

# FCC and ISED Test Report

Apple Inc  
Model: A2780

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

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

FCC ID: BCGA2780      IC: 579C-A2780



Add value.  
Inspire trust.

## COMMERCIAL-IN-CONFIDENCE

Document 75955429-12 Issue 01

### SIGNATURE

A handwritten signature of Steve Marshall.

| NAME           | JOB TITLE       | RESPONSIBLE FOR      | ISSUE DATE       |
|----------------|-----------------|----------------------|------------------|
| Steve Marshall | Senior Engineer | Authorised Signatory | 18 November 2022 |

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD document control rules.

### ENGINEERING STATEMENT

The measurements shown in this report were made in accordance with the procedures described on test pages. All reported testing was carried out on a sample equipment to demonstrate limited compliance with FCC 47 CFR Part 15C, ISED RSS-247 and ISED RSS-GEN. The sample tested was found to comply with the requirements defined in the applied rules.

| RESPONSIBLE FOR   | NAME           | DATE             | SIGNATURE                                  |
|-------------------|----------------|------------------|--|
| Report Generation | Lauren Walters | 18 November 2022 | A handwritten signature of Lauren Walters. |

FCC Accreditation  
90987 Octagon House, Fareham Test Laboratory      ISED Accreditation  
12669A Octagon House, Fareham Test Laboratory

### EXECUTIVE SUMMARY

A sample of this product was tested and found to be compliant with FCC 47 CFR Part 15C: 2020, ISED RSS-247: Issue 2 (02-2017) and ISED RSS-GEN: Issue 5 (04-2018) + A2 (02-2021) for the tests detailed in section 1.3.



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### ACCREDITATION

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

TUV SUD Ltd is a  
TÜV SÜD Group Company

Phone: +44 (0) 1489 558100  
Fax: +44 (0) 1489 558101  
[www.tuvsud.com/en](http://www.tuvsud.com/en)

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

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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           | 18-November-2022 |

**Table 1**

### 1.2 Introduction

|                               |  |
|-------------------------------|--|
| Applicant                     | Apple Inc  |
| Manufacturer                  | Apple Inc  |
| Model Number(s)               | A2780  |
| Serial Number(s)              | FWC3JLYYHC and NW3J007K67  |
| Hardware Version(s)           | REV 1.0  |
| Software Version(s)           | 22A31991j and 22A42770m  |
| Number of Samples Tested      | 2  |
| Test Specification/Issue/Date | FCC 47 CFR Part 15C: 2020<br>ISED RSS-247: Issue 2 (02-2017)<br>ISED RSS-GEN: Issue 5 (04-2018) + A2 (02-2021) |
| Order Number                  | 0540246998   |
| Start of Test                 | 10-August-2022   |
| Finish of Test                | 01-November-2022   |
| Name of Engineer(s)           | Faisal Malyar, Thomas Biddlecombe, Elliot Callender, Ioan-Alexandru Bogatu and Nicolae Mihailiuc               |
| Related Document(s)           | ANSI C63.10 (2013)<br>ANSI C63.10 (2020)<br>ANSI C63.4 (2014)<br>KDB 662911 D01 v02r01                         |



### 1.3 Brief Summary of Results

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

| Section  | Specification Clause  |             |              | Test Description                                       | Result | Comments/Base Standard  |
|--|-----------------------|-------------|--------------|--|--------|---|
|  | Part 15C              | RSS-247     | RSS-GEN      |  |        |   |
| Configuration and Mode: 2.4 GHz Bluetooth - FHSS |                       |             |              |  |        |   |
| -  | 15.203                | -           | -            | Antenna Requirement                                    | N/T    | The device complies with the provisions of this section, as it uses permanently attached integral antennas. |
| 2.1  | 15.205                | 3.1         | 8.10         | Restricted Band Edges                                  | Pass   |   |
| 2.2  | 15.247 (a)(1)         | 5.1         | -            | Frequency Hopping Systems - Average Time of Occupancy  | Pass   |   |
| 2.3  | 15.247 (a)(1)         | 5.1         | -            | Frequency Hopping Systems - Channel Separation         | Pass   |   |
| 2.4  | 15.247 (a)(1)         | 5.1         | -            | Frequency Hopping Systems - Number of Hopping Channels | Pass   |   |
| 2.5  | 15.247 (a)(1)         | 5.1         | 6.7          | Frequency Hopping Systems - 20 dB Bandwidth            | Pass   |   |
| 2.6  | 15.247 (b)            | 5.4         | 6.12         | Maximum Conducted Output Power                         | Pass   |   |
| 2.7  | 15.247 (d) and 15.209 | 3.3 and 5.5 | 6.13 and 8.9 | Spurious Radiated Emissions                            | Pass   |   |
| 2.8  | 15.247 (d)            | 5.5         | -            | Authorised Band Edges                                  | Pass   |   |

Table 2



## 1.4 Product Information

### 1.4.1 Technical Description

The equipment under test was an Apple laptop computer with Bluetooth® and IEEE 802.11 a/b/g/n/ac/ax Wi-Fi capabilities in the 2.4GHz, 5GHz and 6GHz 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.

For tests in SISO operation, conducted tests were performed on the BT Dedicated Core (BT Core 2) as well as the Core from the main radio with the highest antenna gain as Core 0 and Core 1 are identical but with unequal antenna gains.

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  
BT Core 2 (SISO) – iPA BDR/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          | 4.60            | 0.70                      |
| BT Core 1    | 2400 to 2480          | 6.13            | 0.70                      |
| BT Core 2    | 2400 to 2480          | 6.02            | 0.70                      |

**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: A2780, Serial Number: NW3J007K67 |   |                        |                          |
| 0                                       | As supplied by the customer                     | Not Applicable         | Not Applicable           |
| Model: A2780, Serial Number: FWC3JLYYHC |   |                        |                          |
| 0                                       | As supplied by the customer                     | Not Applicable         | Not Applicable           |

**Table 4**



## 1.7 Test Location

TÜV SÜD conducted the following tests at our Octagon House Test Laboratory.

| Test Name  | Name of Engineer(s) | Accreditation |
|--|---------------------|---------------|
| Configuration and Mode: 2.4 GHz Bluetooth - FHSS       |                     |               |
| 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          |

**Table 5**

Office Address:

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

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                            | Faisal Malyar, Nicolae Mihailiuc and Elliot Callender | UKAS          |
| Spurious Radiated Emissions                      | Ioan-Alexandru Bogatu and Nicolae Mihailiuc           | UKAS          |
| Authorised Band Edges                            | Nicolae Mihailiuc, Elliot Callender and Faisal Malyar | UKAS          |

**Table 6**

Office Address:

TÜV SÜD  
Concorde Park  
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 3.1  
ISED RSS-GEN, Clause 8.10

#### 2.1.2 Equipment Under Test and Modification State

A2780, S/N: FWC3JLYYHC - Modification State 0

#### 2.1.3 Date of Test

10-August-2022 to 11-August-2022

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

The following conversion can be applied to convert from dB $\mu$ V/m to  $\mu$ V/m:

$10^{(Field\ Strength\ in\ dB\mu V/m/20)}$ .

#### 2.1.5 Environmental Conditions

Ambient Temperature 22.5 - 22.9 °C

Relative Humidity 42.4 - 65.3 %

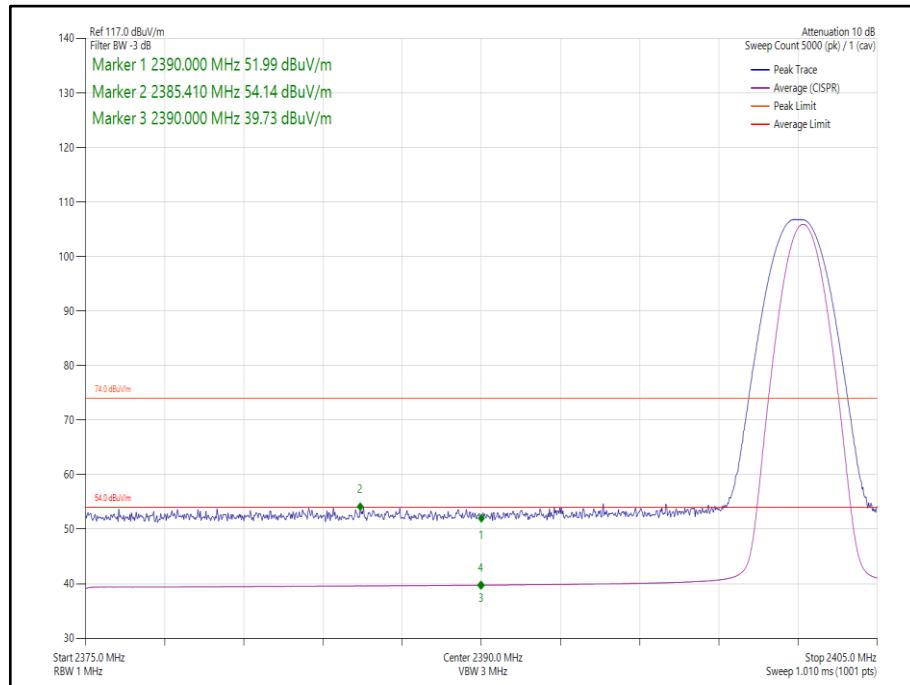
## 2.1.6 Test Results

### 2.4 GHz Bluetooth - FHSS

iPA

| Mode   | Modulation    | Core | Packet Type | Tx Frequency (MHz) | Band Edge Frequency (MHz) | Peak Level (dB $\mu$ V/m) | Average Level (dB $\mu$ V/m) |
|--------|---------------|------|-------------|--------------------|---------------------------|---------------------------|------------------------------|
| Static | GFSK          | 1    | DH5         | 2402               | 2390.0                    | 54.14                     | 39.73                        |
| Static | $\pi/4$ DQPSK | 1    | 2-DH5       | 2402               | 2390.0                    | 54.47                     | 39.62                        |
| Static | 8-DPSK        | 1    | 3-DH5       | 2402               | 2390.0                    | 54.34                     | 39.61                        |
| Static | GFSK          | 1    | DH5         | 2480               | 2483.5                    | 53.95                     | 40.92                        |
| Static | $\pi/4$ DQPSK | 1    | 2-DH5       | 2480               | 2483.5                    | 60.88                     | 47.28                        |
| Static | 8-DPSK        | 1    | 3-DH5       | 2480               | 2483.5                    | 61.11                     | 47.20                        |

**Table 7 - Restricted Band Edge Results**



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

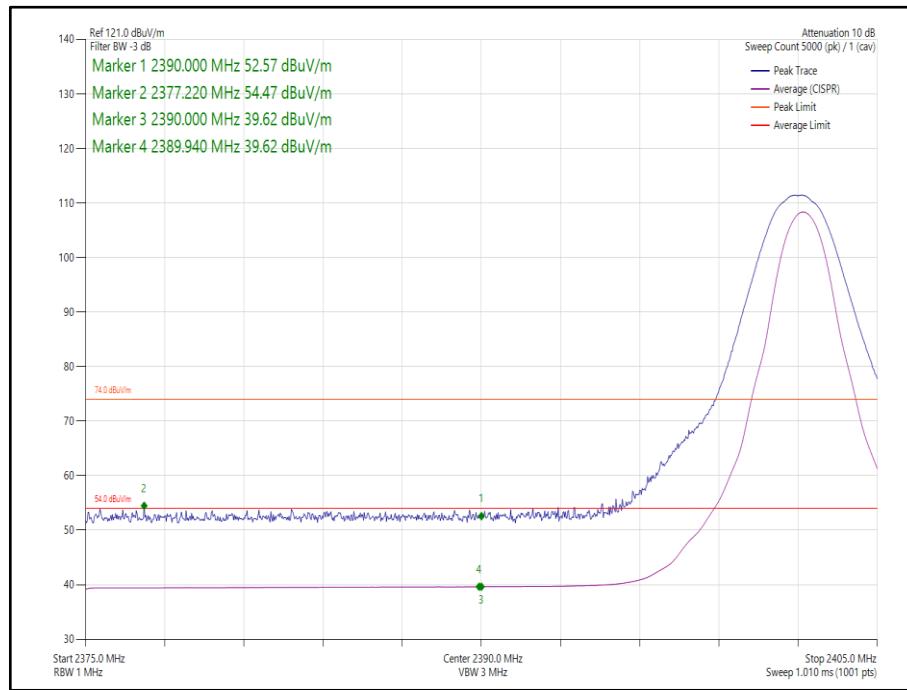


Figure 2 - Static -  $\pi/4$  DQPSK/2-DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

