

# FCC and ISED Test Report

Apple Inc  
Model: A2941

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

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



Add value.  
Inspire trust.

FCC ID: BCGA2941

IC: 579C-A2941

## COMMERCIAL-IN-CONFIDENCE

Document 75957632-09 Issue 01

### SIGNATURE

| NAME           | JOB TITLE       | RESPONSIBLE FOR      | ISSUE DATE    |
|----------------|-----------------|----------------------|---------------|
| Steve Marshall | Senior Engineer | Authorised Signatory | 28 March 2023 |

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 |
|-------------------|-----------------|---------------|-----------|
| Report Generation | Hollie Marshall | 28 March 2023 |           |

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



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## 1 Report Summary

### 1.1 Report Modification Record

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

| Issue | Description of Change | Date of Issue |
|-------|-----------------------|---------------|
| 1     | First Issue           | 28-March-2023 |

**Table 1**

### 1.2 Introduction

|                               |                                                                                                                |
|-------------------------------|----------------------------------------------------------------------------------------------------------------|
| Applicant                     | Apple Inc                                                                                                      |
| Manufacturer                  | Apple Inc                                                                                                      |
| Model Number(s)               | A2941                                                                                                          |
| Serial Number(s)              | F91VYD72Q5, HGQQL724XY and GF6K93M959                                                                          |
| Hardware Version(s)           | REV1.0                                                                                                         |
| Software Version(s)           | 22E11180t, 22E11180t and 22E11181e                                                                             |
| Number of Samples Tested      | 3                                                                                                              |
| Test Specification/Issue/Date | FCC 47 CFR Part 15C: 2021<br>ISED RSS-247: Issue 2 (02-2017)<br>ISED RSS-GEN: Issue 5 (04-2018) + A2 (02-2021) |
| Start of Test                 | 16-January-2023                                                                                                |
| Finish of Test                | 09-March-2023                                                                                                  |
| Name of Engineer(s)           | James Woods, Taha Shafique, Elliot Callender, Thomas Biddlecombe and Mohammad Malik                            |
| Related Document(s)           | ANSI C63.10 (2020)<br>ANSI C63.10 (2013)<br>KDB 662911 D01 v02r01<br>ANSI C63.4 (2014)                         |



### 1.3 Brief Summary of Results

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

| Section                                        | Specification Clause  |             |              | Test Description                                       | Result | Comments/Base Standard                                                                                      |
|------------------------------------------------|-----------------------|-------------|--------------|--------------------------------------------------------|--------|-------------------------------------------------------------------------------------------------------------|
|                                                | Part 15C              | RSS-247     | RSS-GEN      |                                                        |        |                                                                                                             |
| Configuration and Mode: 2.4 GHz Bluetooth FHSS |                       |             |              |                                                        |        |                                                                                                             |
| -                                              | 15.203                | -           | -            | Antenna Requirement                                    | N/T    | The device complies with the provisions of this section, as it uses permanently attached integral antennas. |
| 2.1                                            | 15.205                | 3.3         | 8.10         | Restricted Band Edges                                  | Pass   |                                                                                                             |
| 2.2                                            | 15.247 (a)(1)         | 5.1         | -            | Frequency Hopping Systems - Average Time of Occupancy  | Pass   |                                                                                                             |
| 2.3                                            | 15.247 (a)(1)         | 5.1         | -            | Frequency Hopping Systems - Channel Separation         | Pass   |                                                                                                             |
| 2.4                                            | 15.247 (a)(1)         | 5.1         | -            | Frequency Hopping Systems - Number of Hopping Channels | Pass   |                                                                                                             |
| 2.5                                            | 15.247 (a)(1)         | 5.1         | 6.7          | Frequency Hopping Systems - 20 dB Bandwidth            | Pass   |                                                                                                             |
| 2.6                                            | 15.247 (b)            | 5.4         | 6.12         | Maximum Conducted Output Power                         | Pass   |                                                                                                             |
| 2.7                                            | 15.247 (d)            | 5.5         | -            | Authorised Band Edges                                  | Pass   |                                                                                                             |
| 2.8                                            | 15.209 and 15.247 (d) | 3.3 and 5.5 | 6.13 and 8.9 | Spurious Radiated Emissions                            | Pass   |                                                                                                             |

**Table 2**



## 1.4 Product Information

### 1.4.1 Technical Description

The equipment under test (EUT) was an Apple laptop computer with Bluetooth®, Bluetooth® Low Energy and IEEE 802.11 a/b/g/n/ac/ax Wi-Fi capabilities in the 2.4 GHz and 5 GHz bands.

### 1.4.2 Test Setup

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

During Spurious Radiated Emissions on Bluetooth, the worst-case modes from BDR/EDR/HDR & LE were selected for testing based on output power, channel bandwidth and spectral density. With BDR/EDR & LE1M deemed to be worst case. The spurious Radiated Emissions results for Bluetooth modes are documented across the following two reports.

- BDR/EDR: Document 75957632-09
- LE1M: Document 75957632-10

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.

The EUT supports Bluetooth ePA and iPA. Both modes were tested.

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

BT Core 0 (SISO) – iPA BDR/EDR and ePA EDR  
BT Core 1 (SISO) – iPA BDR/EDR and ePA EDR  
BT Core 0 + BT Core 1 (TxBF) – iPA BDR/EDR and ePA EDR

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

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

### 1.4.3 Antenna Gain Table

| Antenna Port | Frequency Range (MHz) | Peak Gain (dBi) | Conducted Cable Loss (dB) |
|--------------|-----------------------|-----------------|---------------------------|
| BT Core 0    | 2400 to 2480          | 4.85            | 0.8                       |
| BT Core 1    | 2400 to 2480          | 4.50            | 0.8                       |

**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: A2941, Serial Number: GF6K93M959 |                                                 |                        |                          |
| 0                                       | As supplied by the customer                     | Not Applicable         | Not Applicable           |
| Model: A2941, Serial Number: F91VYD72Q5 |                                                 |                        |                          |
| 0                                       | As supplied by the customer                     | Not Applicable         | Not Applicable           |
| Model: A2941, Serial Number: HGQQL724XY |                                                 |                        |                          |
| 0                                       | As supplied by the customer                     | Not Applicable         | Not Applicable           |

**Table 4**

## 1.7 Test Location

TÜV SÜD conducted the following tests at our Concorde Park Test Laboratory.

| Test Name                                              | Name of Engineer(s)                             | Accreditation |
|--------------------------------------------------------|-------------------------------------------------|---------------|
| Configuration and Mode: 2.4 GHz Bluetooth FHSS         |                                                 |               |
| Restricted Band Edges                                  | James Woods, Taha Shafique and Elliot Callender | UKAS          |
| Frequency Hopping Systems - Average Time of Occupancy  | Thomas Biddlecombe                              | UKAS          |
| Frequency Hopping Systems - Channel Separation         | Thomas Biddlecombe                              | UKAS          |
| Frequency Hopping Systems - Number of Hopping Channels | Thomas Biddlecombe                              | UKAS          |
| Frequency Hopping Systems - 20 dB Bandwidth            | Thomas Biddlecombe                              | UKAS          |
| Maximum Conducted Output Power                         | Thomas Biddlecombe                              | UKAS          |
| Authorised Band Edges                                  | James Woods, Taha Shafique and Elliot Callender | UKAS          |
| Spurious Radiated Emissions                            | Mohammad Malik and Elliot Callender             | UKAS          |

**Table 5**

Office Address:

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Concorde Way  
Fareham  
Hampshire  
PO15 5FG  
United Kingdom



## 2 Test Details

### 2.1 Restricted Band Edges

#### 2.1.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.205  
ISED RSS-247, Clause 3.3  
ISED RSS-GEN, Clause 8.10

#### 2.1.2 Equipment Under Test and Modification State

A2941, S/N: F91VYD72Q5 - Modification State 0

#### 2.1.3 Date of Test

16-January-2023 to 17-January-2023

#### 2.1.4 Test Method

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

Plots for average measurements were taken in accordance with ANSI C63.10, clause 4.1.5.2.6. These are shown for information purposes and were used to determine the worst-case measurement point. Final average measurements were then taken in accordance with ANSI C63.10, clause 4.1.4.2.2 to obtain the measurement result recorded in the test results tables.

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

#### 2.1.5 Environmental Conditions

|                     |                |
|---------------------|----------------|
| Ambient Temperature | 21.0 - 23.8 °C |
| Relative Humidity   | 41.4 - 43.0 %  |

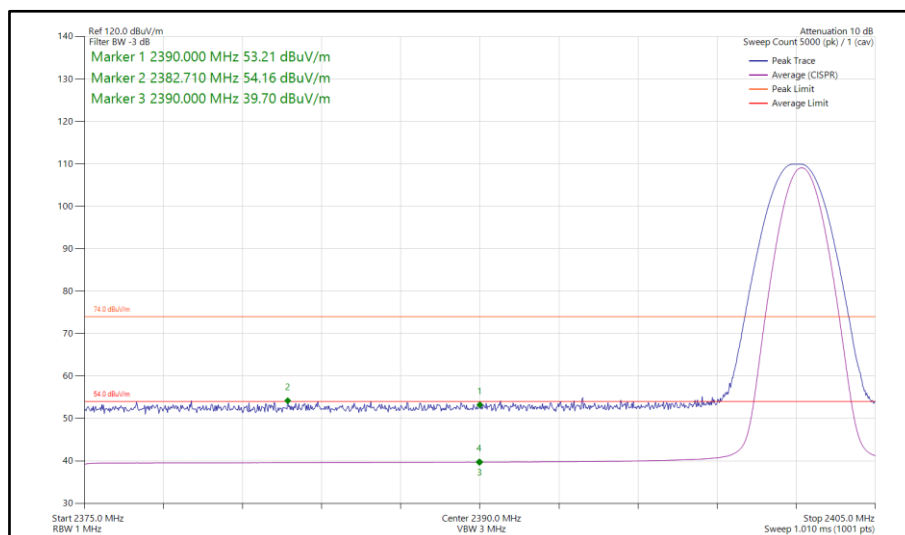
## 2.1.6 Test Results

### 2.4 GHz Bluetooth FHSS

#### iPA - Core 0 (SISO)

| Mode   | Packet Type | TX Frequency (MHz) | Band Edge Frequency (MHz) | Peak Level (dBμV/m) | Average Level (dBμV/m) |
|--------|-------------|--------------------|---------------------------|---------------------|------------------------|
| Static | DH5         | 2402               | 2390                      | 54.16               | 39.70                  |
| Static | 2-DH5       | 2402               | 2390                      | 54.23               | 39.71                  |
| Static | 3-DH5       | 2402               | 2390                      | 54.44               | 39.68                  |
| Static | DH5         | 2480               | 2483.5                    | 56.08               | 47.28                  |
| Static | 2-DH5       | 2480               | 2483.5                    | 54.77               | 43.27                  |
| Static | 3-DH5       | 2480               | 2483.5                    | 54.52               | 43.34                  |

**Table 6 - SISO Restricted Band Edge Results**



**Figure 1 - Bluetooth DH5, SISO, Core 0 - 2402 MHz,  
Band Edge Frequency 2390 MHz**



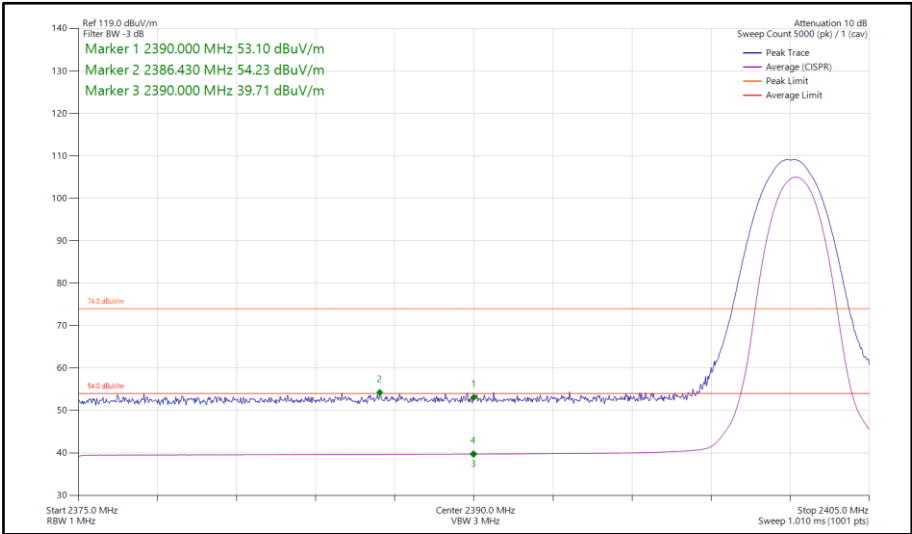


Figure 2 - Bluetooth 2-DH5, SISO, Core 0 - 2402 MHz,  
Band Edge Frequency 2390 MHz

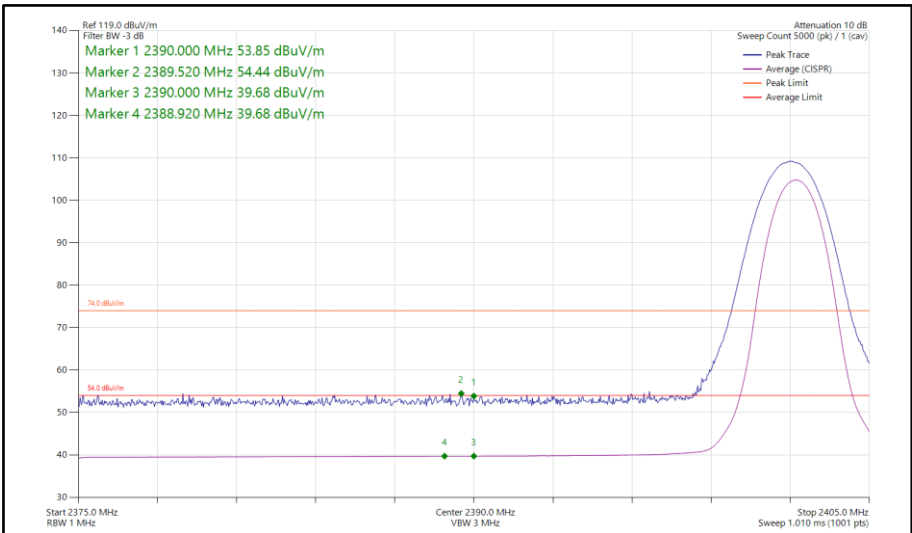
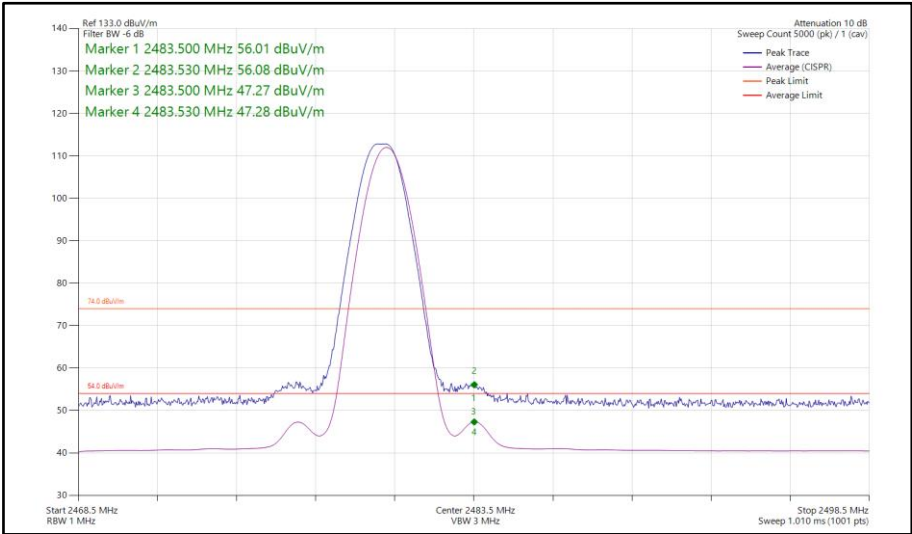
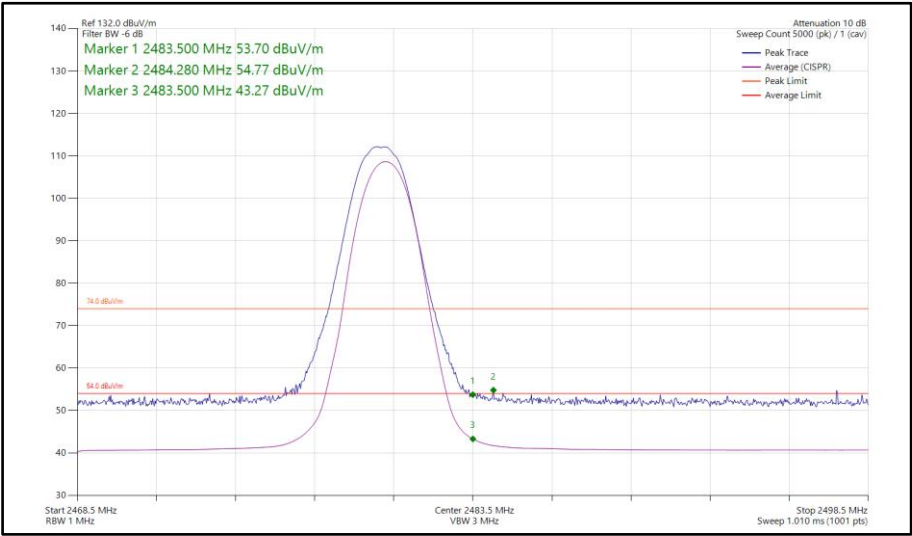


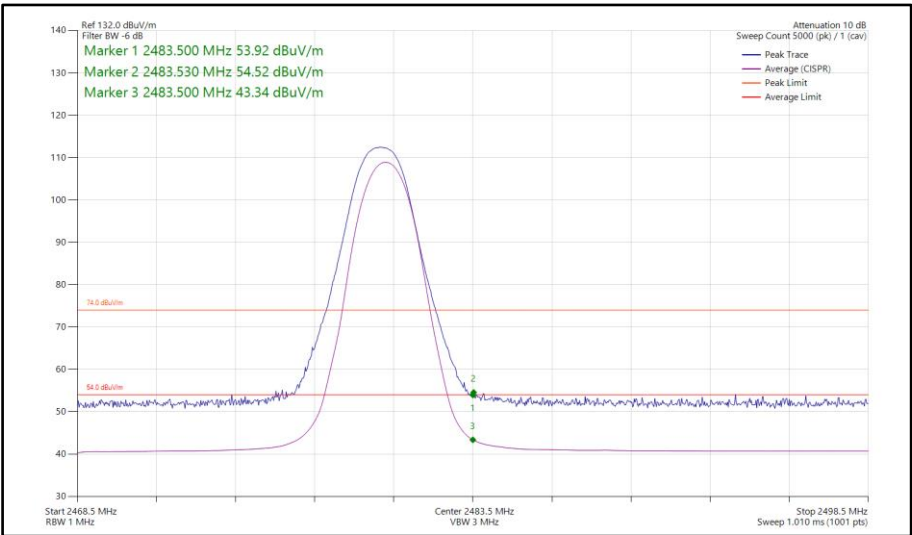
Figure 3 - Bluetooth 3-DH5, SISO, Core 0 - 2402 MHz,  
Band Edge Frequency 2390 MHz



**Figure 4 - Bluetooth DH5, SISO, Core 0 - 2480 MHz,  
Band Edge Frequency 2483.5 MHz**



**Figure 5 - Bluetooth 2-DH5, SISO, Core 0 - 2480 MHz,  
Band Edge Frequency 2483.5 MHz**



**Figure 6 - Bluetooth 3-DH5, SISO, Core 0 - 2480 MHz,  
Band Edge Frequency 2483.5 MHz**

iPA - Core 0-1 (MIMO)

| Mode   | Packet Type | TX Frequency (MHz) | Band Edge Frequency (MHz) | Peak Level (dBμV/m) | Average Level (dBμV/m) |
|--------|-------------|--------------------|---------------------------|---------------------|------------------------|
| Static | DH5         | 2402               | 2390                      | 54.47               | 40.15                  |
| Static | 2-DH5       | 2402               | 2390                      | 54.64               | 40.11                  |
| Static | 3-DH5       | 2402               | 2390                      | 54.98               | 40.11                  |
| Static | DH5         | 2480               | 2483.5                    | 54.92               | 42.75                  |
| Static | 2-DH5       | 2480               | 2483.5                    | 55.49               | 43.60                  |
| Static | 3-DH5       | 2480               | 2483.5                    | 54.64               | 43.84                  |

