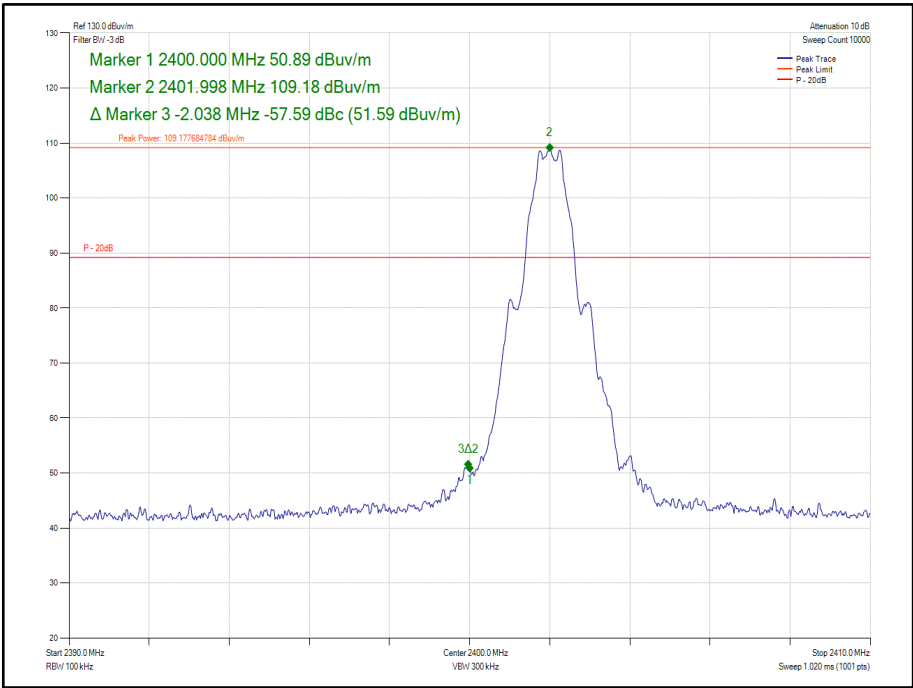


Figure 74 - Core 1 - GFSK / DH1- 2402 MHz – Band Edge Frequency 2400.0 MHz

Table 58 - Authorised Band Edge Results





LE2M

iPA

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	0	2402	2400.0	-31.16

Table 59 - Authorised Band Edge Results

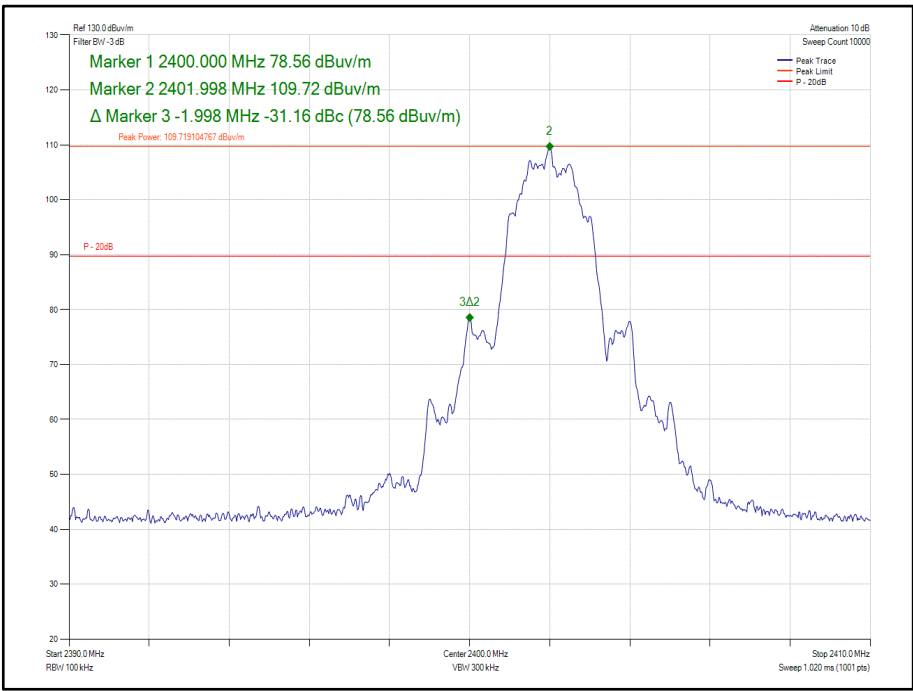


Figure 76 - Core 0 - GFSK / DH1 - 2402 MHz - Band Edge Frequency 2400.0 MHz



Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	1	2402	2400.0	-31.64

Table 60 - Authorised Band Edge Results

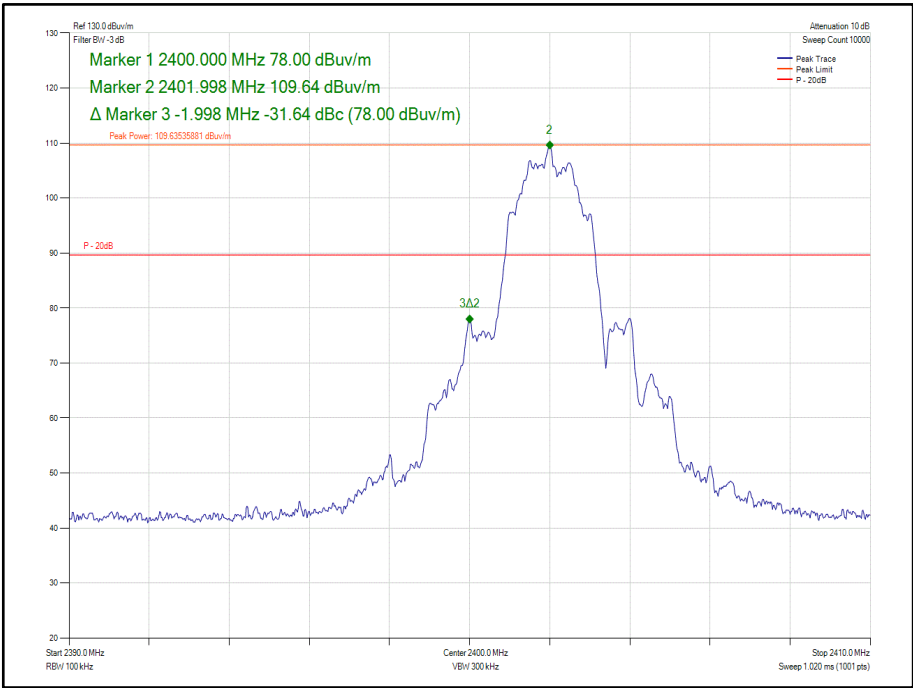


