



TESTING LABORATORY  
CERTIFICATE#4323.01



## FCC PART 15.247 TEST REPORT

For

**M5Stack Technology Co., Ltd**

106, 1st Floor, Building 1, Bright Technology Park, 88 Zhuguang North Road, Xili Taoyuan  
Street, Nanshan District, Shenzhen, Guangdong, China

**FCC ID: 2AN3WM5STACK-CORE2**

|                                        |                                                                                                                                                                                                                            |
|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Report Type:</b><br>Original Report | <b>Product Type:</b><br>M5Stack-CORE2                                                                                                                                                                                      |
| <b>Test Engineer:</b>                  | Lee Li                                                                                                                                                                                                                     |
| <b>Report Number:</b>                  | RSHD200716003-00B                                                                                                                                                                                                          |
| <b>Report Date:</b>                    | 2020-08-04                                                                                                                                                                                                                 |
| <b>Reviewed By:</b>                    | Oscar Ye<br>EMC Manager                                                                                                                                                                                                    |
| <b>Prepared By:</b>                    | Bay Area Compliance Laboratories Corp. (Kunshan)<br>No.248 Chenghu Road,Kunshan,Jiangsu province,China<br>Tel: +86-0512-86175000<br>Fax: +86-0512-88934268<br><a href="http://www.baclcorp.com.cn">www.baclcorp.com.cn</a> |

## **TABLE OF CONTENTS**

|                                                                            |           |
|----------------------------------------------------------------------------|-----------|
| <b>GENERAL INFORMATION.....</b>                                            | <b>4</b>  |
| PRODUCT DESCRIPTION FOR EQUIPMENT UNDER TEST (EUT) .....                   | 4         |
| OBJECTIVE .....                                                            | 4         |
| RELATED SUBMITTAL(S)/GRANT(S).....                                         | 4         |
| TEST METHODOLOGY .....                                                     | 4         |
| MEASUREMENT UNCERTAINTY .....                                              | 5         |
| TEST FACILITY .....                                                        | 5         |
| <b>SYSTEM TEST CONFIGURATION.....</b>                                      | <b>6</b>  |
| DESCRIPTION OF TEST CONFIGURATION .....                                    | 6         |
| EUT EXERCISE SOFTWARE .....                                                | 6         |
| SPECIAL ACCESSORIES.....                                                   | 6         |
| EQUIPMENT MODIFICATIONS .....                                              | 6         |
| SUPPORT EQUIPMENT LIST AND DETAILS .....                                   | 7         |
| EXTERNAL I/O CABLE.....                                                    | 7         |
| BLOCK DIAGRAM OF TEST SETUP .....                                          | 7         |
| <b>SUMMARY OF TEST RESULTS .....</b>                                       | <b>9</b>  |
| <b>TEST EQUIPMENT LIST .....</b>                                           | <b>10</b> |
| <b>FCC §1.1310 &amp; §2.1091- MAXIMUM PERMISSIBLE EXPOSURE (MPE) .....</b> | <b>11</b> |
| APPLICABLE STANDARD .....                                                  | 11        |
| CALCULATED FORMULARY:.....                                                 | 11        |
| CALCULATED DATA (WORST CASE): .....                                        | 11        |
| <b>FCC §15.203 – ANTENNA REQUIREMENT.....</b>                              | <b>12</b> |
| APPLICABLE STANDARD .....                                                  | 12        |
| ANTENNA CONNECTOR CONSTRUCTION .....                                       | 12        |
| <b>FCC §15.207 (a) – AC LINE CONDUCTED EMISSIONS .....</b>                 | <b>13</b> |
| APPLICABLE STANDARD .....                                                  | 13        |
| EUT SETUP .....                                                            | 13        |
| EMI TEST RECEIVER SETUP.....                                               | 13        |
| TEST PROCEDURE .....                                                       | 14        |
| FACTOR & MARGIN CALCULATION .....                                          | 14        |
| TEST RESULTS SUMMARY .....                                                 | 14        |
| TEST DATA .....                                                            | 14        |
| <b>FCC §15.205, §15.209 &amp; §15.247(d) – RADIATED EMISSIONS.....</b>     | <b>17</b> |
| APPLICABLE STANDARD .....                                                  | 17        |
| EUT SETUP .....                                                            | 17        |
| EMI TEST RECEIVER SETUP.....                                               | 18        |
| TEST PROCEDURE .....                                                       | 18        |
| CORRECTED AMPLITUDE & MARGIN CALCULATION .....                             | 18        |
| TEST RESULTS SUMMARY .....                                                 | 18        |
| TEST DATA .....                                                            | 18        |
| <b>FCC §15.247(a) (1)-CHANNEL SEPARATION TEST .....</b>                    | <b>30</b> |
| APPLICABLE STANDARD .....                                                  | 30        |
| TEST PROCEDURE .....                                                       | 30        |
| TEST DATA .....                                                            | 30        |
| <b>FCC §15.247(a) (1) – 20 dB EMISSION BANDWIDTH.....</b>                  | <b>36</b> |
| APPLICABLE STANDARD .....                                                  | 36        |

|                                                                        |           |
|------------------------------------------------------------------------|-----------|
| TEST PROCEDURE .....                                                   | 36        |
| TEST DATA .....                                                        | 36        |
| <b>FCC §15.247(a) (1) (iii)-QUANTITY OF HOPPING CHANNEL TEST .....</b> | <b>42</b> |
| APPLICABLE STANDARD .....                                              | 42        |
| TEST PROCEDURE .....                                                   | 42        |
| TEST DATA .....                                                        | 42        |
| <b>FCC §15.247(a) (1) (iii) - TIME OF OCCUPANCY (DWELL TIME).....</b>  | <b>45</b> |
| APPLICABLE STANDARD .....                                              | 45        |
| TEST PROCEDURE .....                                                   | 45        |
| TEST DATA .....                                                        | 45        |
| <b>FCC §15.247(b) (1) - PEAK OUTPUT POWER MEASUREMENT .....</b>        | <b>61</b> |
| APPLICABLE STANDARD .....                                              | 61        |
| TEST PROCEDURE .....                                                   | 61        |
| TEST DATA .....                                                        | 61        |
| <b>FCC §15.247(d) - BAND EDGES TESTING .....</b>                       | <b>68</b> |
| APPLICABLE STANDARD .....                                              | 68        |
| TEST PROCEDURE .....                                                   | 68        |
| TEST DATA .....                                                        | 68        |

## GENERAL INFORMATION

### Product Description for Equipment under Test (EUT)

|                           |                                   |
|---------------------------|-----------------------------------|
| Applicant:                | M5Stack Technology Co., Ltd       |
| Product Type:             | M5Stack-CORE2                     |
| Tested Model:             | CORE2                             |
| Power Supply:             | DC 3.7 V from battery or DC 5.0 V |
| RF Function:              | Classic BT                        |
| Operating Band/Frequency: | 2402-2480 MHz                     |
| Channel Number:           | 79                                |
| Channel Separation:       | 1 MHz                             |
| Modulation Type:          | GFSK, $\pi/4$ -DQPSK, 8DPSK       |
| Antenna Type:             | PIFA Antenna                      |
| Maximum Antenna Gain:     | 2.0 dBi                           |

*\*All measurement and test data in this report was gathered from production sample serial number: 20200716003.  
(Assigned by the BACL. The EUT supplied by the applicant was received on 2020-07-16)*

### Objective

This test report is prepared on behalf of *M5Stack Technology Co., Ltd* in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commissions rules.

The tests were performed in order to determine Compliance with FCC Part 15, Subpart C, section 15.203, 15.205, 15.207, 15.209 and 15.247 rules.

### Related Submittal(s)/Grant(s)

FCC Part 15.247 DTS submissions with FCC ID: 2AN3WM5STACK-CORE2.

### Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices and 558074 D01 15.247 Meas Guidance v05r02.

All emissions measurement was performed and Bay Area Compliance Laboratories Corp. (Kunshan). The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

**Measurement Uncertainty**

| Item                               |             | Uncertainty |
|------------------------------------|-------------|-------------|
| AC Power Lines Conducted Emissions |             | 3.19dB      |
| RF conducted test with spectrum    |             | 0.9dB       |
| RF Output Power with Power meter   |             | 0.5dB       |
| Radiated emission                  | 30MHz~1GHz  | 6.11dB      |
|                                    | 1GHz~6GHz   | 4.45dB      |
|                                    | 6GHz~18GHz  | 5.23dB      |
|                                    | 18GHz~40GHz | 5.65dB      |
| Occupied Bandwidth                 |             | 0.5kHz      |
| Temperature                        |             | 1.0℃        |
| Humidity                           |             | 6%          |

**Test Facility**

The Test site used by Bay Area Compliance Laboratories Corp. (Kunshan) to collect test data is located on the No.248 Chenghu Road, Kunshan, Jiangsu province, China.

Bay Area Compliance Laboratories Corp. (Kunshan) Lab is accredited to ISO/IEC 17025 by A2LA (Lab code: 4323.01), the FCC designation No. CN1185 under the FCC KDB 974614 D01 and CAB identifier CN0004 under the ISED requirement. The facility also complies with the radiated and AC line conducted test site criteria set forth in ANSI C63.4-2014

## SYSTEM TEST CONFIGURATION

### Description of Test Configuration

Channel list:

| Channel | Frequency (MHz) | Channel | Frequency (MHz) |
|---------|-----------------|---------|-----------------|
| 0       | 2402            | 40      | 2442            |
| 1       | 2403            | ...     | ...             |
| ...     | ...             | ...     | ...             |
| ...     | ...             | 78      | 2480            |
| 39      | 2441            | /       | /               |

EUT was tested with Channel 0, 39 and 78.

### EUT Exercise Software

RF test software: EspRFtestTool

GFSK,  $\pi/4$ -DQPSK , 8DPSK Power level: 6 .

### Special Accessories

No special accessory.

### Equipment Modifications

No modification was made to the EUT tested.

**Support Equipment List and Details**

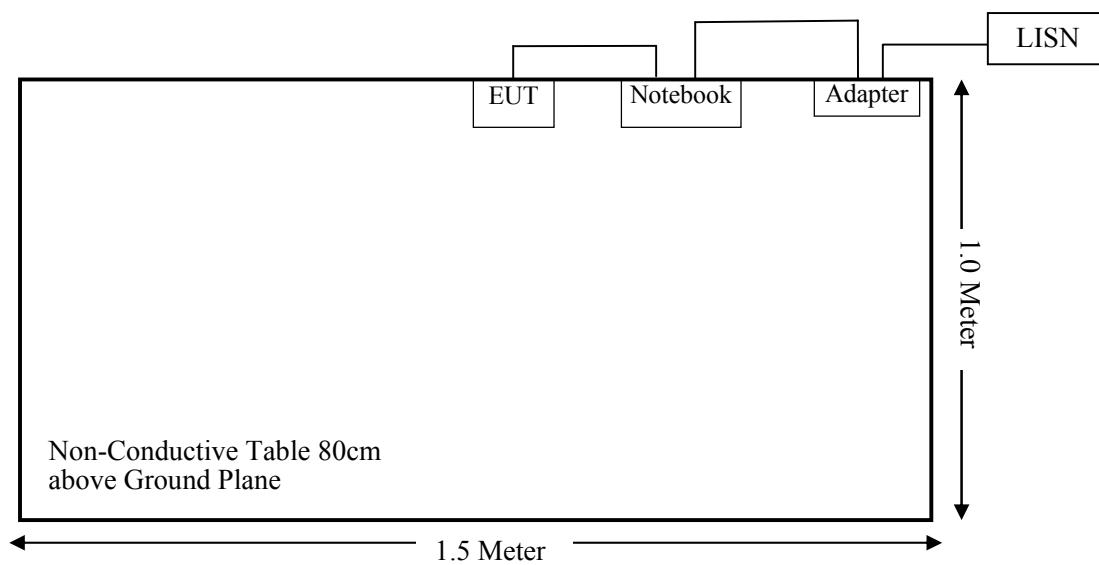
| Manufacturer | Description | Model      | Serial Number |
|--------------|-------------|------------|---------------|
| DELL         | Notebook    | GX620      | D65874152     |
| DELL         | Adapter     | LA65NS0-00 | DF263         |

**External I/O Cable**

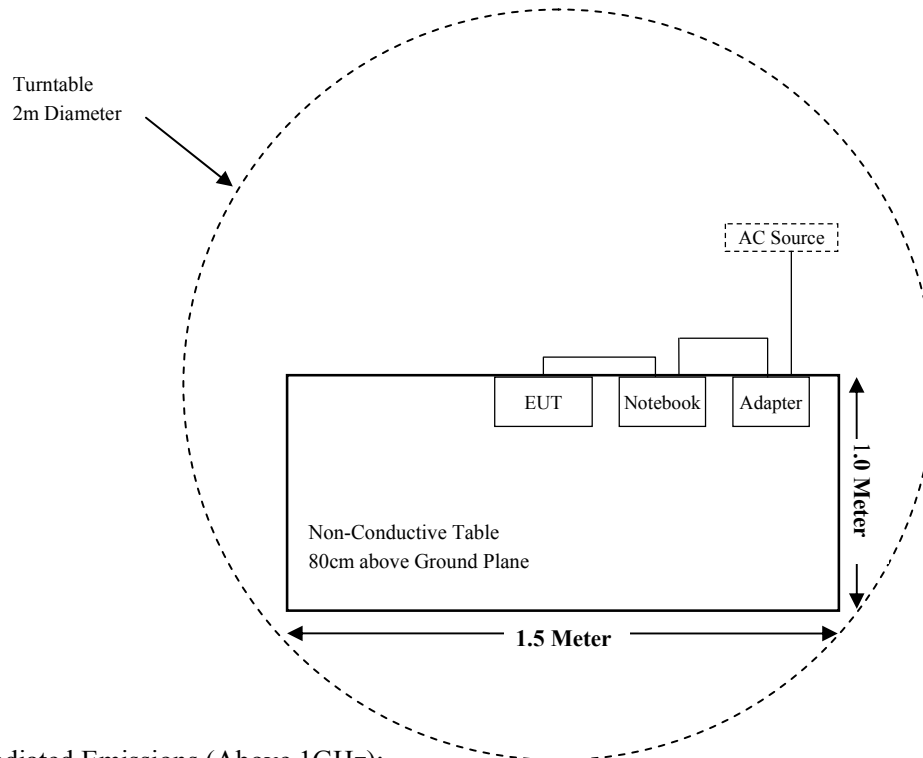
| Cable Description | Shielding Type | Length (m) | From Port | To  |
|-------------------|----------------|------------|-----------|-----|
| USB Cable         | Un-shielding   | 1.0        | Notebook  | EUT |