Table 7 - MIMO Restricted Band Edge Results

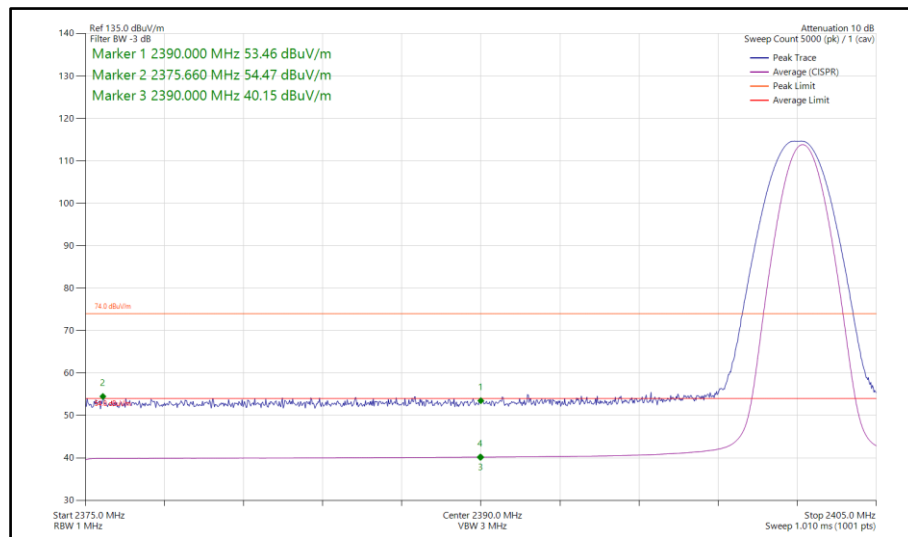
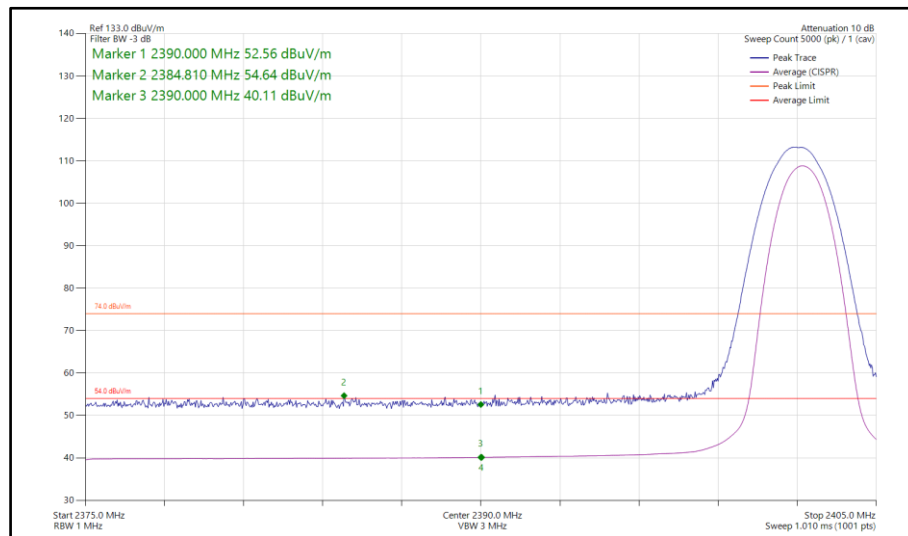
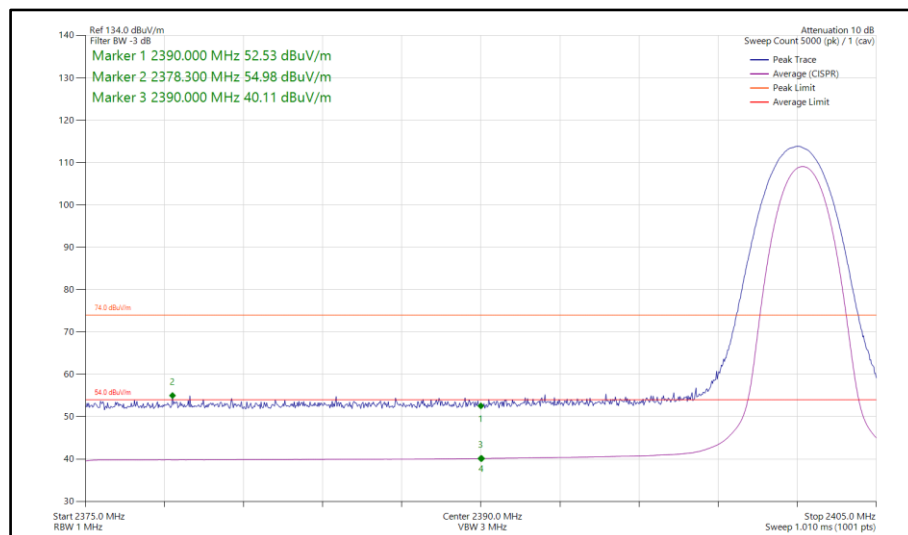


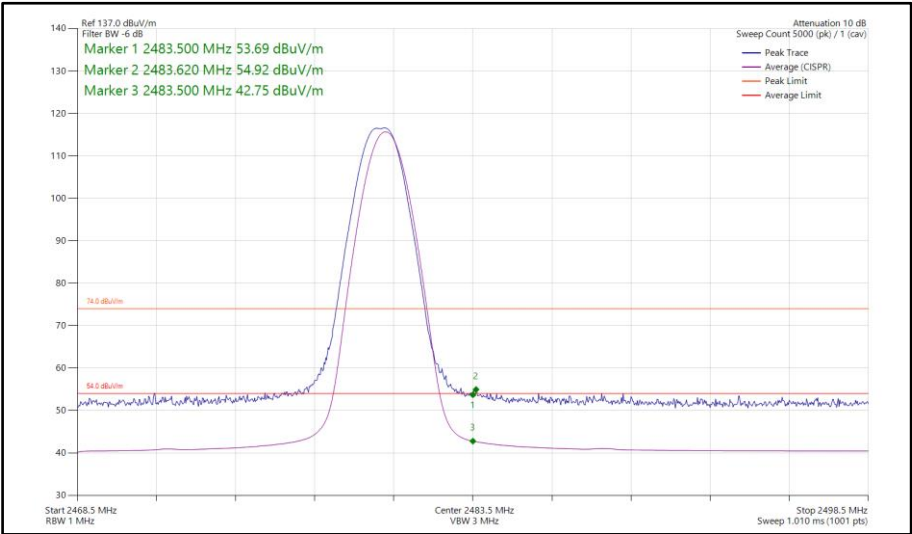
Figure 7 - Bluetooth DH5, MIMO, Core 0-1 - 2402 MHz,  
Band Edge Frequency 2390 MHz



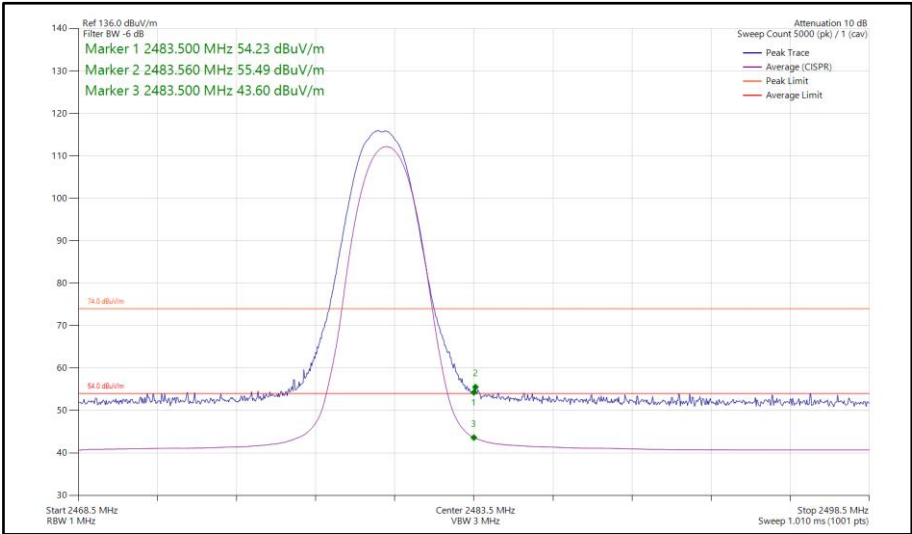
**Figure 8 - Bluetooth 2-DH5, MIMO, Core 0-1 - 2402 MHz,  
Band Edge Frequency 2390 MHz**



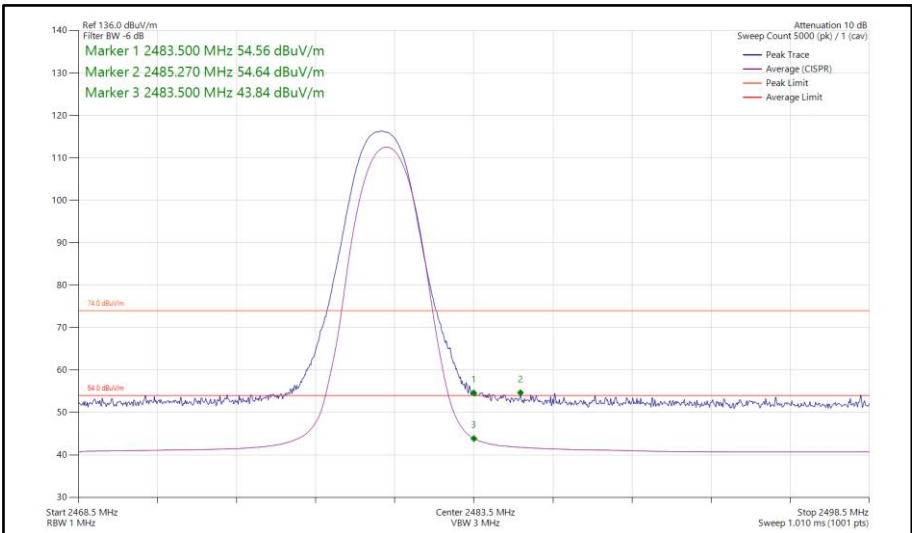
**Figure 9 - Bluetooth 3-DH5, MIMO, Core 0-1 - 2402 MHz,  
Band Edge Frequency 2390 MHz**



**Figure 10 - Bluetooth DH5, MIMO, Core 0-1 - 2480 MHz,  
Band Edge Frequency 2483.5 MHz**



**Figure 11 - Bluetooth 2-DH5, MIMO, Core 0-1 - 2480 MHz,  
Band Edge Frequency 2483.5 MHz**

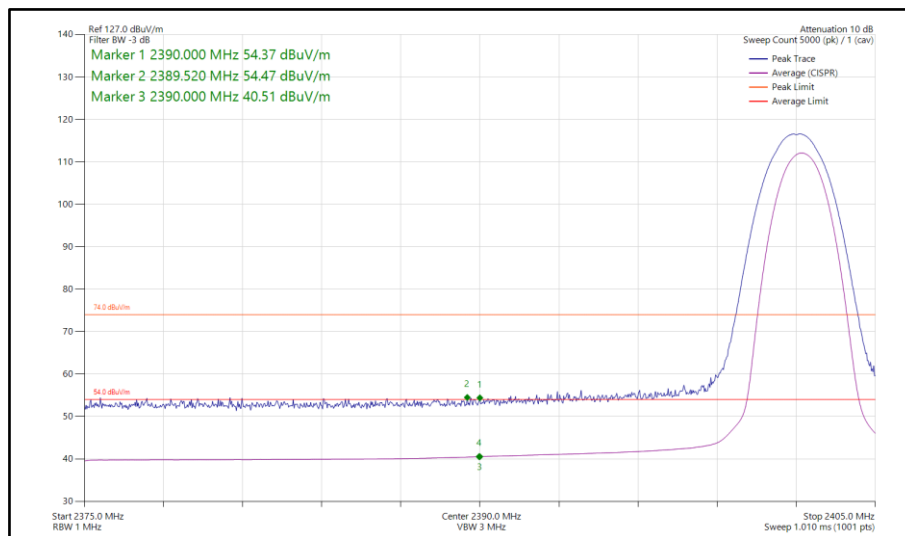


**Figure 12 - Bluetooth 3-DH5, MIMO, Core 0-1 - 2480 MHz,  
Band Edge Frequency 2483.5 MHz**

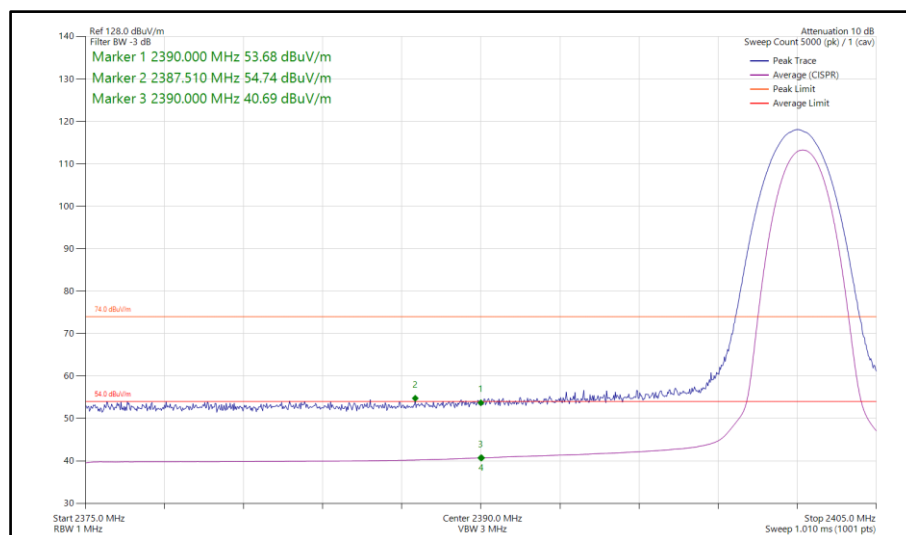
ePA - Core 0 (SISO)

| Mode   | Packet Type | TX Frequency (MHz) | Band Edge Frequency (MHz) | Peak Level (dB $\mu$ V/m) | Average Level (dB $\mu$ V/m) |
|--------|-------------|--------------------|---------------------------|---------------------------|------------------------------|
| Static | 2-DH5       | 2402               | 2390                      | 54.47                     | 40.51                        |
| Static | 3-DH5       | 2402               | 2390                      | 54.74                     | 40.69                        |
| Static | 2-DH5       | 2480               | 2483.5                    | 55.80                     | 44.29                        |
| Static | 3-DH5       | 2480               | 2483.5                    | 56.62                     | 45.36                        |

**Table 8 - SISO Restricted Band Edge Results**



**Figure 13 - Bluetooth 2-DH5, SISO, Core 0 - 2402 MHz, Band Edge Frequency 2390 MHz**



**Figure 14 - Bluetooth 3-DH5, SISO, Core 0 - 2402 MHz, Band Edge Frequency 2390 MHz**



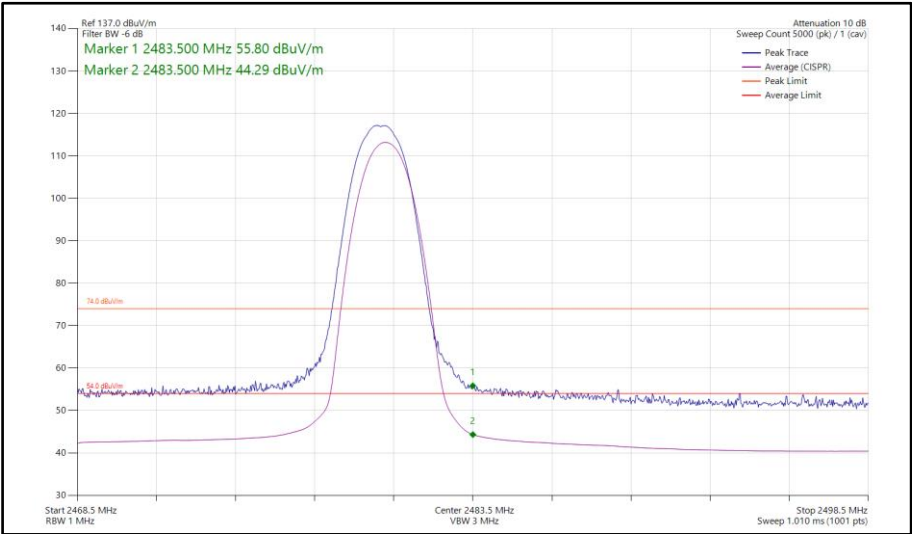


Figure 15 - Bluetooth 2-DH5, SISO, Core 0 - 2480 MHz,  
Band Edge Frequency 2483.5 MHz

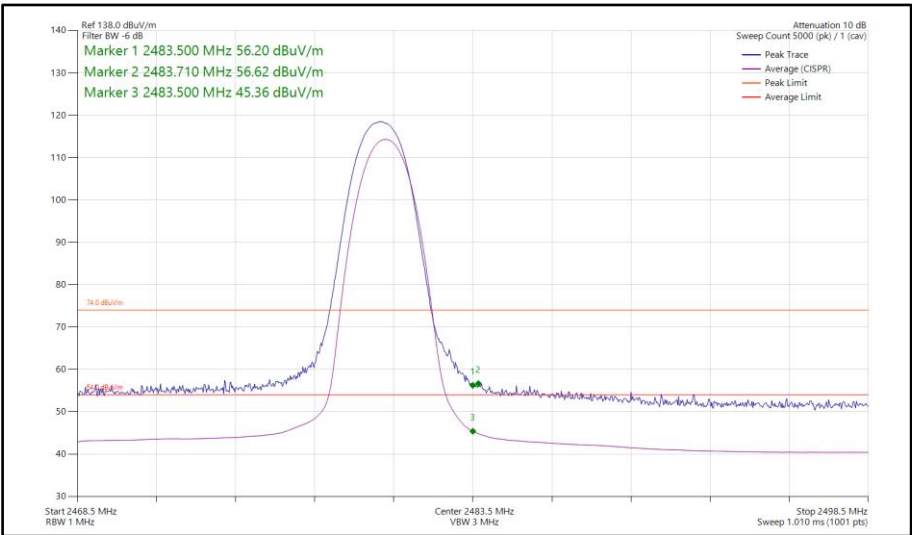


Figure 16 - Bluetooth 3-DH5, SISO, Core 0 - 2480 MHz,  
Band Edge Frequency 2483.5 MHz

ePA - Core 0-1 (MIMO)

| Mode   | Packet Type | TX Frequency (MHz) | Band Edge Frequency (MHz) | Peak Level (dB $\mu$ V/m) | Average Level (dB $\mu$ V/m) |
|--------|-------------|--------------------|---------------------------|---------------------------|------------------------------|
| Static | 2-DH5       | 2402               | 2390                      | 55.56                     | 41.14                        |
| Static | 3-DH5       | 2402               | 2390                      | 55.83                     | 41.92                        |
| Static | 2-DH5       | 2480               | 2483.5                    | 58.24                     | 47.29                        |
| Static | 3-DH5       | 2480               | 2483.5                    | 60.44                     | 49.25                        |

Table 9 - MIMO Restricted Band Edge Results

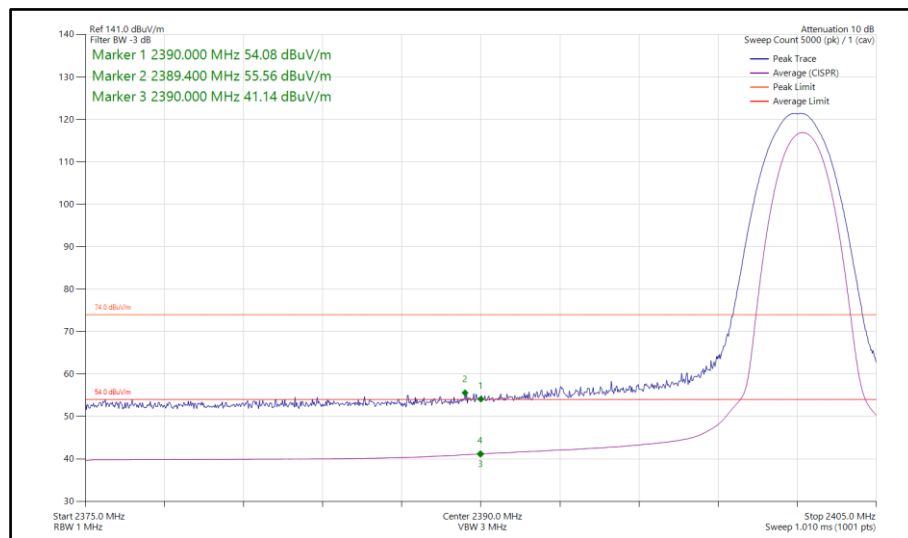


Figure 17 - Bluetooth 2-DH5, MIMO, Core 0-1 - 2402 MHz, Band Edge Frequency 2390 MHz

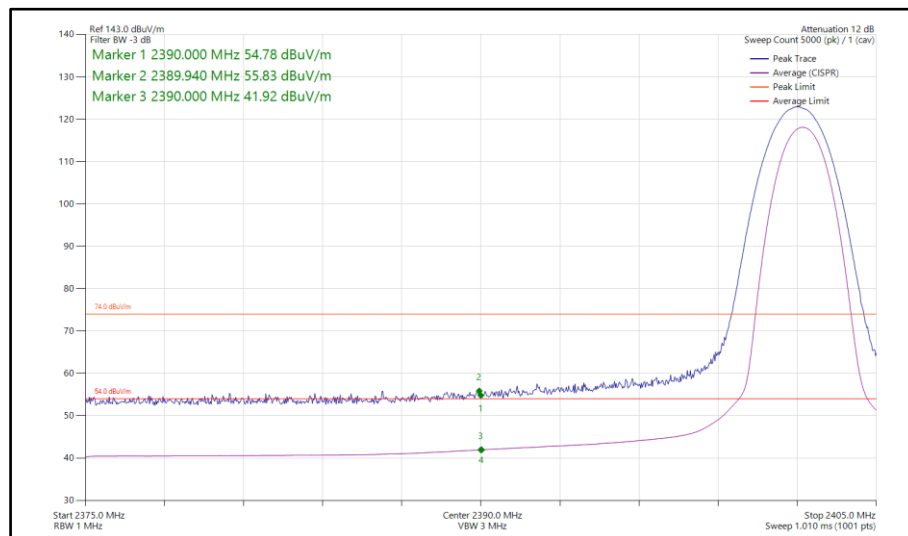


Figure 18 - Bluetooth 3-DH5, MIMO, Core 0-1 - 2402 MHz, Band Edge Frequency 2390 MHz