Figure 77 - Core 1 - GFSK / DH1 - 2402 MHz - Band Edge Frequency 2400.0 MHz



Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
GFSK	DH1	0-1	2402	2400.0	-31.15

Table 61 - Authorised Band Edge Results

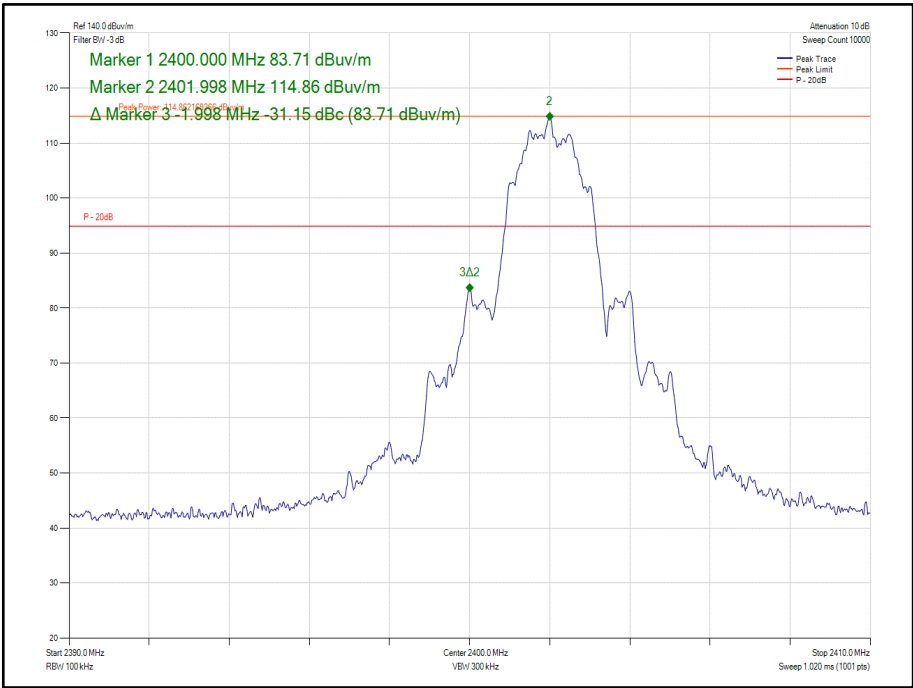


Figure 78 - Core 0-1 - GFSK / DH1 - 2402 MHz - Band Edge Frequency 2400.0 MHz



ePA

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
$\pi/4$ DQPSK	DH1	0	2402	2400.0	-31.12

Table 62 - Authorised Band Edge Results

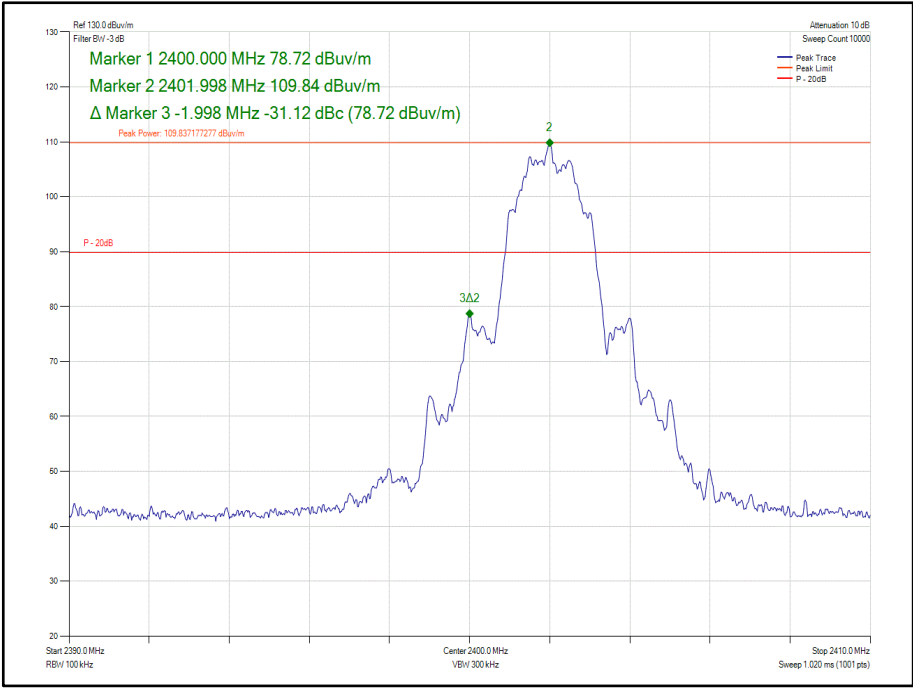


Figure 79 - Core 0 - $\pi/4$ DQPSK / DH1 - 2402 MHz - Band Edge Frequency 2400.0 MHz



Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
$\pi/4$ DQPSK	DH1	1	2402	2400.0	-31.48

Table 63 - Authorised Band Edge Results

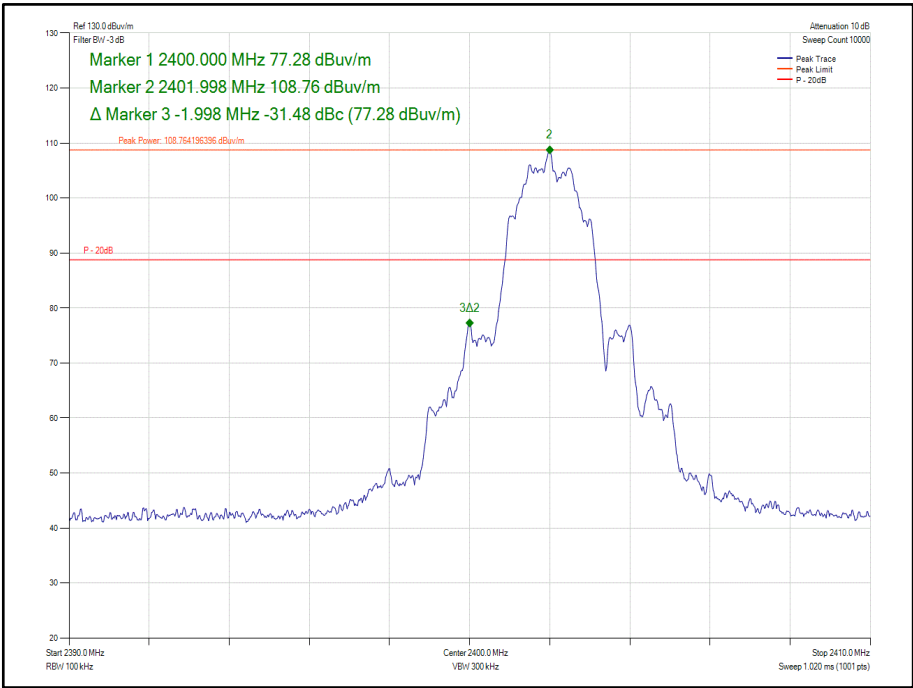


Figure 80 - Core 1 - $\pi/4$ DQPSK / DH1 - 2402 MHz - Band Edge Frequency 2400.0 MHz



Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
$\pi/4$ DQPSK	DH1	0-1	2402	2400.0	-31.38

Table 64 - Authorised Band Edge Results

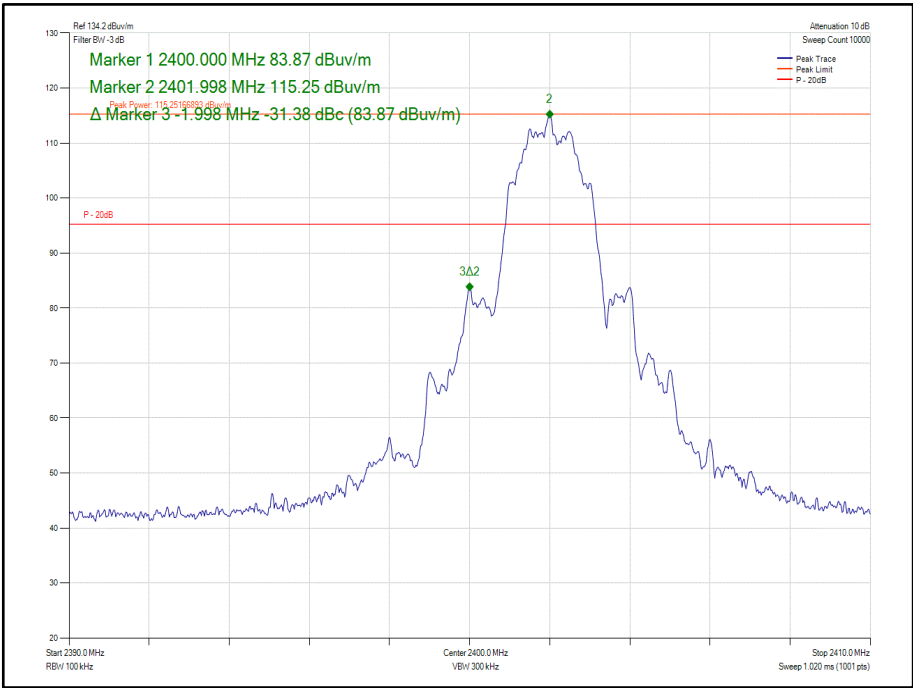


Figure 81 - Core 0-1 - $\pi/4$ DQPSK / DH1 - 2402 MHz - Band Edge Frequency 2400.0 MHz



HDR4

iPA

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
$\pi/4$ DQPSK	HDR4	0	2404	2400.0	-60.13