**Block Diagram of Test Setup**

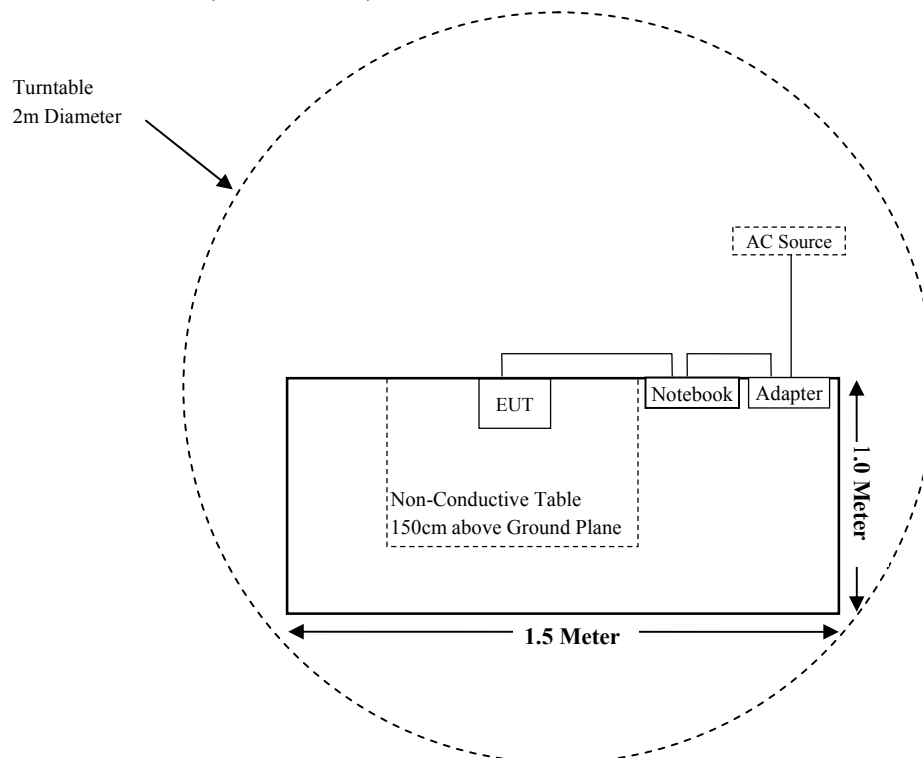
For Conducted Emissions:



For Radiated Emissions (Below 1GHz):



For Radiated Emissions (Above 1GHz):



**SUMMARY OF TEST RESULTS**

| <b>FCC Rules</b>               | <b>Description of Test</b>                      | <b>Result</b> |
|--------------------------------|-------------------------------------------------|---------------|
| §15.247 (I), §1.1310 & §2.1091 | MAXIMUM PERMISSIBLE EXPOSURE (MPE)              | Compliant     |
| §15.203                        | Antenna Requirement                             | Compliant     |
| §15.207(a)                     | AC Line Conducted Emissions                     | Compliant     |
| §15.205, §15.209 & §15.247(d)  | Radiated Emissions & Restricted Bands Emissions | Compliant     |
| §15.247(a)(1)                  | 20 dB Emission Bandwidth                        | Compliant     |
| §15.247(a)(1)                  | Channel Separation Test                         | Compliant     |
| §15.247(a)(1)(iii)             | Time of Occupancy (Dwell Time)                  | Compliant     |
| §15.247(a)(1)(iii)             | Quantity of hopping channel Test                | Compliant     |
| §15.247(b)(1)                  | Peak Output Power Measurement                   | Compliant     |
| §15.247(d)                     | Band edges                                      | Compliant     |

**TEST EQUIPMENT LIST**

| Manufacturer                               | Description        | Model                 | Serial Number | Calibration Date | Calibration Due Date |
|--------------------------------------------|--------------------|-----------------------|---------------|------------------|----------------------|
| <b>Radiated Emission Test (Chamber 1#)</b> |                    |                       |               |                  |                      |
| Rohde & Schwarz                            | EMI Test Receiver  | ESCI                  | 100195        | 2019-12-14       | 2020-12-13           |
| Sunol Sciences                             | Broadband Antenna  | JB3                   | A090413-1     | 2017-12-26       | 2020-12-25           |
| Sonoma Instrunent                          | Pre-amplifier      | 310N                  | 171205        | 2019-08-14       | 2020-08-13           |
| Rohde & Schwarz                            | Auto test Software | EMC32                 | 100361        | /                | /                    |
| MICRO-COAX                                 | Coaxial Cable      | Cable-8               | 008           | 2019-08-15       | 2020-08-14           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-9               | 009           | 2019-08-15       | 2020-08-14           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-10              | 010           | 2019-08-15       | 2020-08-14           |
| <b>Radiated Emission Test (Chamber 2#)</b> |                    |                       |               |                  |                      |
| Rohde & Schwarz                            | EMI Test Receiver  | ESU40                 | 100207        | 2020-04-01       | 2021-03-31           |
| ETS-LINDGREN                               | Horn Antenna       | 3115                  | 6229          | 2020-01-10       | 2023-01-09           |
| ETS-LINDGREN                               | Horn Antenna       | 3116                  | 00084159      | 2019-10-18       | 2022-10-17           |
| A.H.Systems,inc                            | Amplifier          | PAM-0118P             | 512           | 2020-02-20       | 2021-02-19           |
| EM Electronics Corporation                 | Amplifier          | EM18G40G              | 060726        | 2020-03-22       | 2021-03-21           |
| MICRO-TRONICS                              | Band Reject Filter | BRM50702              | G024          | 2019-08-05       | 2020-08-04           |
| Narda                                      | Attenuator         | 10dB                  | 010           | 2019-08-15       | 2020-08-14           |
| Rohde & Schwarz                            | Auto test Software | EMC32                 | 100361        | /                | /                    |
| MICRO-COAX                                 | Coaxial Cable      | Cable-6               | 006           | 2019-12-12       | 2020-12-11           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-11              | 011           | 2019-08-15       | 2020-08-14           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-12              | 012           | 2019-08-15       | 2020-08-14           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-13              | 013           | 2019-08-15       | 2020-08-14           |
| <b>RF Conducted Test</b>                   |                    |                       |               |                  |                      |
| Rohde & Schwarz                            | Signal Analyzer    | FSIQ26                | 836131/009    | 2019-12-14       | 2020-12-13           |
| Rohde & Schwarz                            | Signal Analyzer    | FSV40                 | 101116        | 2019-08-05       | 2020-08-04           |
| Narda                                      | Attenuator         | 10dB                  | 010           | 2019-08-15       | 2020-08-14           |
| M5Stack Technology                         | RF Cable           | M5Stack Technology 01 | C01           | Each Time        | /                    |
| <b>Conducted Emission Test</b>             |                    |                       |               |                  |                      |
| Rohde & Schwarz                            | EMI Test Receiver  | ESCS30                | 834115/007    | 2019-11-30       | 2020-11-29           |
| Rohde & Schwarz                            | LISN               | ENV216                | 3560655016    | 2019-11-30       | 2020-11-29           |
| Audix                                      | Test Software      | e3                    | V9            | --               | --                   |
| Rohde & Schwarz                            | Pulse limiter      | ESH3-Z2               | 0357.8810.54  | 2019-08-10       | 2020-08-09           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-15              | 015           | 2019-08-15       | 2020-08-14           |

\* **Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

## **FCC §1.1310 & §2.1091- MAXIMUM PERMISSIBLE EXPOSURE (MPE)**

### **Applicable Standard**

According to subpart 15.247 (i) and subpart 1.1310, 2.1091 systems operating under the provisions of this section shall be operated in a manner that ensures the public is not exposed to RF energy level in excess of the communication guidelines.

| <b>Limits for General Population/Uncontrolled Exposure</b> |                                      |                                      |                                          |                                 |
|------------------------------------------------------------|--------------------------------------|--------------------------------------|------------------------------------------|---------------------------------|
| <b>Frequency Range (MHz)</b>                               | <b>Electric Field Strength (V/m)</b> | <b>Magnetic Field Strength (A/m)</b> | <b>Power Density (mW/cm<sup>2</sup>)</b> | <b>Averaging Time (minutes)</b> |
| 0.3-1.34                                                   | 614                                  | 1.63                                 | *(100)                                   | 30                              |
| 1.34-30                                                    | 824/f                                | 2.19/f                               | *(180/f <sup>2</sup> )                   | 30                              |
| 30-300                                                     | 27.5                                 | 0.073                                | 0.2                                      | 30                              |
| 300-1500                                                   | /                                    | /                                    | f/1500                                   | 30                              |
| 1500-100,000                                               | /                                    | /                                    | 1.0                                      | 30                              |

f = frequency in MHz; \* = Plane-wave equivalent power density

### **Calculated Formulary:**

Predication of MPE limit at a given distance

$S = PG/4\pi R^2$  = power density (in appropriate units, e.g. mW/cm<sup>2</sup>);

P = power input to the antenna (in appropriate units, e.g., mW);

G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor, is normally numeric gain;

R = distance to the center of radiation of the antenna (appropriate units, e.g., cm);

### **Calculated Data (worst case):**

| <b>Mode</b>  | <b>Frequency Range (MHz)</b> | <b>Maximum Antenna Gain</b> |                  | <b>Tune-up Conducted Power</b> |             | <b>Evaluation Distance (cm)</b> | <b>Power Density (mW/cm<sup>2</sup>)</b> | <b>MPE Limit (mW/cm<sup>2</sup>)</b> |
|--------------|------------------------------|-----------------------------|------------------|--------------------------------|-------------|---------------------------------|------------------------------------------|--------------------------------------|
|              |                              | <b>(dBi)</b>                | <b>(numeric)</b> | <b>(dBm)</b>                   | <b>(mW)</b> |                                 |                                          |                                      |
| 802.11b      | 2412-2462                    | 2.00                        | 1.58             | 22.50                          | 177.83      | 20                              | 0.0559                                   | 1.0                                  |
| 802.11g      |                              | 2.00                        | 1.58             | 21.50                          | 141.25      | 20                              | 0.0444                                   | 1.0                                  |
| 802.11n-HT20 |                              | 2.00                        | 1.58             | 22.00                          | 158.49      | 20                              | 0.0498                                   | 1.0                                  |
| 802.11n-HT40 | 2422-2452                    | 2.00                        | 1.58             | 22.50                          | 177.83      | 20                              | 0.0559                                   | 1.0                                  |
| BLE          | 2402-2480                    | 2.00                        | 1.58             | 4.50                           | 2.82        | 20                              | 0.0009                                   | 1.0                                  |
| BT           | 2402-2480                    | 2.00                        | 1.58             | 7.00                           | 5.01        | 20                              | 0.0016                                   | 1.0                                  |

**Note:** 1. For the above tune up power were declared by the manufacturer.

2. Wi-Fi and BT/BLE can't transmit simultaneously.

**Result:** The device meet FCC MPE at 20 cm distance.

---

**FCC §15.203 – ANTENNA REQUIREMENT**

---

**Applicable Standard**

According to FCC § 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

**Antenna Connector Construction**

The EUT has an internal PIFA antenna for Bluetooth, which the antenna gain is 2.0 dBi, fulfill the requirement of this section. Please refer to the EUT photos.

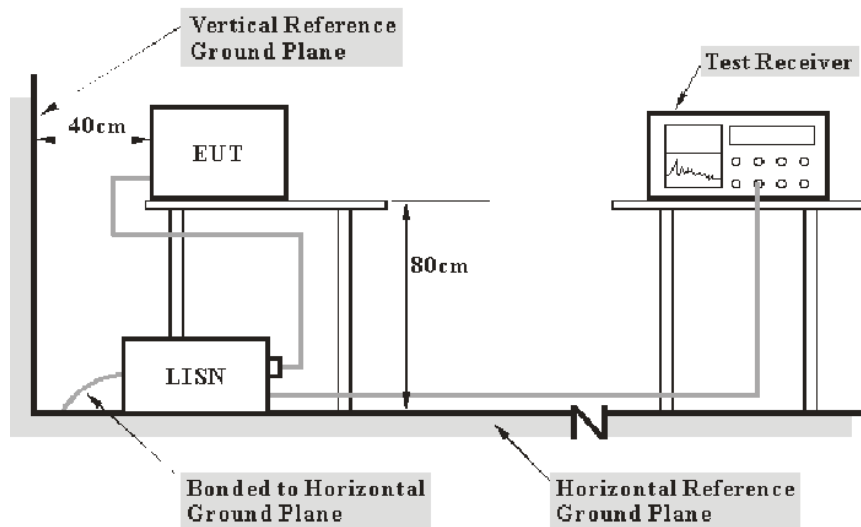
**Result:** Compliant.

## FCC §15.207 (a) – AC LINE CONDUCTED EMISSIONS

### Applicable Standard

FCC §15.207(a)

### EUT Setup



Note: 1. Support units were connected to second LISN.  
 2. Both of LISNs (AMN) 80 cm from EUT and at the least 80 cm from other units and other metal planes support units.

The measurement procedure of EUT setup is according with ANSI C63.10-2013. The related limit was specified in FCC Part 15.207.

### EMI Test Receiver Setup

The EMI test receiver was set to investigate the spectrum from 150 kHz to 30 MHz.

During the conducted emission test, the EMI test receiver was set with the following configurations:

| Frequency Range  | IF B/W |
|------------------|--------|
| 150 kHz – 30 MHz | 9 kHz  |

## Test Procedure

ANSI C63.10-2013 clause 6.2

During the conducted emission test, the adapter was connected to the outlet of the LISN.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All final data was recorded in the Quasi-peak and average detection mode.

## Factor & Margin Calculation

The factor is calculated by adding LISN VDF (Voltage Division Factor), Cable Loss and Attenuator. The basic equation is as follows:

$$\text{Factor (dB)} = \text{LISN VDF (dB)} + \text{Cable Loss (dB)} + \text{Attenuator (dB)}$$

The “**Over Limit**” column of the following data tables indicates the degree of compliance with the applicable limit. For example, an over Limit of 7dB means the emission is 7 dB above the limit. The equation for over Limit calculation is as follows:

$$\text{Over Limit (dB)} = \text{Read level (dB}\mu\text{V)} + \text{Factor (dB)} - \text{Limit (dB}\mu\text{V)}$$

## Test Results Summary

According to the recorded data in following table, the EUT complied with the FCC Part 15.207.

## Test Data

### Environmental Conditions

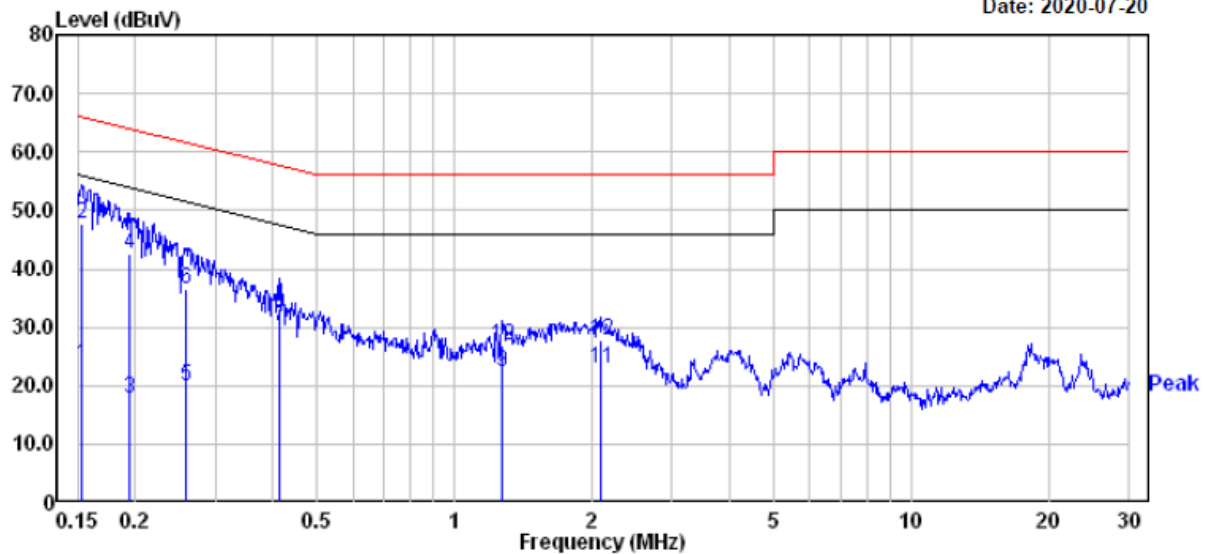
|                    |          |
|--------------------|----------|
| Temperature:       | 24.6°C   |
| Relative Humidity: | 50%      |
| ATM Pressure:      | 101.3kPa |