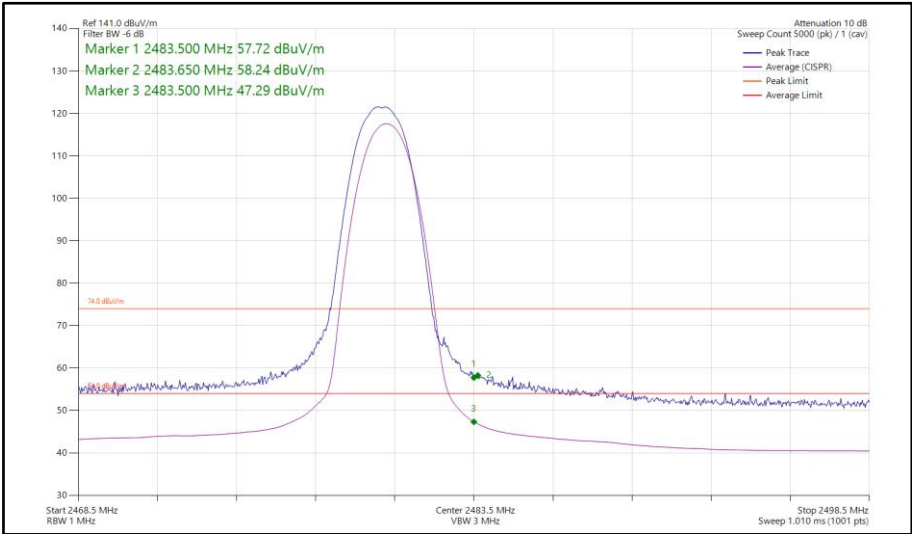


Figure 19 - Bluetooth 2-DH5, MIMO, Core 0-1 - 2480 MHz,  
Band Edge Frequency 2483.5 MHz

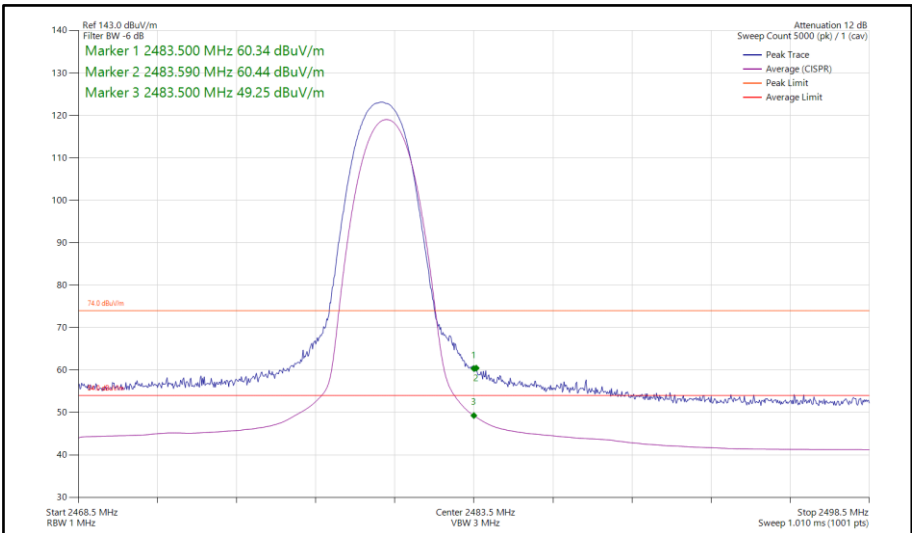


Figure 20 - Bluetooth 3-DH5, MIMO, Core 0-1 - 2480 MHz,  
Band Edge Frequency 2483.5 MHz



FCC 47 CFR Part 15, Limit Clause 15.209

| Frequency (MHz) | Field Strength ( $\mu\text{V/m}$ at 3 m) |
|-----------------|------------------------------------------|
| 30 to 88        | 100                                      |
| 88 to 216       | 150                                      |
| 216 to 960      | 200                                      |
| Above 960       | 500                                      |

**Table 10**

ISED RSS-GEN, Limit Clause 8.9

| Frequency (MHz) | Field Strength ( $\mu\text{V/m}$ at 3 m) |
|-----------------|------------------------------------------|
| 30 to 88        | 100                                      |
| 88 to 216       | 150                                      |
| 216 to 960      | 200                                      |
| Above 960*      | 500                                      |

**Table 11**

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



## 2.1.7 Test Location and Test Equipment Used

This test was carried out in RF Chamber 15.

| Instrument                           | Manufacturer       | Type No              | TE No | Calibration Period (months) | Calibration Expires |
|--------------------------------------|--------------------|----------------------|-------|-----------------------------|---------------------|
| Emissions Software                   | TUV SUD            | EmX V3.1.10          | 5125  | -                           | Software            |
| EMI Test Receiver                    | Rohde & Schwarz    | ESW44                | 5911  | 12                          | 24-Mar-2023         |
| 1500W (300V 12A) AC Power Supply     | iTech              | IT7324               | 5956  | -                           | O/P Mon             |
| 5m Semi-Anechoic Chamber (Dual-Axis) | Albatross Projects | RF Chamber 15        | 5963  | 36                          | 28-Apr-2025         |
| Mast & Turntable Controller          | Maturo Gmbh        | FCU3.0               | 5966  | -                           | TU                  |
| Tilt Antenna Mast                    | Maturo Gmbh        | BAM4.5-P             | 5967  | -                           | TU                  |
| Turntable                            | Maturo Gmbh        | TT1.5SI              | 5968  | -                           | TU                  |
| Cable (SMA to SMA 1m)                | Junkosha           | MWX221-01000AMSAMS/A | 5996  | 12                          | 06-Jun-2023         |
| Cable (SMA to SMA 1m)                | Junkosha           | MWX221-01000AMSAMS/A | 6007  | 12                          | 06-Jun-2023         |
| Cable (SMA to SMA 6.5m)              | Junkosha           | MWX221-06500AMSAMS/B | 6014  | 12                          | 07-Jun-2023         |
| Horn Antenna (1-10 GHz)              | Schwarzbeck        | BBHA9120B            | 6140  | 12                          | 21-Jun-2023         |
| Digital Multimeter                   | Fluke              | 115                  | 6147  | 12                          | 16-Jun-2023         |
| Humidity & Temperature meter         | R.S Components     | 1364                 | 6150  | 12                          | 17-Jun-2023         |
| SAC Switch Unit                      | TUV SUD            | TUV_SSU_001          | 6191  | 12                          | 12-Dec-2023         |

**Table 12**

TU - Traceability Unscheduled

O/P Mon – Output Monitored using calibrated equipment



## **2.2 Frequency Hopping Systems - Average Time of Occupancy**

### **2.2.1 Specification Reference**

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

### **2.2.2 Equipment Under Test and Modification State**

A2941, S/N: GF6K93M959 - Modification State 0

### **2.2.3 Date of Test**

28-March-2023

### **2.2.4 Test Method**

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

### **2.2.5 Environmental Conditions**

|                     |         |
|---------------------|---------|
| Ambient Temperature | 21.2 °C |
| Relative Humidity   | 34.3 %  |



2.2.6 Test Results

2.4 GHz Bluetooth FHSS

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

| DUT Configuration      |                           |                          |      |
|------------------------|---------------------------|--------------------------|------|
| Mode:                  | ePA $\pi/4$ DQPSK (2-DH5) | Duty Cycle (%):          | 76.8 |
| Antenna Configuration: | SISO                      | DCCF (dB):               | -    |
| Active Port(s):        | A (Core 0)                | Peak Antenna Gain (dBi): | -    |

| Test Frequency<br>(MHz) | Time of Occupancy  |                         |                           | Limit<br>(ms) |
|-------------------------|--------------------|-------------------------|---------------------------|---------------|
|                         | Dwell Time<br>(ms) | Number of Transmissions | Time of Occupancy<br>(ms) |               |
| 2402                    | 2.891              | 97                      | 280.5                     | 400.0         |

Table 13 - Time of Occupancy Results



Figure 21 -  $\pi/4$  DQPSK - 2402 MHz Accumulated Transmit Time



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

| DUT Configuration      |                           |                          |      |
|------------------------|---------------------------|--------------------------|------|
| Mode:                  | ePA $\pi/4$ DQPSK (2-DH5) | Duty Cycle (%):          | 77.1 |
| Antenna Configuration: | Beamforming               | DCCF (dB):               | -    |
| Active Port(s):        | A+B (Core 0 + Core 1)     | Peak Antenna Gain (dBi): | -    |

| Test Frequency<br>(MHz) | Time of Occupancy  |                         |                           | Limit<br>(ms) |
|-------------------------|--------------------|-------------------------|---------------------------|---------------|
|                         | Dwell Time<br>(ms) | Number of Transmissions | Time of Occupancy<br>(ms) |               |
| 2402                    | 2.891              | 99                      | 286.2                     | 400.0         |

Table 14 - Time of Occupancy Results

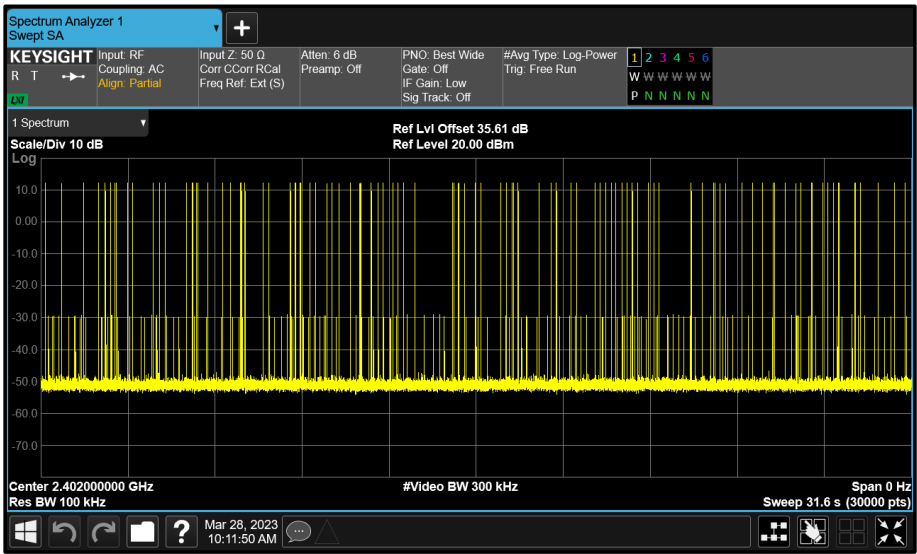


Figure 22 -  $\pi/4$  DQPSK - 2402 MHz Accumulated Transmit Time





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

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

| Test Frequency<br>(MHz) | Time of Occupancy  |                         |                           | Limit<br>(ms) |
|-------------------------|--------------------|-------------------------|---------------------------|---------------|
|                         | Dwell Time<br>(ms) | Number of Transmissions | Time of Occupancy<br>(ms) |               |
| 2402                    | 2.888              | 112                     | 323.5                     | 400.0         |

Table 15 - Time of Occupancy Results

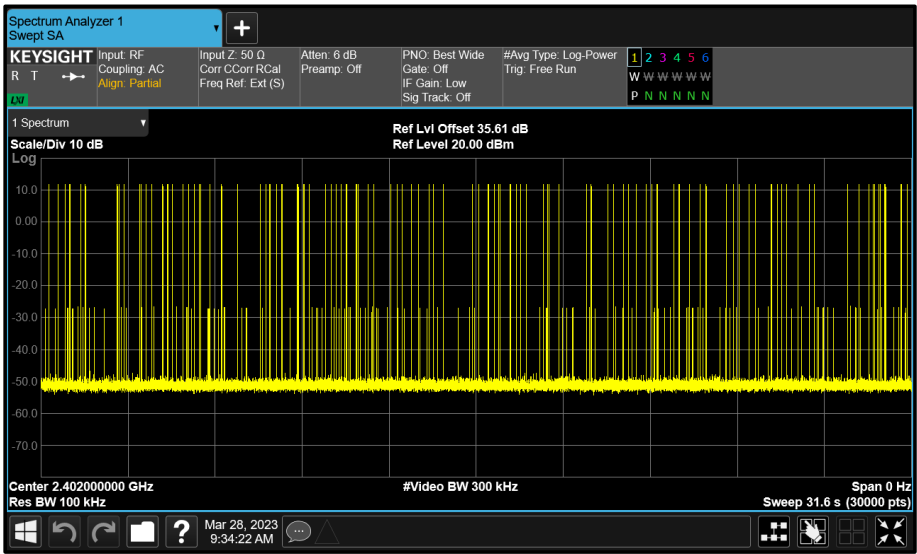


Figure 23 - GFSK - 2402 MHz Accumulated Transmit Time



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

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

| Test Frequency<br>(MHz) | Time of Occupancy  |                         |                           | Limit<br>(ms) |
|-------------------------|--------------------|-------------------------|---------------------------|---------------|
|                         | Dwell Time<br>(ms) | Number of Transmissions | Time of Occupancy<br>(ms) |               |
| 2402                    | 2.888              | 119                     | 343.7                     | 400.0         |

Table 16 - Time of Occupancy Results

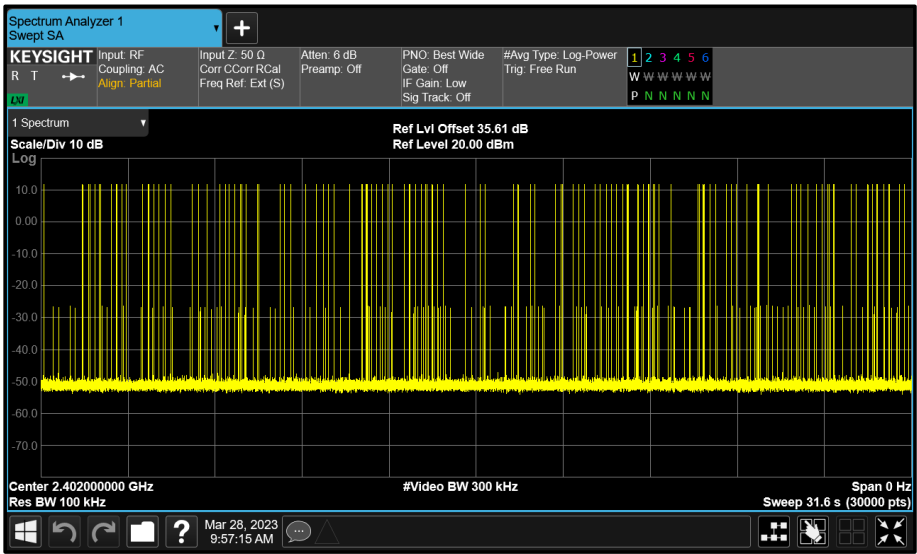


Figure 24 - GFSK - 2402 MHz Accumulated Transmit Time



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

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

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

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

## 2.2.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 14.

| Instrument                   | Manufacturer          | Type No         | TE No | Calibration Period (months) | Calibration Expires |
|------------------------------|-----------------------|-----------------|-------|-----------------------------|---------------------|
| Hygrometer                   | Rotronic              | I-1000          | 3068  | 12                          | 21-Sep-2023         |
| Multi-GNSS Simulator (GPS)   | Spirent               | GSS6700         | 4596  | 12                          | 22-Aug-2023         |
| AC Programmable Power Supply | iTech                 | IT7324          | 5225  | -                           | O/P Mon             |
| MXA Signal Analyser          | Keysight Technologies | N9020B          | 5529  | 24                          | 13-Dec-2024         |
| Signal Conditioning Unit     | TUV SUD               | SPECTRUM SCU001 | 5546  | 12                          | 06-Apr-2023         |
| Digital Multimeter           | Fluke                 | 115             | 6147  | 12                          | 16-Jun-2023         |

**Table 17**

O/P Mon – Output Monitored using calibrated equipment



## **2.3 Frequency Hopping Systems - Channel Separation**

### **2.3.1 Specification Reference**

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

### **2.3.2 Equipment Under Test and Modification State**

A2941, S/N: GF6K93M959 - Modification State 0

### **2.3.3 Date of Test**

09-March-2023

### **2.3.4 Test Method**

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

### **2.3.5 Environmental Conditions**

|                     |         |
|---------------------|---------|
| Ambient Temperature | 21.8 °C |
| Relative Humidity   | 32.6 %  |



2.3.6 Test Results

2.4 GHz Bluetooth FHSS

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

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth<br>(MHz) | Carrier Frequency Separation (MHz) |          |       | Limit<br>(kHz) |
|-------------------------|--------------------------|------------------------------------|----------|-------|----------------|
|                         |                          | F1C                                | F2C      | FHS   |                |
| 2441                    | 1.351                    | 2440.999                           | 2441.998 | 0.999 | $\geq 900.8$   |

Table 18 - Carrier Frequency Separation Results

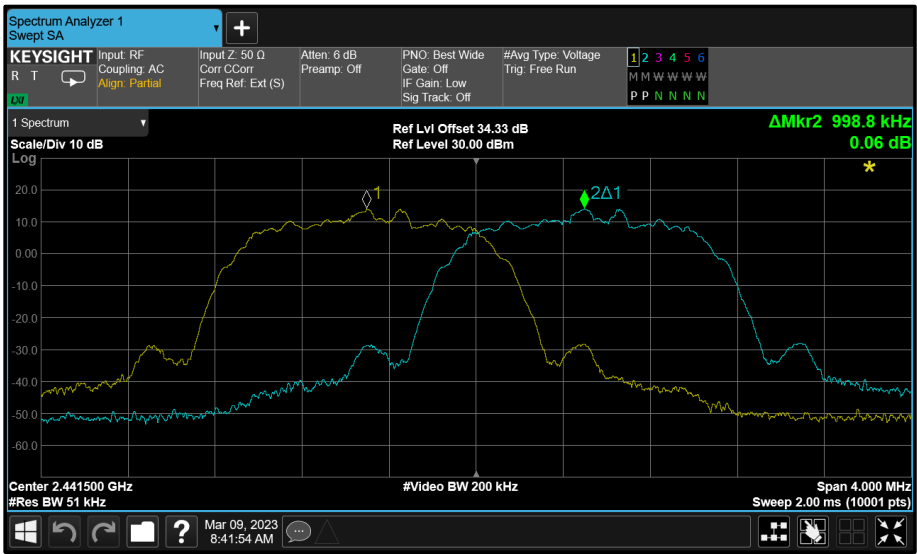


Figure 25 -  $\pi/4$  DQPSK - 2441 MHz (CH39)



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

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth<br>(MHz) | Carrier Frequency Separation (MHz) |          |       | Limit<br>(kHz) |
|-------------------------|--------------------------|------------------------------------|----------|-------|----------------|
|                         |                          | F1C                                | F2C      | FHS   |                |
| 2441                    | 1.321                    | 2441.006                           | 2442.007 | 1.001 | ≥880.5         |

Table 19 - Carrier Frequency Separation Results

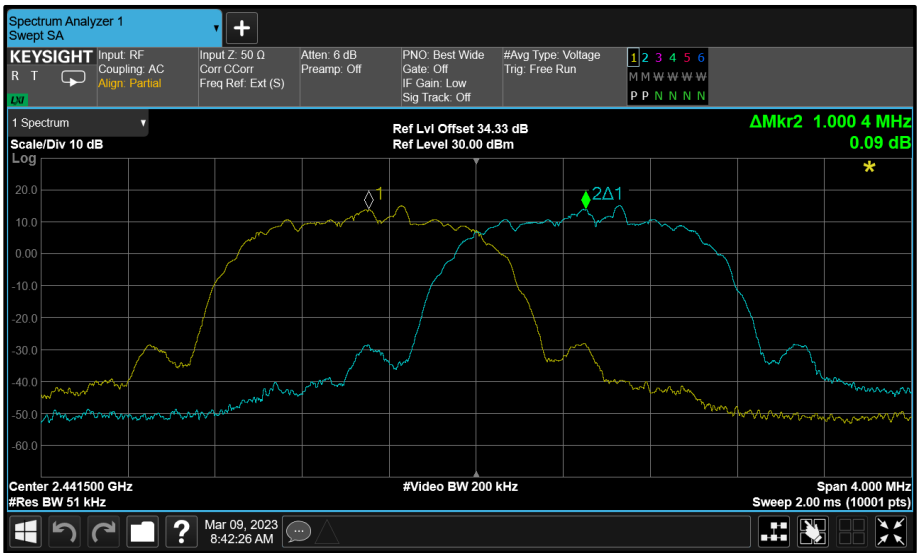


Figure 26 - 8-DPSK - 2441 MHz (CH39)