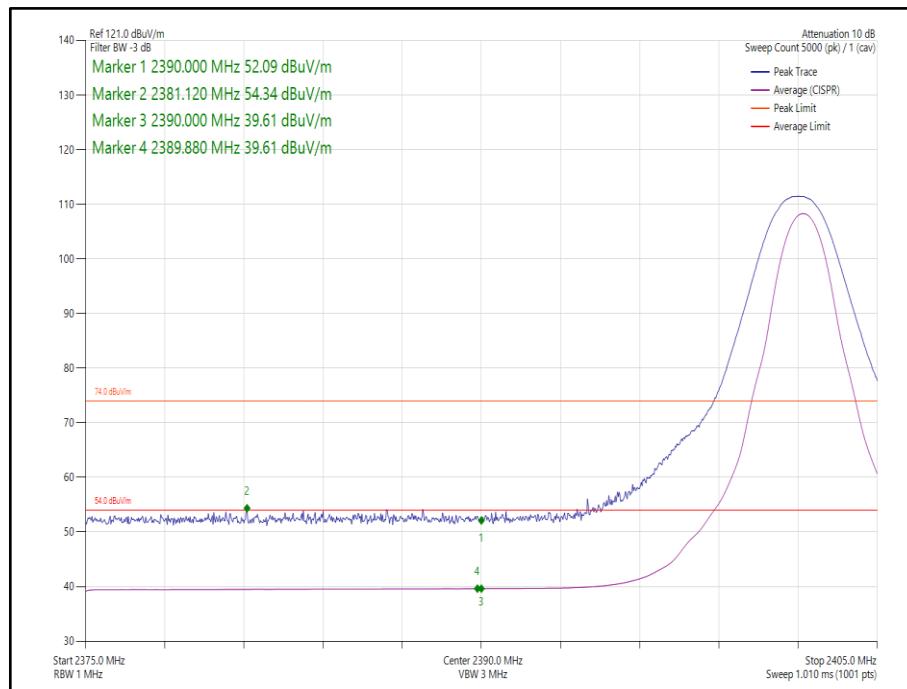


Figure 3 - Static - 8-DPSK/3-DH5 - 2402 MHz Band Edge Frequency 2390.0 MHz

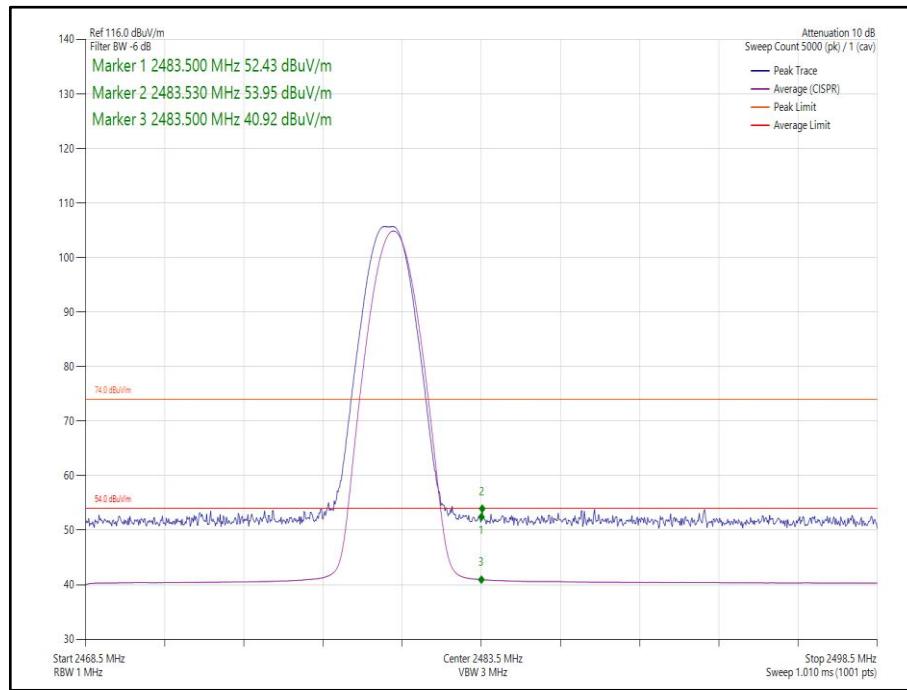


Figure 4 - Static - GFSK/DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

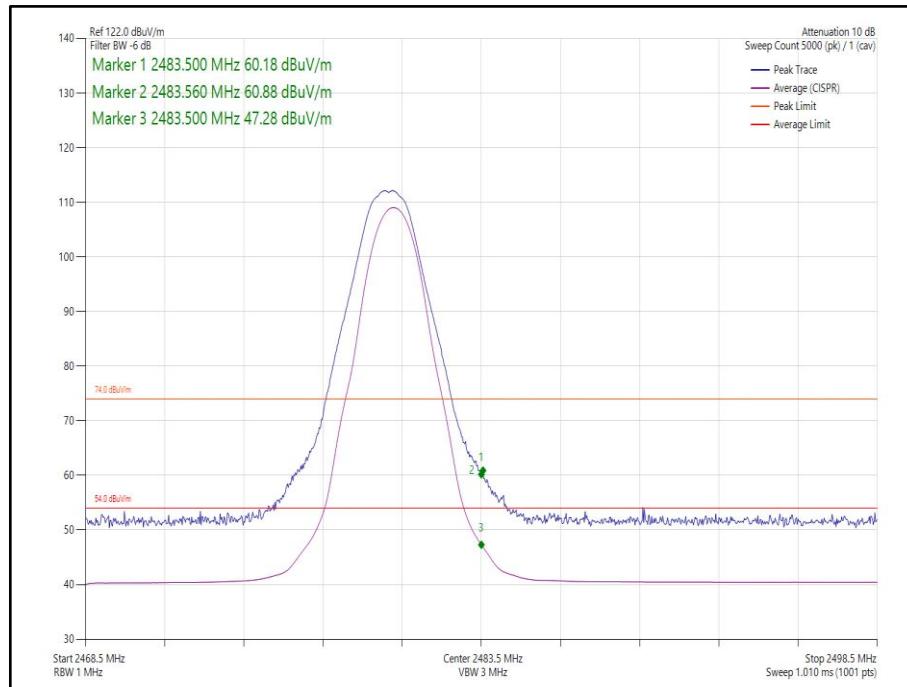
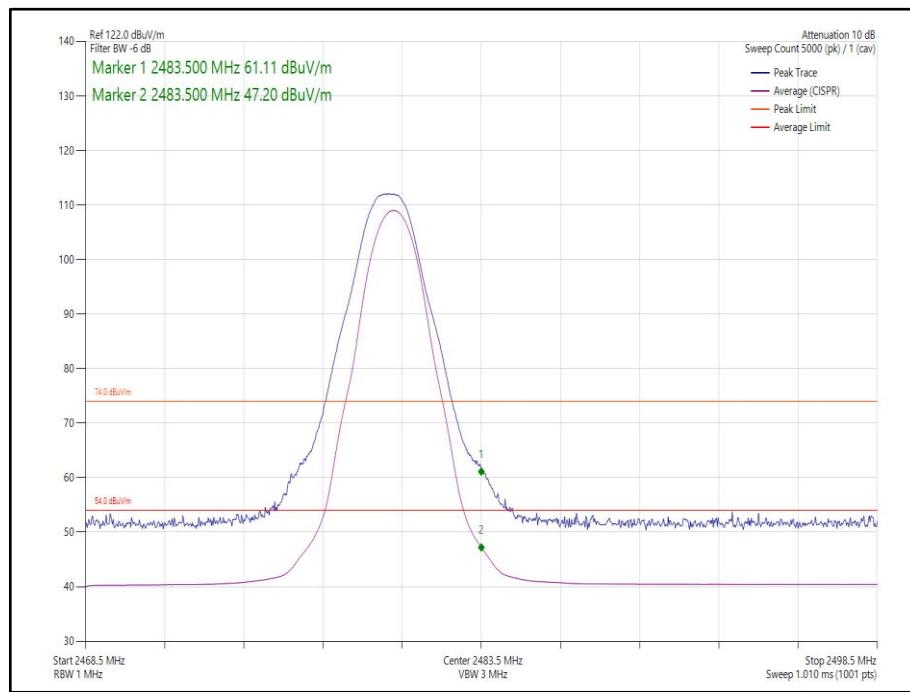


Figure 5 - Static -  $\pi/4$  DQPSK/2-DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz



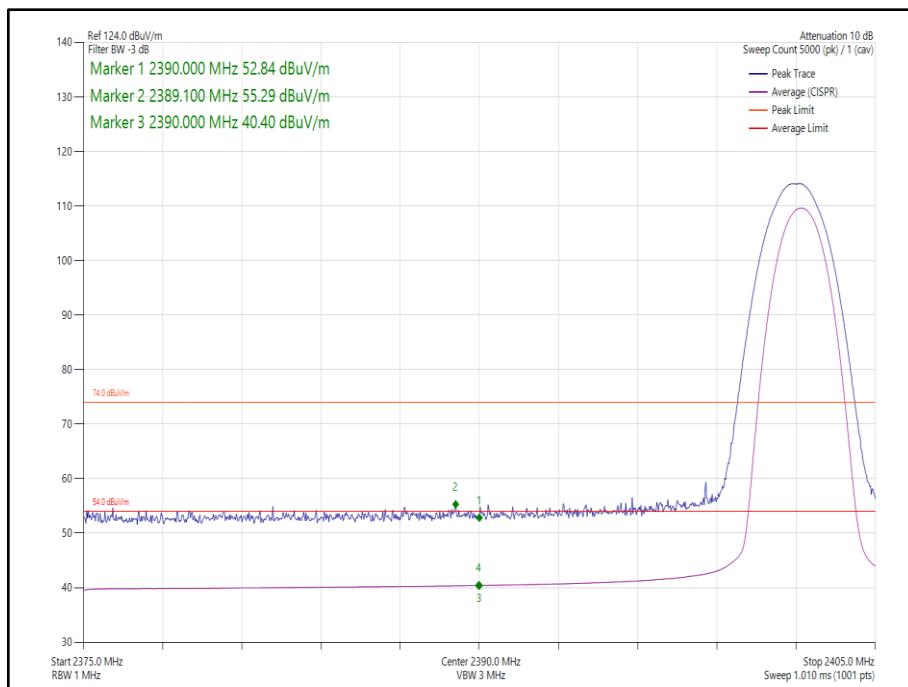
**Figure 6 - Static - 8-DPSK/3-DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz**

#### 2.4 GHz Bluetooth (FHSS)

##### ePA

| Mode   | Modulation    | Core | Packet Type | Tx Frequency (MHz) | Band Edge Frequency (MHz) | Peak Level (dB $\mu$ V/m) | Average Level (dB $\mu$ V/m) |
|--------|---------------|------|-------------|--------------------|---------------------------|---------------------------|------------------------------|
| Static | $\pi/4$ DQPSK | 1    | 2-DH5       | 2402               | 2390.0                    | 55.29                     | 40.40                        |
| Static | 8-DPSK        | 1    | 3-DH5       | 2402               | 2390.0                    | 55.26                     | 40.50                        |
| Static | $\pi/4$ DQPSK | 1    | 2-DH5       | 2480               | 2483.5                    | 54.95                     | 42.82                        |
| Static | 8-DPSK        | 1    | 3-DH5       | 2480               | 2483.5                    | 55.50                     | 42.99                        |