*The testing was performed by Lee Li on 2020-07-20.*

*EUT operation mode: Transmitting in high channel of 8DPSK mode (Worst case)*

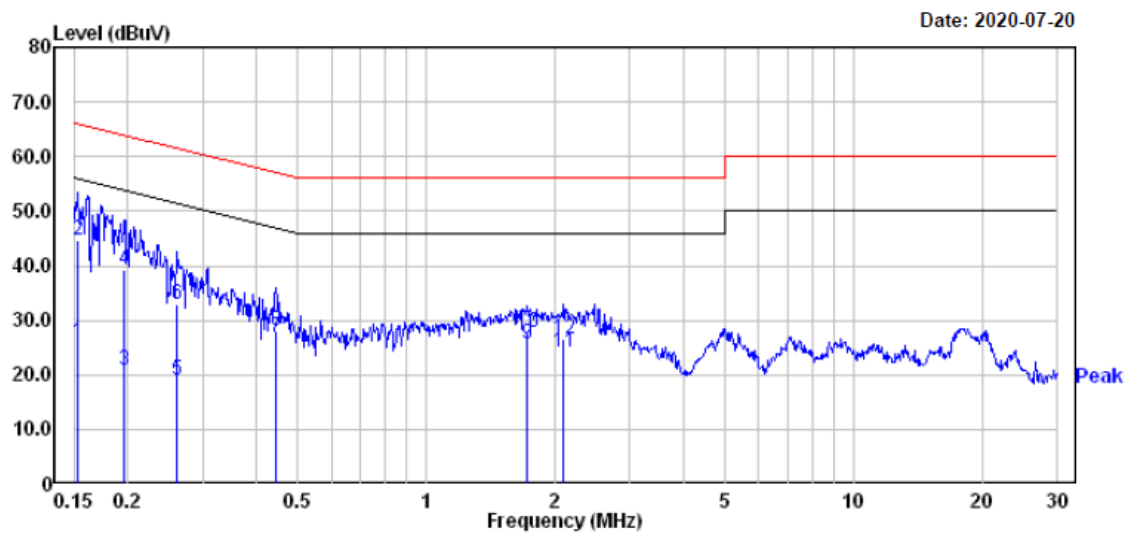
## AC 120V/60 Hz, Line

Date: 2020-07-20



|    | Freq  | Read Level | Factor | Level | Limit Line | Over Limit | Remark  |
|----|-------|------------|--------|-------|------------|------------|---------|
|    | MHz   | dBuV       | dB     | dBuV  | dBuV       | dB         |         |
| 1  | 0.152 | 3.60       | 19.82  | 23.42 | 55.87      | -32.45     | Average |
| 2  | 0.152 | 27.80      | 19.82  | 47.62 | 65.87      | -18.25     | QP      |
| 3  | 0.194 | -1.90      | 19.82  | 17.92 | 53.84      | -35.92     | Average |
| 4  | 0.194 | 22.70      | 19.82  | 42.52 | 63.84      | -21.32     | QP      |
| 5  | 0.259 | 0.20       | 19.82  | 20.02 | 51.47      | -31.45     | Average |
| 6  | 0.259 | 16.70      | 19.82  | 36.52 | 61.47      | -24.95     | QP      |
| 7  | 0.415 | 10.50      | 19.74  | 30.24 | 47.55      | -17.31     | Average |
| 8  | 0.415 | 12.50      | 19.74  | 32.24 | 57.55      | -25.31     | QP      |
| 9  | 1.276 | 2.60       | 19.82  | 22.42 | 46.00      | -23.58     | Average |
| 10 | 1.276 | 6.90       | 19.82  | 26.72 | 56.00      | -29.28     | QP      |
| 11 | 2.099 | 3.10       | 19.75  | 22.85 | 46.00      | -23.15     | Average |
| 12 | 2.099 | 8.00       | 19.75  | 27.75 | 56.00      | -28.25     | QP      |

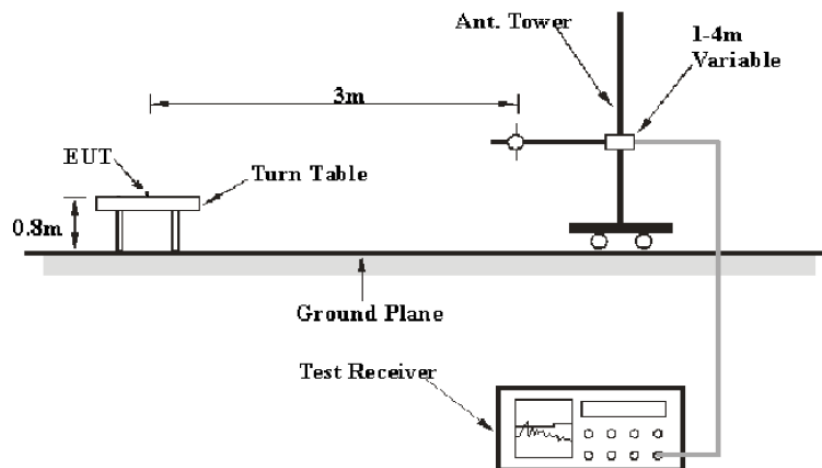
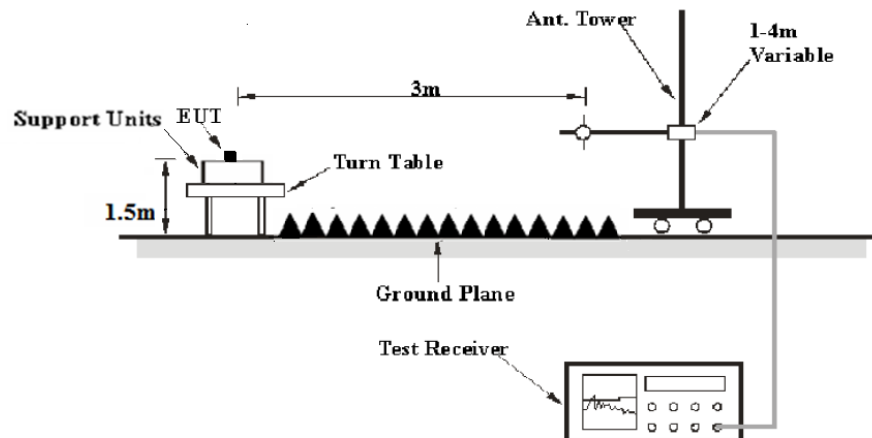
## AC 120V/60 Hz, Neutral



|    | Freq  | Read Level | Factor | Level | Limit Line | Over Limit | Remark  |
|----|-------|------------|--------|-------|------------|------------|---------|
|    | MHz   | dBuV       | dB     | dBuV  | dBuV       | dB         |         |
| 1  | 0.152 | 6.00       | 19.82  | 25.82 | 55.87      | -30.05     | Average |
| 2  | 0.152 | 24.80      | 19.82  | 44.62 | 65.87      | -21.25     | QP      |
| 3  | 0.197 | 1.10       | 19.82  | 20.92 | 53.76      | -32.84     | Average |
| 4  | 0.197 | 19.30      | 19.82  | 39.12 | 63.76      | -24.64     | QP      |
| 5  | 0.262 | -0.70      | 19.82  | 19.12 | 51.38      | -32.26     | Average |
| 6  | 0.262 | 13.10      | 19.82  | 32.92 | 61.38      | -28.46     | QP      |
| 7  | 0.444 | 7.10       | 19.75  | 26.85 | 46.98      | -20.13     | Average |
| 8  | 0.444 | 8.40       | 19.75  | 28.15 | 56.98      | -28.83     | QP      |
| 9  | 1.725 | 5.90       | 19.84  | 25.74 | 46.00      | -20.26     | Average |
| 10 | 1.725 | 7.80       | 19.84  | 27.64 | 56.00      | -28.36     | QP      |
| 11 | 2.099 | 4.40       | 19.75  | 24.15 | 46.00      | -21.85     | Average |
| 12 | 2.099 | 6.70       | 19.75  | 26.45 | 56.00      | -29.55     | QP      |

**FCC §15.205, §15.209 & §15.247(d) – RADIATED EMISSIONS****Applicable Standard**

FCC §15.205; §15.209; §15.247(d)

**EUT Setup****Below 1 GHz:****Above 1GHz:**

The radiated emission tests were performed in the 3 meters, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC 15.209 and FCC 15.247 limits.

## EMI Test Receiver Setup

The system was investigated from 30 MHz to 25 GHz.

During the radiated emission test, the EMI test receiver Setup was set with the following configurations:

| Frequency Range   | RBW     | Video B/W | IF B/W  | Detector |
|-------------------|---------|-----------|---------|----------|
| 30 MHz – 1000 MHz | 120 kHz | 300 kHz   | 120 kHz | QP       |
| Above 1GHz        | 1MHz    | 3 MHz     | /       | PK       |
|                   | 1MHz    | 3 MHz     | /       | Ave.     |

## Test Procedure

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

All final data was recorded in Quasi-peak detection mode for frequency range of 30 MHz -1 GHz and peak and Average detection modes for frequencies above 1 GHz.

## Corrected Amplitude & Margin Calculation

The Corrected Amplitude is calculated by adding the Antenna Factor and Cable Loss, and subtracting the Amplifier Gain from the Meter Reading. The basic equation is as follows:

$$\text{Corrected Amplitude (dB}\mu\text{V /m)} = \text{Meter Reading (dB}\mu\text{V)} + \text{Antenna Factor (dB/m)} + \text{Cable Loss (dB)} - \text{Amplifier Gain (dB)}$$

The “**Margin**” column of the following data tables indicates the degree of Compliance with the applicable limit. For example, a margin of 7dB means the emission is 7dB below the limit. The equation for margin calculation is as follows:

$$\text{Margin (dB)} = \text{Limit (dB}\mu\text{V/m)} - \text{Corrected Amplitude (dB}\mu\text{V /m)}$$

## Test Results Summary

According to the recorded data in following table, the EUT complied with the FCC Title 47, Part 15, Subpart C, section 15.205, 15.209 and 15.247.

## Test Data

### Environmental Conditions

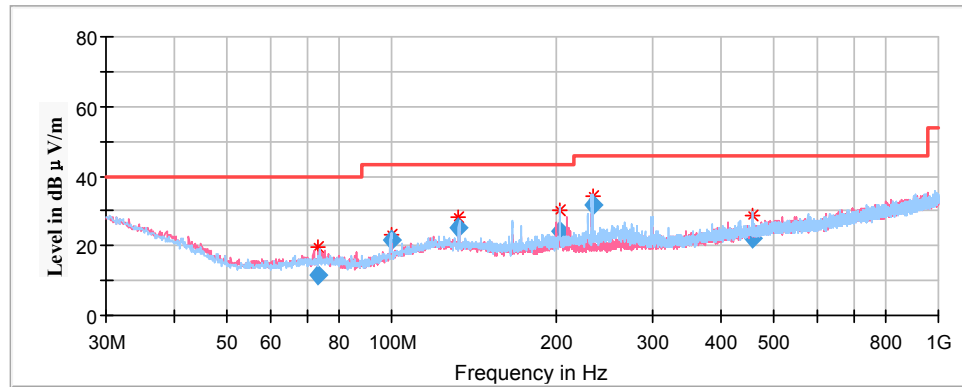
|                    |                    |
|--------------------|--------------------|
| Temperature:       | 24.8℃~25℃          |
| Relative Humidity: | 49 %~50 %          |
| ATM Pressure:      | 101.1kPa ~101.2kPa |

*The testing was performed by Lee Li from 2020-07-21 to 2020-07-31.*

*EUT operation mode: Transmitting*

**Spurious Emission Test:****30MHz-1GHz:**

*Pre-Scan with GFSK,  $\pi/4$ -DQPSK, 8DPSK modes of operation in the X,Y and Z axes of orientation, the worst case high channel of 8DPSK Mode in Z-axis of orientation was recorded*



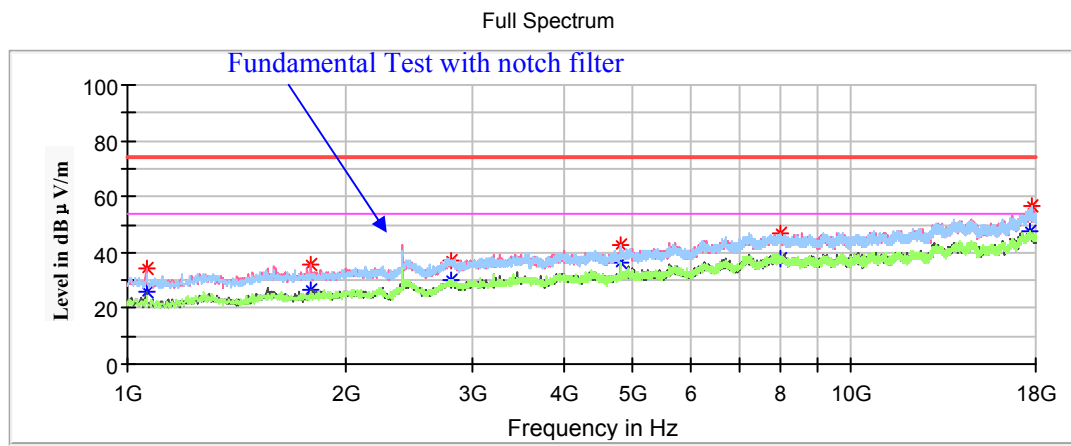
| Frequency (MHz) | Corrected Amplitude | Rx Antenna  |             | Turntable Degree | Corrected Factor (dB/m) | Limit (dBμV/m) | Margin (dB) |
|-----------------|---------------------|-------------|-------------|------------------|-------------------------|----------------|-------------|
|                 | Quasi-peak (dBμV/m) | Height (cm) | Polar (H/V) |                  |                         |                |             |
| 73.38           | 11.50               | 200.0       | H           | 144.0            | -17.9                   | 40.00          | 28.50       |
| 99.90           | 21.40               | 200.0       | H           | 160.0            | -15.4                   | 43.50          | 22.10       |
| 132.78          | 25.08               | 200.0       | H           | 87.0             | -12.1                   | 43.50          | 18.42       |
| 203.20          | 24.24               | 200.0       | H           | 250.0            | -12.8                   | 43.50          | 19.26       |
| 233.22          | 31.85               | 100.0       | H           | 114.0            | -12.6                   | 46.00          | 14.15       |
| 456.30          | 22.34               | 100.0       | H           | 263.0            | -7.2                    | 46.00          | 23.66       |

**1GHz-18GHz:**

*Pre-Scan with GFSK,  $\pi/4$ -DQPSK, 8DPSK modes of operation in the X,Y and Z axes of orientation, the worst case 8DPSK Mode in Z-axis of orientation was recorded*

Note:

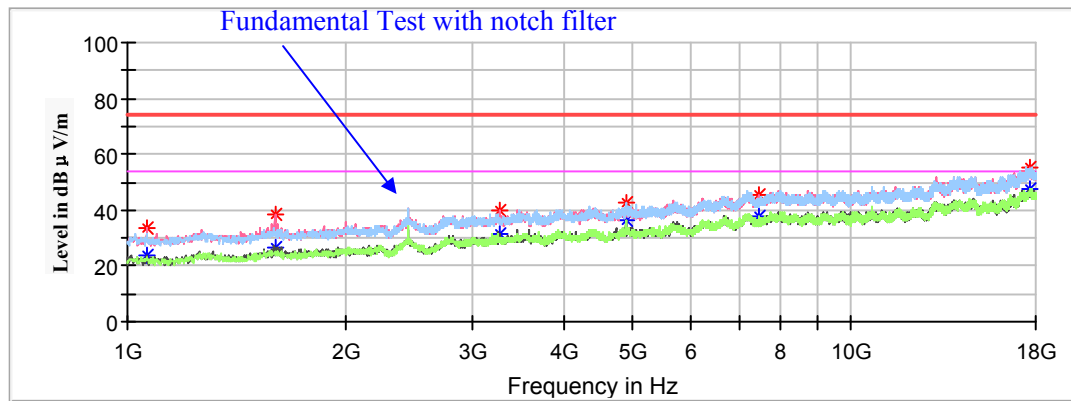
1. This test was performed with the 2.4-2.5 GHz notch filter.
2. Corrected Factor (dB/m) = Antenna factor (RX) (dB/m) + Cable Loss (dB) – Amplifier Factor (dB)  
 Corrected Amplitude (dB $\mu$ V/m) = Corrected Factor (dB/m) + Reading (dB $\mu$ V)  
 Margin (dB) = Limit (dB $\mu$ V/m) – Corrected Amplitude (dB $\mu$ V/m)