Table 65 - Authorised Band Edge Results

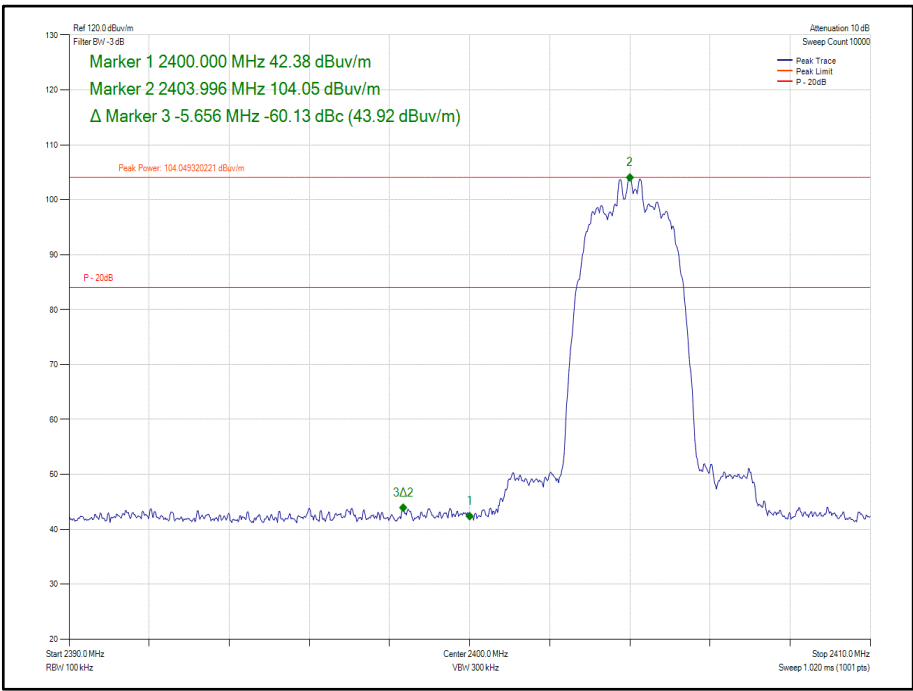


Figure 82 - Core 0 - $\pi/4$ DQPSK / HDR4- 2404 MHz – Band Edge Frequency 2400.0 MHz



Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
$\pi/4$ DQPSK	HDR4	1	2404	2400.0	-58.54

Table 66 - Authorised Band Edge Results

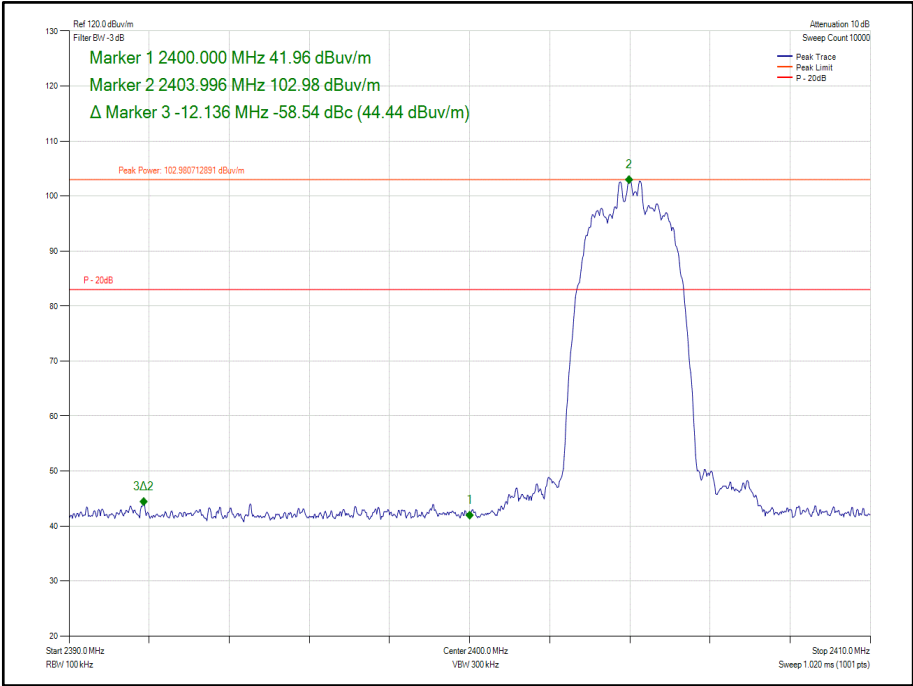


Figure 83 - Core 1 - $\pi/4$ DQPSK / HDR4- 2404 MHz – Band Edge Frequency 2400.0 MHz



Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
$\pi/4$ DQPSK	HDR4	0-1	2404	2400.0	-64.30