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

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth<br>(MHz) | Carrier Frequency Separation (MHz) |          |       | Limit<br>(kHz) |
|-------------------------|--------------------------|------------------------------------|----------|-------|----------------|
|                         |                          | F1C                                | F2C      | FHS   |                |
| 2441                    | 1.352                    | 2440.996                           | 2441.997 | 1.001 | $\geq 901.1$   |

Table 20 - Carrier Frequency Separation Results

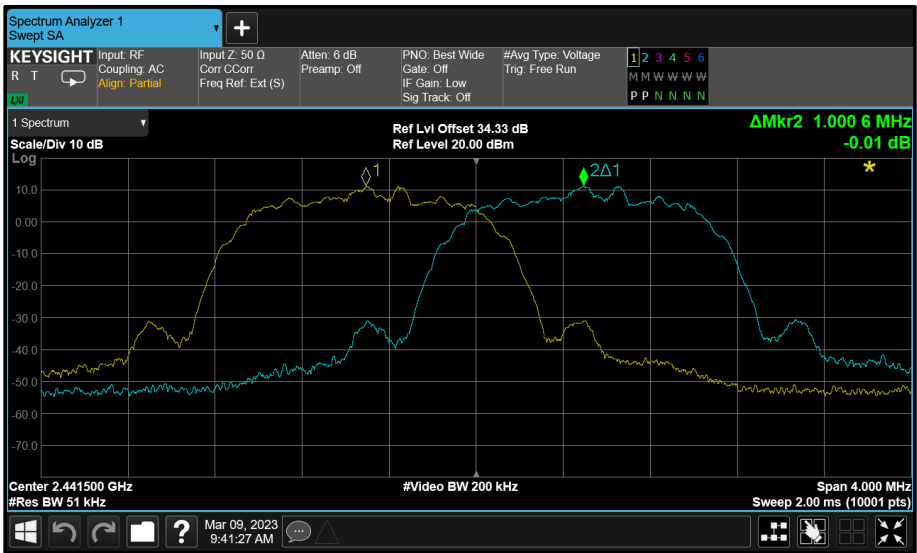


Figure 27 -  $\pi/4$  DQPSK - 2441 MHz (CH39)



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

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth<br>(MHz) | Carrier Frequency Separation (MHz) |          |       | Limit<br>(kHz) |
|-------------------------|--------------------------|------------------------------------|----------|-------|----------------|
|                         |                          | F1C                                | F2C      | FHS   |                |
| 2441                    | 1.321                    | 2441.004                           | 2442.005 | 1.001 | ≥880.8         |

Table 21 - Carrier Frequency Separation Results

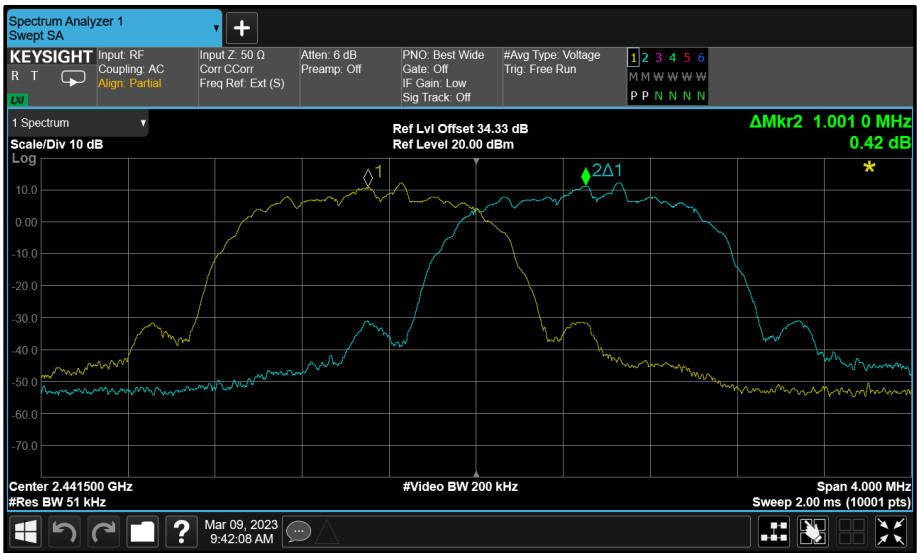


Figure 28 - 8-DPSK - 2441 MHz (CH39)





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

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth<br>(MHz) | Carrier Frequency Separation (MHz) |          |       | Limit<br>(kHz) |
|-------------------------|--------------------------|------------------------------------|----------|-------|----------------|
|                         |                          | F1C                                | F2C      | FHS   |                |
| 2441                    | 0.924                    | 2441.017                           | 2442.016 | 0.999 | ≥615.8         |

Table 22 - Carrier Frequency Separation Results

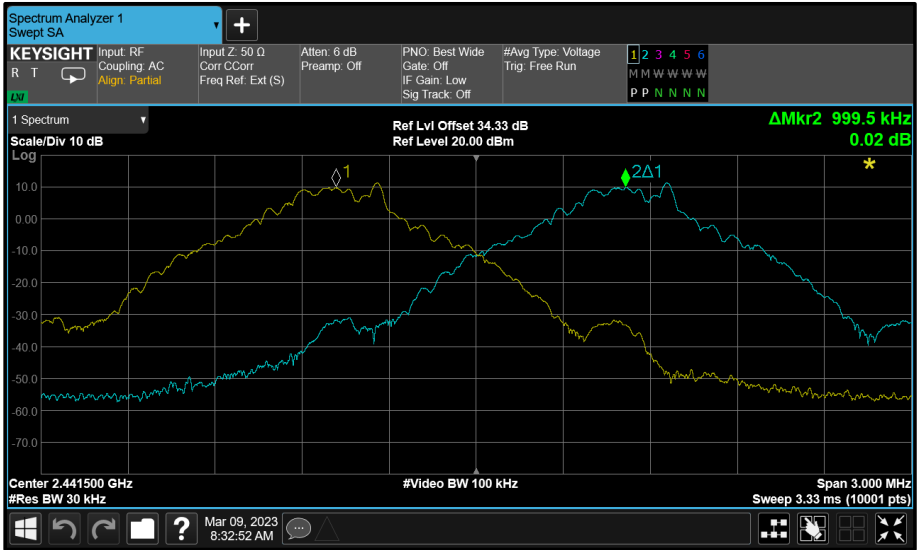


Figure 29 - GFSK - 2441 MHz (CH39)



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

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth<br>(MHz) | Carrier Frequency Separation (MHz) |          |       | Limit<br>(kHz) |
|-------------------------|--------------------------|------------------------------------|----------|-------|----------------|
|                         |                          | F1C                                | F2C      | FHS   |                |
| 2441                    | 1.353                    | 2440.999                           | 2441.999 | 1.000 | $\geq 901.9$   |

Table 23 - Carrier Frequency Separation Results

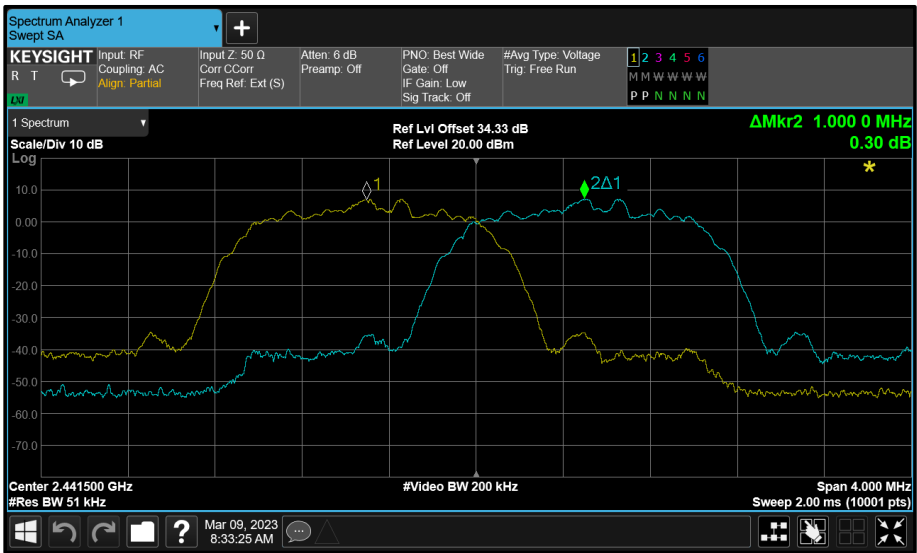


Figure 30 -  $\pi/4$  DQPSK - 2441 MHz (CH39)



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

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth<br>(MHz) | Carrier Frequency Separation (MHz) |          |       | Limit<br>(kHz) |
|-------------------------|--------------------------|------------------------------------|----------|-------|----------------|
|                         |                          | F1C                                | F2C      | FHS   |                |
| 2441                    | 1.322                    | 2441.007                           | 2442.007 | 1.000 | ≥881.1         |

Table 24 - Carrier Frequency Separation Results

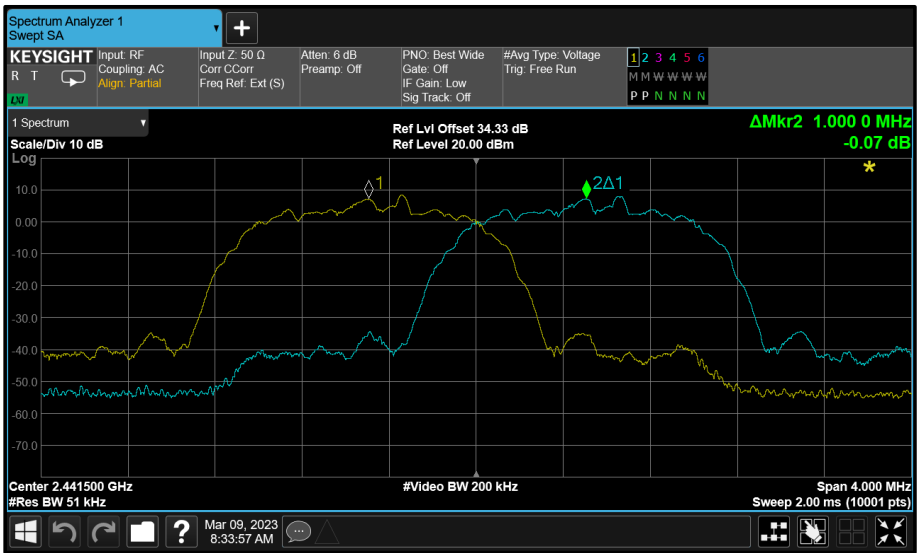


Figure 31 - 8-DPSK - 2441 MHz (CH39)



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

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth<br>(MHz) | Carrier Frequency Separation (MHz) |          |       | Limit<br>(kHz) |
|-------------------------|--------------------------|------------------------------------|----------|-------|----------------|
|                         |                          | F1C                                | F2C      | FHS   |                |
| 2441                    | 0.926                    | 2441.017                           | 2442.017 | 1.000 | ≥617.4         |

Table 25 - Carrier Frequency Separation Results

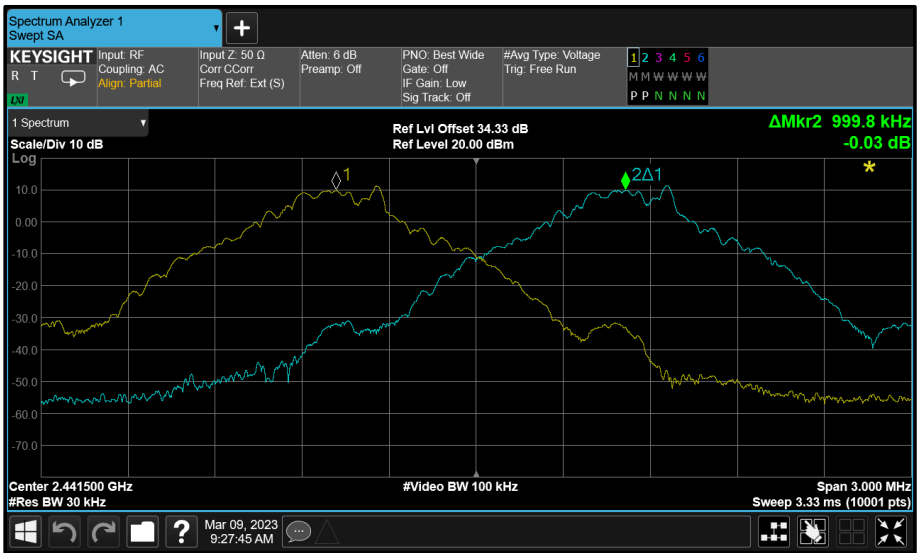


Figure 32 - GFSK - 2441 MHz (CH39)



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

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth<br>(MHz) | Carrier Frequency Separation (MHz) |          |       | Limit<br>(kHz) |
|-------------------------|--------------------------|------------------------------------|----------|-------|----------------|
|                         |                          | F1C                                | F2C      | FHS   |                |
| 2441                    | 1.353                    | 2440.999                           | 2441.998 | 0.999 | $\geq 902.1$   |

Table 26 - Carrier Frequency Separation Results

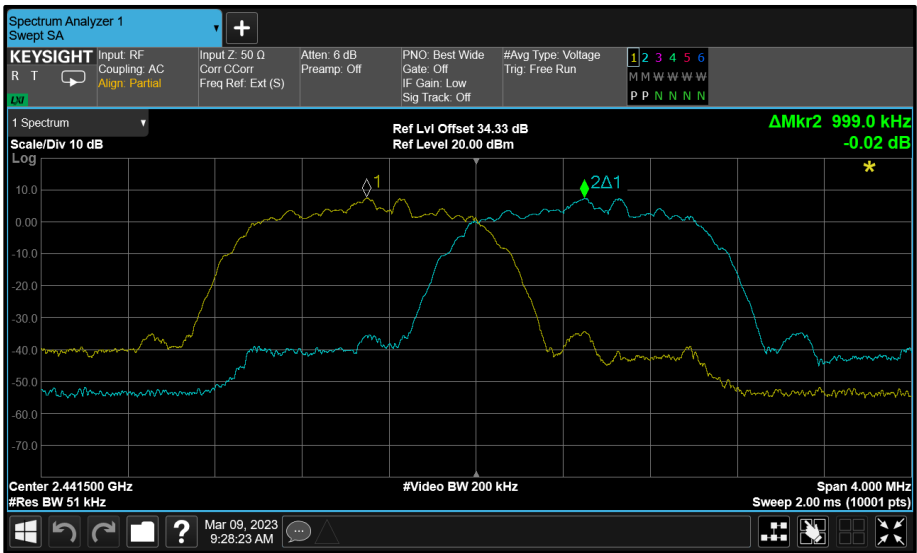


Figure 33 -  $\pi/4$  DQPSK - 2441 MHz (CH39)



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

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth<br>(MHz) | Carrier Frequency Separation (MHz) |          |       | Limit<br>(kHz) |
|-------------------------|--------------------------|------------------------------------|----------|-------|----------------|
|                         |                          | F1C                                | F2C      | FHS   |                |
| 2441                    | 1.322                    | 2441.007                           | 2442.007 | 1.000 | ≥881.3         |

Table 27 - Carrier Frequency Separation Results



Figure 34 - 8-DPSK - 2441 MHz (CH39)



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

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

Alternatively, frequency hopping systems operating in the band 2400-2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 0.125 W.

ISED RSS-247, Limit Clause 5.1 (b)

FHSs shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the -20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2400-2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W.

### 2.3.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 14.

| Instrument                   | Manufacturer          | Type No         | TE No | Calibration Period (months) | Calibration Expires |
|------------------------------|-----------------------|-----------------|-------|-----------------------------|---------------------|
| Hygrometer                   | Rotronic              | I-1000          | 3068  | 12                          | 21-Sep-2023         |
| Multi-GNSS Simulator (GPS)   | Spirent               | GSS6700         | 4596  | 12                          | 22-Aug-2023         |
| AC Programmable Power Supply | iTech                 | IT7324          | 5225  | -                           | O/P Mon             |
| MXA Signal Analyser          | Keysight Technologies | N9020B          | 5529  | 24                          | 13-Dec-2024         |
| Signal Conditioning Unit     | TUV SUD               | SPECTRUM SCU001 | 5546  | 12                          | 06-Apr-2023         |
| Digital Multimeter           | Fluke                 | 115             | 6147  | 12                          | 16-Jun-2023         |

**Table 28**

O/P Mon – Output Monitored using calibrated equipment



## **2.4 Frequency Hopping Systems - Number of Hopping Channels**

### **2.4.1 Specification Reference**

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

### **2.4.2 Equipment Under Test and Modification State**

A2941, S/N: GF6K93M959 - Modification State 0

### **2.4.3 Date of Test**

09-March-2023

### **2.4.4 Test Method**

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

### **2.4.5 Environmental Conditions**

|                     |         |
|---------------------|---------|
| Ambient Temperature | 21.8 °C |
| Relative Humidity   | 32.6 %  |





2.4.6 Test Results

2.4 GHz Bluetooth FHSS

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

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

| Number of Hopping Frequencies | Limit       |
|-------------------------------|-------------|
| 79                            | $\geq 15.0$ |

Table 29 - Number of Hopping Frequencies Results

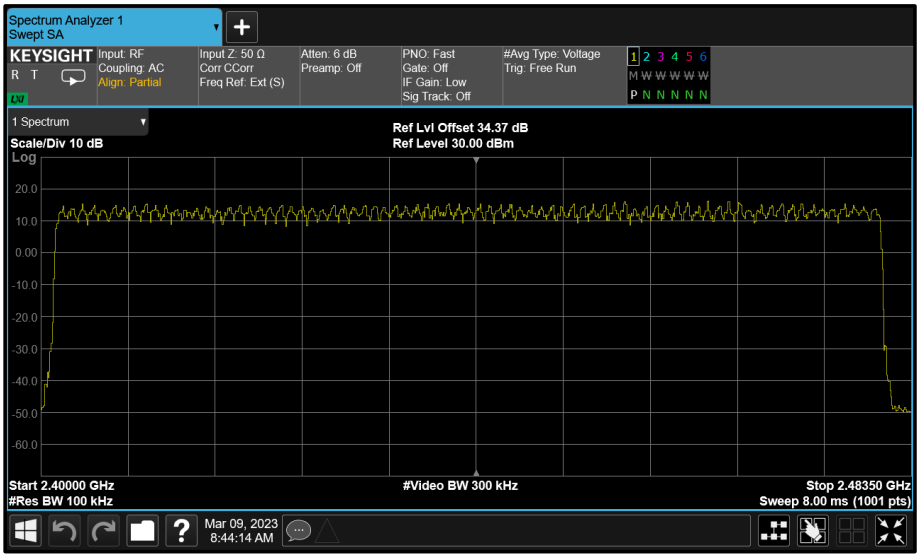


Figure 35 -  $\pi/4$  DQPSK (2-DH5) - Number of Hopping Channels



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

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

| Number of Hopping Frequencies | Limit       |
|-------------------------------|-------------|
| 79                            | $\geq 15.0$ |

Table 30 - Number of Hopping Frequencies Results

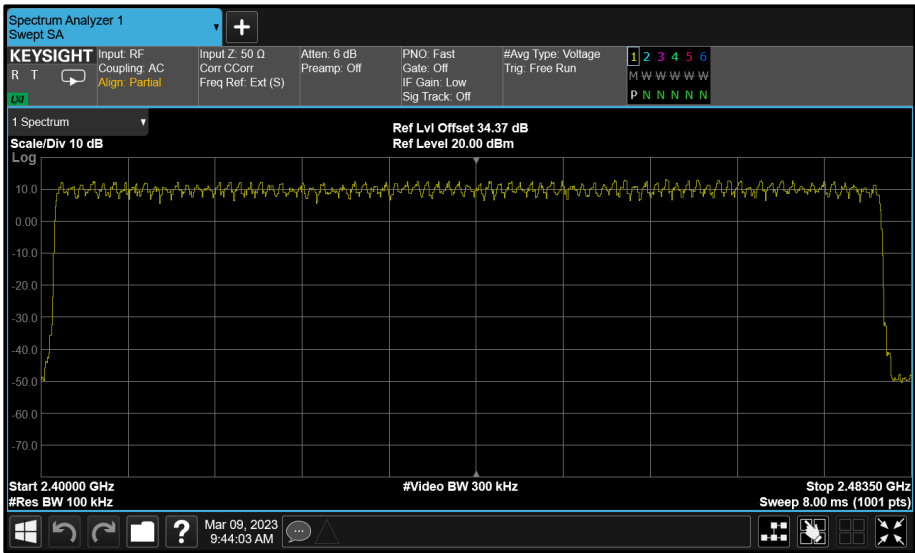


Figure 36 -  $\pi/4$  DQPSK (2-DH5) - Number of Hopping Channels



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

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

| Number of Hopping Frequencies |  | Limit |
|-------------------------------|--|-------|
| 79                            |  | ≥15.0 |