**Low Channel: 2402MHz**

| Frequency (MHz) | Corrected Amplitude    |                        | Rx Antenna  |             | Turntable Degree | Corrected Factor (dB/m) | Limit (dB $\mu$ V/m) | Margin (dB) |
|-----------------|------------------------|------------------------|-------------|-------------|------------------|-------------------------|----------------------|-------------|
|                 | MaxPeak (dB $\mu$ V/m) | Average (dB $\mu$ V/m) | Height (cm) | Polar (H/V) |                  |                         |                      |             |
| 1061.20         | ---                    | 25.92                  | 200.0       | V           | 313.0            | -18.7                   | 54.00                | 28.08       |
| 1061.20         | 34.14                  | ---                    | 200.0       | V           | 313.0            | -18.7                   | 74.00                | 39.86       |
| 1793.90         | 35.91                  | ---                    | 150.0       | V           | 257.0            | -15.2                   | 74.00                | 38.09       |
| 1793.90         | ---                    | 26.28                  | 150.0       | V           | 257.0            | -15.2                   | 54.00                | 27.72       |
| 2805.40         | ---                    | 30.23                  | 200.0       | H           | 65.0             | -11.0                   | 54.00                | 23.77       |
| 2805.40         | 37.13                  | ---                    | 200.0       | H           | 65.0             | -11.0                   | 74.00                | 36.87       |
| 4804.00         | 42.99                  | ---                    | 200.0       | H           | 0.0              | -5.6                    | 74.00                | 31.01       |
| 4804.00         | ---                    | 36.58                  | 200.0       | H           | 0.0              | -5.6                    | 54.00                | 17.42       |
| 8007.40         | ---                    | 37.90                  | 150.0       | H           | 283.0            | 1.8                     | 54.00                | 16.10       |
| 8007.40         | 46.89                  | ---                    | 150.0       | H           | 283.0            | 1.8                     | 74.00                | 27.11       |
| 17673.60        | ---                    | 47.56                  | 200.0       | V           | 142.0            | 8.9                     | 54.00                | 6.44        |
| 17753.50        | 56.68                  | ---                    | 200.0       | V           | 142.0            | 8.9                     | 74.00                | 17.32       |

**Middle Channel: 2441MHz**

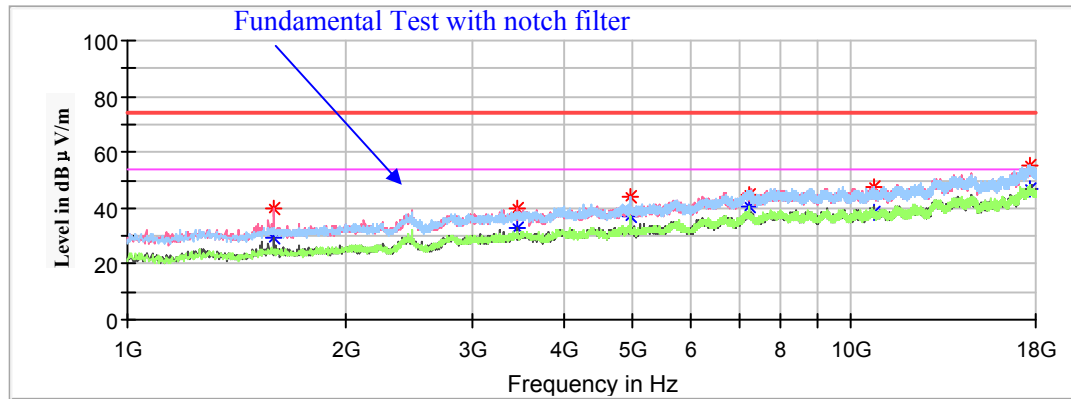
Full Spectrum



| Frequency (MHz) | Corrected Amplitude |                  | Rx Antenna  |             | Turntable Degree | Corrected Factor (dB/m) | Limit (dBμV/m) | Margin (dB) |
|-----------------|---------------------|------------------|-------------|-------------|------------------|-------------------------|----------------|-------------|
|                 | MaxPeak (dBμV/m)    | Average (dBμV/m) | Height (cm) | Polar (H/V) |                  |                         |                |             |
| 1061.20         | ---                 | 23.77            | 200.0       | V           | 313.0            | -18.7                   | 54.00          | 30.23       |
| 1061.20         | 33.33               | ---              | 200.0       | V           | 300.0            | -18.7                   | 74.00          | 40.67       |
| 1598.40         | ---                 | 26.66            | 150.0       | V           | 244.0            | -16.0                   | 54.00          | 27.34       |
| 1598.40         | 38.70               | ---              | 150.0       | V           | 244.0            | -16.0                   | 74.00          | 35.30       |
| 3267.80         | ---                 | 31.33            | 200.0       | V           | 108.0            | -9.4                    | 54.00          | 22.67       |
| 3267.80         | 39.54               | ---              | 200.0       | V           | 108.0            | -9.4                    | 74.00          | 34.46       |
| 4882.00         | 42.92               | ---              | 150.0       | V           | 283.0            | -5.4                    | 74.00          | 31.08       |
| 4882.00         | ---                 | 36.64            | 150.0       | V           | 283.0            | -5.4                    | 54.00          | 17.36       |
| 7437.90         | 45.35               | ---              | 200.0       | V           | 63.0             | 0.9                     | 74.00          | 28.65       |
| 7437.90         | ---                 | 37.52            | 200.0       | V           | 63.0             | 0.9                     | 54.00          | 16.48       |
| 17656.60        | 55.37               | ---              | 150.0       | V           | 324.0            | 8.9                     | 74.00          | 18.63       |
| 17656.60        | ---                 | 47.81            | 150.0       | V           | 324.0            | 8.9                     | 54.00          | 6.19        |

**High Channel: 2480MHz**

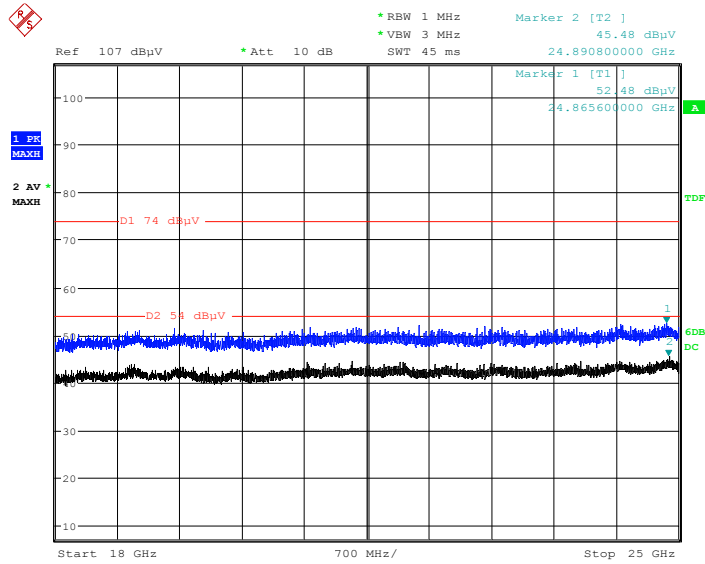
Full Spectrum



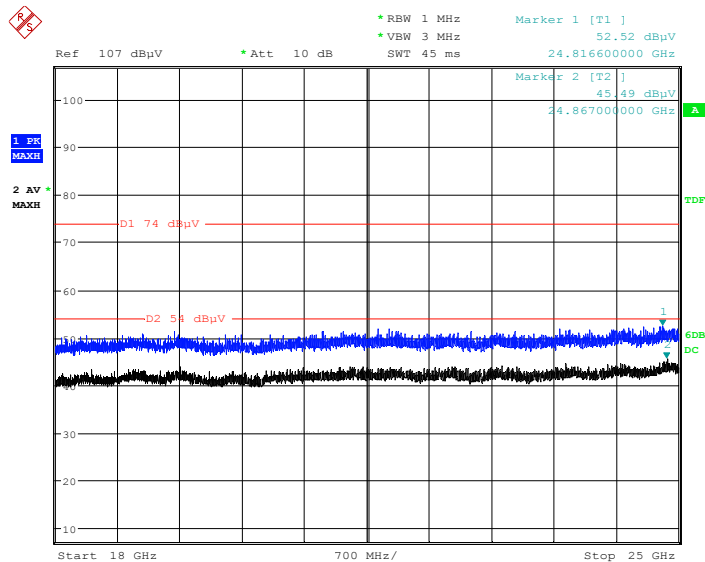
| Frequency (MHz) | Corrected Amplitude |                  | Rx Antenna  |             | Turntable Degree | Corrected Factor (dB/m) | Limit (dBμV/m) | Margin (dB) |
|-----------------|---------------------|------------------|-------------|-------------|------------------|-------------------------|----------------|-------------|
|                 | MaxPeak (dBμV/m)    | Average (dBμV/m) | Height (cm) | Polar (H/V) |                  |                         |                |             |
| 1593.30         | 40.15               | ---              | 150.0       | V           | 249.0            | -16.0                   | 74.00          | 33.85       |
| 1593.30         | ---                 | 29.36            | 150.0       | V           | 249.0            | -16.0                   | 54.00          | 24.64       |
| 3454.80         | ---                 | 33.12            | 200.0       | V           | 358.0            | -8.9                    | 54.00          | 20.88       |
| 3454.80         | 40.04               | ---              | 200.0       | V           | 358.0            | -8.9                    | 74.00          | 33.96       |
| 4960.00         | 43.76               | ---              | 150.0       | H           | 0.0              | -5.3                    | 74.00          | 30.24       |
| 4960.00         | ---                 | 37.40            | 150.0       | H           | 0.0              | -5.3                    | 54.00          | 16.60       |
| 7213.50         | 44.85               | ---              | 150.0       | H           | 95.0             | 0.4                     | 74.00          | 29.15       |
| 7213.50         | ---                 | 40.53            | 150.0       | H           | 95.0             | 0.4                     | 54.00          | 13.47       |
| 10751.20        | ---                 | 38.75            | 200.0       | H           | 10.0             | 2.6                     | 54.00          | 15.25       |
| 10751.20        | 47.41               | ---              | 200.0       | H           | 10.0             | 2.6                     | 74.00          | 26.59       |
| 17668.50        | ---                 | 46.70            | 150.0       | V           | 249.0            | 8.9                     | 54.00          | 7.30        |
| 17668.50        | 55.27               | ---              | 150.0       | V           | 249.0            | 8.9                     | 74.00          | 18.73       |

**18GHz-25GHz:**

*Pre-Scan with GFSK,  $\pi/4$ -DQPSK, 8DPSK modes of operation in the X,Y and Z axes of orientation, the worst case high channel of 8DPSK Mode in Z-axis of orientation was recorded*

**Horizontal**

Date: 31.JUL.2020 07:57:23

**Vertical**

Date: 31.JUL.2020 08:13:18

**Fundamental Test & Restricted Bands Emissions:**

*Pre-Scan with GFSK,  $\pi/4$ -DQPSK, 8DPSK modes of operation in the X,Y and Z axes of orientation, the worst case 8DPSK Mode in Z-axis of orientation was recorded*

Note:

1. Corrected Factor (dB/m) = Antenna factor (RX) (dB/m) + Cable Loss (dB) – Amplifier Factor (dB)

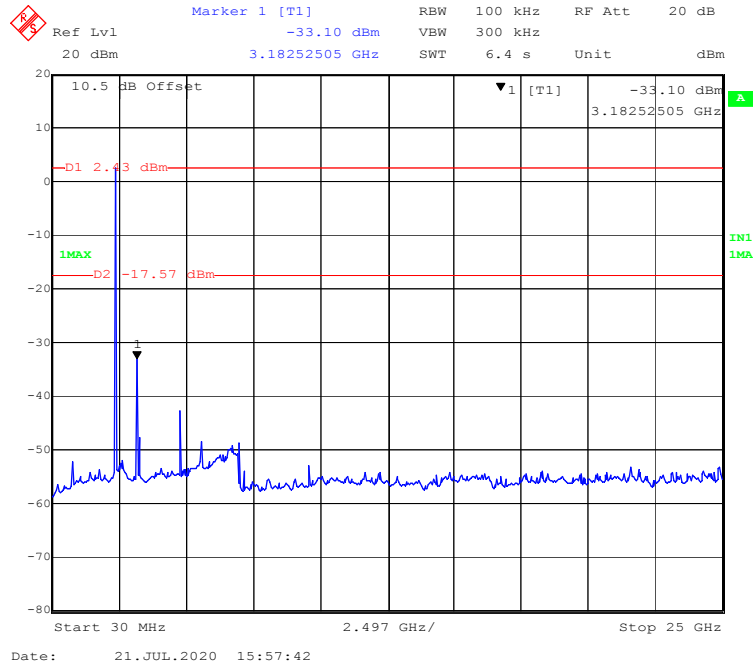
Corrected Amplitude (dB $\mu$ V /m) = Corrected Factor (dB/m) + Reading (dB $\mu$ V)

Margin (dB) = Limit (dB $\mu$ V/m) – Corrected Amplitude (dB $\mu$ V /m)

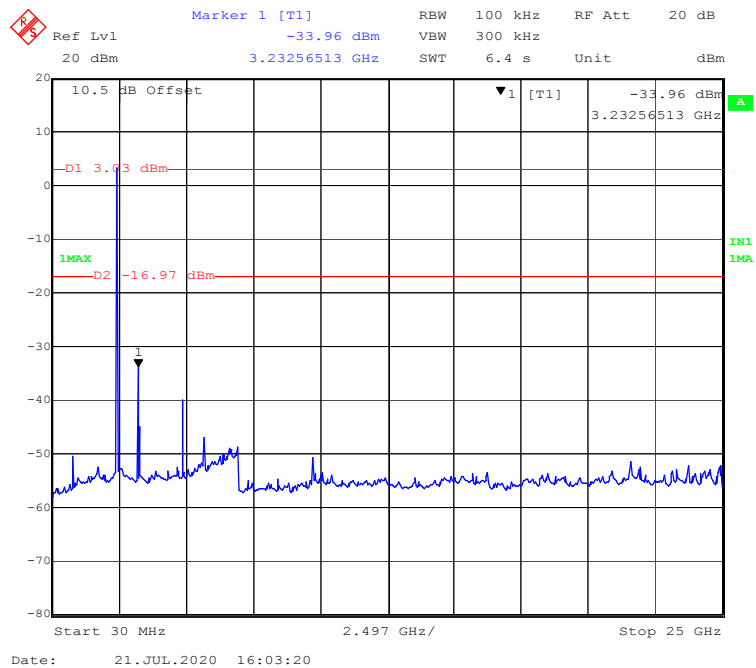
| Frequency<br>(MHz)    | Corrected Amplitude |                     | Rx Antenna     |                | Turntable<br>Degree | Corrected<br>Factor<br>(dB/m) | Limit<br>(dBμV/m) | Margin<br>(dB) |
|-----------------------|---------------------|---------------------|----------------|----------------|---------------------|-------------------------------|-------------------|----------------|
|                       | MaxPeak<br>(dBμV/m) | Average<br>(dBμV/m) | Height<br>(cm) | Polar<br>(H/V) |                     |                               |                   |                |
| Low Channel: 2402MHz  |                     |                     |                |                |                     |                               |                   |                |
| 2390.00               | ---                 | 38.50               | 150.0          | V              | 331.0               | -2.9                          | 54.00             | 15.50          |
| 2390.00               | 42.68               | ---                 | 150.0          | V              | 331.0               | -2.9                          | 74.00             | 31.32          |
| High Channel: 2480MHz |                     |                     |                |                |                     |                               |                   |                |
| 2483.50               | 48.25               | ---                 | 150.0          | V              | 229.0               | -2.5                          | 74.00             | 25.75          |
| 2483.50               | ---                 | 43.54               | 150.0          | V              | 229.0               | -2.5                          | 54.00             | 10.46          |