Table 67 - Authorised Band Edge Results

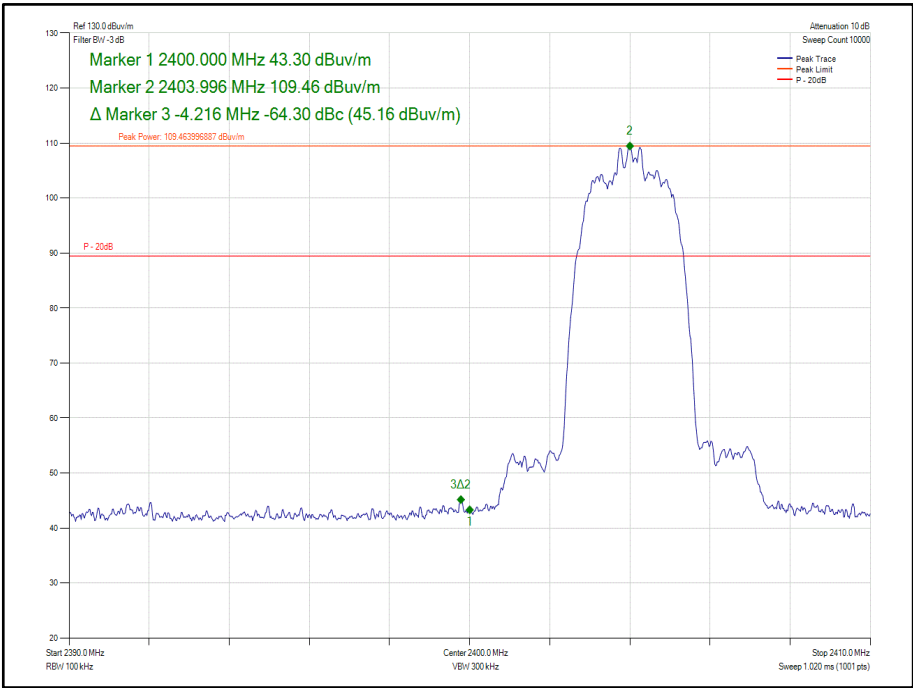


Figure 84 - Core 0-1 - $\pi/4$ DQPSK / HDR4- 2404 MHz – Band Edge Frequency 2400.0 MHz



ePA

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
$\pi/4$ DQPSK	HDR4	0	2404	2400.0	-63.61

Table 68 - Authorised Band Edge Results

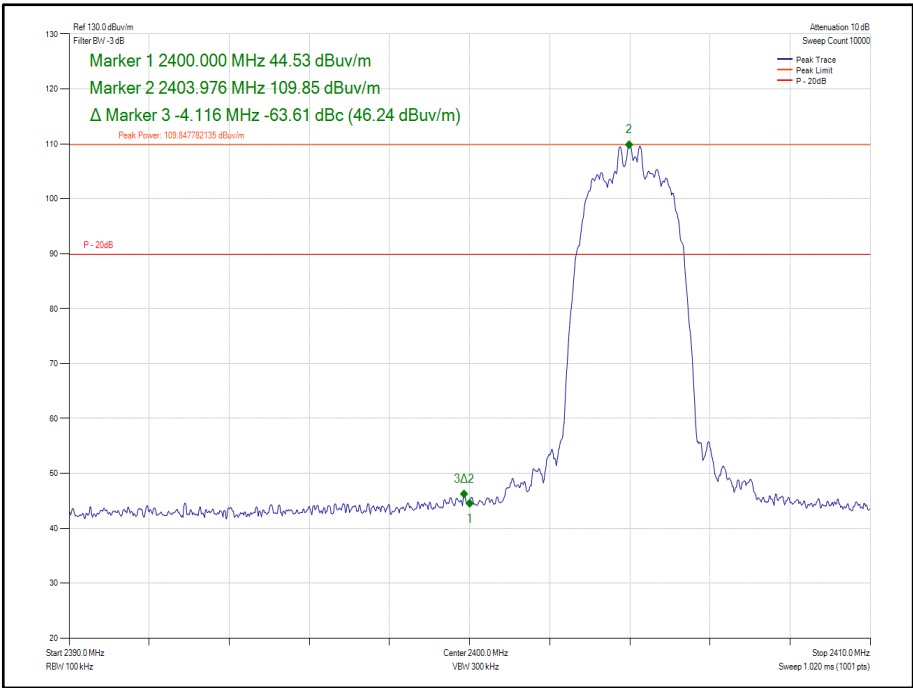


Figure 85 Core 0 - $\pi/4$ DQPSK / HDR4- 2404 MHz – Band Edge Frequency 2400.0 MHz



Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
$\pi/4$ DQPSK	HDR4	1	2404	2400.0	-64.94

Table 69 - Authorised Band Edge Results

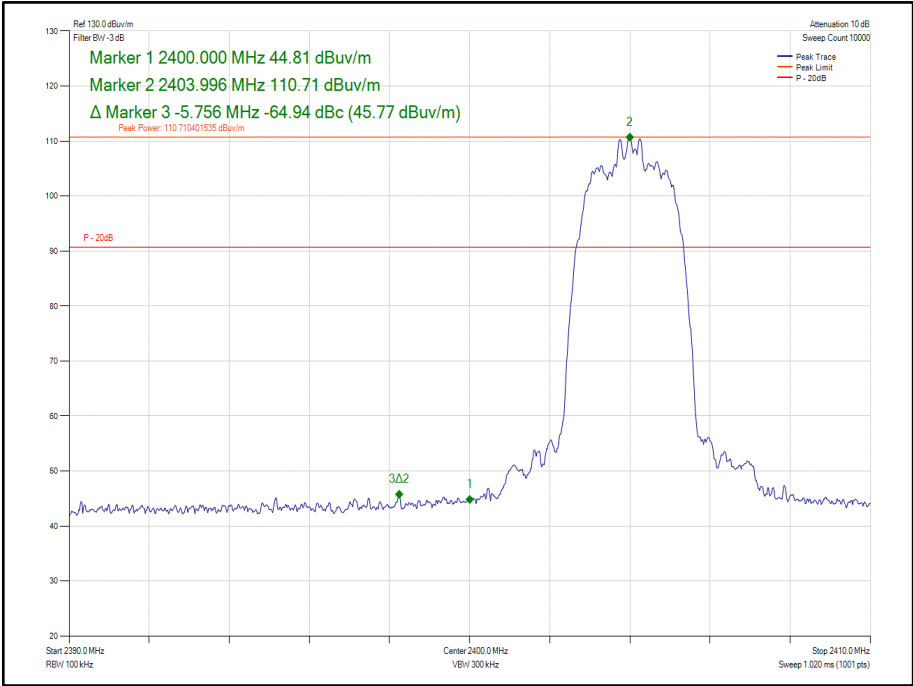


Figure 86 - Core 1 - $\pi/4$ DQPSK / HDR4- 2404 MHz – Band Edge Frequency 2400.0 MHz



Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
$\pi/4$ DQPSK	HDR4	0-1	2404	2400.0	-69.28

Table 70 - Authorised Band Edge Results

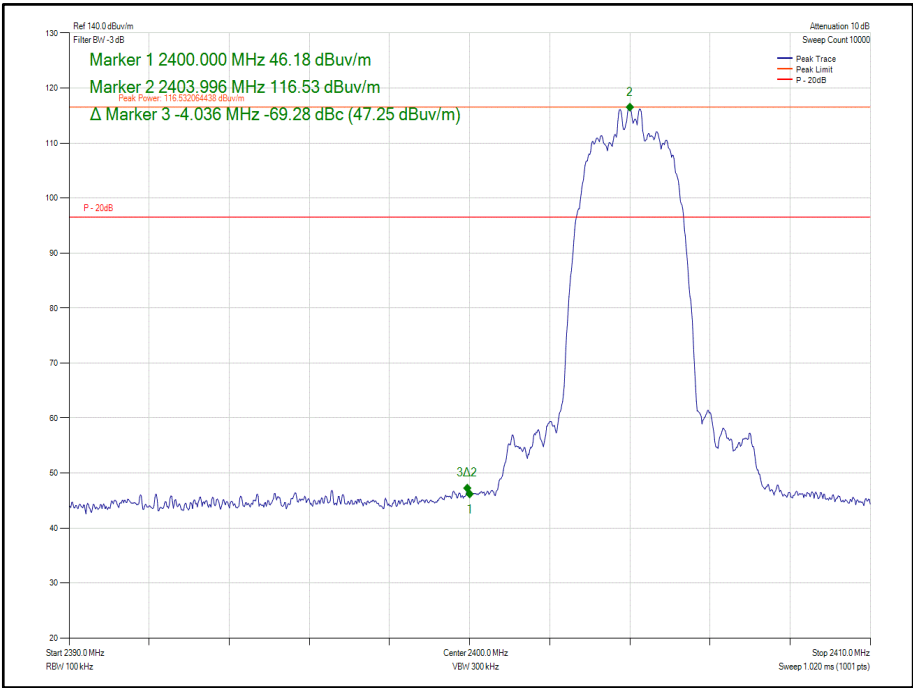


Figure 87 Core 0-1 - $\pi/4$ DQPSK / HDR4- 2404 MHz – Band Edge Frequency 2400.0 MHz



HDR8

iPA

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
$\pi/4$ DQPSK	HDR8	0	2404	2400.0	-55.55

Table 71 - Authorised Band Edge Results

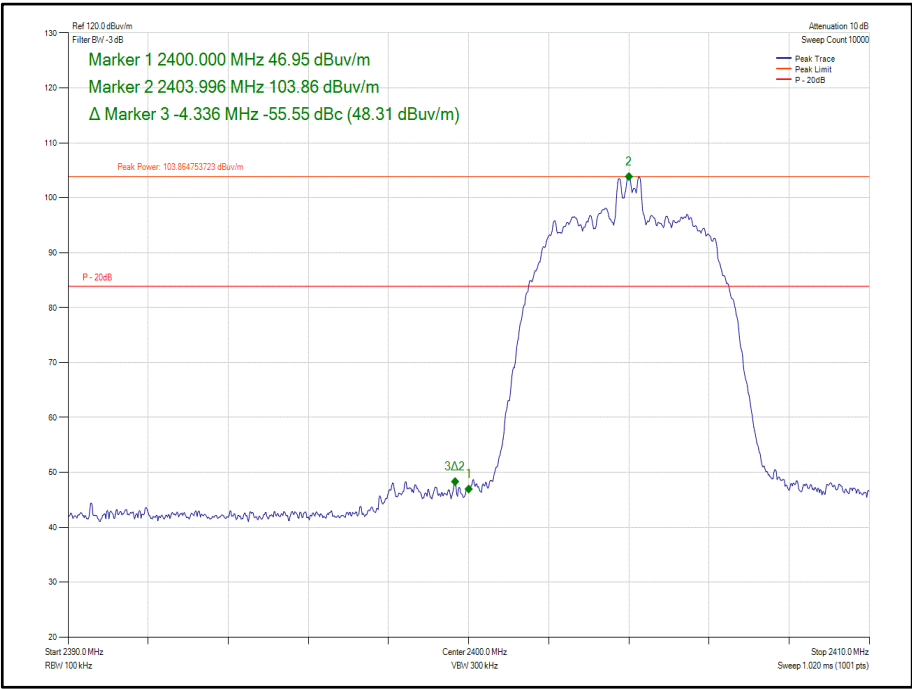


Figure 88 - Core 0 - $\pi/4$ DQPSK / HDR8 - 2404 MHz - Band Edge Frequency 2400.0 MHz



Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
$\pi/4$ DQPSK	HDR8	1	2404	2400.0	-57.79