Table 31 - Number of Hopping Frequencies Results

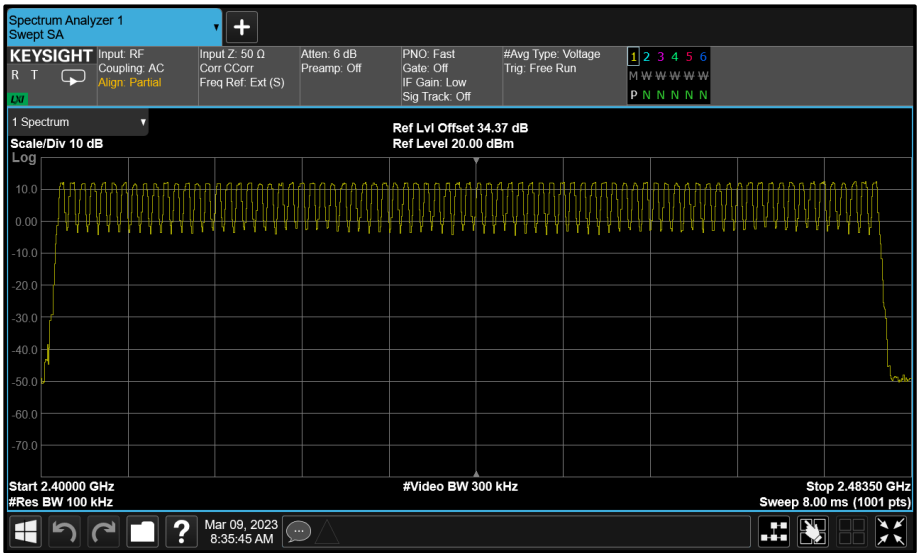


Figure 37 - GFSK (DH5) - Number of Hopping Channels

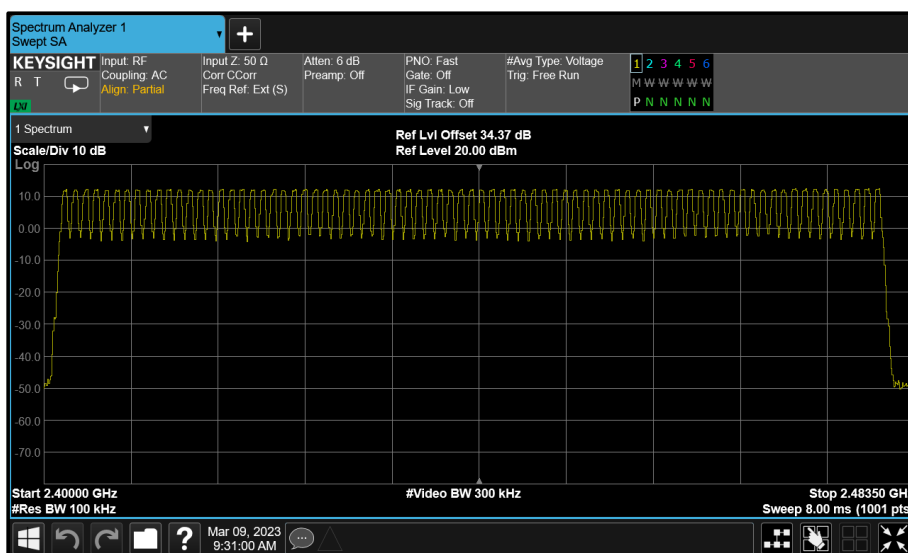


| Test Configuration       |                                         |                 |              |
|--------------------------|-----------------------------------------|-----------------|--------------|
| Frequency Range:         | 2400-2483.5 MHz                         | Band:           | 2.4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

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

| Number of Hopping Frequencies | Limit |
|-------------------------------|-------|
| 79                            | ≥15.0 |

**Table 32 - Number of Hopping Frequencies Results**



**Figure 38 - GFSK (DH5) - Number of Hopping Channels**

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

≥ 15 channels

ISED RSS-247, Limit Clause 5.1 (d)

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



#### 2.4.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 14.

| Instrument                   | Manufacturer          | Type No         | TE No | Calibration Period (months) | Calibration Expires |
|------------------------------|-----------------------|-----------------|-------|-----------------------------|---------------------|
| Hygrometer                   | Rotronic              | I-1000          | 3068  | 12                          | 21-Sep-2023         |
| Multi-GNSS Simulator (GPS)   | Spirent               | GSS6700         | 4596  | 12                          | 22-Aug-2023         |
| AC Programmable Power Supply | iTech                 | IT7324          | 5225  | -                           | O/P Mon             |
| MXA Signal Analyser          | Keysight Technologies | N9020B          | 5529  | 24                          | 13-Dec-2024         |
| Signal Conditioning Unit     | TUV SUD               | SPECTRUM SCU001 | 5546  | 12                          | 06-Apr-2023         |
| Digital Multimeter           | Fluke                 | 115             | 6147  | 12                          | 16-Jun-2023         |

**Table 33**

O/P Mon – Output Monitored using calibrated equipment



## **2.5 Frequency Hopping Systems - 20 dB Bandwidth**

### **2.5.1 Specification Reference**

FCC 47 CFR Part 15C, Clause 15.247 (a)(1)  
ISED RSS-247, Clause 5.1  
ISED RSS-GEN, Clause 6.7

### **2.5.2 Equipment Under Test and Modification State**

A2941, S/N: GF6K93M959 - Modification State 0

### **2.5.3 Date of Test**

09-March-2023

### **2.5.4 Test Method**

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

### **2.5.5 Environmental Conditions**

|                     |         |
|---------------------|---------|
| Ambient Temperature | 21.8 °C |
| Relative Humidity   | 32.6 %  |



2.5.6 Test Results

2.4 GHz Bluetooth FHSS

| Test Configuration       |                                  |                 |              |
|--------------------------|----------------------------------|-----------------|--------------|
| Frequency Range:         | 2400-2483.5 MHz                  | Band:           | 2.4 GHz      |
| Limit Clause(s):         | FCC 15.247 (a)(1)<br>RSS-247 5.1 | Test Method(s): | C63.10 6.9.2 |
| Additional Reference(s): | -                                |                 |              |

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

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) |       |   |   |
|----------------------|-----------------------|-------|---|---|
|                      | A                     | B     | C | D |
| 2402                 | -                     | 1.330 | - | - |
| 2441                 | -                     | 1.325 | - | - |
| 2480                 | -                     | 1.325 | - | - |

Table 34 - 20 dB Bandwidth Results

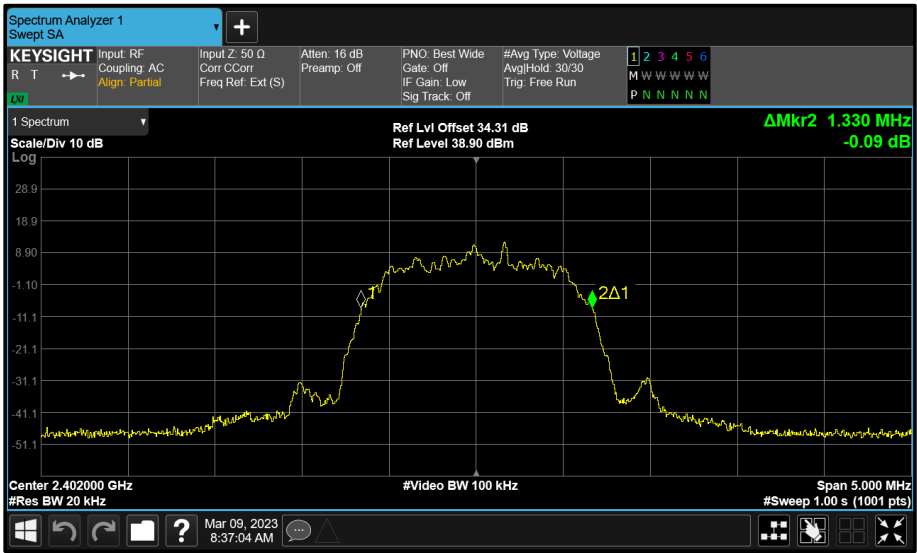


Figure 39 - Core 0 (B) 2402 MHz (CH0) 20 dB Bandwidth

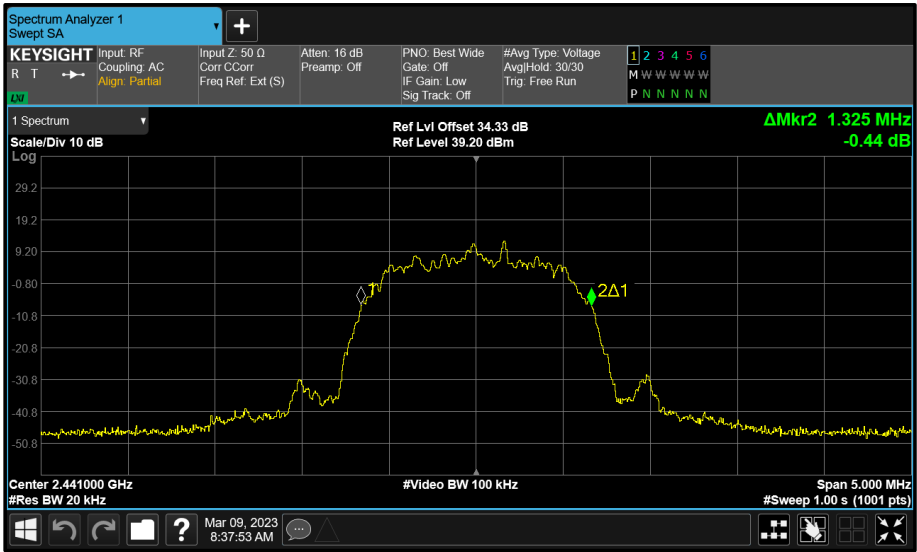


Figure 40 - Core 0 (B) 2441 MHz (CH39) 20 dB Bandwidth

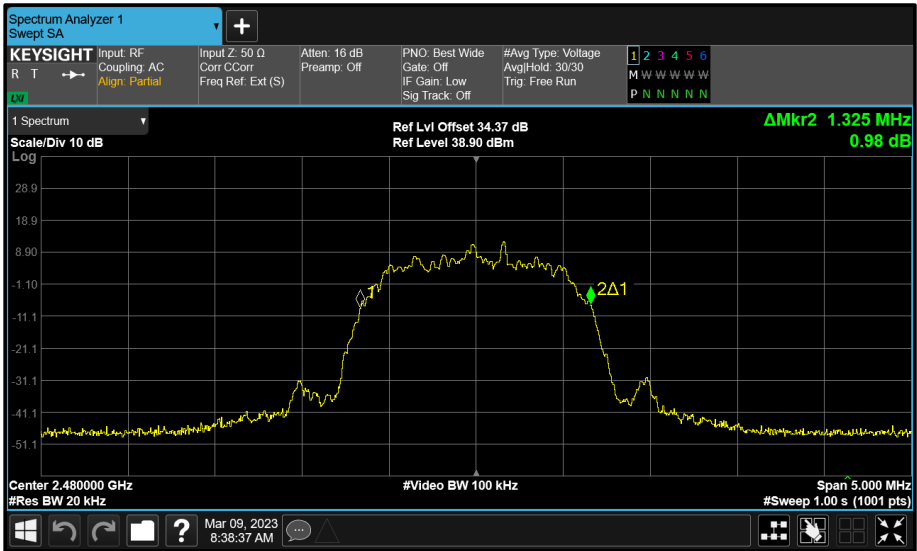


Figure 41 - Core 0 (B) 2480 MHz (CH78) 20 dB Bandwidth





| Test Configuration       |  |                                  |                 |              |
|--------------------------|--|----------------------------------|-----------------|--------------|
| Frequency Range:         |  | 2400-2483.5 MHz                  | Band:           | 2.4 GHz      |
| Limit Clause(s):         |  | FCC 15.247 (a)(1)<br>RSS-247 5.1 | Test Method(s): | C63.10 6.9.2 |
| Additional Reference(s): |  | -                                |                 |              |

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth (MHz) |       |   |   |
|-------------------------|-----------------------|-------|---|---|
|                         | A                     | B     | C | D |
| 2402                    | -                     | 1.260 | - | - |
| 2441                    | -                     | 1.260 | - | - |
| 2480                    | -                     | 1.260 | - | - |

Table 35 - 20 dB Bandwidth Results

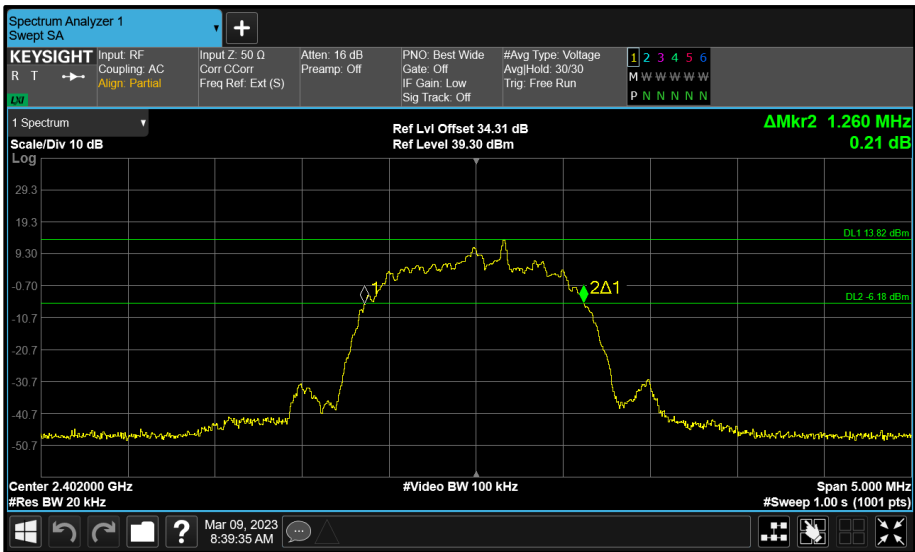


Figure 42 - Core 0 (B) 2402 MHz (CH0) 20 dB Bandwidth

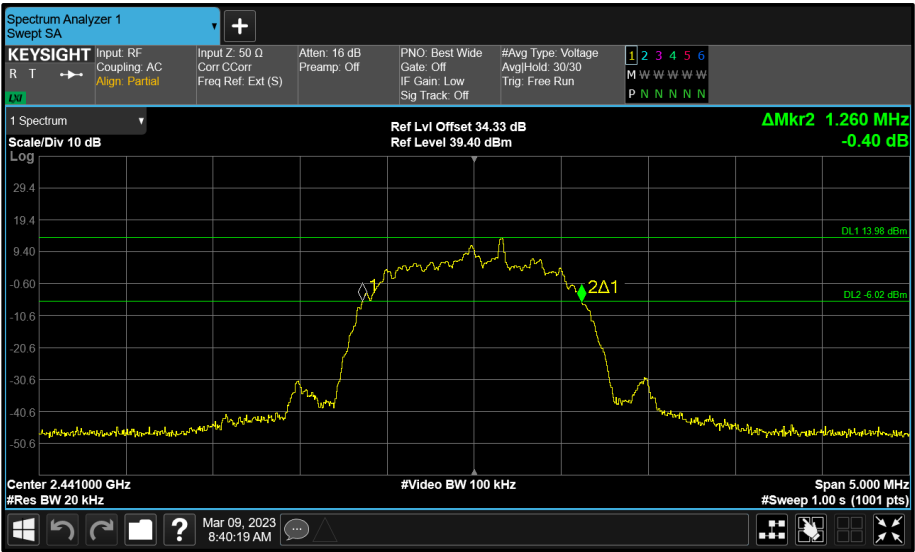


Figure 43 - Core 0 (B) 2441 MHz (CH39) 20 dB Bandwidth

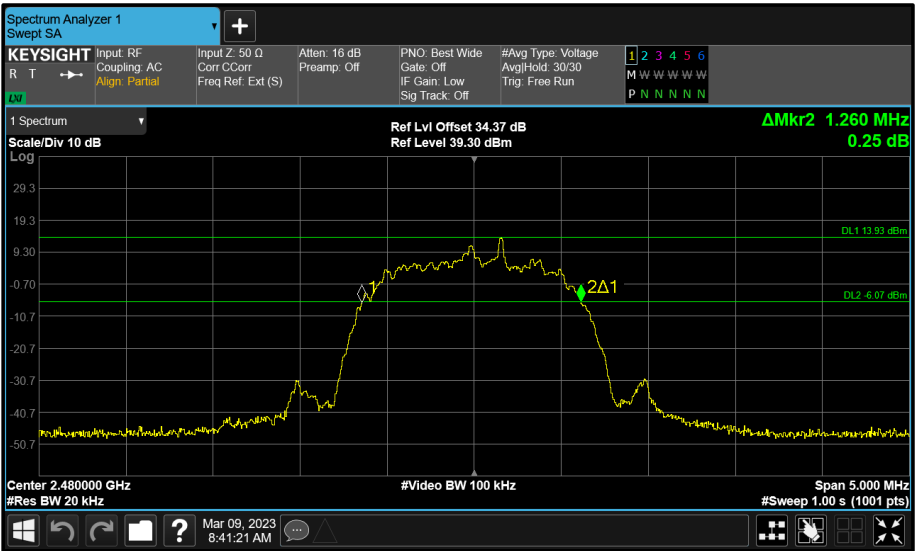


Figure 44 - Core 0 (B) 2480 MHz (CH78) 20 dB Bandwidth



| Test Configuration       |  |                                  |                 |              |
|--------------------------|--|----------------------------------|-----------------|--------------|
| Frequency Range:         |  | 2400-2483.5 MHz                  | Band:           | 2.4 GHz      |
| Limit Clause(s):         |  | FCC 15.247 (a)(1)<br>RSS-247 5.1 | Test Method(s): | C63.10 6.9.2 |
| Additional Reference(s): |  | -                                |                 |              |

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth (MHz) |       |       |   |
|-------------------------|-----------------------|-------|-------|---|
|                         | A                     | B     | C     | D |
| 2402                    | -                     | 1.325 | 1.325 | - |
| 2441                    | -                     | 1.330 | 1.320 | - |
| 2480                    | -                     | 1.325 | 1.325 | - |