# Conducted Spurious Emissions at Antenna Port

## BDR (GFSK): Low Channel



## BDR (GFSK): Middle Channel



Marker 1 [T1] -35.25 dBm

Ref Lvl 20 dBm RBW 100 kHz RF Att 20 dB  
 20 dBm VBW 300 kHz  
 3.28260521 GHz SWT 6.4 s Unit dBm

10.5 dB Offset

▼ 1 [T1] -35.25 dBm  
 3.28260521 GHz

D1 4.28 dBm

1MAX D2 -15.82 dBm

1

Start 30 MHz 2.497 GHz/ Stop 25 GHz

Date: 21.JUL.2020 16:10:56

Ref Lvl 20 dBm RBW 100 kHz RF Att 20 dB  
 Marker 1 [T1] -32.51 dBm VBW 300 kHz Unit dBm  
 20 dBm 3.18252505 GHz SWT 6.4 s

10.5 dB Offset

▼1 [T1] -32.51 dBm  
 3.18252505 GHz

D1 -2.69 dBm

1MAX

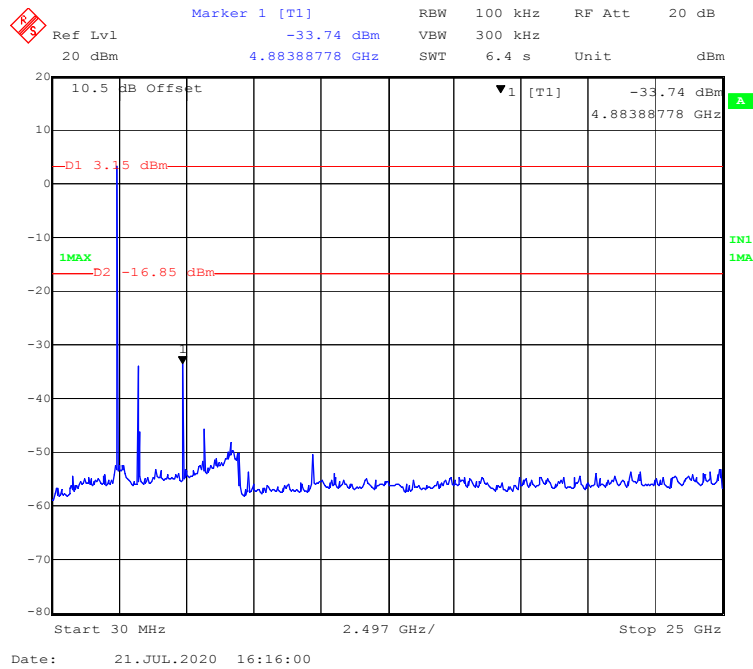
D2 -17.61 dBm

IN1  
 IMA

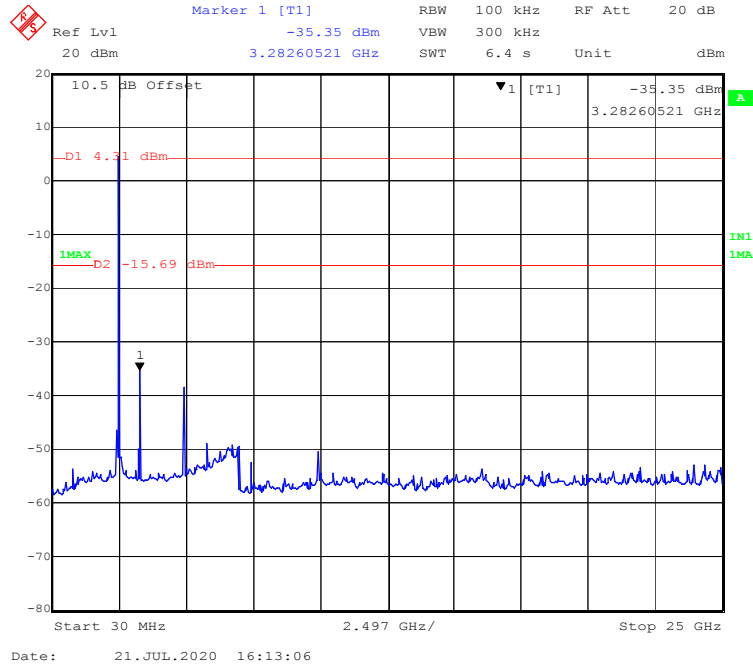
Start 30 MHz 2.497 GHz/ Stop 25 GHz

Date: 21.JUL.2020 16:18:27

### EDR ( $\pi/4$ -DQPSK): Middle Channel



### EDR ( $\pi/4$ -DQPSK): High Channel



Marker 1 [T1]  
-32.88 dBm  
RBW 100 kHz RF Att 20 dB  
20 dBm 3.18252505 GHz Unit dBm

10.5 dB Offset

▼ 1 [T1] -32.88 dBm  
3.18252505 GHz

D1 2.46 dBm

1MAX

D2 -17.84 dBm

IN1  
1MA

Start 30 MHz 2.497 GHz/ Stop 25 GHz

Date: 21.JUL.2020 16:19:58

Marker 1 [T1]  
 Ref Lvl -33.83 dBm  
 20 dBm 3.23256513 GHz  
 RBW 100 kHz RF Att 20 dB  
 VBW 300 kHz  
 SWT 6.4 s Unit dBm

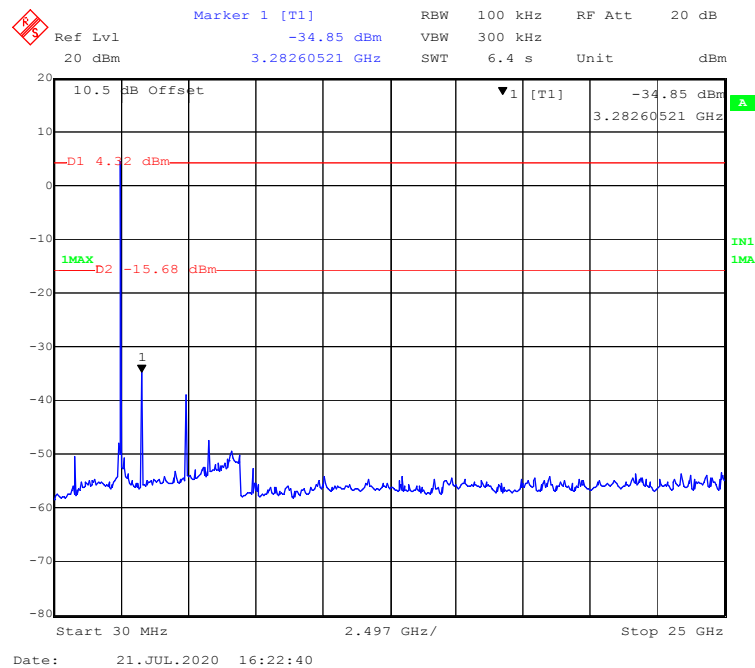
10.5 dB Offset  
 ▼ 1 [T1] -33.83 dBm  
 3.23256513 GHz

D1 3.48 dBm  
 1MAX -16.52 dBm

Start 30 MHz 2.497 GHz/ Stop 25 GHz

Date: 21.JUL.2020 16:21:29

EDR (8DPSK): High Channel



## FCC §15.247(a) (1)-CHANNEL SEPARATION TEST

### Applicable Standard

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 2400-2483.5 MHz band 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 125 mW.

### Test Procedure

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

- Span: Wide enough to capture the peaks of two adjacent channels.
- RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
- Video (or average) bandwidth (VBW)  $\geq$  RBW.
- Sweep: Auto.
- Detector function: Peak.
- Trace: Max hold.
- Allow the trace to stabilize.

Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

### Test Data

#### Environmental Conditions

|                    |           |
|--------------------|-----------|
| Temperature:       | 24.5 °C   |
| Relative Humidity: | 50 %      |
| ATM Pressure:      | 101.3 kPa |

*The testing was performed by Lee Li on 2020-07-29.*

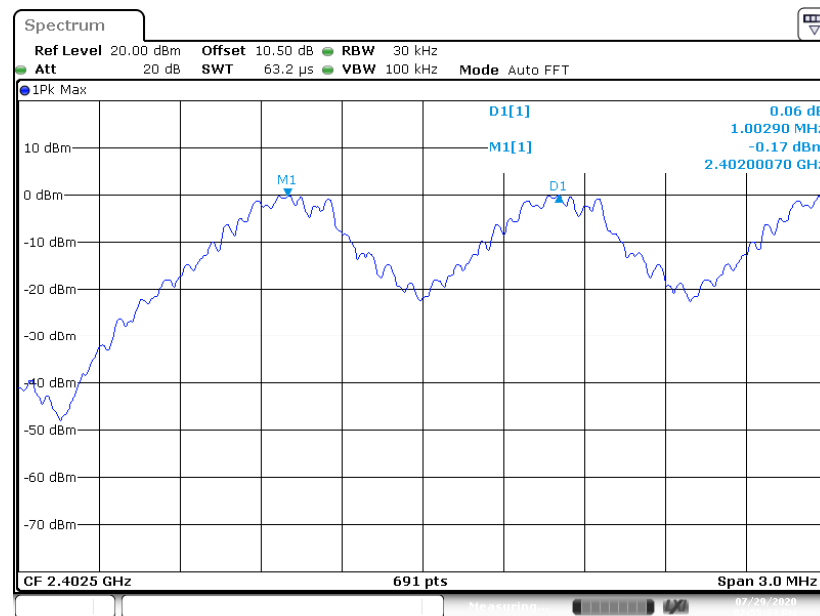
*EUT operation mode: Transmitting*

*Test Result: Compliant.*

| Mode                  | Channel  | Frequency (MHz) | Channel Separation (MHz) | Limit (MHz) | Result |
|-----------------------|----------|-----------------|--------------------------|-------------|--------|
| BDR (GFSK)            | Low      | 2402            | 1.003                    | 0.956       | Pass   |
|                       | Adjacent | 2403            |                          |             |        |
|                       | Middle   | 2441            | 1.003                    | 0.956       | Pass   |
|                       | Adjacent | 2442            |                          |             |        |
|                       | High     | 2480            | 1.003                    | 0.956       | Pass   |
|                       | Adjacent | 2479            |                          |             |        |
| EDR ( $\pi/4$ -DQPSK) | Low      | 2402            | 1.003                    | 0.878       | Pass   |
|                       | Adjacent | 2403            |                          |             |        |
|                       | Middle   | 2441            | 1.003                    | 0.878       | Pass   |
|                       | Adjacent | 2442            |                          |             |        |
|                       | High     | 2480            | 1.003                    | 0.882       | Pass   |
|                       | Adjacent | 2479            |                          |             |        |
| EDR (8DPSK)           | Low      | 2402            | 1.003                    | 0.878       | Pass   |
|                       | Adjacent | 2403            |                          |             |        |
|                       | Middle   | 2441            | 1.003                    | 0.878       | Pass   |
|                       | Adjacent | 2442            |                          |             |        |
|                       | High     | 2480            | 1.003                    | 0.878       | Pass   |
|                       | Adjacent | 2479            |                          |             |        |

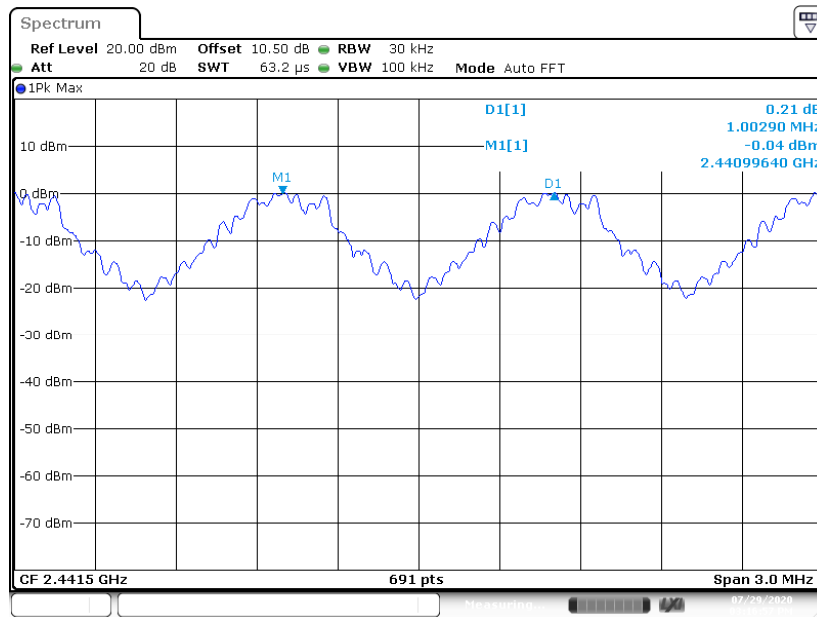
Note: For BDR mode, Limit = 20 dB bandwidth , For EDR mode, Limit = 20 dB bandwidth\*2/3