**Table 8 - Restricted Band Edge Results**



**Figure 7 - Static -  $\pi/4$  DQPSK/2-DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz**

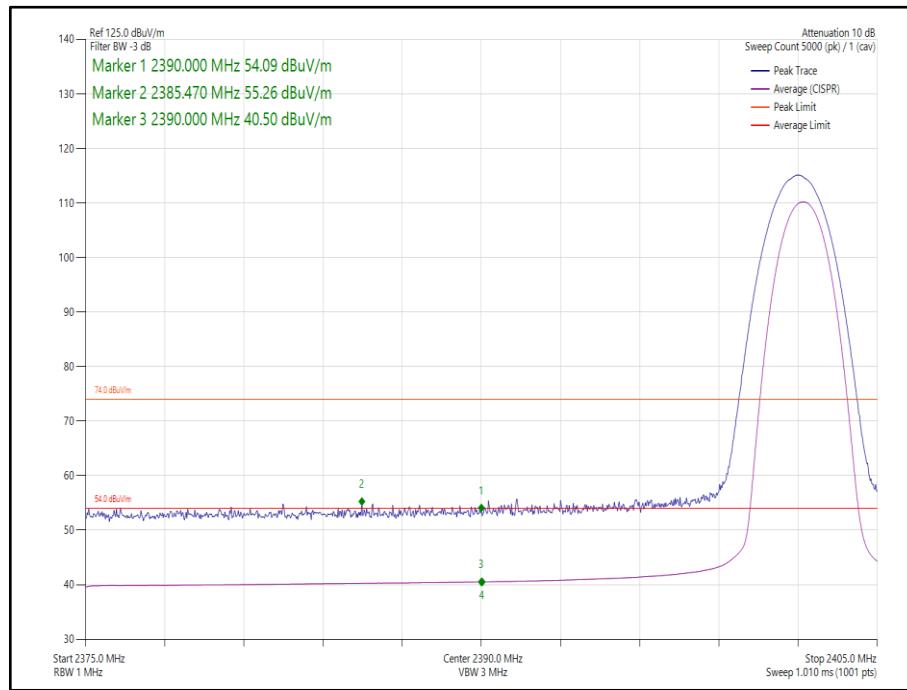


Figure 8 - Static - 8-DPSK/3-DH5 - 2402 MHz Band Edge Frequency 2390.0 MHz

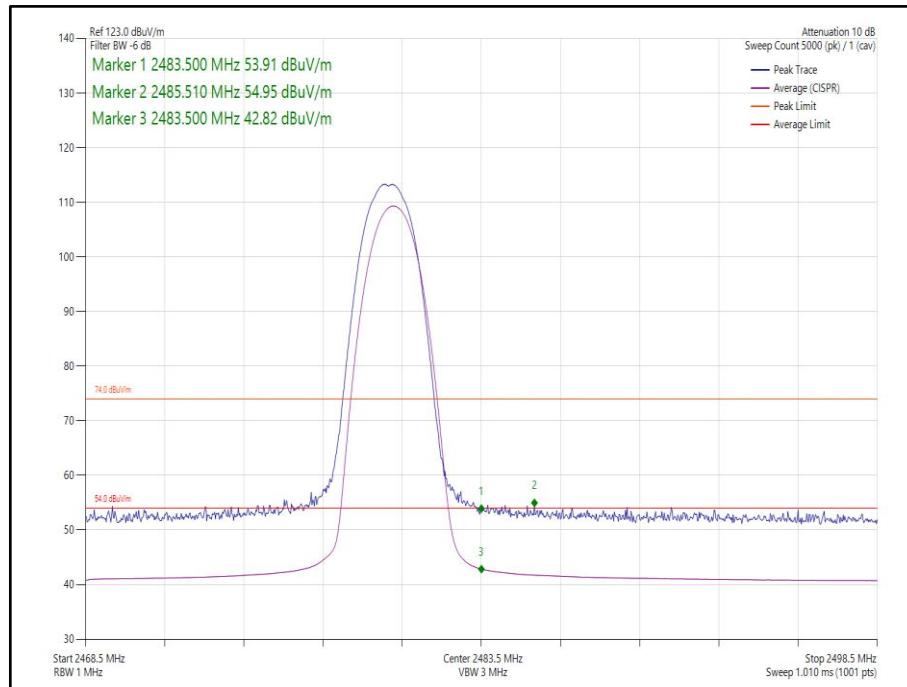
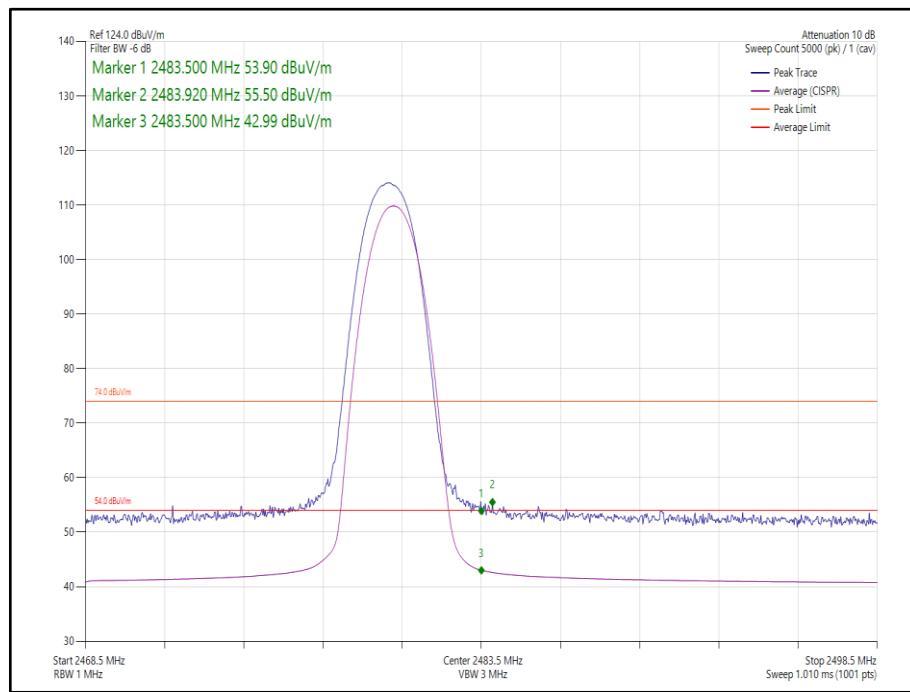


Figure 9 - Static -  $\pi/4$  DQPSK/2-DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz



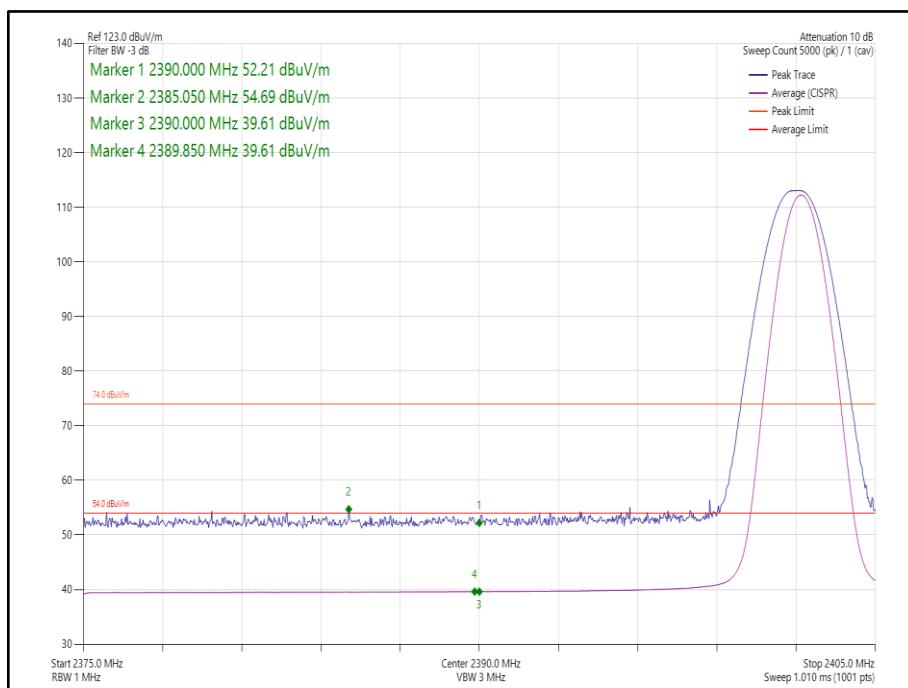
**Figure 10 - Static - 8-DPSK/3-DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz**

## 2.4 GHz Bluetooth (FHSS)

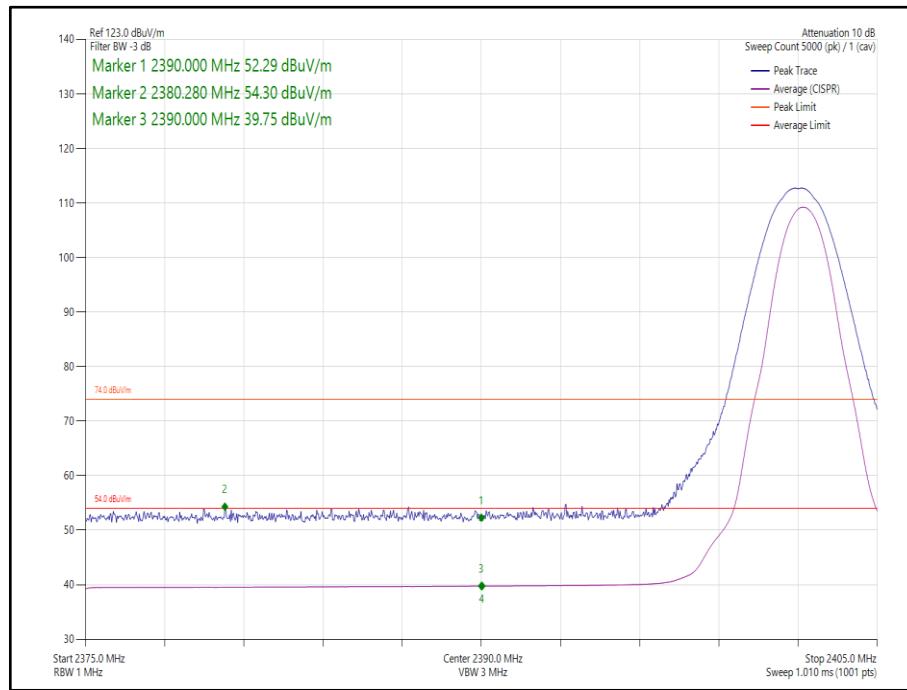
iPA

| Mode   | Modulation    | Core | Packet Type | Tx Frequency (MHz) | Band Edge Frequency (MHz) | Peak Level (dB $\mu$ V/m) | Average Level (dB $\mu$ V/m) |
|--------|---------------|------|-------------|--------------------|---------------------------|---------------------------|------------------------------|
| Static | GFSK          | 2    | DH5         | 2402               | 2390.0                    | 54.69                     | 39.61                        |
| Static | $\pi/4$ DQPSK | 2    | 2-DH5       | 2402               | 2390.0                    | 54.30                     | 39.75                        |
| Static | 8-DPSK        | 2    | 3-DH5       | 2402               | 2390.0                    | 54.60                     | 39.73                        |
| Static | GFSK          | 2    | DH5         | 2480               | 2483.5                    | 53.92                     | 41.48                        |
| Static | $\pi/4$ DQPSK | 2    | 2-DH5       | 2480               | 2483.5                    | 65.44                     | 52.33                        |
| Static | 8-DPSK        | 2    | 3-DH5       | 2480               | 2483.5                    | 66.25                     | 52.18                        |

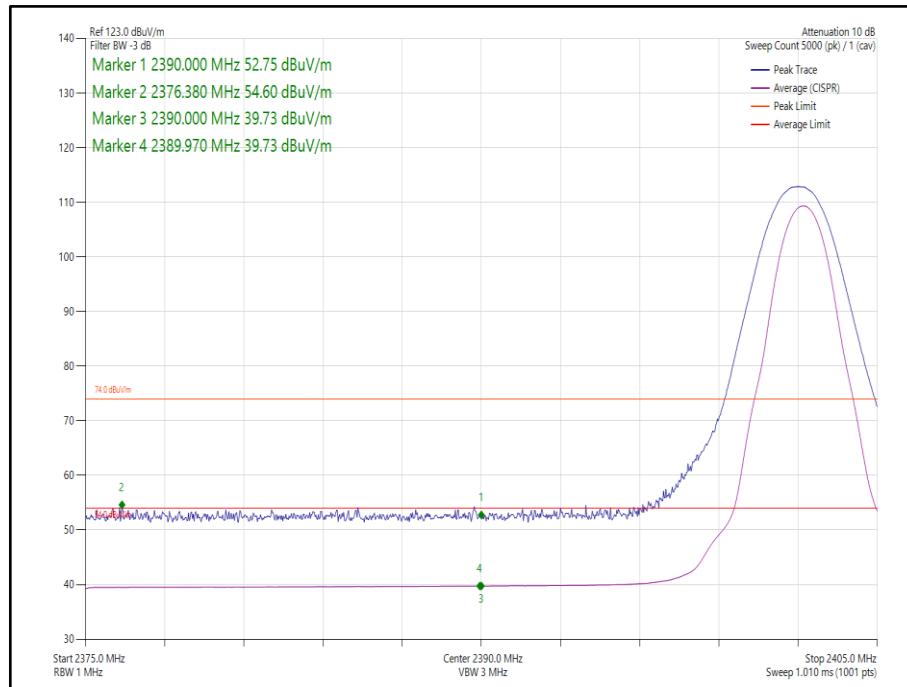
**Table 9 - Restricted Band Edge Results**