Table 36 - 20 dB Bandwidth Results

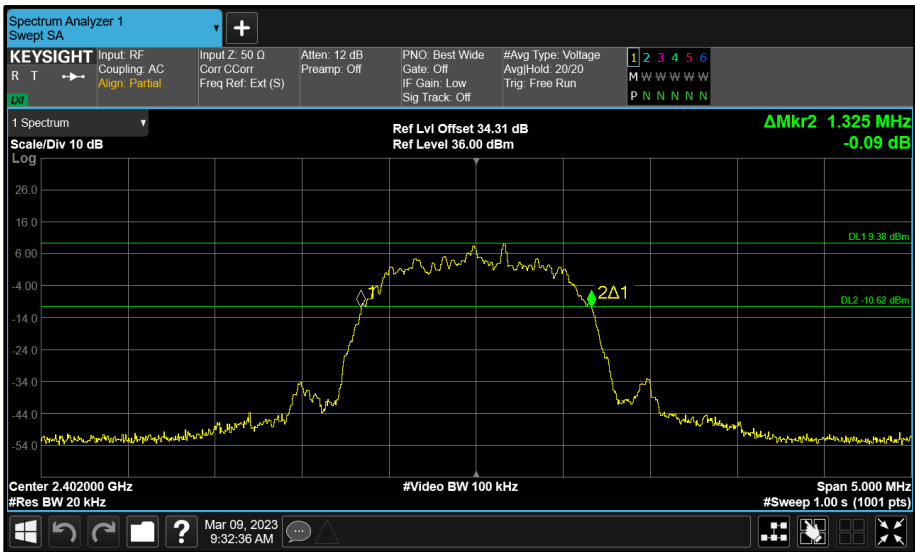


Figure 45 - Core 0 (B) 2402 MHz (CH0) 20 dB Bandwidth

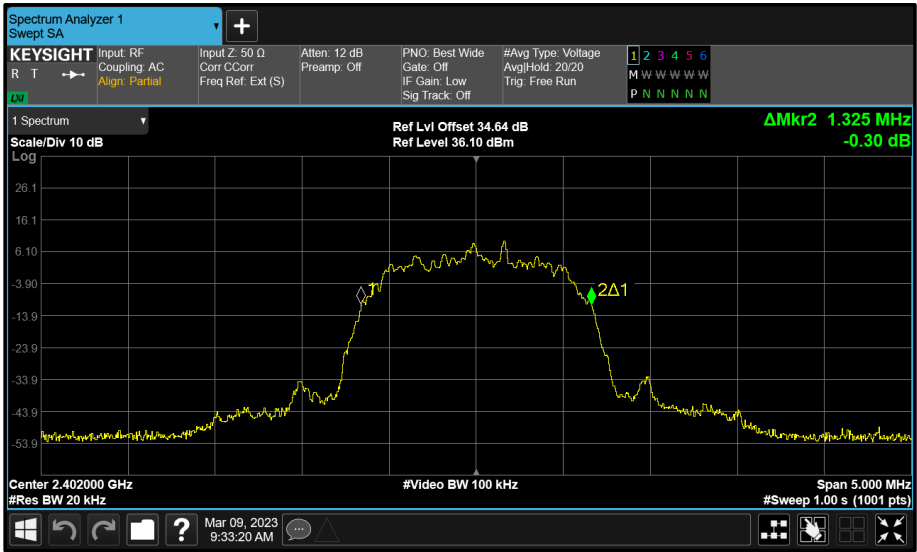


Figure 46 - Core 1 (C) 2402 MHz (CH0) 20 dB Bandwidth

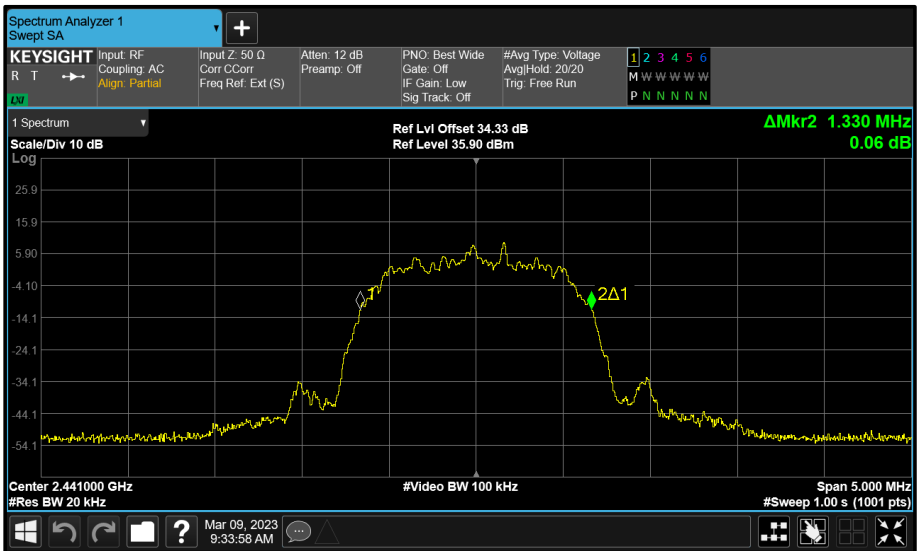


Figure 47 - Core 0 (B) 2441 MHz (CH39) 20 dB Bandwidth

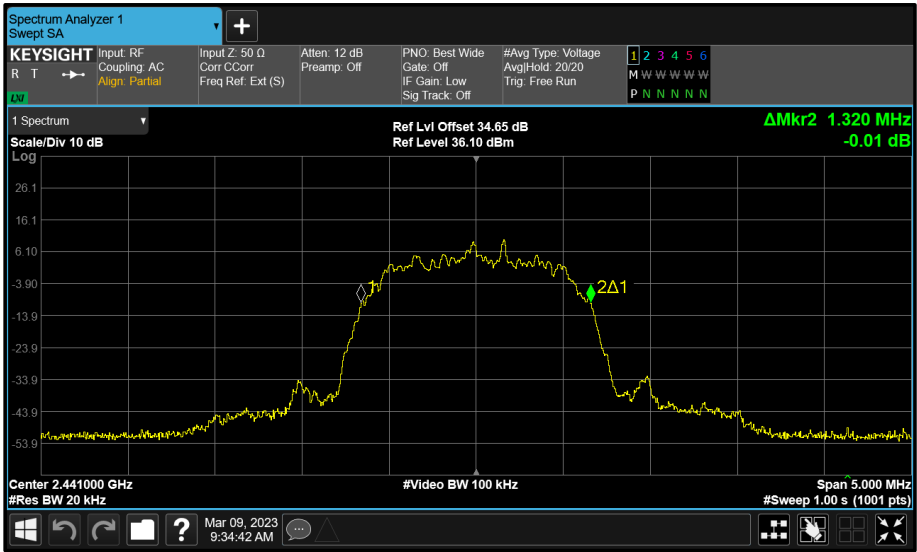


Figure 48 - Core 1 (C) 2441 MHz (CH39) 20 dB Bandwidth

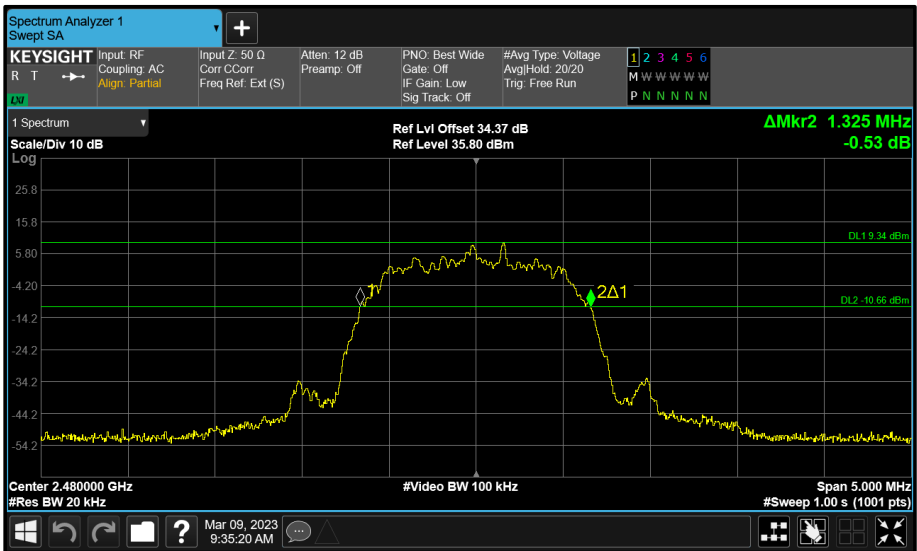


Figure 49 - Core 0 (B) 2480 MHz (CH78) 20 dB Bandwidth

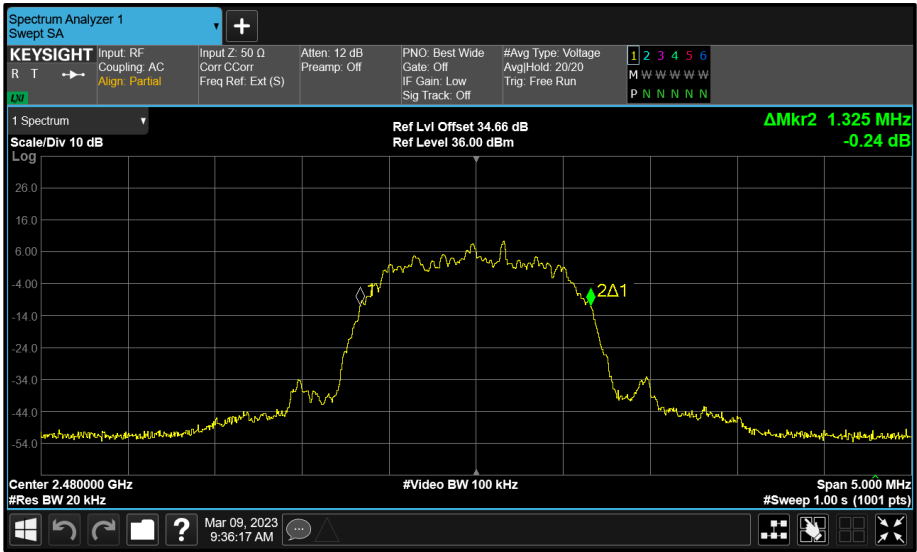
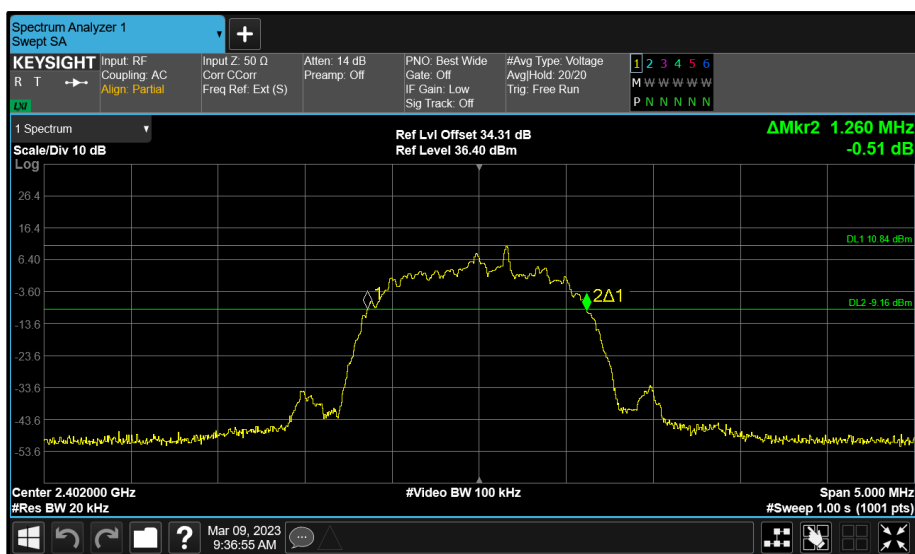


Figure 50 - Core 1 (C) 2480 MHz (CH78) 20 dB Bandwidth

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) |       |       |   |
|----------------------|-----------------------|-------|-------|---|
|                      | A                     | B     | C     | D |
| 2402                 | -                     | 1.260 | 1.260 | - |
| 2441                 | -                     | 1.260 | 1.255 | - |
| 2480                 | -                     | 1.260 | 1.260 | - |







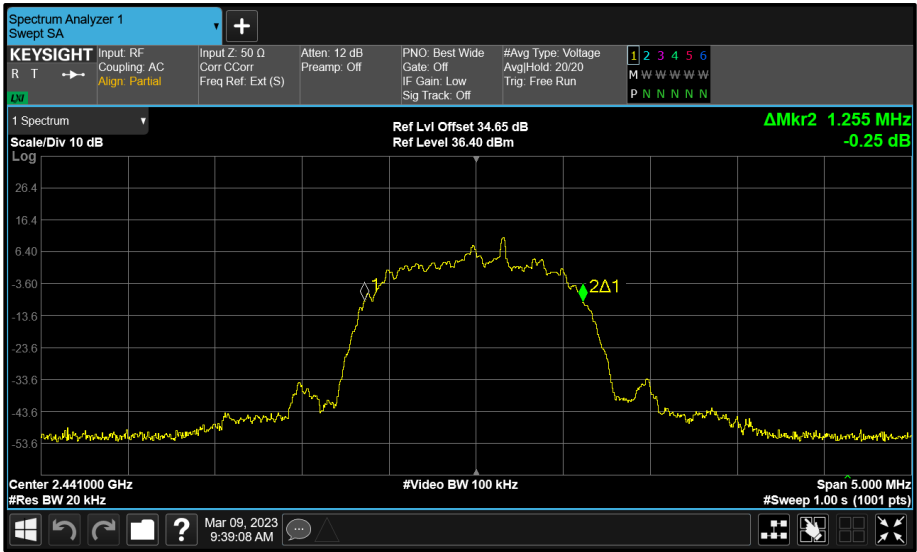


Figure 54 - Core 1 (C) 2441 MHz (CH39) 20 dB Bandwidth

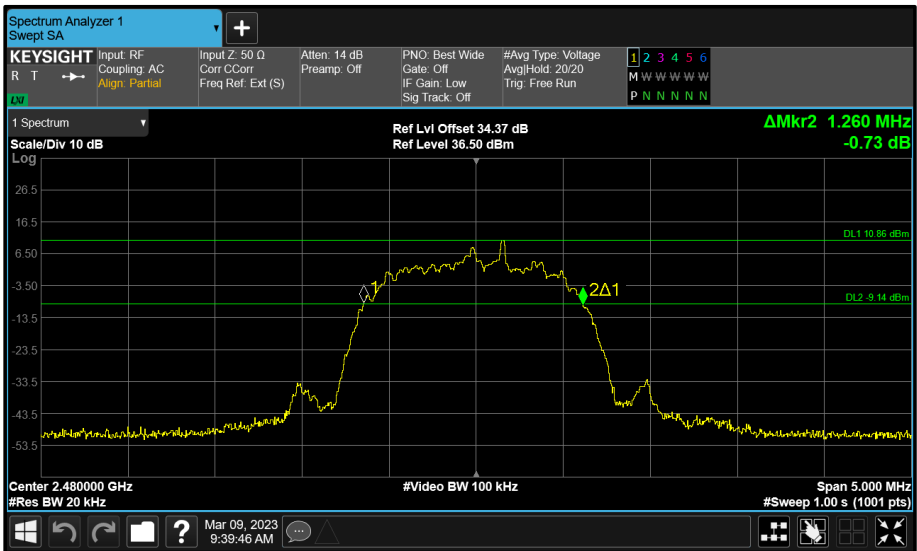


Figure 55 - Core 0 (B) 2480 MHz (CH78) 20 dB Bandwidth

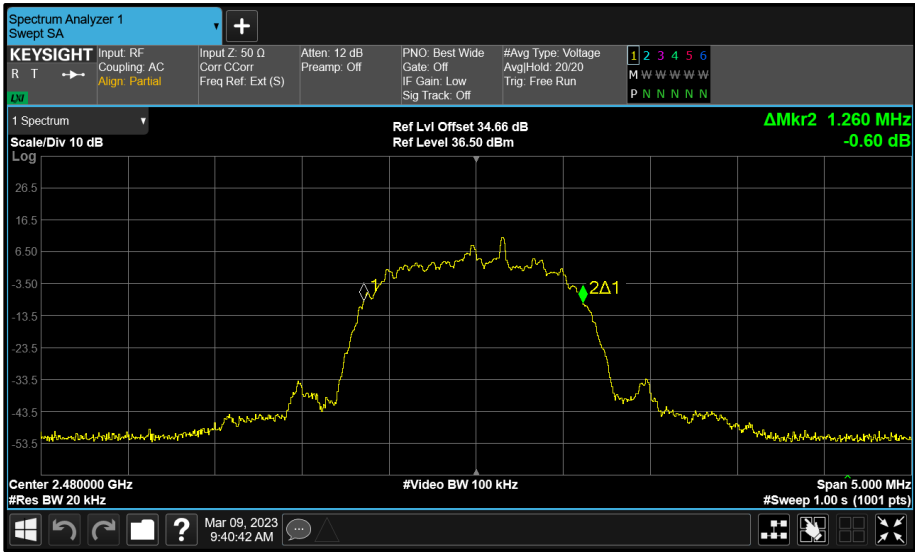


Figure 56 - Core 1 (C) 2480 MHz (CH78) 20 dB Bandwidth



| Test Configuration       |  |                                  |                 |              |
|--------------------------|--|----------------------------------|-----------------|--------------|
| Frequency Range:         |  | 2400-2483.5 MHz                  | Band:           | 2.4 GHz      |
| Limit Clause(s):         |  | FCC 15.247 (a)(1)<br>RSS-247 5.1 | Test Method(s): | C63.10 6.9.2 |
| Additional Reference(s): |  | -                                |                 |              |

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth (MHz) |       |   |   |
|-------------------------|-----------------------|-------|---|---|
|                         | A                     | B     | C | D |
| 2402                    | -                     | 0.855 | - | - |
| 2441                    | -                     | 0.858 | - | - |
| 2480                    | -                     | 0.855 | - | - |

Table 38 - 20 dB Bandwidth Results

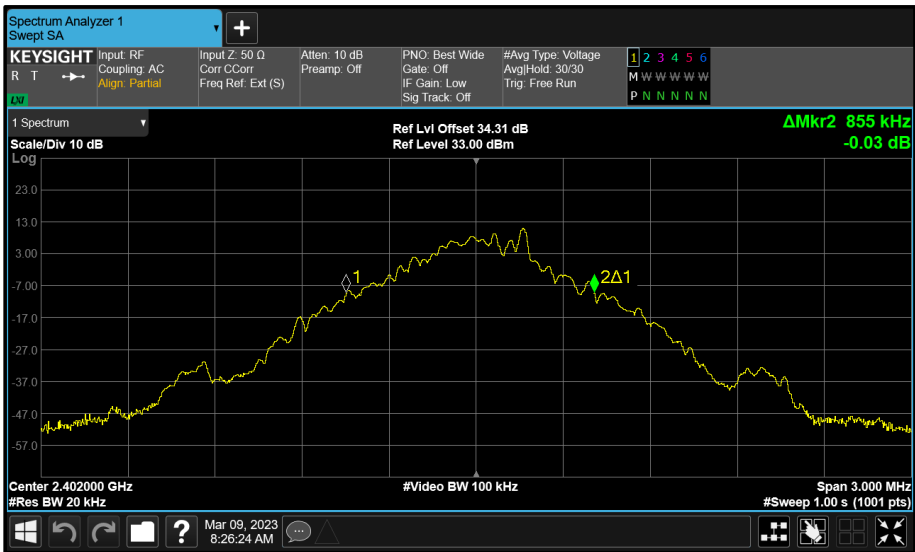


Figure 57 - Core 0 (B) 2402 MHz (CH0) 20 dB Bandwidth

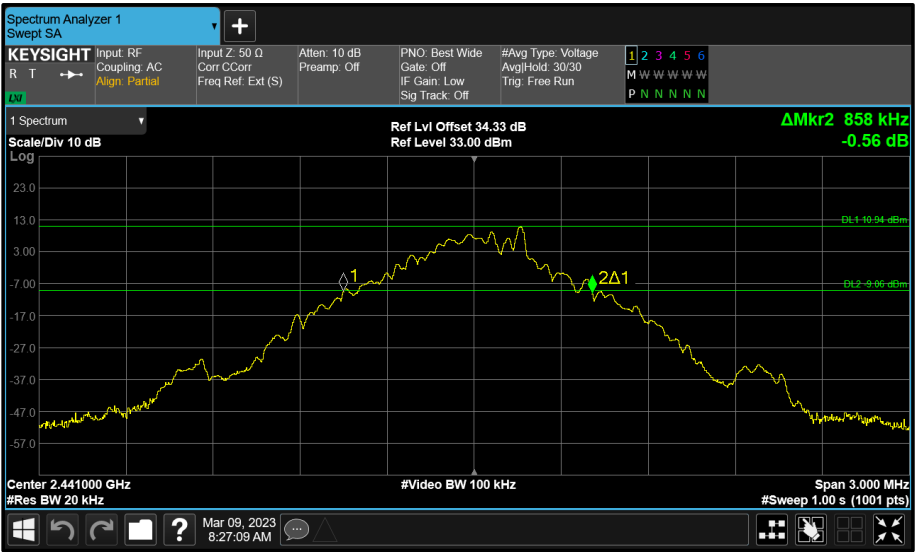


Figure 58 - Core 0 (B) 2441 MHz (CH39) 20 dB Bandwidth

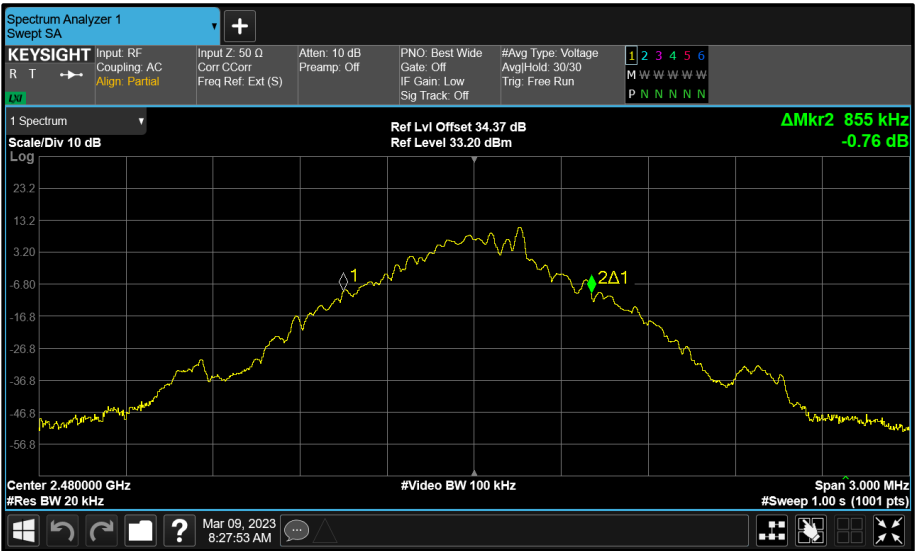


Figure 59 - Core 0 (B) 2480 MHz (CH78) 20 dB Bandwidth



| Test Configuration       |                                  |                 |              |
|--------------------------|----------------------------------|-----------------|--------------|
| Frequency Range:         | 2400-2483.5 MHz                  | Band:           | 2.4 GHz      |
| Limit Clause(s):         | FCC 15.247 (a)(1)<br>RSS-247 5.1 | Test Method(s): | C63.10 6.9.2 |
| Additional Reference(s): | -                                |                 |              |

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

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) |       |       |   |
|----------------------|-----------------------|-------|-------|---|
|                      | A                     | B     | C     | D |
| 2402                 | -                     | 0.855 | 0.855 | - |
| 2441                 | -                     | 0.855 | 0.855 | - |
| 2480                 | -                     | 0.855 | 0.855 | - |