### BDR (GFSK): Low Channel



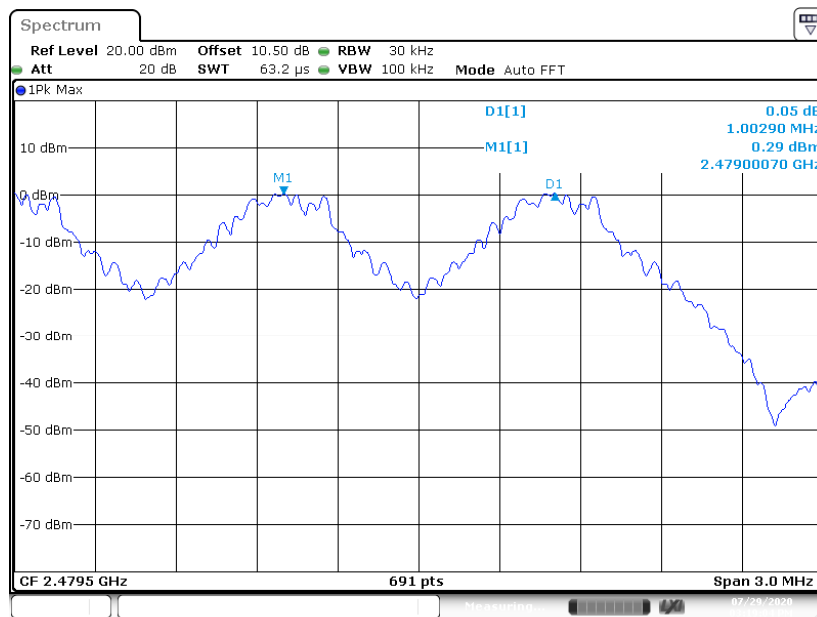
Date: 29 JUL 2020 14:55:23

### BDR (GFSK): Middle Channel



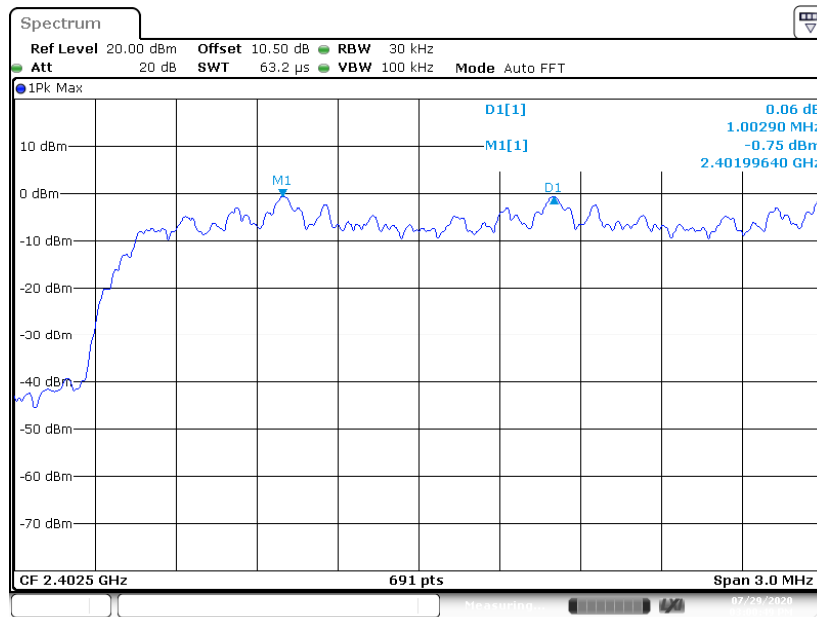
Date: 29 JUL 2020 15:16:57

### BDR (GFSK): High Channel



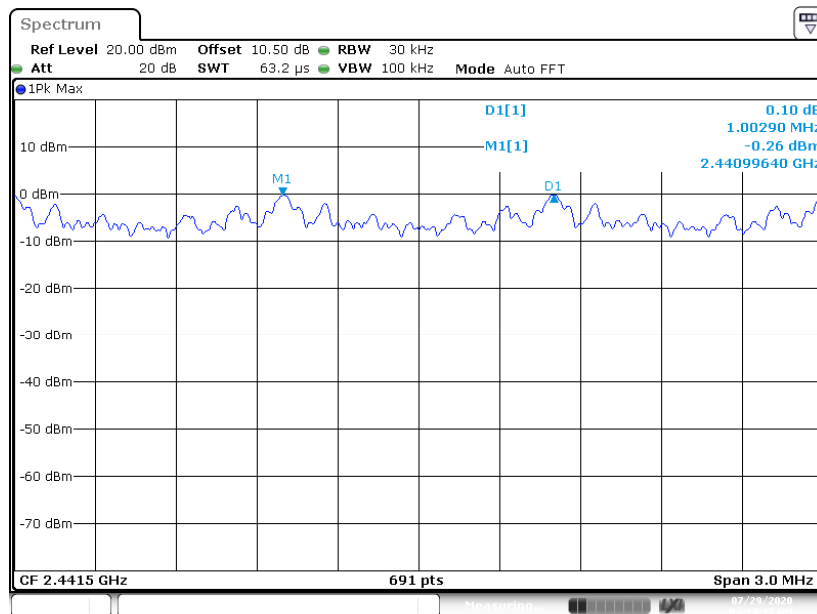
Date: 29 JUL 2020 15:19:04

### EDR ( $\pi/4$ -DQPSK): Low Channel

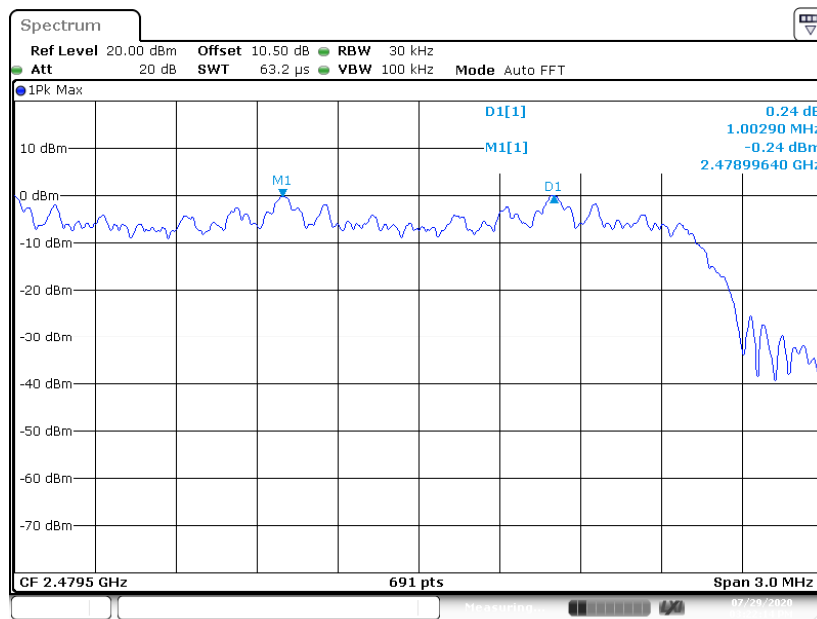
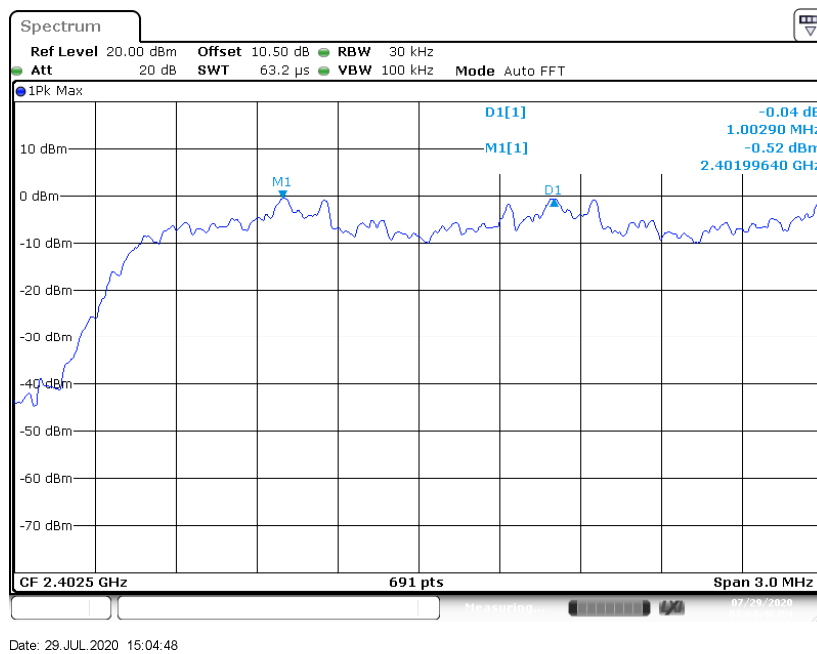


Date: 29.JUL.2020 15:00:49

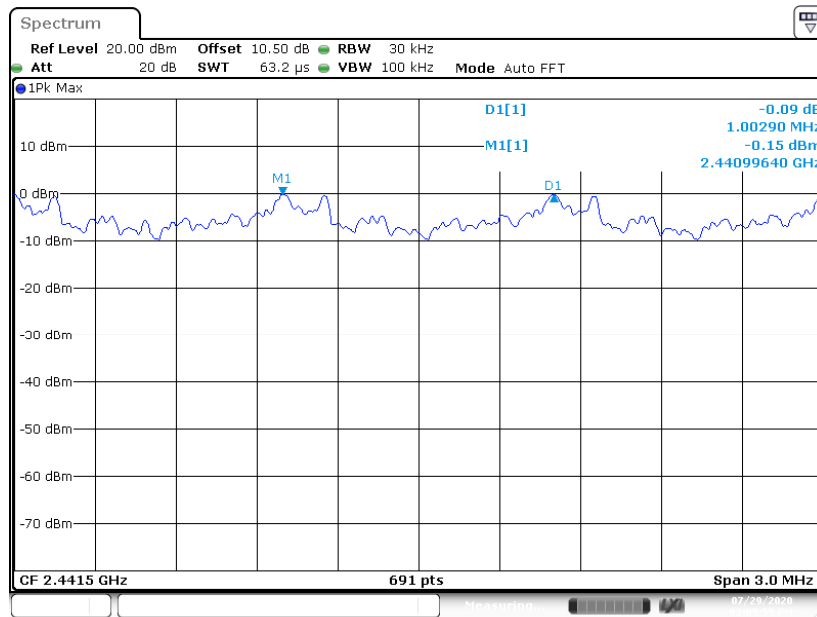
### EDR ( $\pi/4$ -DQPSK): Middle Channel



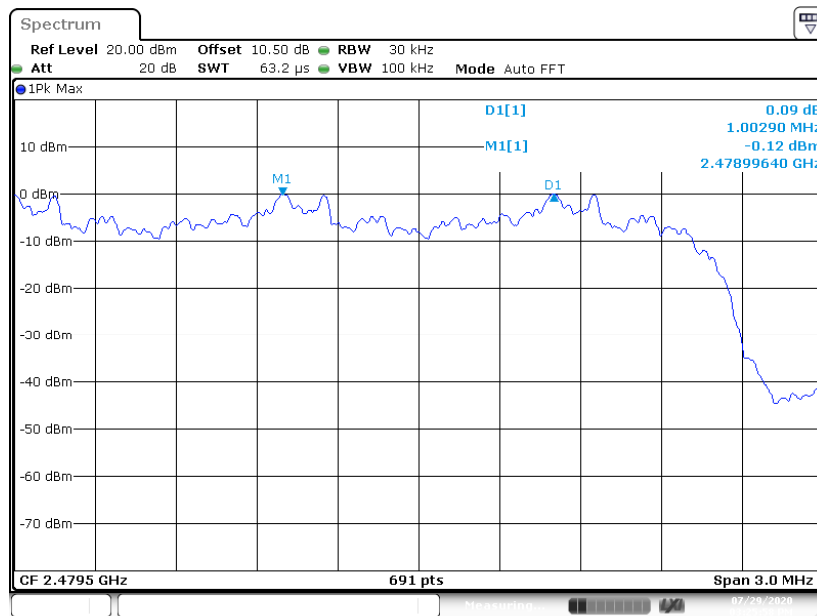
Date: 29.JUL.2020 15:14:17

**EDR ( $\pi/4$ -DQPSK): High Channel****EDR (8DPSK): Low Channel**

### EDR (8DPSK): Middle Channel



### EDR (8DPSK): High Channel



**FCC §15.247(a) (1) – 20 dB EMISSION BANDWIDTH****Applicable Standard**

Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band 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 125 mW.

**Test Procedure**

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
3. Measure the frequency difference of two frequencies that were attenuated 20 dB from the reference level. Record the frequency difference as the emission bandwidth.
4. Repeat above procedures until all frequencies measured were complete.

**Test Data****Environmental Conditions**

|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 24.7 °C   |
| <b>Relative Humidity:</b> | 50 %      |
| <b>ATM Pressure:</b>      | 101.3 kPa |

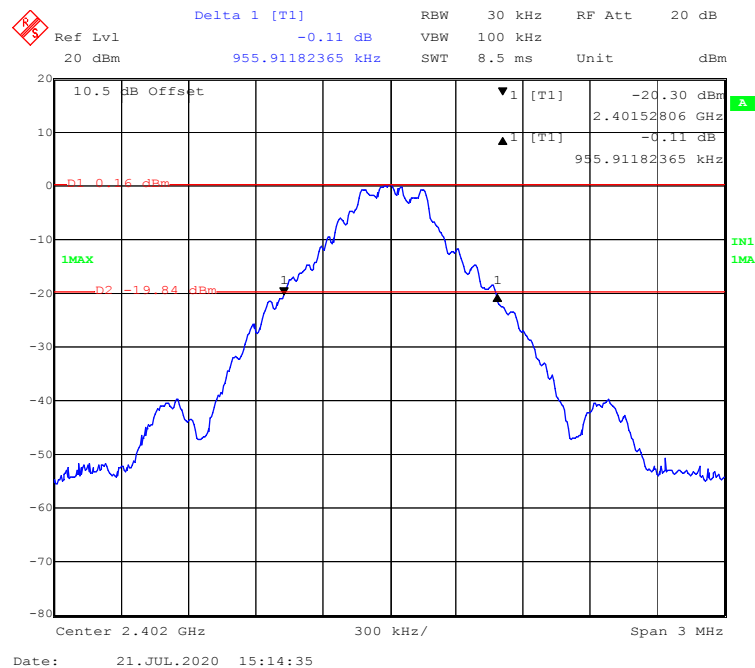
*The testing was performed by Lee Li on 2020-07-21.*

*EUT operation mode: Transmitting*

*Test Result: Compliant.*

| Mode                                  | Channel | Frequency (MHz) | 20 dB Emission Bandwidth (MHz) |
|---------------------------------------|---------|-----------------|--------------------------------|
| <b>BDR (GFSK)</b>                     | Low     | 2402            | 0.956                          |
|                                       | Middle  | 2441            | 0.956                          |
|                                       | High    | 2480            | 0.956                          |
| <b>EDR (<math>\pi/4</math>-DQPSK)</b> | Low     | 2402            | 1.317                          |
|                                       | Middle  | 2441            | 1.317                          |
|                                       | High    | 2480            | 1.323                          |
| <b>EDR (8DPSK)</b>                    | Low     | 2402            | 1.317                          |
|                                       | Middle  | 2441            | 1.317                          |
|                                       | High    | 2480            | 1.317                          |

### BDR (GFSK): Low Channel





Delta 1 [T1] -0.15 dB RBW 30 kHz RF Att 20 dB  
Ref Lvl 20 dBm 955.91182365 kHz SWT 8.5 ms Unit dBm

10.5 dB Offset

▼ 1 [T1] -19.35 dBm  
2.44052806 GHz

▲ 1 [T1] -0.15 dB  
955.91182365 kHz

D1 1.21 dBm

1MAX

D2 -18.79 dBm

3 1

Center 2.441 GHz 300 kHz/ Span 3 MHz

Date: 21.JUL.2020 15:11:14

Delta 1 [T1]