**Figure 11 - Static - GFSK/DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz**



**Figure 12 - Static -  $\pi/4$  DQPSK/2-DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz**



**Figure 13 - Static - 8-DPSK/3-DH5 - 2402 MHz Band Edge Frequency 2390.0 MHz**

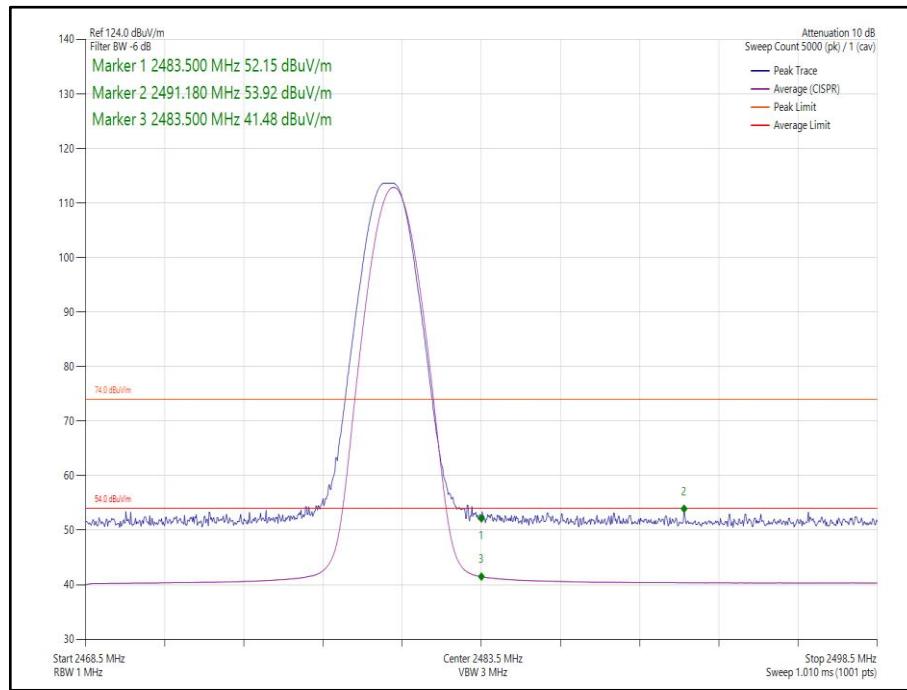


Figure 14 - Static - GFSK/DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

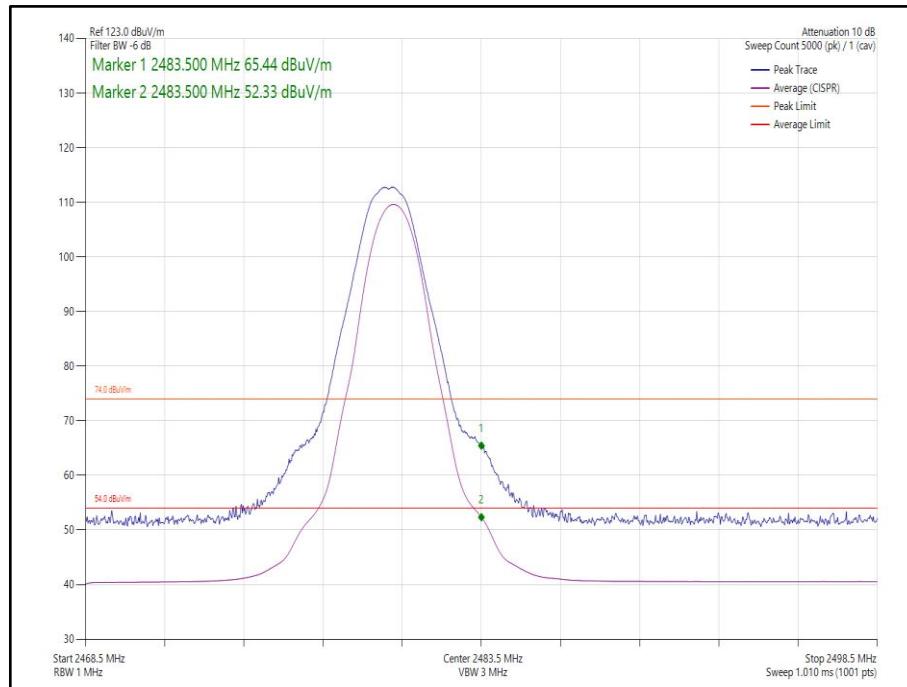
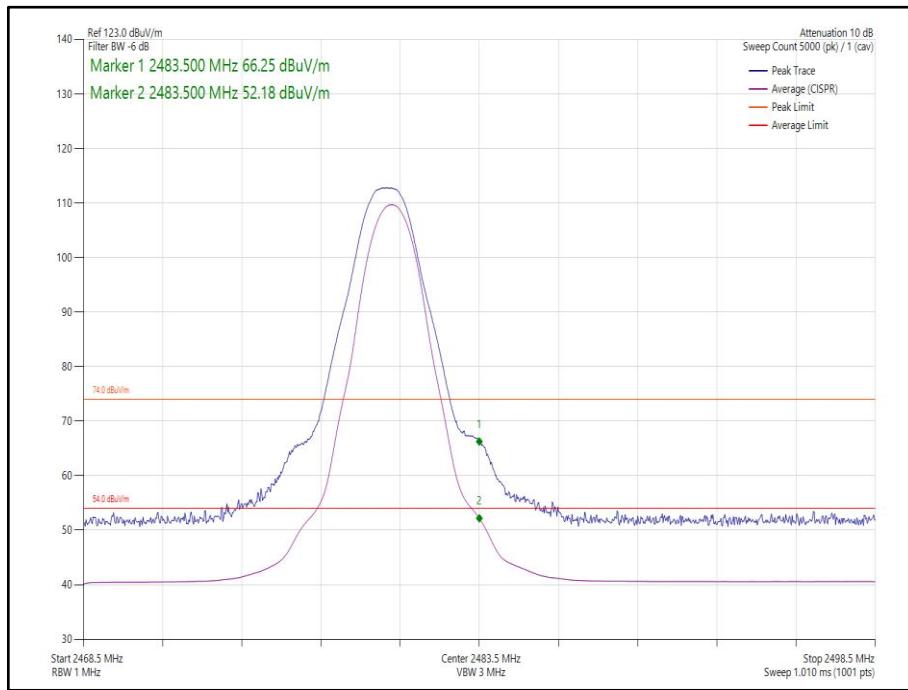


Figure 15 - Static -  $\pi/4$  DQPSK/2-DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz



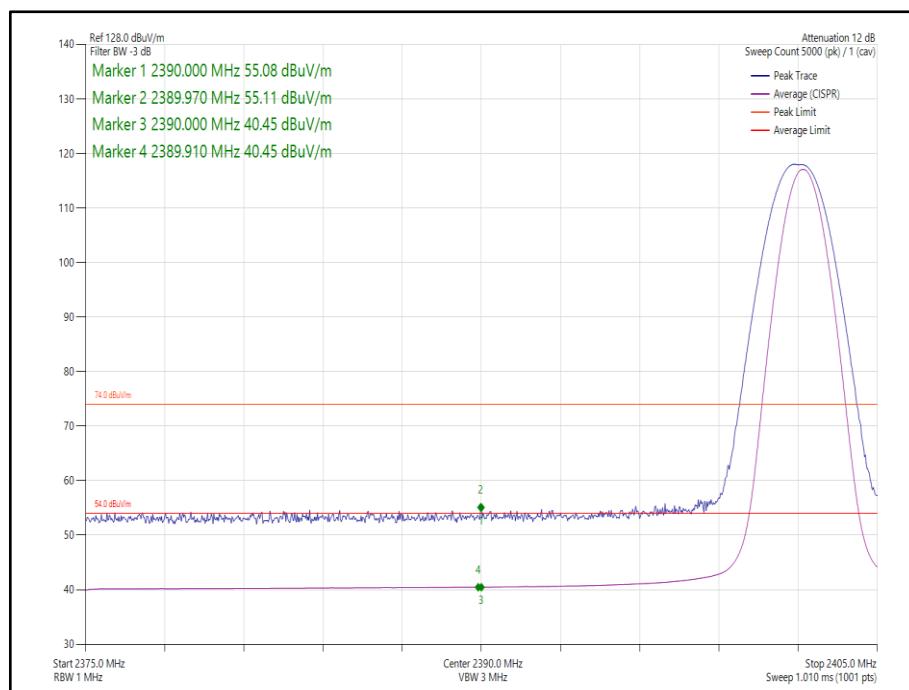
**Figure 16 - Static - 8-DPSK/3-DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz**

## 2.4 GHz Bluetooth (FHSS)

### iPA

| Mode   | Modulation    | Core | Packet Type | Tx Frequency (MHz) | Band Edge Frequency (MHz) | Peak Level (dB $\mu$ V/m) | Average Level (dB $\mu$ V/m) |
|--------|---------------|------|-------------|--------------------|---------------------------|---------------------------|------------------------------|
| Static | GFSK          | 0-1  | DH5         | 2402               | 2390.0                    | 55.11                     | 40.45                        |
| Static | $\pi/4$ DQPSK | 0-1  | 2-DH5       | 2402               | 2390.0                    | 54.37                     | 39.99                        |
| Static | 8-DPSK        | 0-1  | 3-DH5       | 2402               | 2390.0                    | 55.58                     | 40.56                        |
| Static | GFSK          | 0-1  | DH5         | 2480               | 2483.5                    | 55.14                     | 43.56                        |
| Static | $\pi/4$ DQPSK | 0-1  | 2-DH5       | 2480               | 2483.5                    | 60.01                     | 46.51                        |
| Static | 8-DPSK        | 0-1  | 3-DH5       | 2480               | 2483.5                    | 60.41                     | 46.22                        |

**Table 10 - Restricted Band Edge Results**



**Figure 17 - Static - GFSK/DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz**

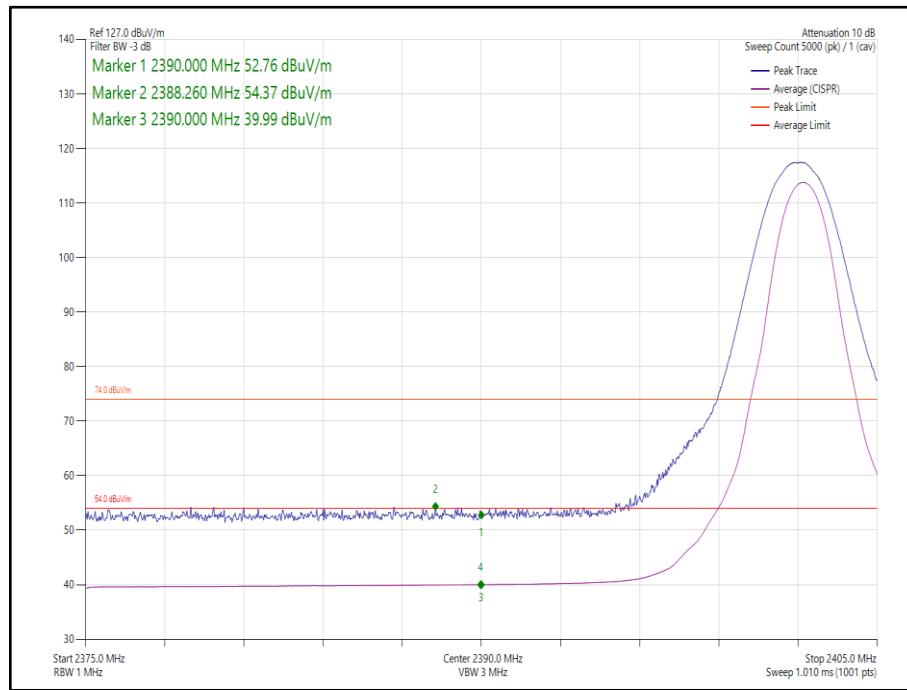


Figure 18 - Static -  $\pi/4$  DQPSK/2-DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz

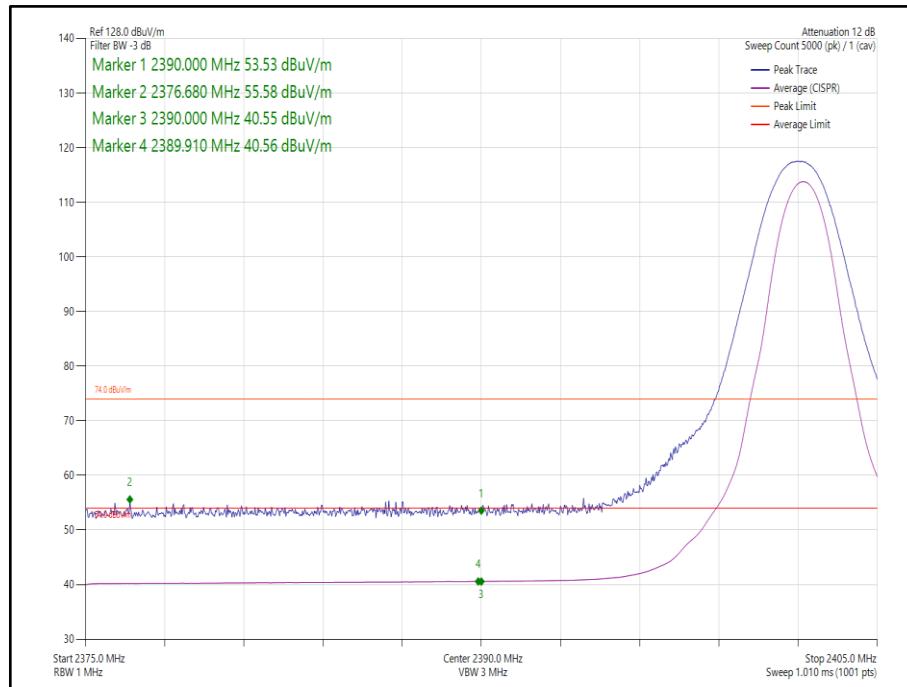


Figure 19 - Static - 8-DPSK/3-DH5 - 2402 MHz Band Edge Frequency 2390.0 MHz

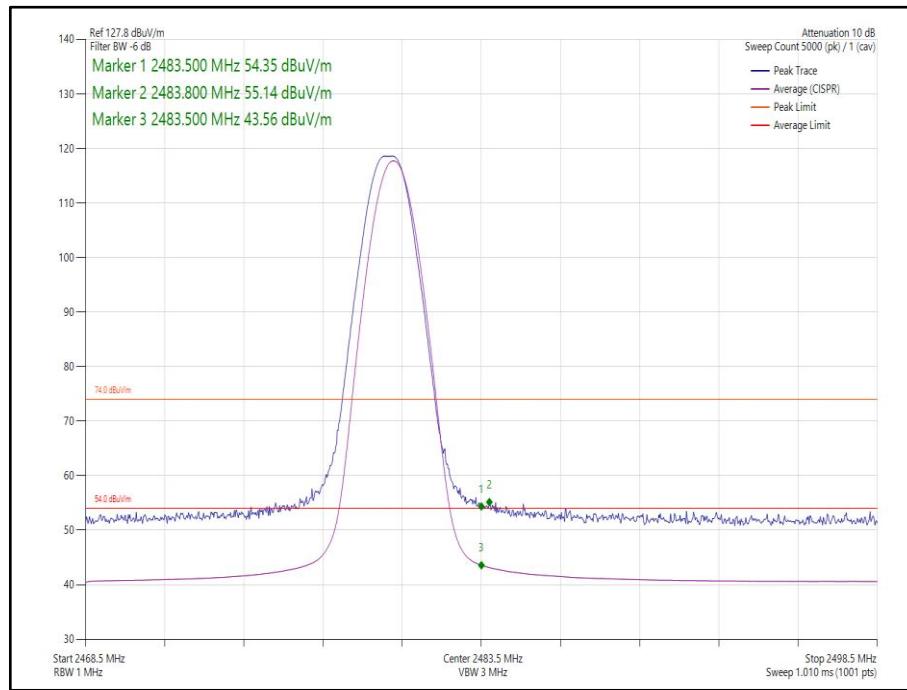


Figure 20 - Static - GFSK/DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz

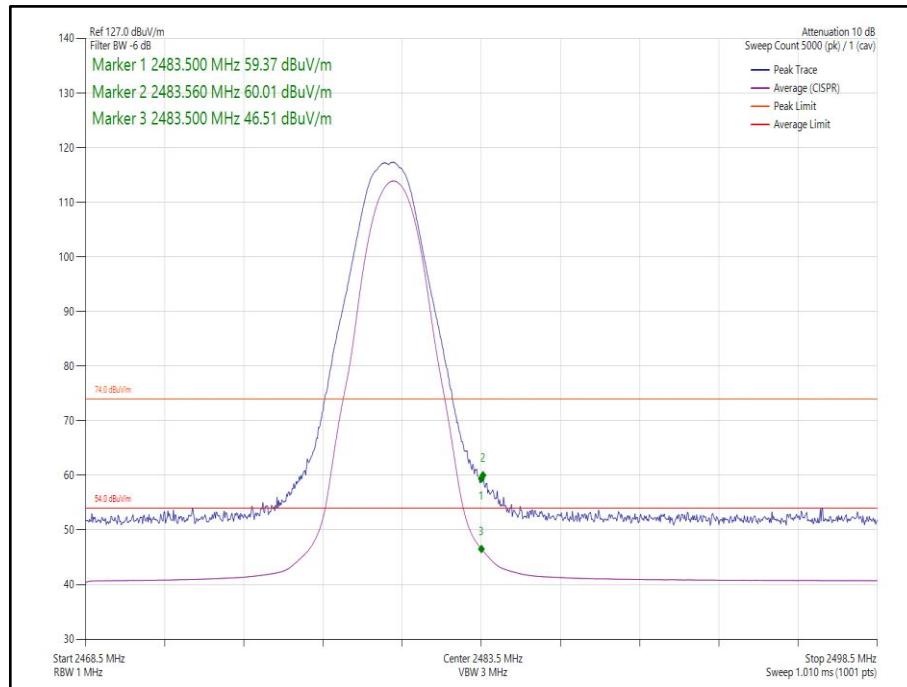
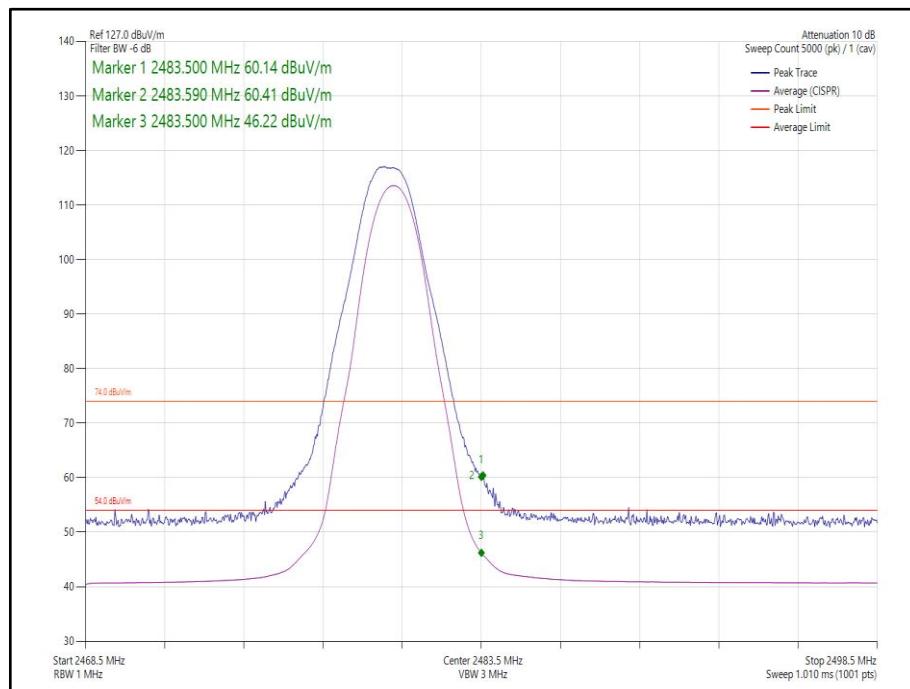


Figure 21 - Static -  $\pi/4$  DQPSK/2-DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz



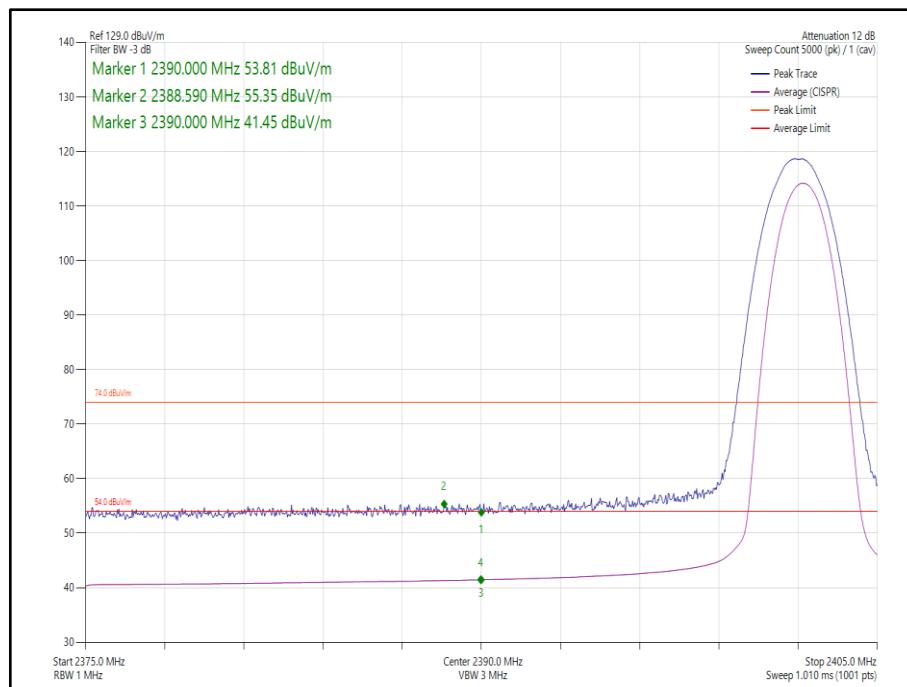
**Figure 22 - Static - 8-DPSK/3-DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz**

## 2.4 GHz Bluetooth (FHSS)

### ePA

| Mode   | Modulation    | Core | Packet Type | Tx Frequency (MHz) | Band Edge Frequency (MHz) | Peak Level (dB $\mu$ V/m) | Average Level (dB $\mu$ V/m) |
|--------|---------------|------|-------------|--------------------|---------------------------|---------------------------|------------------------------|
| Static | $\pi/4$ DQPSK | 0-1  | 2-DH5       | 2402               | 2390.0                    | 55.35                     | 41.45                        |
| Static | 8-DPSK        | 0-1  | 3-DH5       | 2402               | 2390.0                    | 56.30                     | 41.48                        |
| Static | $\pi/4$ DQPSK | 0-1  | 2-DH5       | 2480               | 2483.5                    | 55.95                     | 44.41                        |
| Static | 8-DPSK        | 0-1  | 3-DH5       | 2480               | 2483.5                    | 56.53                     | 44.38                        |

**Table 11 - Restricted Band Edge Results**



**Figure 23 - Static -  $\pi/4$  DQPSK/2-DH5 - 2402 MHz - Band Edge Frequency 2390.0 MHz**

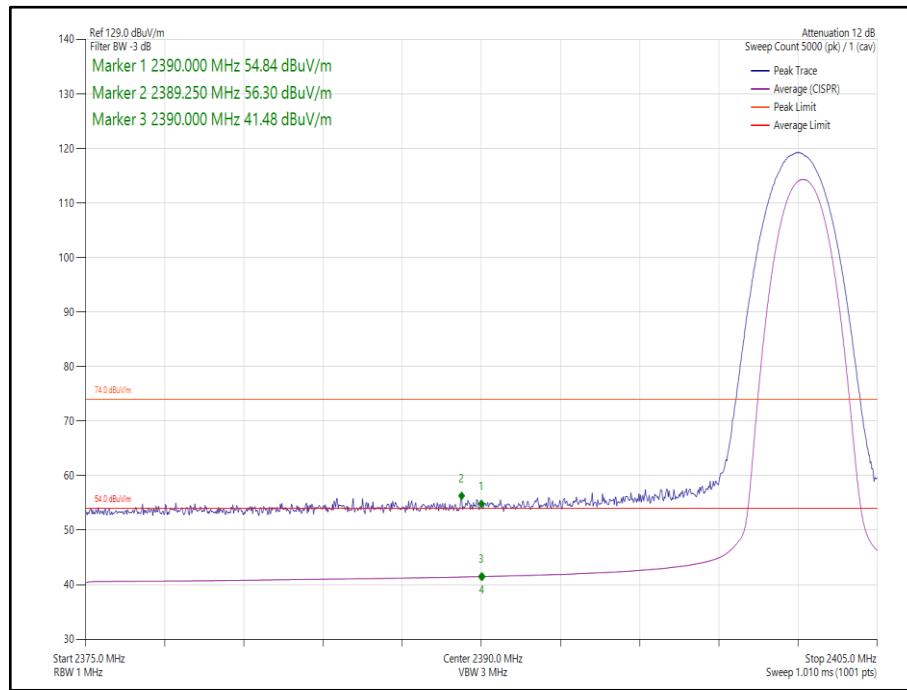


Figure 24 - Static - 8-DPSK/3-DH5 - 2402 MHz Band Edge Frequency 2390.0 MHz

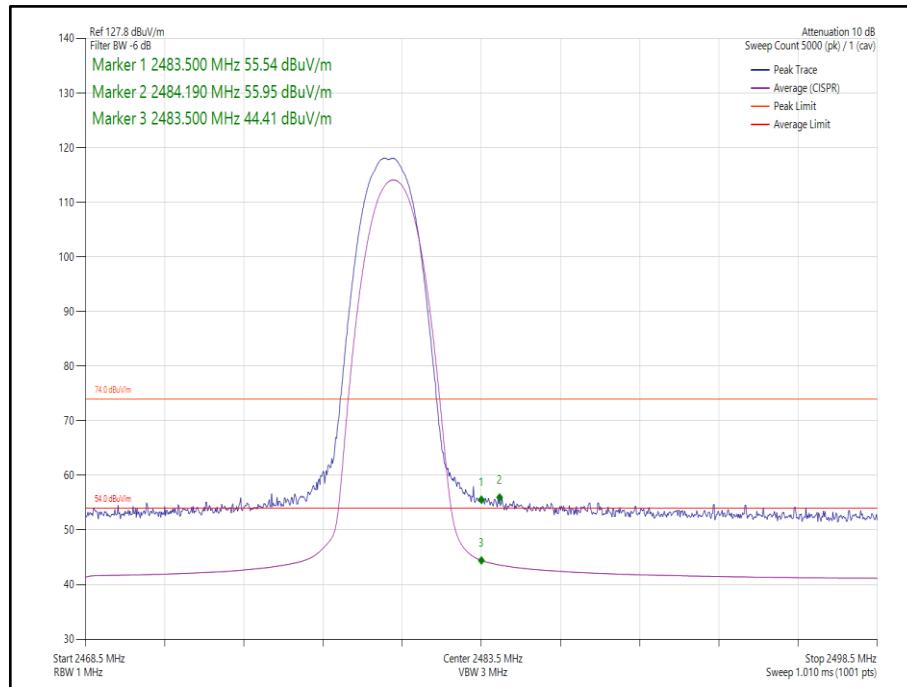
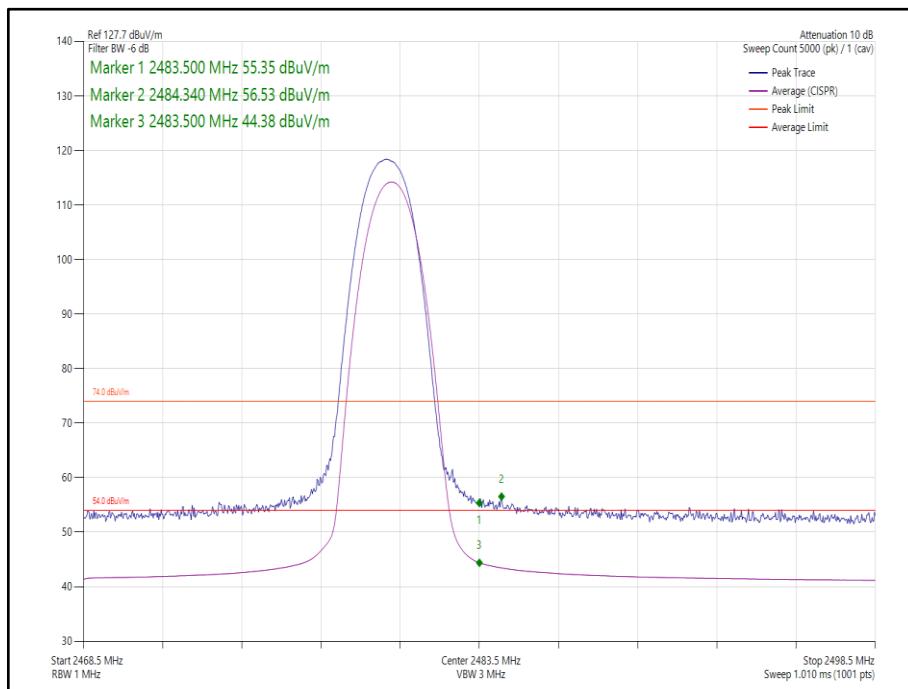