Table 39 - 20 dB Bandwidth Results

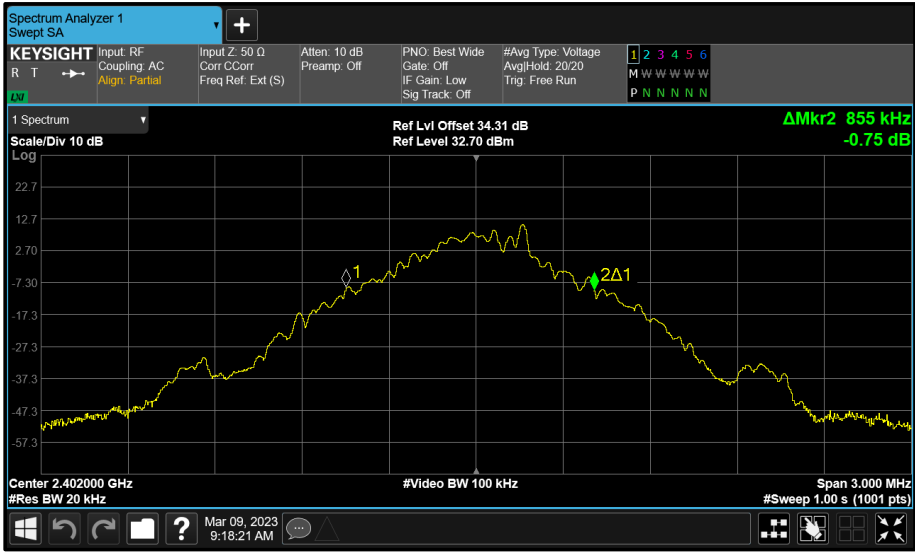


Figure 60 - Core 0 (B) 2402 MHz (CH0) 20 dB Bandwidth

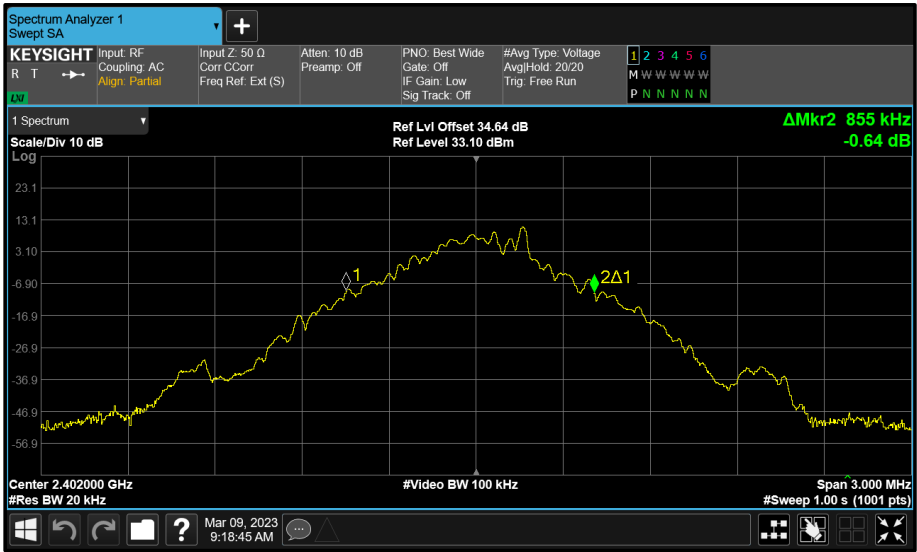


Figure 61 - Core 1 (C) 2402 MHz (CH0) 20 dB Bandwidth

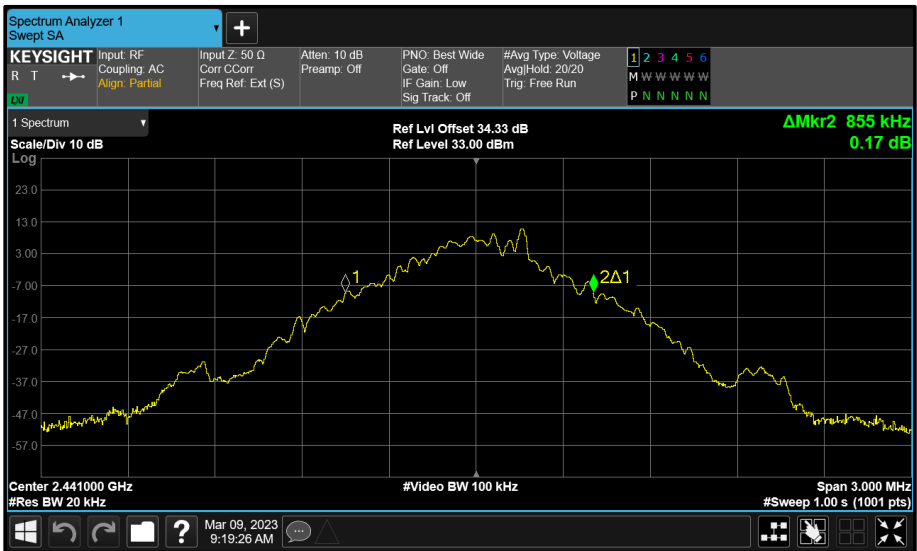


Figure 62 - Core 0 (B) 2441 MHz (CH39) 20 dB Bandwidth

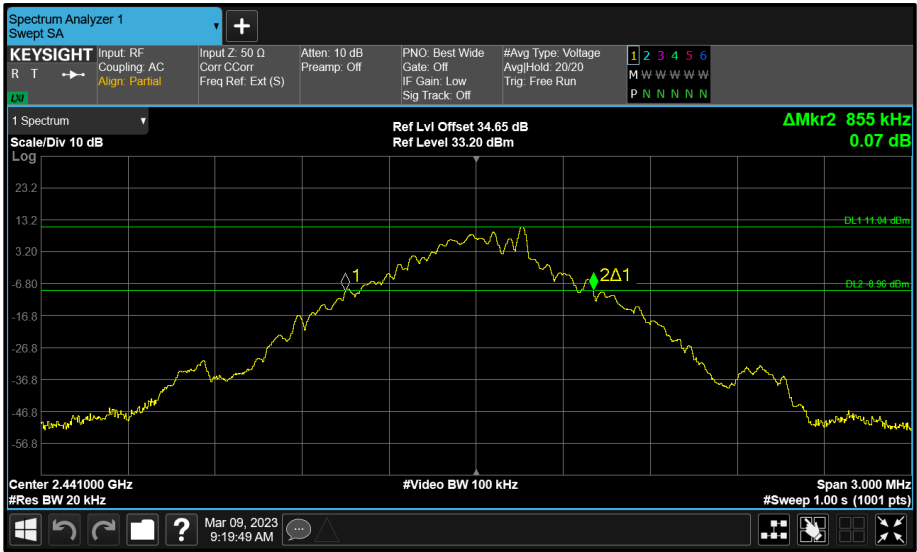


Figure 63 - Core 1 (C) 2441 MHz (CH39) 20 dB Bandwidth

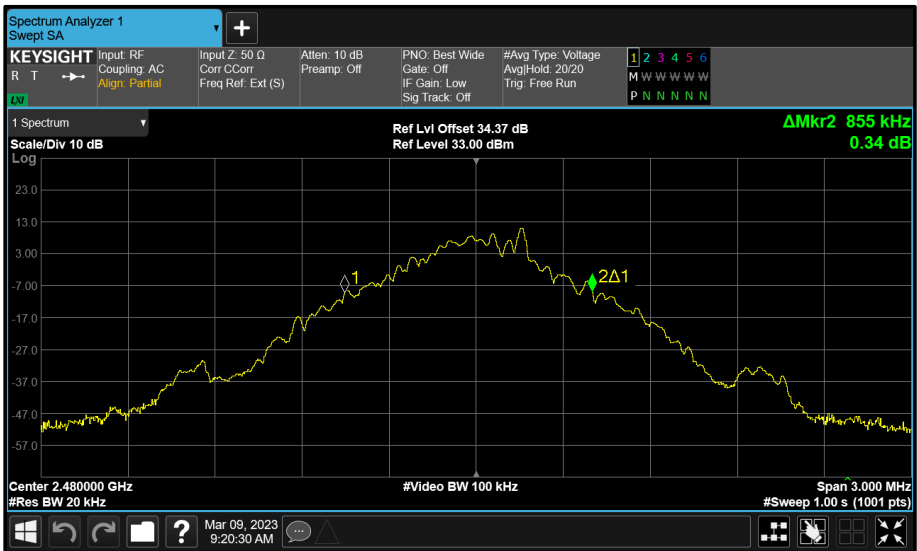


Figure 64 - Core 0 (B) 2480 MHz (CH78) 20 dB Bandwidth

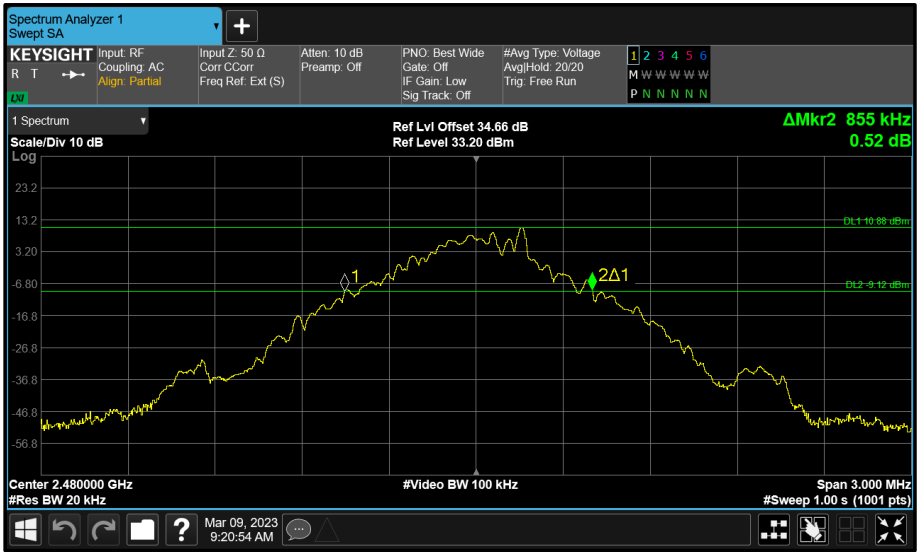


Figure 65 - Core 1 (C) 2480 MHz (CH78) 20 dB Bandwidth





| Test Configuration       |  |                                  |                 |              |
|--------------------------|--|----------------------------------|-----------------|--------------|
| Frequency Range:         |  | 2400-2483.5 MHz                  | Band:           | 2.4 GHz      |
| Limit Clause(s):         |  | FCC 15.247 (a)(1)<br>RSS-247 5.1 | Test Method(s): | C63.10 6.9.2 |
| Additional Reference(s): |  | -                                |                 |              |

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth (MHz) |       |   |   |
|-------------------------|-----------------------|-------|---|---|
|                         | A                     | B     | C | D |
| 2402                    | -                     | 1.330 | - | - |
| 2441                    | -                     | 1.325 | - | - |
| 2480                    | -                     | 1.330 | - | - |

Table 40 - 20 dB Bandwidth Results

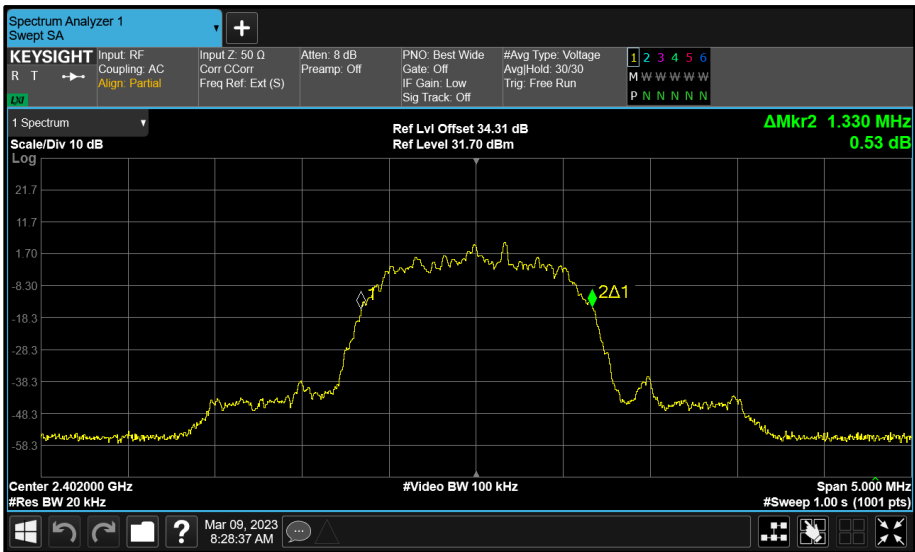


Figure 66 - Core 0 (B) 2402 MHz (CH0) 20 dB Bandwidth

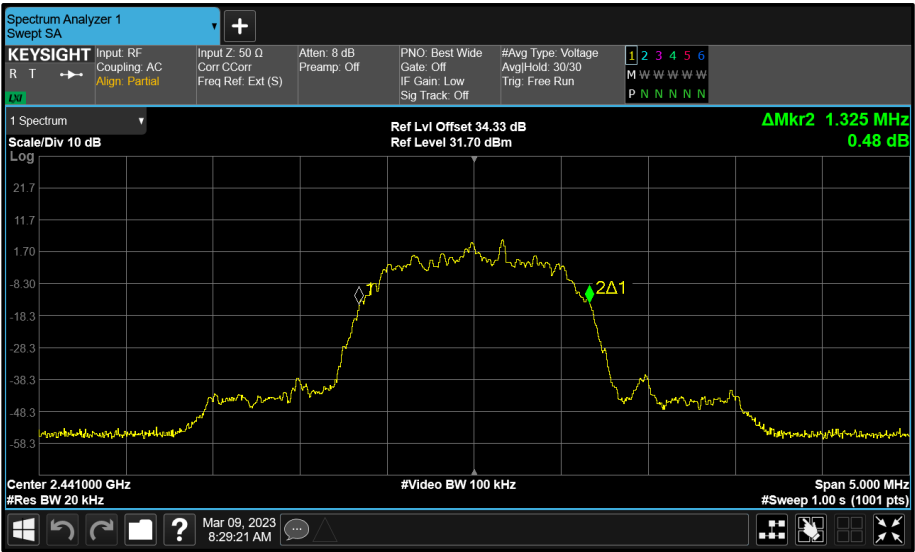


Figure 67 - Core 0 (B) 2441 MHz (CH39) 20 dB Bandwidth

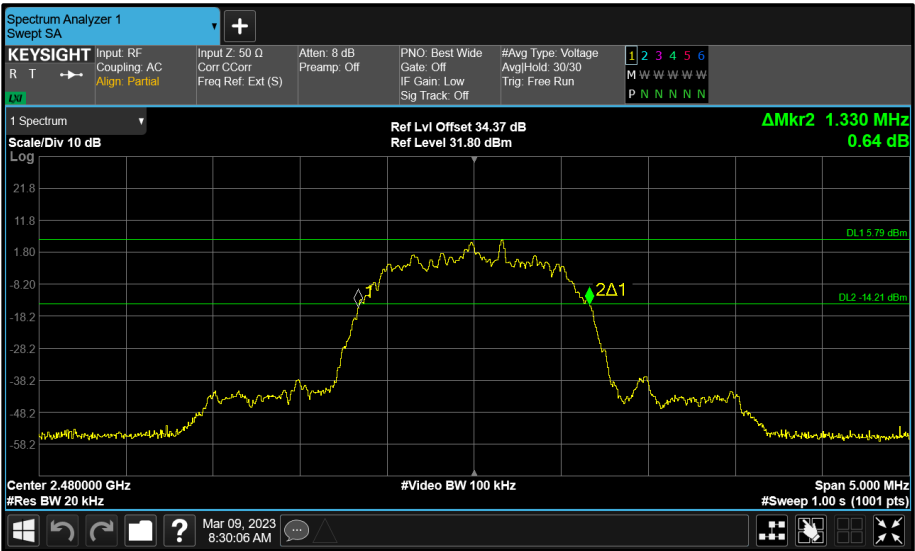


Figure 68 - Core 0 (B) 2480 MHz (CH78) 20 dB Bandwidth



| Test Configuration       |  |                                  |                 |              |
|--------------------------|--|----------------------------------|-----------------|--------------|
| Frequency Range:         |  | 2400-2483.5 MHz                  | Band:           | 2.4 GHz      |
| Limit Clause(s):         |  | FCC 15.247 (a)(1)<br>RSS-247 5.1 | Test Method(s): | C63.10 6.9.2 |
| Additional Reference(s): |  | -                                |                 |              |

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth (MHz) |       |   |   |
|-------------------------|-----------------------|-------|---|---|
|                         | A                     | B     | C | D |
| 2402                    | -                     | 1.260 | - | - |
| 2441                    | -                     | 1.260 | - | - |
| 2480                    | -                     | 1.260 | - | - |

Table 41 - 20 dB Bandwidth Results

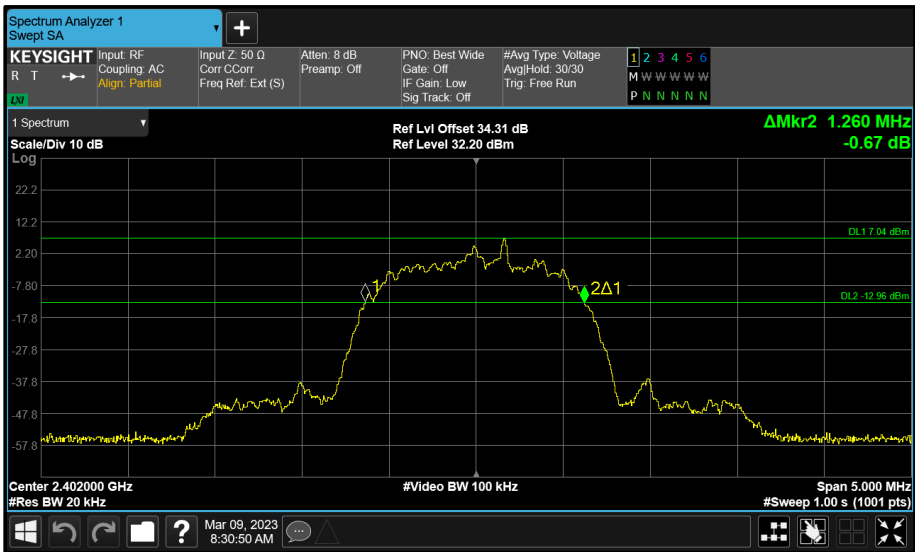


Figure 69 - Core 0 (B) 2402 MHz (CH0) 20 dB Bandwidth

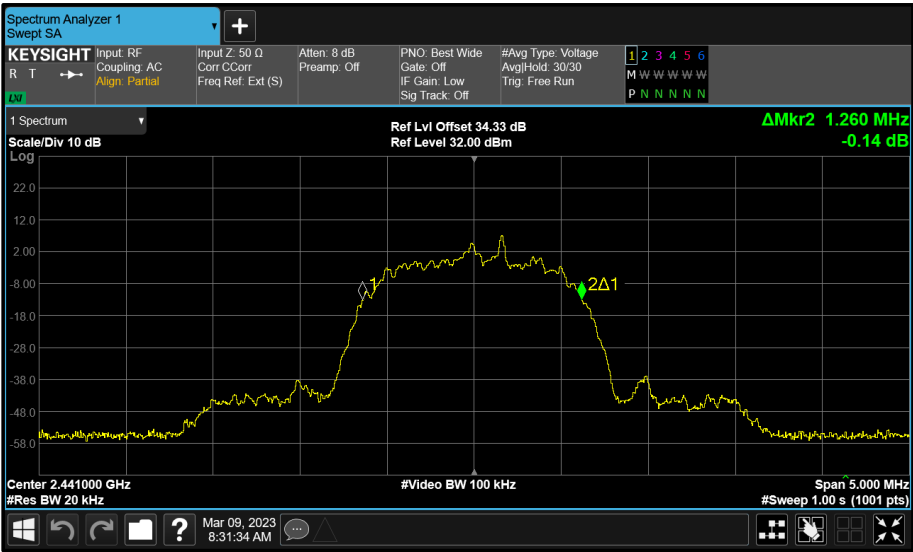


Figure 70 - Core 0 (B) 2441 MHz (CH39) 20 dB Bandwidth

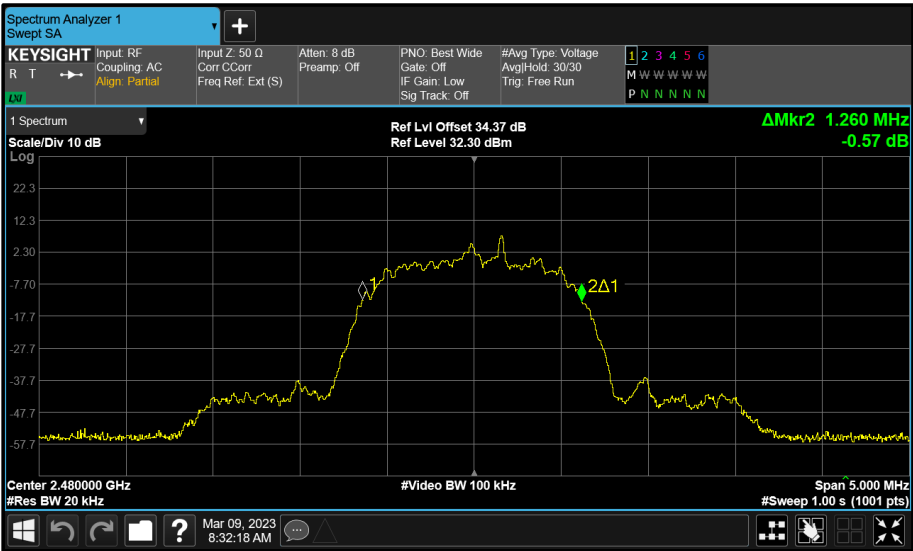


Figure 71 - Core 0 (B) 2480 MHz (CH78) 20 dB Bandwidth



| Test Configuration       |  |                                  |                 |              |
|--------------------------|--|----------------------------------|-----------------|--------------|
| Frequency Range:         |  | 2400-2483.5 MHz                  | Band:           | 2.4 GHz      |
| Limit Clause(s):         |  | FCC 15.247 (a)(1)<br>RSS-247 5.1 | Test Method(s): | C63.10 6.9.2 |
| Additional Reference(s): |  | -                                |                 |              |