Ref Lvl -0.46 dB

RBW 30 kHz

RF Att 20 dB

20 dBm

955.91182365 kHz

SWT 8.5 ms

Unit dBm

10.5 dB Offset

-18.66 dBm

2.47952806 GHz

-0.46 dB

955.91182365 kHz

-D1 1.82 dBm

1MAX

-18.18 dBm

IN1

1MA

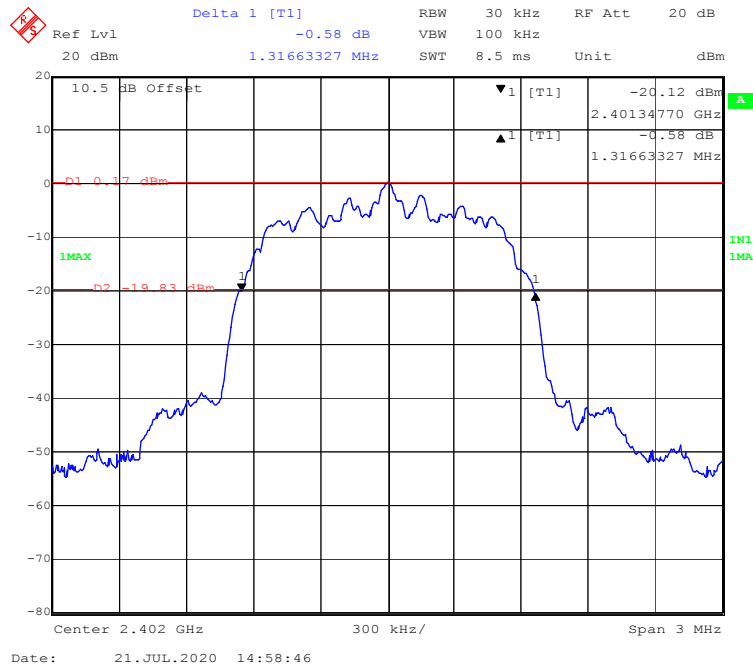
Center 2.48 GHz

300 kHz/

Span 3 MHz

Date: 21.JUL.2020 15:08:12

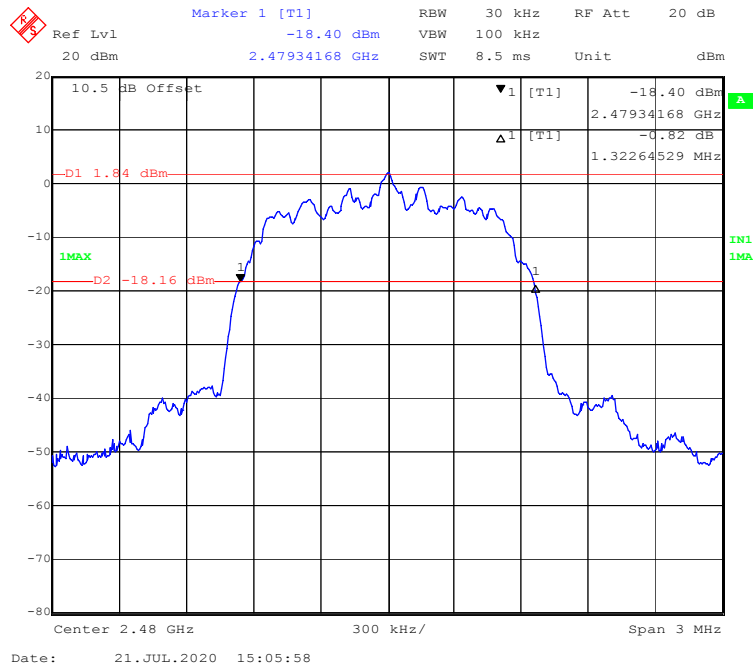
### EDR ( $\pi/4$ -DQPSK): Low Channel



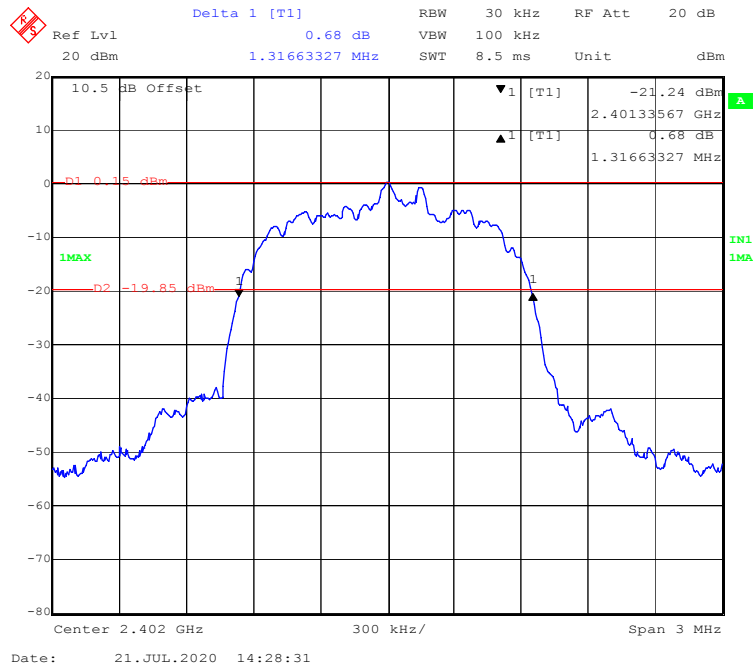
### EDR( $\pi/4$ -DQPSK): Middle Channel



### EDR ( $\pi/4$ -DQPSK): High Channel



### EDR (8DPSK): Low Channel



Delta 1 [T1] 0.91 dB

Ref Lvl 20 dBm

RBW 30 kHz

VBW 100 kHz

SWT 8.5 ms

RF Att 20 dB

Unit dBm

10.5 dB Offset

-D1 1.22 dBm

1MAX

-D2 -18.78 dBm

▼1 [T1] -20.39 dBm

▲1 [T1] 0.91 dB

1.31663327 MHz

Center 2.441 GHz

300 kHz/

Span 3 MHz

Date: 21.JUL.2020 14:32:06

Delta 1 [T1] 1.08 dB RBW 30 kHz RF Att 20 dB  
 Ref Lvl 20 dBm 1.31663327 MHz BW 100 kHz Unit dBm  
 20 dBm 8.5 ms

10.5 dB Offset  
 -19.87 dBm  
 2.47933567 GHz  
 1.08 dB  
 1.31663327 MHz  
 -18.22 dBm  
 1MAX  
 IN1  
 1MA

Center 2.48 GHz 300 kHz/  
 Span 3 MHz

Date: 21.JUL.2020 14:44:35

**FCC §15.247(a) (1) (iii)-QUANTITY OF HOPPING CHANNEL TEST****Applicable Standard**

Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 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. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

**Test Procedure**

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

- a. Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
- b. RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- c. VBW  $\geq$  RBW.
- d. Sweep: Auto.
- e. Detector function: Peak.
- f. Trace: Max hold.
- g. Allow the trace to stabilize.

It might prove necessary to break the span up into subranges to show clearly all of the hopping frequencies.

**Test Data****Environmental Conditions**

|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 24.6 °C   |
| <b>Relative Humidity:</b> | 50 %      |
| <b>ATM Pressure:</b>      | 101.3 kPa |

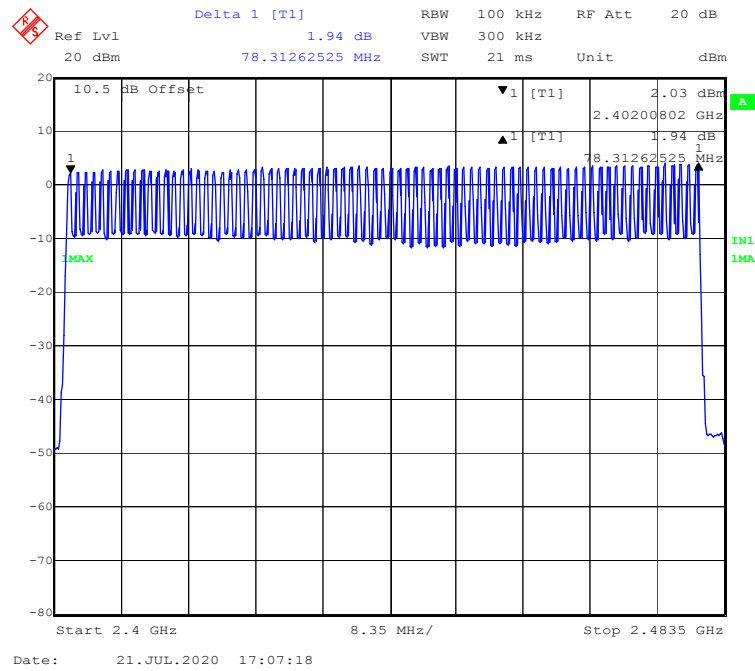
*The testing was performed by Lee Li on 2020-07-21.*

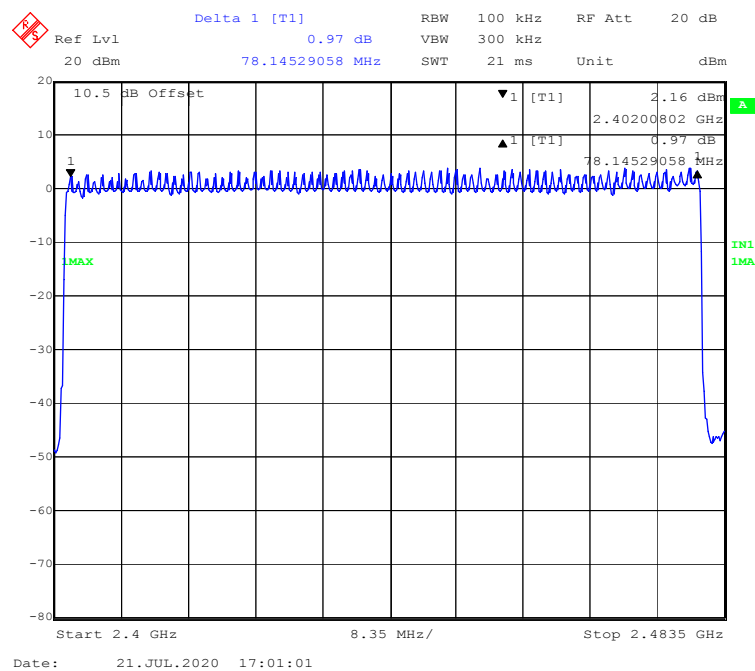
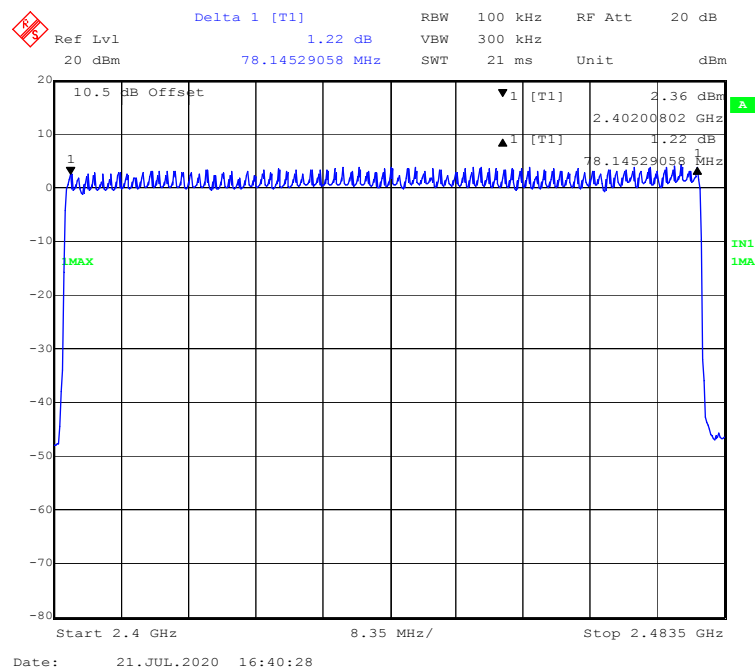
*EUT operation mode: Hopping*

*Test Result: Compliant.*

| Mode            | Frequency Range (MHz) | Number of Hopping Channel (CH) | Limit (CH) |
|-----------------|-----------------------|--------------------------------|------------|
| BDR (GFSK)      | 2400-2483.5           | 79                             | ≥15        |
| EDR (π/4-DQPSK) | 2400-2483.5           | 79                             | ≥15        |
| EDR (8DPSK)     | 2400-2483.5           | 79                             | ≥15        |

### BDR (GFSK): Number of Hopping Channels



**EDR ( $\pi/4$ -DQPSK): Number of Hopping Channels****EDR (8DPSK): Number of Hopping Channels**

**FCC §15.247(a) (1) (iii) - TIME OF OCCUPANCY (DWELL TIME)****Applicable Standard**

Frequency hopping systems in the 2400-2483.5 MHz shall use at least 15 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. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

**Test Procedure**

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

- a Span: Zero span, centered on a hopping channel.
- b RBW shall be  $\leq$  channel spacing and where possible RBW should be set  $\geq 1 / T$ , where T is the expected dwell time per channel.
- c Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
- d Detector function: Peak.
- e Trace: Max hold.

**Test Data****Environmental Conditions**

|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 24.6 °C   |
| <b>Relative Humidity:</b> | 50 %      |
| <b>ATM Pressure:</b>      | 101.3 kPa |

*The testing was performed by Lee Li on 2020-07-21.*

*EUT operation mode: Hopping*

| Mode                  |      | Channel                                              | Pulse Width (ms) | Dwell Time (s) | Limit (s) | Result |
|-----------------------|------|------------------------------------------------------|------------------|----------------|-----------|--------|
| BDR (GFSK)            | DH1  | Low                                                  | 0.389            | 0.124          | 0.4       | Pass   |
|                       |      | Middle                                               | 0.389            | 0.124          | 0.4       | Pass   |
|                       |      | High                                                 | 0.389            | 0.124          | 0.4       | Pass   |
|                       |      | Note: DH1:Dwell time = Pulse time*(1600/2/79)*31.6S  |                  |                |           |        |
|                       | DH3  | Low                                                  | 1.653            | 0.264          | 0.4       | Pass   |
|                       |      | Middle                                               | 1.653            | 0.264          | 0.4       | Pass   |
|                       |      | High                                                 | 1.653            | 0.264          | 0.4       | Pass   |
|                       |      | Note: DH3:Dwell time = Pulse time*(1600/4/79)*31.6S  |                  |                |           |        |
|                       | DH5  | Low                                                  | 2.928            | 0.312          | 0.4       | Pass   |
|                       |      | Middle                                               | 2.918            | 0.311          | 0.4       | Pass   |
|                       |      | High                                                 | 2.908            | 0.310          | 0.4       | Pass   |
|                       |      | Note: DH5:Dwell time = Pulse time*(1600/6/79)*31.6S  |                  |                |           |        |
| EDR ( $\pi/4$ -DQPSK) | 2DH1 | Low                                                  | 0.403            | 0.129          | 0.4       | Pass   |
|                       |      | Middle                                               | 0.403            | 0.129          | 0.4       | Pass   |
|                       |      | High                                                 | 0.401            | 0.128          | 0.4       | Pass   |
|                       |      | Note: 2DH1:Dwell time = Pulse time*(1600/2/79)*31.6S |                  |                |           |        |
|                       | 2DH3 | Low                                                  | 1.665            | 0.266          | 0.4       | Pass   |
|                       |      | Middle                                               | 1.665            | 0.266          | 0.4       | Pass   |
|                       |      | High                                                 | 1.665            | 0.266          | 0.4       | Pass   |
|                       |      | Note: 2DH3:Dwell time = Pulse time*(1600/4/79)*31.6S |                  |                |           |        |
|                       | 2DH5 | Low                                                  | 2.928            | 0.312          | 0.4       | Pass   |
|                       |      | Middle                                               | 2.928            | 0.312          | 0.4       | Pass   |
|                       |      | High                                                 | 2.928            | 0.312          | 0.4       | Pass   |
|                       |      | Note: 2DH5:Dwell time = Pulse time*(1600/6/79)*31.6S |                  |                |           |        |
| EDR (8DPSK)           | 3DH1 | Low                                                  | 0.403            | 0.129          | 0.4       | Pass   |
|                       |      | Middle                                               | 0.401            | 0.128          | 0.4       | Pass   |
|                       |      | High                                                 | 0.403            | 0.129          | 0.4       | Pass   |
|                       |      | Note:3 DH1:Dwell time = Pulse time*(1600/2/79)*31.6S |                  |                |           |        |
|                       | 3DH3 | Low                                                  | 1.665            | 0.266          | 0.4       | Pass   |
|                       |      | Middle                                               | 1.665            | 0.266          | 0.4       | Pass   |
|                       |      | High                                                 | 1.665            | 0.266          | 0.4       | Pass   |
|                       |      | Note: 3DH3:Dwell time = Pulse time*(1600/4/79)*31.6S |                  |                |           |        |
|                       | 3DH5 | Low                                                  | 2.928            | 0.312          | 0.4       | Pass   |
|                       |      | Middle                                               | 2.927            | 0.312          | 0.4       | Pass   |
|                       |      | High                                                 | 2.927            | 0.312          | 0.4       | Pass   |
|                       |      | Note: 3DH5:Dwell time = Pulse time*(1600/6/79)*31.6S |                  |                |           |        |