Figure 25 - Static -  $\pi/4$  DQPSK/2-DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz



**Figure 26 - Static - 8-DPSK/3-DH5 - 2480 MHz - Band Edge Frequency 2483.5 MHz**

FCC 47 CFR Part 15, Limit Clause 15.209

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

**Table 12**

ISED RSS-GEN, Limit Clause 8.9

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

**Table 13**

\*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 16.

| Instrument                       | Manufacturer    | Type No.             | TE No. | Calibration Period (months) | Calibration Expiry Date |
|----------------------------------|-----------------|----------------------|--------|-----------------------------|-------------------------|
| Test Receiver                    | Rohde & Schwarz | ESW44                | 5914   | 12                          | 21-Feb-2023             |
| 1500W (300V 12A) AC Power Supply | iTech           | IT7324               | 5957   | -                           | O/P Mon                 |
| 3m Semi-Anechoic Chamber         | Schaffner       | RF Chamber 16        | 5972   | 36                          | 24-May-2025             |
| Mast & Turntable Controller      | Maturo GmbH     | FCU3.0               | 5973   | -                           | TU                      |
| Tilt Antenna Mast                | Maturo GmbH     | BAM4.5-P             | 5974   | -                           | TU                      |
| Turntable                        | Maturo GmbH     | TT1.5SI              | 5975   | -                           | TU                      |
| Cable (SMA to SMA 1m)            | Junkosha        | MWX221-01000AMSAMS/A | 5996   | 12                          | 06-Jun-2023             |
| Cable (N to N 1m)                | Junkosha        | MWX221-01000NMSNMS/B | 5999   | 12                          | 05-Jun-2023             |
| Cable (N to N 7m)                | Junkosha        | MWX221-07000NMSNMS/B | 6005   | 12                          | 05-Jun-2023             |
| Cable (N to N 8m)                | Junkosha        | MWX221-08000NMSNMS/A | 6006   | 12                          | 05-Jun-2023             |
| Horn Antenna (1-10 GHz)          | Schwarzbeck     | BBHA9120B            | 6140   | 12                          | 21-Jun-2023             |
| Digital Multimeter               | Fluke           | 115                  | 6146   | 12                          | 16-Jun-2023             |
| Humidity & Temperature meter     | R.S Components  | 1364                 | 6148   | 12                          | 17-Jun-2023             |
| SAC Switch Unit                  | TÜV SUD         | SSU002               | 6190   | 12                          | 08-Aug-2023             |

**Table 14**

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**

A2780, S/N: NW3J007K67 - Modification State 0

### **2.2.3 Date of Test**

19-October-2022 to 01-November-2022

### **2.2.4 Test Method**

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

### **2.2.5 Environmental Conditions**

|                     |                |
|---------------------|----------------|
| Ambient Temperature | 22.7 - 23.5 °C |
| Relative Humidity   | 52.3 - 56.9 %  |



## 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 π/4 DQPSK (2-DH5) | Duty Cycle (%):          | 52.7 |
| Antenna Configuration: | SISO                  | DCCF (dB):               | -    |
| Active Port(s):        | B (Core 1)            | Peak Antenna Gain (dBi): | -    |

| Test Frequency (MHz) | Time of Occupancy |                         |                        | Limit (ms) |
|----------------------|-------------------|-------------------------|------------------------|------------|
|                      | Dwell Time (ms)   | Number of Transmissions | Time of Occupancy (ms) |            |
| 2402                 | 1.984             | 119                     | 236.1                  | 400.0      |
| 2480                 | 1.984             | 112                     | 222.3                  | 400.0      |

**Table 15 - Time of Occupancy Results**



Figure 27 -  $\pi/4$  DQPSK - 2402 MHz Accumulated Transmit Time



Figure 28 -  $\pi/4$  DQPSK - 2480 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 π/4 DQPSK (2-DH5) | Duty Cycle (%):          | 52.8 |
| 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                    | 1.981              | 90                      | 178.3                     | 400.0         |
| 2480                    | 1.981              | 114                     | 225.9                     | 400.0         |

**Table 16 - Time of Occupancy Results**



Figure 29 -  $\pi/4$  DQPSK - 2402 MHz Accumulated Transmit Time



Figure 30 -  $\pi/4$  DQPSK - 2480 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):        | B (Core 1)     | Peak Antenna Gain (dBi): | -    |

| Test Frequency (MHz) | Time of Occupancy |                         |                        | Limit (ms) |
|----------------------|-------------------|-------------------------|------------------------|------------|
|                      | Dwell Time (ms)   | Number of Transmissions | Time of Occupancy (ms) |            |
| 2402                 | 2.888             | 106                     | 306.2                  | 400.0      |
| 2480                 | 2.888             | 98                      | 283.1                  | 400.0      |

**Table 17 - Time of Occupancy Results**



Figure 31 - GFSK - 2402 MHz Accumulated Transmit Time



Figure 32 - GFSK - 2480 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):        | C (Core 2)     | Peak Antenna Gain (dBi): | -    |

| Test Frequency (MHz) | Time of Occupancy |                         |                        | Limit (ms) |
|----------------------|-------------------|-------------------------|------------------------|------------|
|                      | Dwell Time (ms)   | Number of Transmissions | Time of Occupancy (ms) |            |
| 2402                 | 2.888             | 95                      | 274.4                  | 400.0      |
| 2480                 | 2.888             | 91                      | 262.8                  | 400.0      |

**Table 18 - Time of Occupancy Results**



Figure 33 - GFSK - 2402 MHz Accumulated Transmit Time



Figure 34 - GFSK - 2480 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 (MHz) | Time of Occupancy |                         |                        | Limit (ms) |
|----------------------|-------------------|-------------------------|------------------------|------------|
|                      | Dwell Time (ms)   | Number of Transmissions | Time of Occupancy (ms) |            |
| 2402                 | 2.888             | 124                     | 358.2                  | 400.0      |
| 2480                 | 2.888             | 109                     | 314.8                  | 400.0      |

**Table 19 - Time of Occupancy Results**



Figure 35 - GFSK - 2402 MHz Accumulated Transmit Time



Figure 36 - GFSK - 2480 MHz Accumulated Transmit Time

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

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

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

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



## 2.2.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

| Instrument                   | Manufacturer          | Type No.                  | TE No. | Calibration Period (months) | Calibration Expiry Date |
|------------------------------|-----------------------|---------------------------|--------|-----------------------------|-------------------------|
| Multimeter                   | Fluke                 | 79 Series III             | 611    | 12                          | 21-Dec-2022             |
| Hygrometer                   | Rotronic              | I-1000                    | 3220   | 12                          | 05-Nov-2022             |
| Frequency Standard           | Spectracom            | SecureSync 1200-0408-0601 | 4393   | 6                           | 01-Feb-2023             |
| AC Programmable Power Supply | iTech                 | IT7324                    | 5226   | -                           | O/P Mon                 |
| MXA Signal Analyser          | Keysight Technologies | N9020B                    | 5529   | 24                          | 13-Sep-2024             |
| Signal Conditioning Unit     | TUV SUD               | SPECTRUM SCU002           | 5759   | 12                          | 05-Jul-2023             |

**Table 20**

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**

A2780, S/N: NW3J007K67 - Modification State 0

### **2.3.3 Date of Test**

19-October-2022 to 28-October-2022

### **2.3.4 Test Method**

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

### **2.3.5 Environmental Conditions**

|                     |                |
|---------------------|----------------|
| Ambient Temperature | 22.7 - 23.5 °C |
| Relative Humidity   | 52.3 - 56.9 %  |

### 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 π/4 DQPSK (2-DH5) | Duty Cycle (%):          | - |
| Antenna Configuration: | SISO                  | DCCF (dB):               | - |
| Active Port(s):        | B (Core 1)            | Peak Antenna Gain (dBi): | - |

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) | Carrier Frequency Separation (MHz) |          |       | Limit (kHz) |
|----------------------|-----------------------|------------------------------------|----------|-------|-------------|
|                      |                       | F1C                                | F2C      | FHS   |             |
| 2441                 | 1.347                 | 2440.988                           | 2441.987 | 0.999 | ≥898.1      |

Table 21 - Carrier Frequency Separation Results



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



| Test Configuration       |                                    |                 |              |
|--------------------------|------------------------------------|-----------------|--------------|
| Frequency Range:         | 2400-2483.5 MHz                    | Band:           | 2.4 GHz      |
| Limit Clause(s):         | FCC 15.247(a)(1)<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 1)         | Peak Antenna Gain (dBi): | - |

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) | Carrier Frequency Separation (MHz) |          |       | Limit (kHz) |
|----------------------|-----------------------|------------------------------------|----------|-------|-------------|
|                      |                       | F1C                                | F2C      | FHS   |             |
| 2441                 | 1.321                 | 2440.995                           | 2441.995 | 1.000 | ≥880.5      |

Table 22 - Carrier Frequency Separation Results



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



| Test Configuration       |                                    |                 |              |
|--------------------------|------------------------------------|-----------------|--------------|
| Frequency Range:         | 2400-2483.5 MHz                    | Band:           | 2.4 GHz      |
| Limit Clause(s):         | FCC 15.247(a)(1)<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):        | A+B (Core 0 + Core 1)     | Peak Antenna Gain (dBi): | - |

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) | Carrier Frequency Separation (MHz) |          |       | Limit (kHz) |
|----------------------|-----------------------|------------------------------------|----------|-------|-------------|
|                      |                       | F1C                                | F2C      | FHS   |             |
| 2441                 | 1.339                 | 2440.988                           | 2441.987 | 0.999 | ≥892.5      |

Table 23 - Carrier Frequency Separation Results



Figure 39 -  $\pi/4$  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):        | A+B (Core 0 + Core 1) | Peak Antenna Gain (dBi): | - |

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) | Carrier Frequency Separation (MHz) |          |       | Limit (kHz) |
|----------------------|-----------------------|------------------------------------|----------|-------|-------------|
|                      |                       | F1C                                | F2C      | FHS   |             |
| 2441                 | 1.321                 | 2440.994                           | 2441.994 | 1.000 | ≥880.8      |

Table 24 - Carrier Frequency Separation Results



Figure 40 - 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 1)     | Peak Antenna Gain (dBi): | - |

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) | Carrier Frequency Separation (MHz) |          |       | Limit (kHz) |
|----------------------|-----------------------|------------------------------------|----------|-------|-------------|
|                      |                       | F1C                                | F2C      | FHS   |             |
| 2441                 | 0.933                 | 2441.008                           | 2442.008 | 1.000 | ≥621.8      |

Table 25 - Carrier Frequency Separation Results



Figure 41 - 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 π/4 DQPSK (2-DH5) | Duty Cycle (%):          | - |
| Antenna Configuration: | SISO                  | DCCF (dB):               | - |
| Active Port(s):        | B (Core 1)            | Peak Antenna Gain (dBi): | - |

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) | Carrier Frequency Separation (MHz) |          |       | Limit (kHz) |
|----------------------|-----------------------|------------------------------------|----------|-------|-------------|
|                      |                       | F1C                                | F2C      | FHS   |             |
| 2441                 | 1.350                 | 2440.989                           | 2441.989 | 1.000 | ≥899.7      |

Table 26 - Carrier Frequency Separation Results



Figure 42 - π/4 DQPSK - 2441 MHz (CH39)



| Test Configuration       |                                    |                 |              |
|--------------------------|------------------------------------|-----------------|--------------|
| Frequency Range:         | 2400-2483.5 MHz                    | Band:           | 2.4 GHz      |
| Limit Clause(s):         | FCC 15.247(a)(1)<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 1)         | Peak Antenna Gain (dBi): | - |

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) | Carrier Frequency Separation (MHz) |          |       | Limit (kHz) |
|----------------------|-----------------------|------------------------------------|----------|-------|-------------|
|                      |                       | F1C                                | F2C      | FHS   |             |
| 2441                 | 1.325                 | 2440.996                           | 2441.996 | 1.000 | ≥883.5      |

Table 27 - Carrier Frequency Separation Results



Figure 43 - 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):        | C (Core 2)     | Peak Antenna Gain (dBi): | - |

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) | Carrier Frequency Separation (MHz) |          |       | Limit (kHz) |
|----------------------|-----------------------|------------------------------------|----------|-------|-------------|
|                      |                       | F1C                                | F2C      | FHS   |             |
| 2441                 | 0.928                 | 2441.006                           | 2442.006 | 1.000 | ≥618.8      |