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth (MHz) |       |       |   |
|-------------------------|-----------------------|-------|-------|---|
|                         | A                     | B     | C     | D |
| 2402                    | -                     | 1.330 | 1.330 | - |
| 2441                    | -                     | 1.325 | 1.325 | - |
| 2480                    | -                     | 1.330 | 1.330 | - |

Table 42 - 20 dB Bandwidth Results

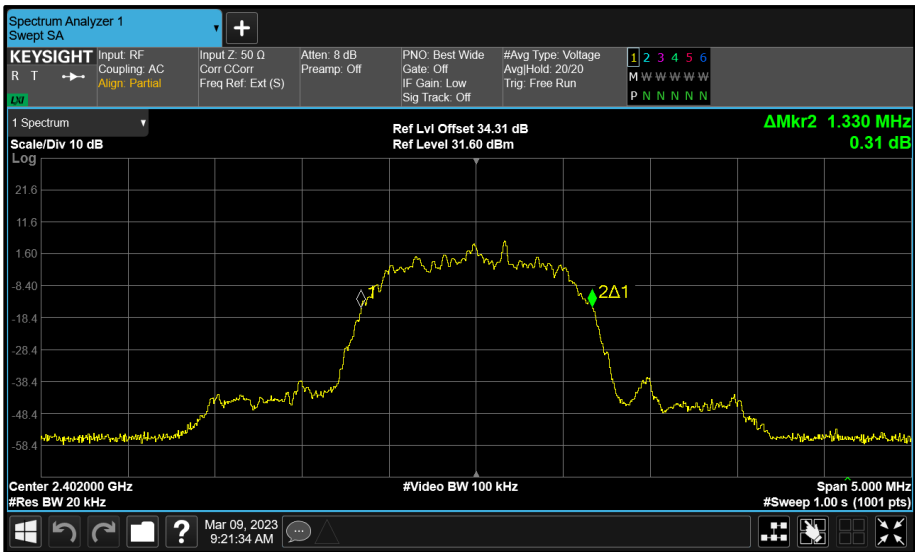


Figure 72 - Core 0 (B) 2402 MHz (CH0) 20 dB Bandwidth

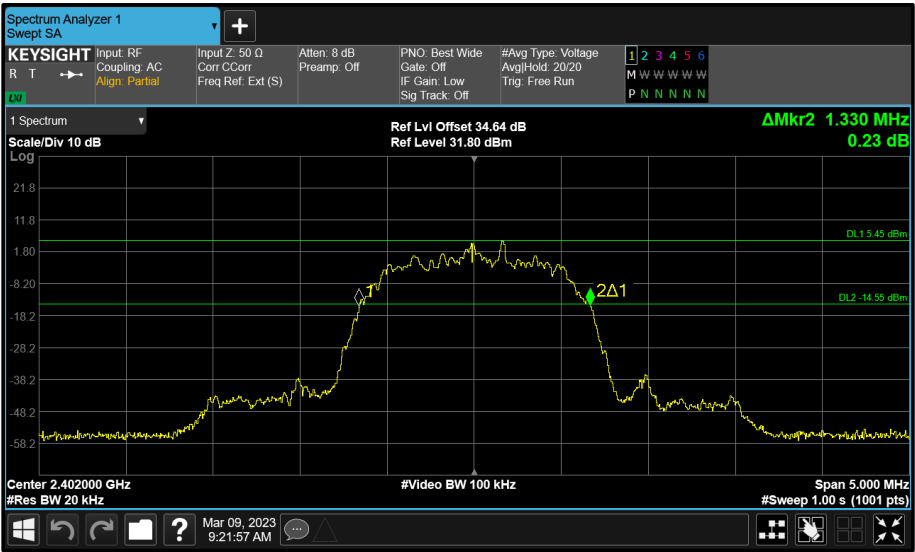


Figure 73 - Core 1 (C) 2402 MHz (CH0) 20 dB Bandwidth

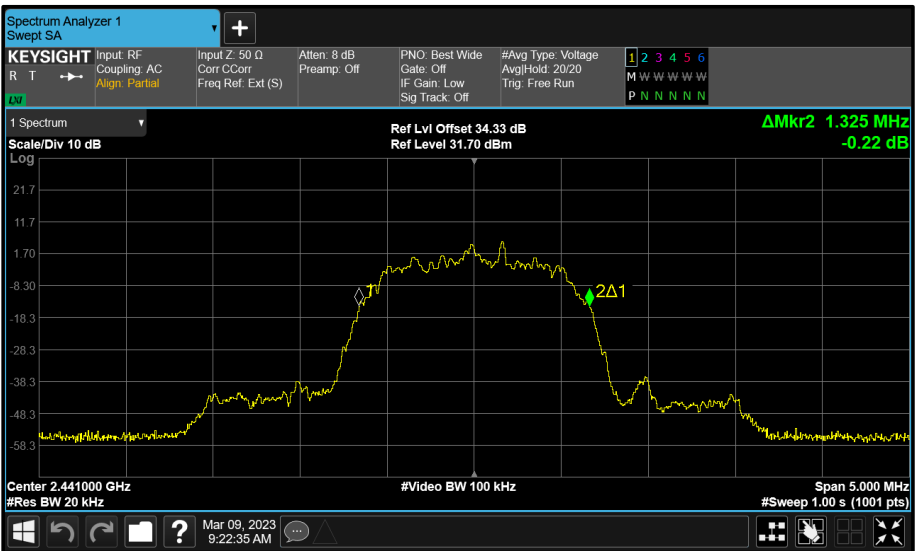


Figure 74 - Core 0 (B) 2441 MHz (CH39) 20 dB Bandwidth

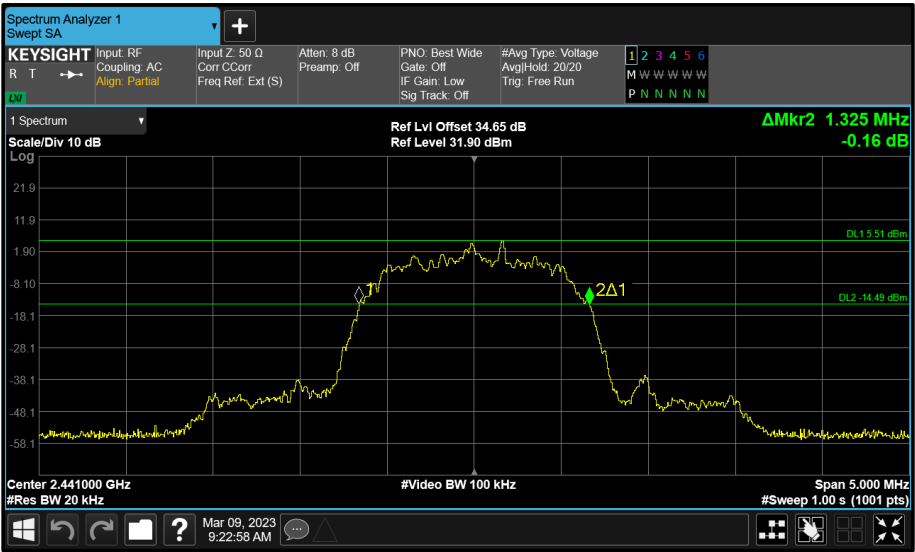


Figure 75 - Core 1 (C) 2441 MHz (CH39) 20 dB Bandwidth

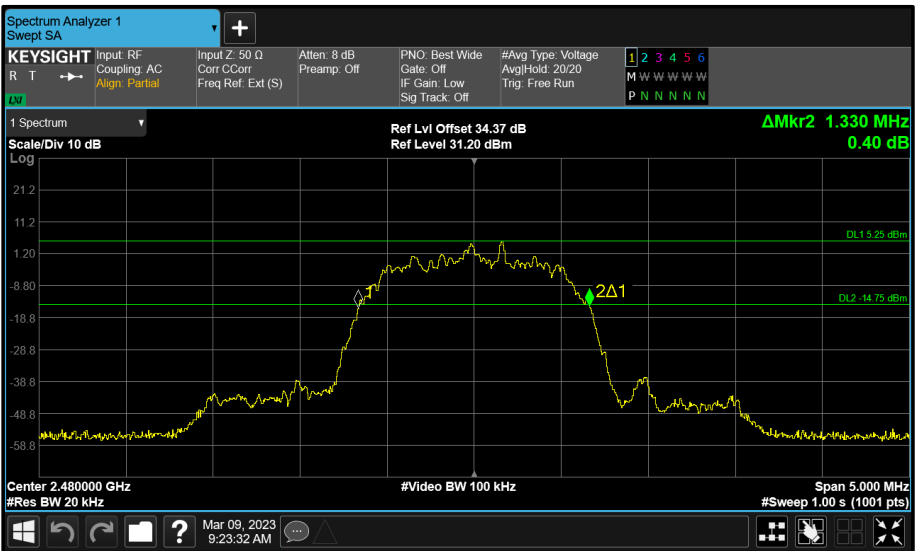


Figure 76 - Core 0 (B) 2480 MHz (CH78) 20 dB Bandwidth







| Test Configuration       |  |                                  |                 |              |
|--------------------------|--|----------------------------------|-----------------|--------------|
| Frequency Range:         |  | 2400-2483.5 MHz                  | Band:           | 2.4 GHz      |
| Limit Clause(s):         |  | FCC 15.247 (a)(1)<br>RSS-247 5.1 | Test Method(s): | C63.10 6.9.2 |
| Additional Reference(s): |  | -                                |                 |              |

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

| Test Frequency<br>(MHz) | 20 dB Bandwidth (MHz) |       |       |   |
|-------------------------|-----------------------|-------|-------|---|
|                         | A                     | B     | C     | D |
| 2402                    | -                     | 1.260 | 1.260 | - |
| 2441                    | -                     | 1.260 | 1.260 | - |
| 2480                    | -                     | 1.265 | 1.265 | - |

Table 43 - 20 dB Bandwidth Results

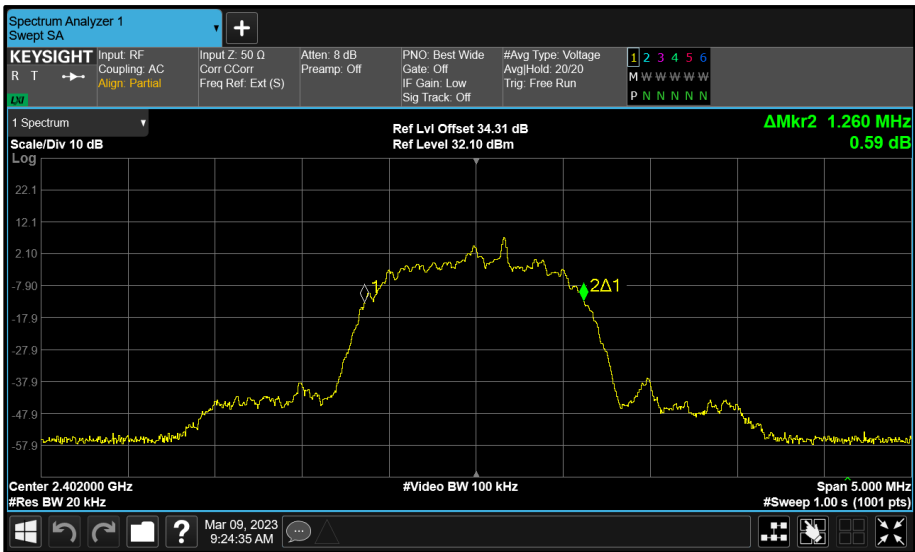


Figure 78 - Core 0 (B) 2402 MHz (CH0) 20 dB Bandwidth

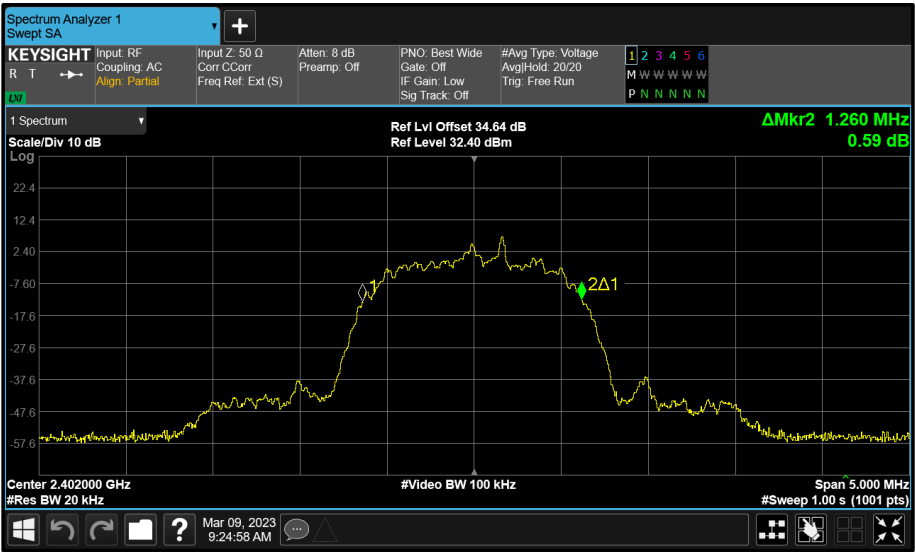


Figure 79 - Core 1 (C) 2402 MHz (CH0) 20 dB Bandwidth

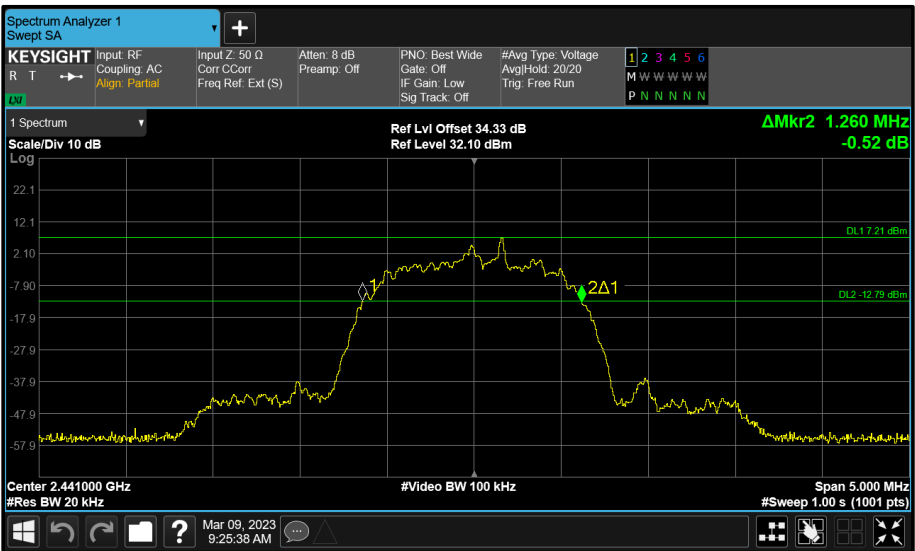


Figure 80 - Core 0 (B) 2441 MHz (CH39) 20 dB Bandwidth

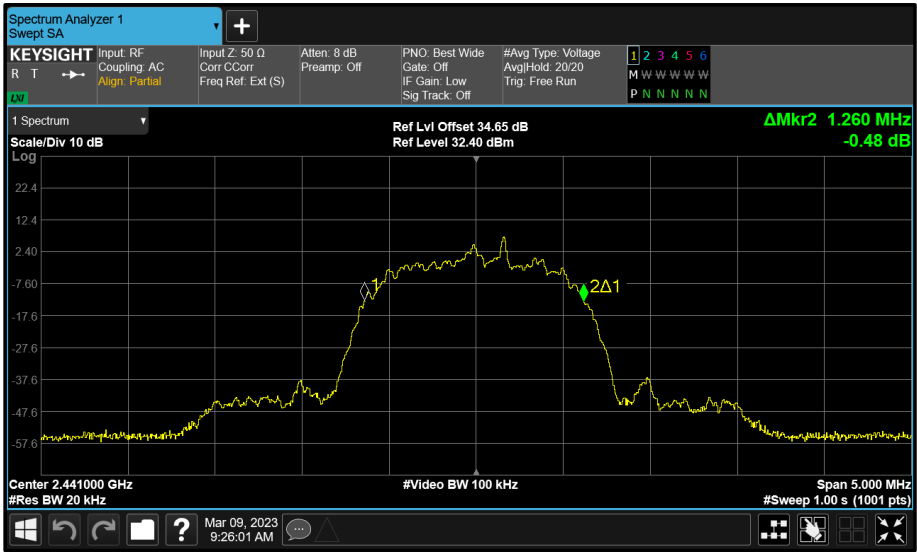


Figure 81 - Core 1 (C) 2441 MHz (CH39) 20 dB Bandwidth

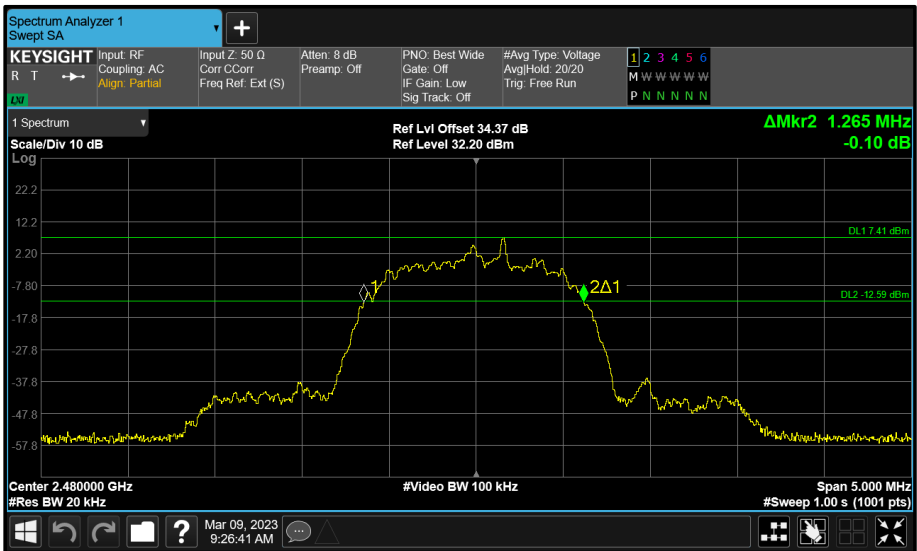


Figure 82 - Core 0 (B) 2480 MHz (CH78) 20 dB Bandwidth

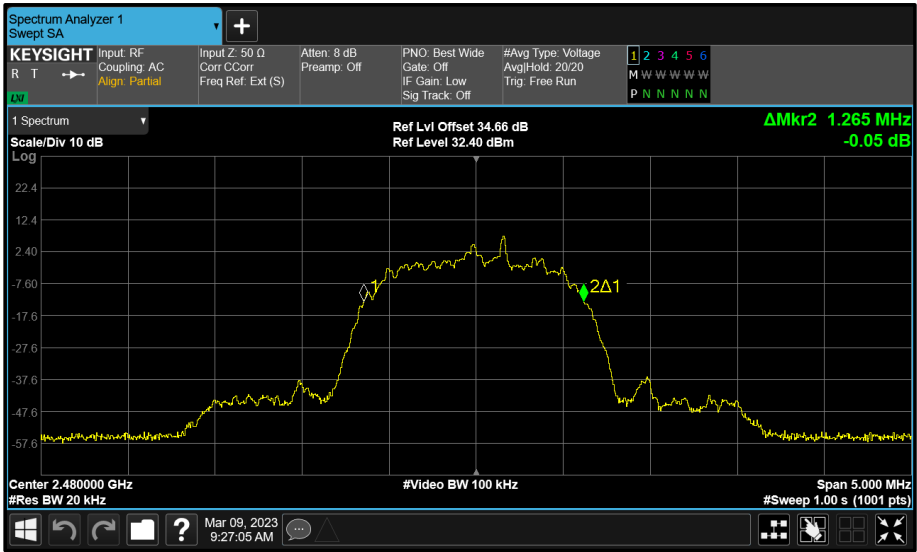


Figure 83 - Core 1 (C) 2480 MHz (CH78) 20 dB Bandwidth

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

None specified.

**2.5.7 Test Location and Test Equipment Used**

This test was carried out in RF Laboratory 14.

| Instrument                   | Manufacturer          | Type No         | TE No | Calibration Period (months) | Calibration Expires |
|------------------------------|-----------------------|-----------------|-------|-----------------------------|---------------------|
| Hygrometer                   | Rotronic              | I-1000          | 3068  | 12                          | 21-Sep-2023         |
| Multi-GNSS Simulator (GPS)   | Spirent               | GSS6700         | 4596  | 12                          | 22-Aug-2023         |
| AC Programmable Power Supply | iTech                 | IT7324          | 5225  | -                           | O/P Mon             |
| MXA Signal Analyser          | Keysight Technologies | N9020B          | 5529  | 24                          | 13-Dec-2024         |
| Signal Conditioning Unit     | TUV SUD               | SPECTRUM SCU001 | 5546  | 12                          | 06-Apr-2023         |
| Digital Multimeter           | Fluke                 | 115             | 6147  | 12                          | 16-Jun-2023         |

Table 44

O/P Mon – Output Monitored using calibrated equipment