Table 72 - Authorised Band Edge Results

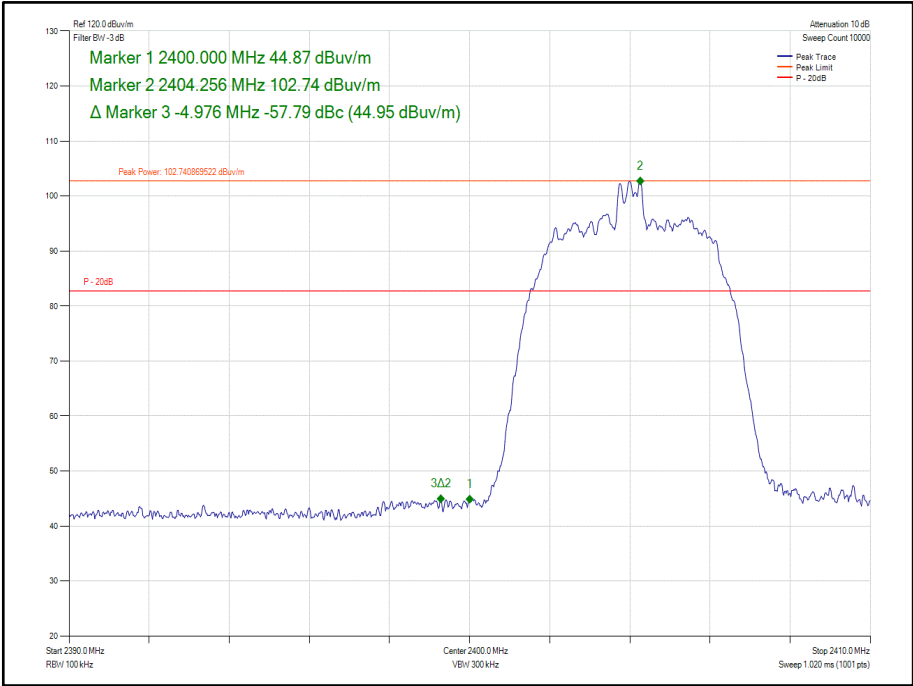


Figure 89 - Core 1 - $\pi/4$ DQPSK / HDR8 - 2404 MHz - Band Edge Frequency 2400.0 MHz



Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
$\pi/4$ DQPSK	HDR8	0-1	2404	2400.0	-58.71

Table 73 - Authorised Band Edge Results

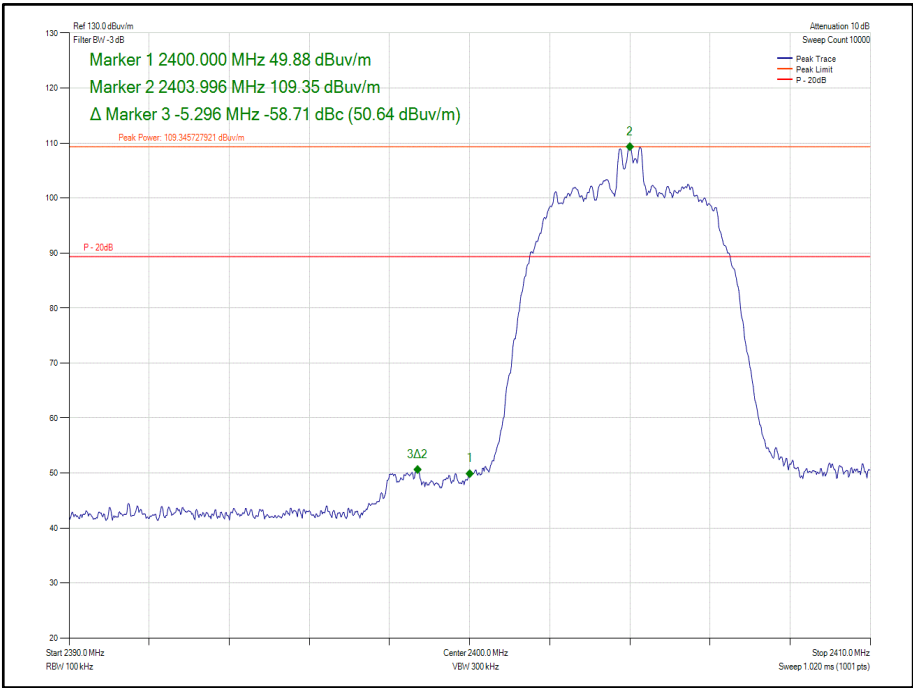


Figure 90 Core 0-1 - $\pi/4$ DQPSK / HDR8 - 2404 MHz - Band Edge Frequency 2400.0 MHz



ePA

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
$\pi/4$ DQPSK	HDR8	0	2404	2400.0	-63.24

Table 74 - Authorised Band Edge Results

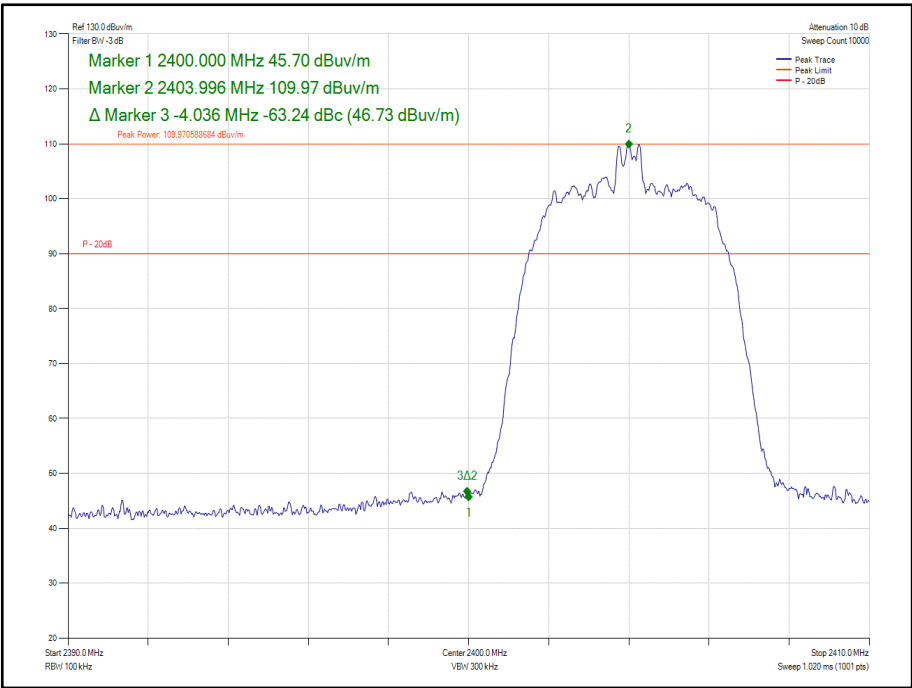


Figure 91 - Core 0 - $\pi/4$ DQPSK / HDR8 - 2404 MHz - Band Edge Frequency 2400.0 MHz



Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
$\pi/4$ DQPSK	HDR8	1	2404	2400.0	-60.36

Table 75 - Authorised Band Edge Results

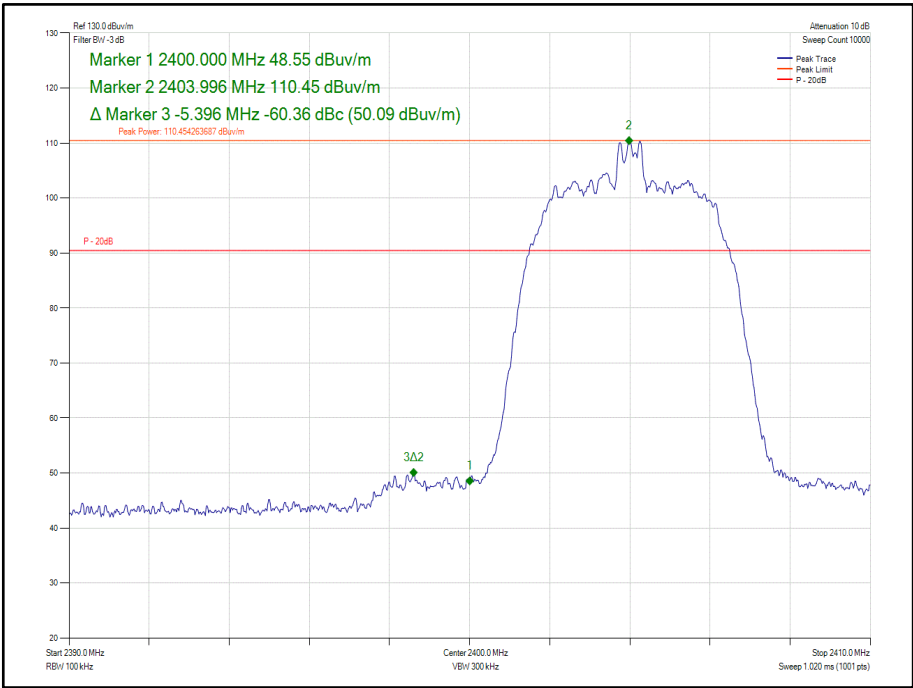


Figure 92 Core 1 - $\pi/4$ DQPSK HDR8 - 2404 MHz - Band Edge Frequency 2400.0 MHz

Modulation	Packet Type	Core	Tx Frequency (MHz)	Band Edge Frequency (MHz)	Level (dBc)
$\pi/4$ DQPSK	HDR8	0-1	2404	2400.0	-63.22

Table 76 - Authorised Band Edge Results

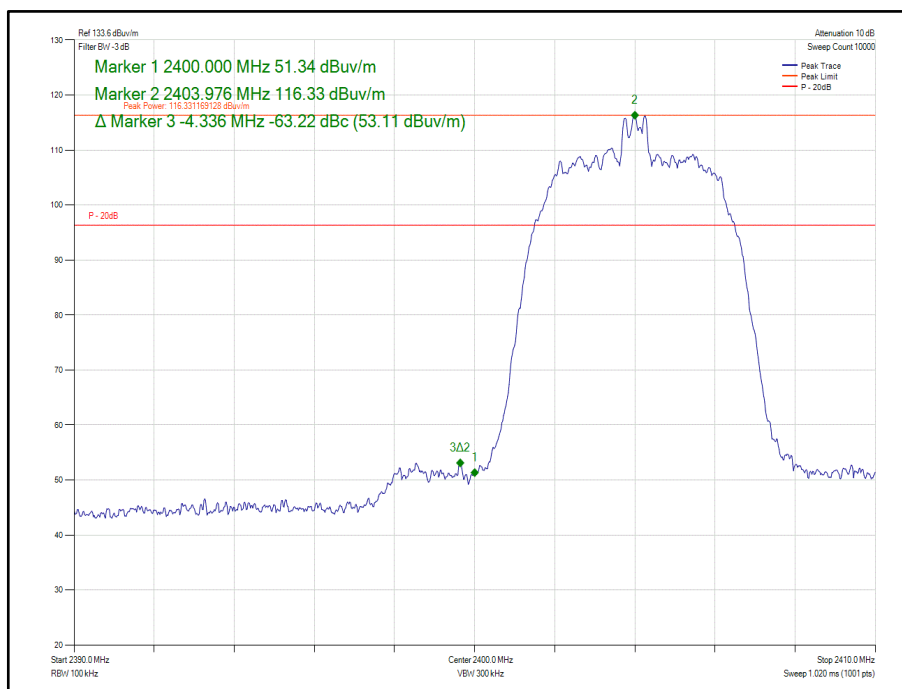


Figure 93 - Core 0-1 - $\pi/4$ DQPSK / HDR8 - 2404 MHz - Band Edge Frequency 2400.0 MHz

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.