Table 28 - Carrier Frequency Separation Results



Figure 44 - 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 π/4 DQPSK (2-DH5) | Duty Cycle (%):          | - |
| Antenna Configuration: | SISO                  | DCCF (dB):               | - |
| Active Port(s):        | C (Core 2)            | Peak Antenna Gain (dBi): | - |

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) | Carrier Frequency Separation (MHz) |          |       | Limit (kHz) |
|----------------------|-----------------------|------------------------------------|----------|-------|-------------|
|                      |                       | F1C                                | F2C      | FHS   |             |
| 2441                 | 1.347                 | 2440.990                           | 2441.988 | 0.998 | ≥898.1      |

Table 29 - Carrier Frequency Separation Results

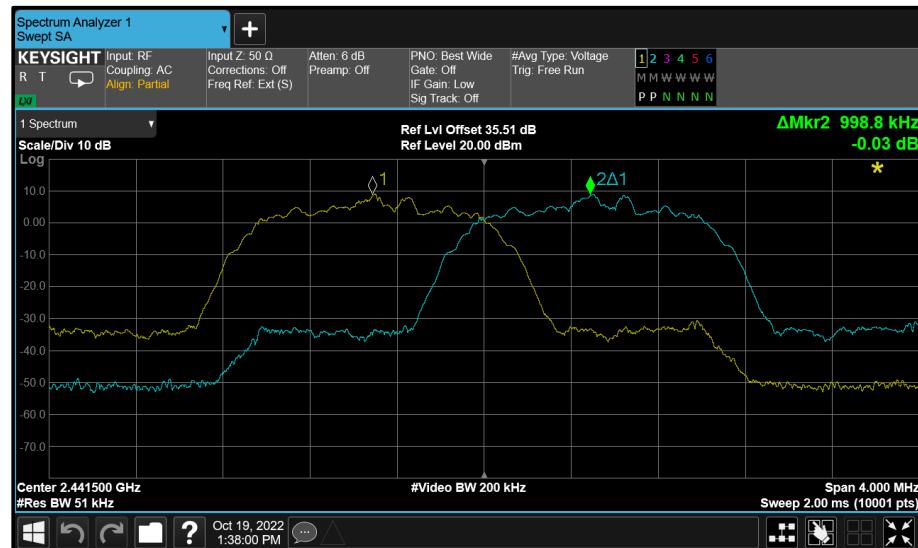


Figure 45 - π/4 DQPSK - 2441 MHz (CH39)



| Test Configuration       |                                    |                 |              |
|--------------------------|------------------------------------|-----------------|--------------|
| Frequency Range:         | 2400-2483.5 MHz                    | Band:           | 2.4 GHz      |
| Limit Clause(s):         | FCC 15.247(a)(1)<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):        | C (Core 2)         | Peak Antenna Gain (dBi): | - |

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) | Carrier Frequency Separation (MHz) |          |       | Limit (kHz) |
|----------------------|-----------------------|------------------------------------|----------|-------|-------------|
|                      |                       | F1C                                | F2C      | FHS   |             |
| 2441                 | 1.320                 | 2440.997                           | 2441.996 | 0.999 | ≥880.3      |

Table 30 - Carrier Frequency Separation Results



Figure 46 - 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):        | A+B (Core 0 + Core 1) | Peak Antenna Gain (dBi): | - |

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) | Carrier Frequency Separation (MHz) |          |       | Limit (kHz) |
|----------------------|-----------------------|------------------------------------|----------|-------|-------------|
|                      |                       | F1C                                | F2C      | FHS   |             |
| 2441                 | 0.923                 | 2441.005                           | 2442.006 | 1.001 | ≥615.4      |

Table 31 - Carrier Frequency Separation Results



Figure 47 - 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 π/4 DQPSK (2-DH5) | Duty Cycle (%):          | - |
| Antenna Configuration: | Beamforming           | DCCF (dB):               | - |
| Active Port(s):        | A+B (Core 0 + Core 1) | Peak Antenna Gain (dBi): | - |

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) | Carrier Frequency Separation (MHz) |          |       | Limit (kHz) |
|----------------------|-----------------------|------------------------------------|----------|-------|-------------|
|                      |                       | F1C                                | F2C      | FHS   |             |
| 2441                 | 1.346                 | 2440.989                           | 2441.990 | 1.001 | ≥897.3      |

Table 32 - Carrier Frequency Separation Results



Figure 48 - π/4 DQPSK - 2441 MHz (CH39)



| Test Configuration       |                                    |                 |              |
|--------------------------|------------------------------------|-----------------|--------------|
| Frequency Range:         | 2400-2483.5 MHz                    | Band:           | 2.4 GHz      |
| Limit Clause(s):         | FCC 15.247(a)(1)<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):        | A+B (Core 0 + Core 1) | Peak Antenna Gain (dBi): | - |

| Test Frequency (MHz) | 20 dB Bandwidth (MHz) | Carrier Frequency Separation (MHz) |          |       | Limit (kHz) |
|----------------------|-----------------------|------------------------------------|----------|-------|-------------|
|                      |                       | F1C                                | F2C      | FHS   |             |
| 2441                 | 1.323                 | 2440.997                           | 2441.996 | 0.999 | ≥881.9      |

Table 33 - Carrier Frequency Separation Results



Figure 49 - 8-DPSK - 2441 MHz (CH39)



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

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

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

ISED RSS-247, Limit Clause 5.1 (b)

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



### 2.3.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

| Instrument                   | Manufacturer          | Type No.                  | TE No. | Calibration Period (months) | Calibration Expiry Date |
|------------------------------|-----------------------|---------------------------|--------|-----------------------------|-------------------------|
| Multimeter                   | Fluke                 | 79 Series III             | 611    | 12                          | 21-Dec-2022             |
| Hygrometer                   | Rotronic              | I-1000                    | 3220   | 12                          | 05-Nov-2022             |
| Frequency Standard           | Spectracom            | SecureSync 1200-0408-0601 | 4393   | 6                           | 01-Feb-2023             |
| AC Programmable Power Supply | iTech                 | IT7324                    | 5226   | -                           | O/P Mon                 |
| MXA Signal Analyser          | Keysight Technologies | N9020B                    | 5529   | 24                          | 13-Sep-2024             |
| Signal Conditioning Unit     | TUV SUD               | SPECTRUM SCU002           | 5759   | 12                          | 05-Jul-2023             |

**Table 34**

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**

A2780, S/N: NW3J007K67 - Modification State 0

### **2.4.3 Date of Test**

19-October-2022 to 28-October-2022

### **2.4.4 Test Method**

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

### **2.4.5 Environmental Conditions**

|                     |                |
|---------------------|----------------|
| Ambient Temperature | 22.7 - 23.5 °C |
| Relative Humidity   | 52.3 - 56.9 %  |



## 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 π/4 DQPSK (2-DH5) | Duty Cycle (%):          | - |
| Antenna Configuration: | SISO                  | DCCF (dB):               | - |
| Active Port(s):        | B (Core 1)            | Peak Antenna Gain (dBi): | - |

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

Table 35 - Number of Hopping Frequencies Results

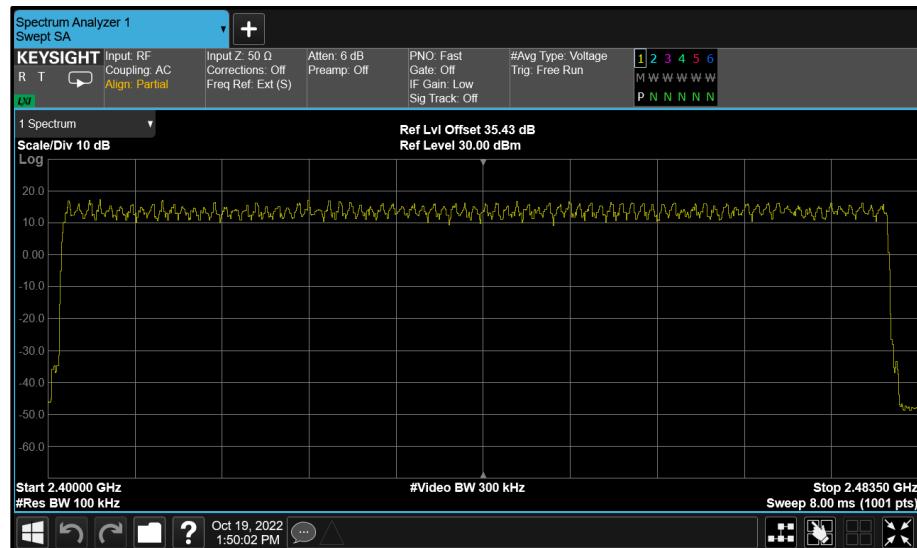


Figure 50 - π/4 DQPSK (2-DH5) - Number of Hopping Channels



| 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):        | A+B (Core 0 + Core 1)     | Peak Antenna Gain (dBi): | - |

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

Table 36 - Number of Hopping Frequencies Results

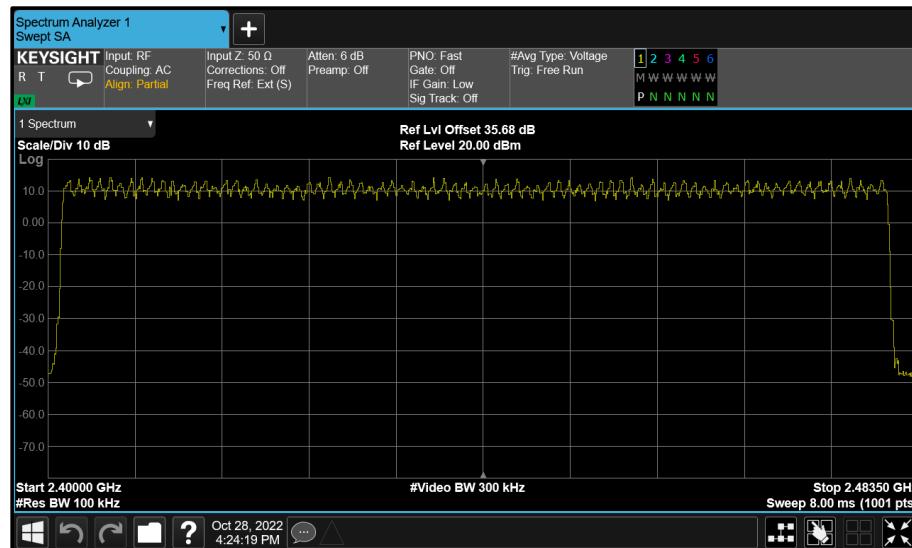


Figure 51 -  $\pi/4$  DQPSK (2-DH5) - Number of Hopping Channels



| 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 1)     | Peak Antenna Gain (dBi): | - |

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

Table 37 - Number of Hopping Frequencies Results

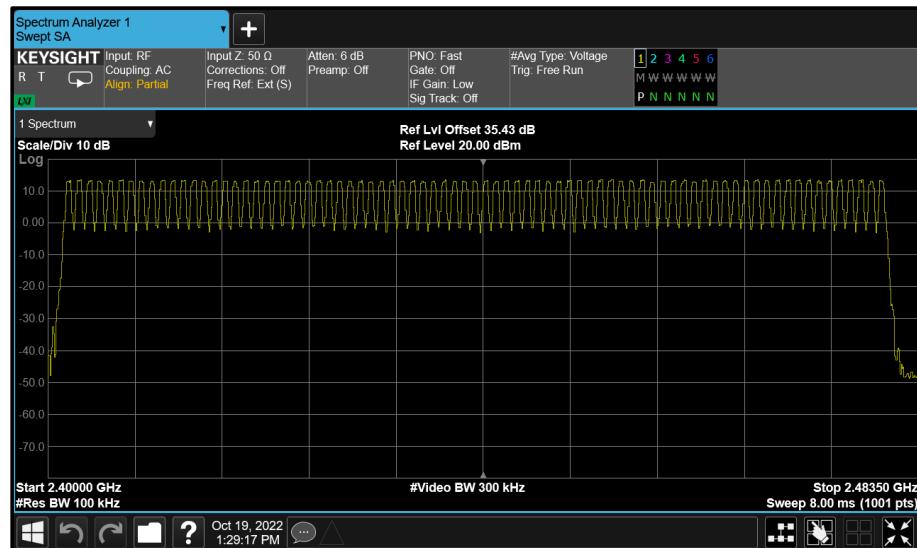


Figure 52 - GFSK (DH5) - Number of Hopping Channels



| Test Configuration       |   |                 |              |
|--------------------------|---|-----------------|--------------|
| Frequency Range:         | 2400-2483.5 MHz                         | Band:           | 2.4 GHz      |
| Limit Clause(s):         | FCC 15.247(a)(1)(iii)<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):        | C (Core 2)     | Peak Antenna Gain (dBi): | - |

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

Table 38 - Number of Hopping Frequencies Results

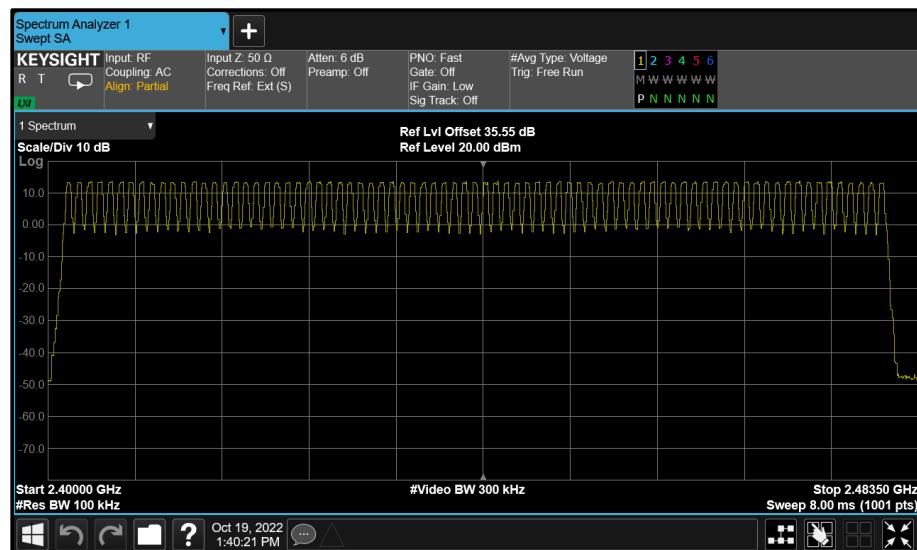


Figure 53 - GFSK (DH5) - Number of Hopping Channels

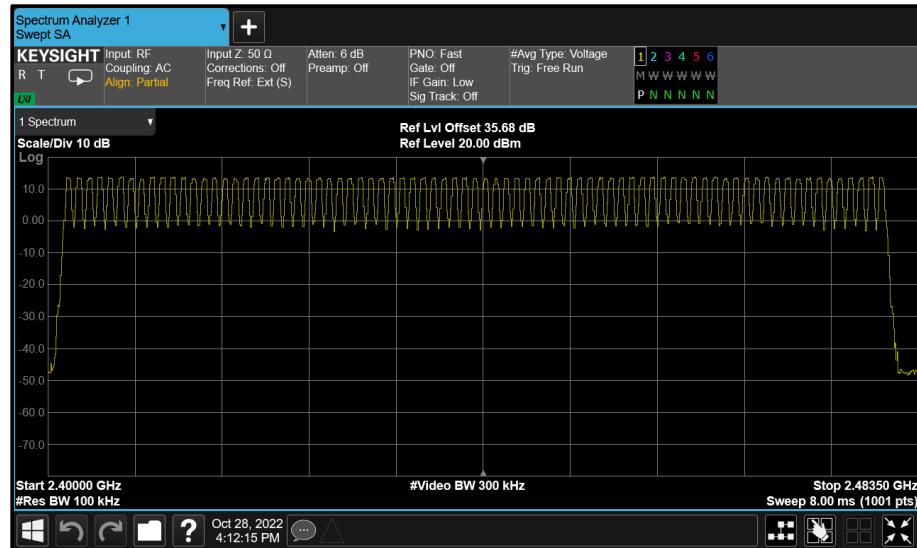


| Test Configuration       |   |                 |              |
|--------------------------|---|-----------------|--------------|
| Frequency Range:         | 2400-2483.5 MHz                         | Band:           | 2.4 GHz      |
| Limit Clause(s):         | FCC 15.247(a)(1)(iii)<br>RSS-247 5.1 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):        | A+B (Core 0 + Core 1) | Peak Antenna Gain (dBi): | - |

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

**Table 39 - Number of Hopping Frequencies Results**



**Figure 54 - 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)

FHSs 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 1.

| Instrument                   | Manufacturer          | Type No.                  | TE No. | Calibration Period (months) | Calibration Expiry Date |
|------------------------------|-----------------------|---------------------------|--------|-----------------------------|-------------------------|
| Multimeter                   | Fluke                 | 79 Series III             | 611    | 12                          | 21-Dec-2022             |
| Hygrometer                   | Rotronic              | I-1000                    | 3220   | 12                          | 05-Nov-2022             |
| Frequency Standard           | Spectracom            | SecureSync 1200-0408-0601 | 4393   | 6                           | 01-Feb-2023             |
| AC Programmable Power Supply | iTech                 | IT7324                    | 5226   | -                           | O/P Mon                 |
| MXA Signal Analyser          | Keysight Technologies | N9020B                    | 5529   | 24                          | 13-Sep-2024             |
| Signal Conditioning Unit     | TUV SUD               | SPECTRUM SCU002           | 5759   | 12                          | 05-Jul-2023             |

**Table 40**

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**

A2780, S/N: NW3J007K67 - Modification State 0

### **2.5.3 Date of Test**

19-October-2022 to 28-October-2022

### **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 | 22.7 - 23.5 °C |
| Relative Humidity   | 52.3 - 56.9 %  |



## 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 π/4 DQPSK (2-DH5) | Duty Cycle (%):          | - |
| Antenna Configuration: | SISO                  | DCCF (dB):               | - |
| Active Port(s):        | B (Core 1)            | Peak Antenna Gain (dBi): | - |

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

**Table 41 - 20 dB Bandwidth Results**



Figure 55 - Core 1 (B) 2402 MHz (CH0) 20 dB Bandwidth

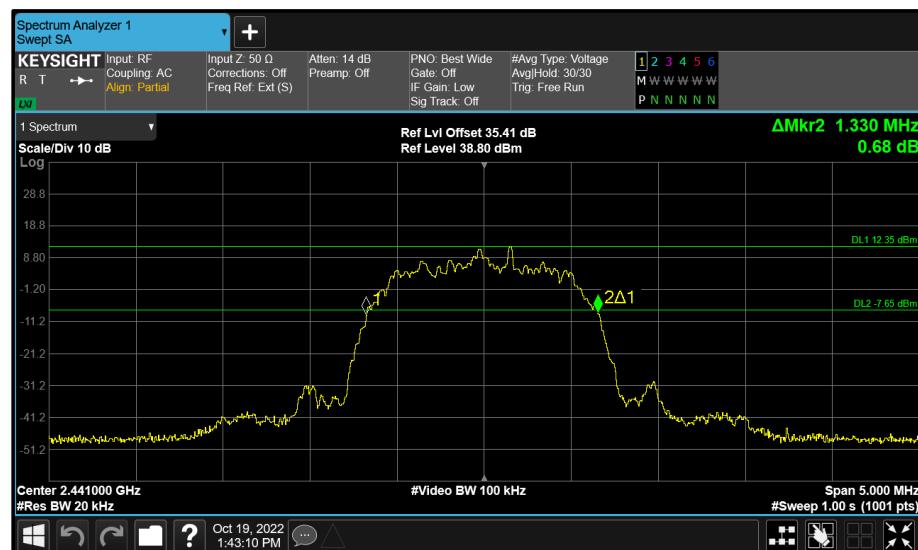


Figure 56 - Core 1 (B) 2441 MHz (CH39) 20 dB Bandwidth



Figure 57 - Core 1 (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 1)         | Peak Antenna Gain (dBi): | - |

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

**Table 42 - 20 dB Bandwidth Results**



Figure 58 - Core 1 (B) 2402 MHz (CH0) 20 dB Bandwidth



Figure 59 - Core 1 (B) 2441 MHz (CH39) 20 dB Bandwidth



Figure 60 - Core 1 (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 π/4 DQPSK (2-DH5) | Duty Cycle (%):          | - |
| Antenna Configuration: | Beamforming           | DCCF (dB):               | - |
| Active Port(s):        | A+B (Core 0 + Core 1) | Peak Antenna Gain (dBi): | - |

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

**Table 43 - 20 dB Bandwidth Results**



Figure 61 - Core 0 (A) 2402 MHz (CH0) 20 dB Bandwidth



Figure 62 - Core 1 (B) 2402 MHz (CH0) 20 dB Bandwidth



Figure 63 - Core 0 (A) 2441 MHz (CH39) 20 dB Bandwidth



Figure 64 - Core 1 (B) 2441 MHz (CH39) 20 dB Bandwidth



Figure 65 - Core 0 (A) 2480 MHz (CH78) 20 dB Bandwidth



Figure 66 - Core 1 (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: | Beamforming           | DCCF (dB):               | - |
| Active Port(s):        | A+B (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                    | 1.260                 | 1.260 | - | - |

**Table 44 - 20 dB Bandwidth Results**

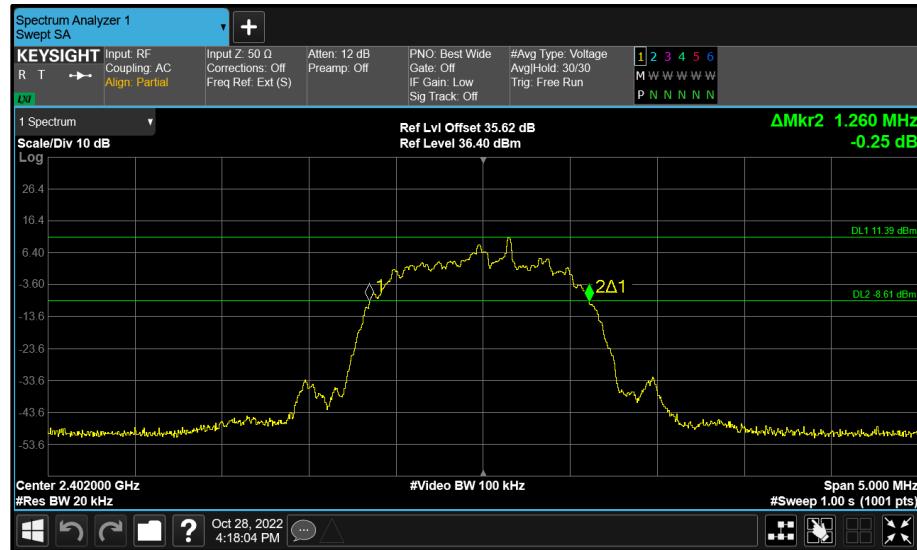


Figure 67 - Core 0 (A) 2402 MHz (CH0) 20 dB Bandwidth



Figure 68 - Core 1 (B) 2402 MHz (CH0) 20 dB Bandwidth



Figure 69 - Core 0 (A) 2441 MHz (CH39) 20 dB Bandwidth



Figure 70 - Core 1 (B) 2441 MHz (CH39) 20 dB Bandwidth



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



Figure 72 - Core 1 (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: | SISO           | DCCF (dB):               | - |
| Active Port(s):        | B (Core 1)     | Peak Antenna Gain (dBi): | - |

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

**Table 45 - 20 dB Bandwidth Results**

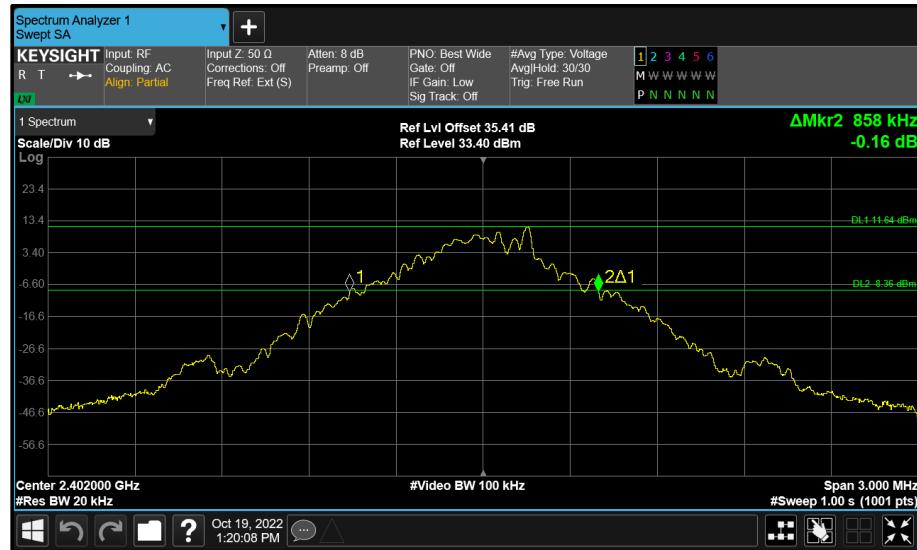


Figure 73 - Core 1 (B) 2402 MHz (CH0) 20 dB Bandwidth



Figure 74 - Core 1 (B) 2441 MHz (CH39) 20 dB Bandwidth



Figure 75 - Core 1 (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: | SISO           | DCCF (dB):               | - |
| Active Port(s):        | C (Core 2)     | Peak Antenna Gain (dBi): | - |

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

**Table 46 - 20 dB Bandwidth Results**



Figure 76 - Core 2 (C) 2402 MHz (CH0) 20 dB Bandwidth



Figure 77 - Core 2 (C) 2441 MHz (CH39) 20 dB Bandwidth



Figure 78 - Core 2 (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: | Beamforming           | DCCF (dB):               | - |
| Active Port(s):        | A+B (Core 0 + Core 1) | Peak Antenna Gain (dBi): | - |

| Test Frequency<br>(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 47 - 20 dB Bandwidth Results**



Figure 79 - Core 0 (A) 2402 MHz (CH0) 20 dB Bandwidth



Figure 80 - Core 1 (B) 2402 MHz (CH0) 20 dB Bandwidth



Figure 81 - Core 0 (A) 2441 MHz (CH39) 20 dB Bandwidth



Figure 82 - Core 1 (B) 2441 MHz (CH39) 20 dB Bandwidth