Delta 1 [T1] 1.19 dB

RBW 500 kHz RF Att 20 dB

Ref Lvl 20 dBm

SWT 1 ms Unit dBm

10.5 dB Offset

▼ 1 [T1] -59.29 dBm

▲ 1 [T1] 1.19 dB

388.777555 ns

TR

Center 2.402 GHz 100 ns/

Date: 21.JUL.2020 17:09:51

Delta 1 [T1] 0.32 dB

RBW 500 kHz RF Att 20 dB

Ref Lvl 20 dBm

SWT 1 ms Unit dBm

10.5 dB Offset

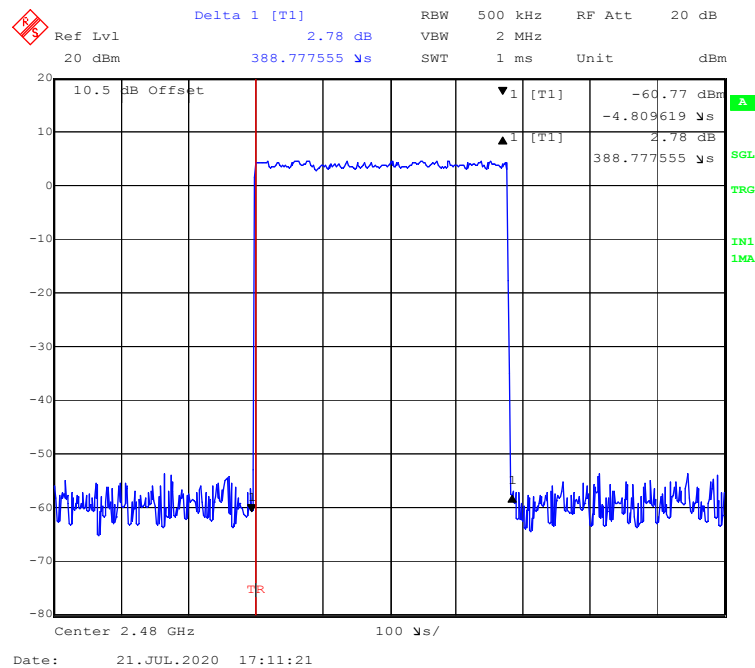
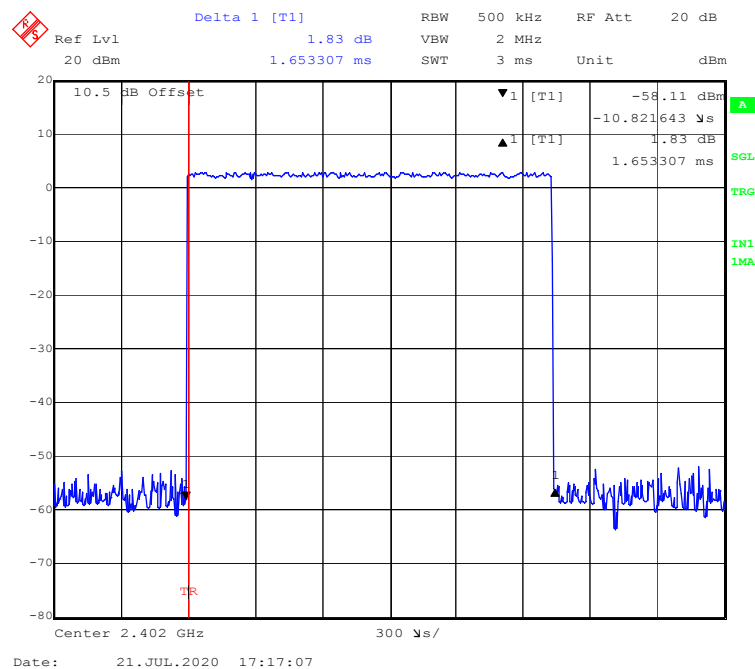
▼ 1 [T1] -60.80 dBm

▲ 1 [T1] -4.809619 μs

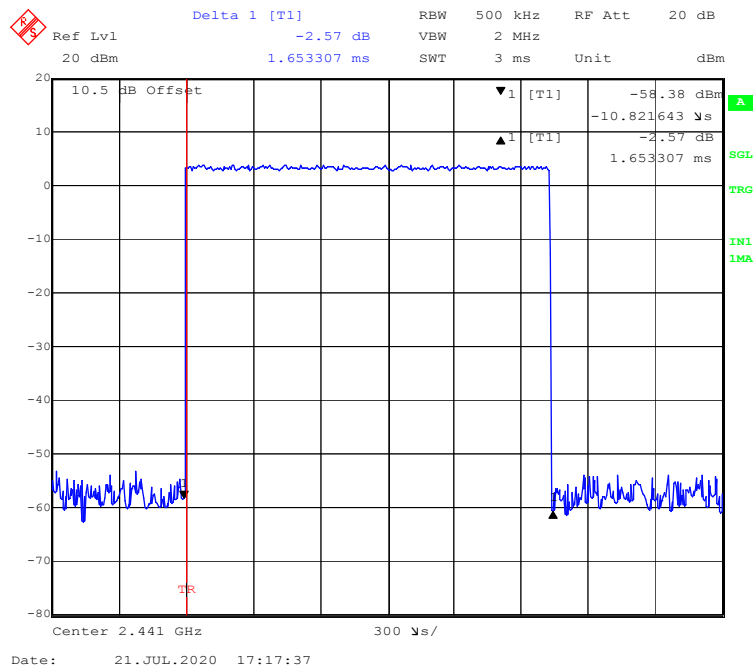
388.777555 μs

Center 2.441 GHz 100 μs/

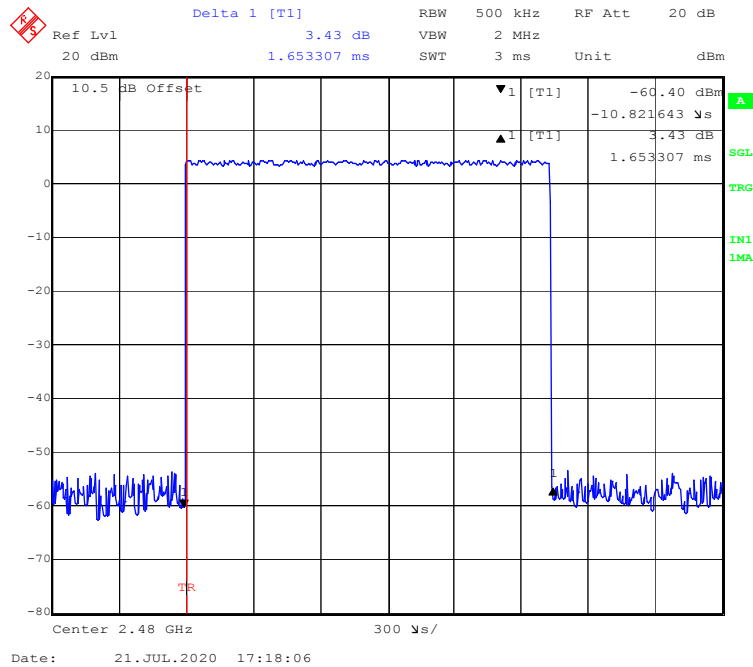
Date: 21.JUL.2020 17:10:54

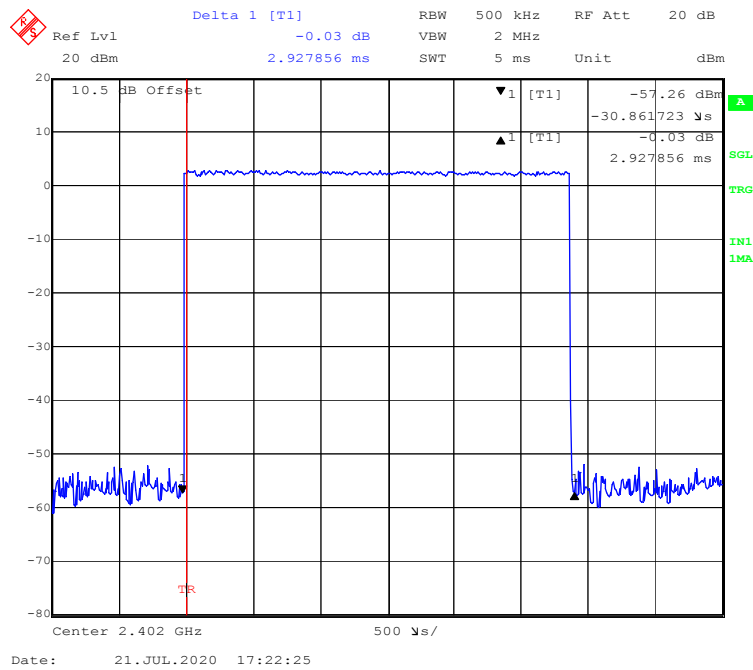
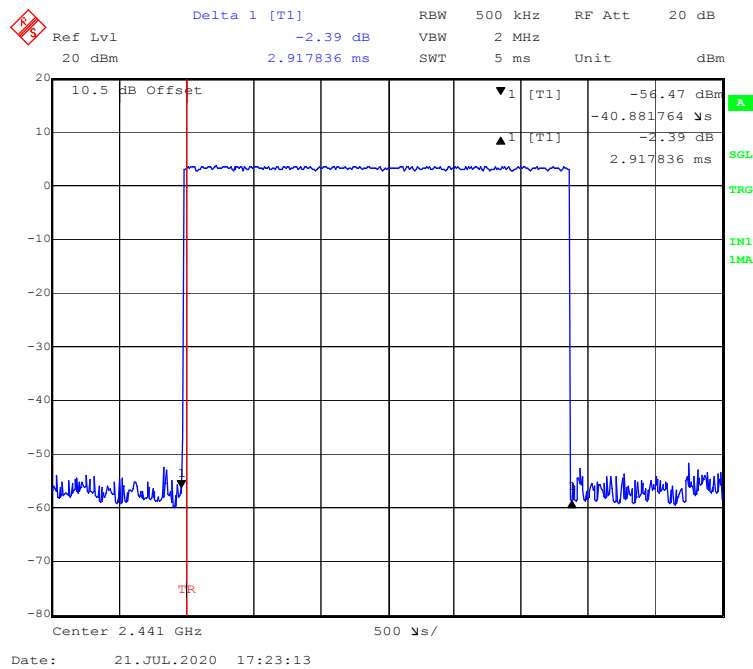
**BDR (GFSK): Pulse time, High Channel, DH1****BDR (GFSK): Pulse time, Low Channel, DH3**

### BDR (GFSK): Pulse time, Middle Channel, DH3

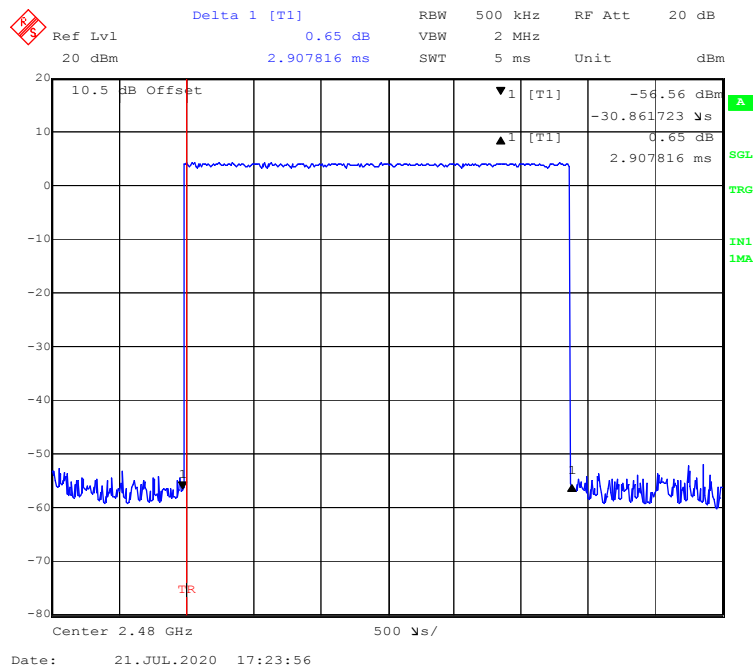


### BDR (GFSK): Pulse time, High Channel, DH3

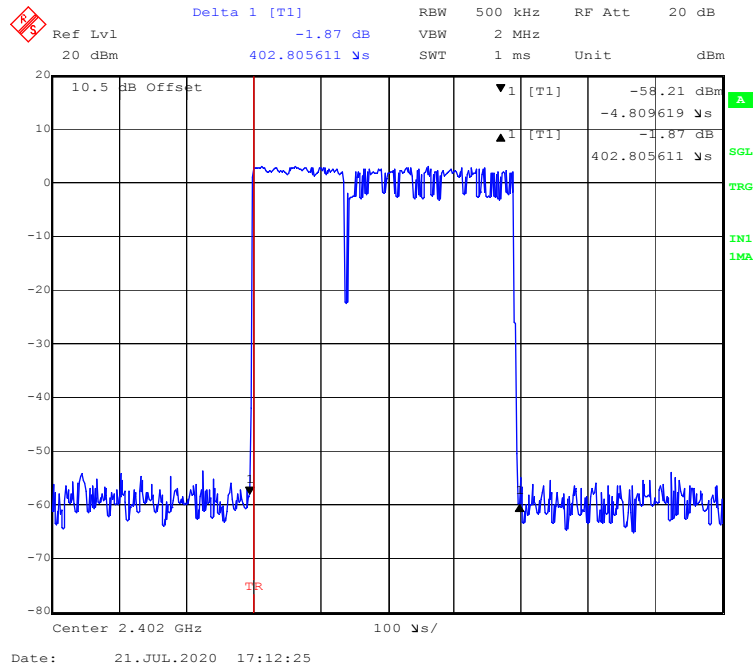


**BDR (GFSK): Pulse time, Low Channel, DH5****BDR (GFSK): Pulse time, Middle Channel, DH5**

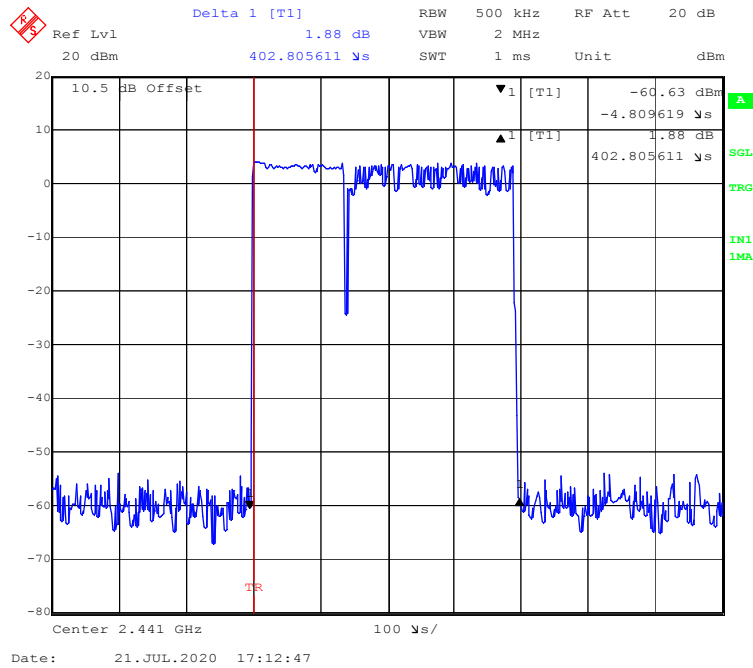
### BDR (GFSK): Pulse time, High Channel, DH5



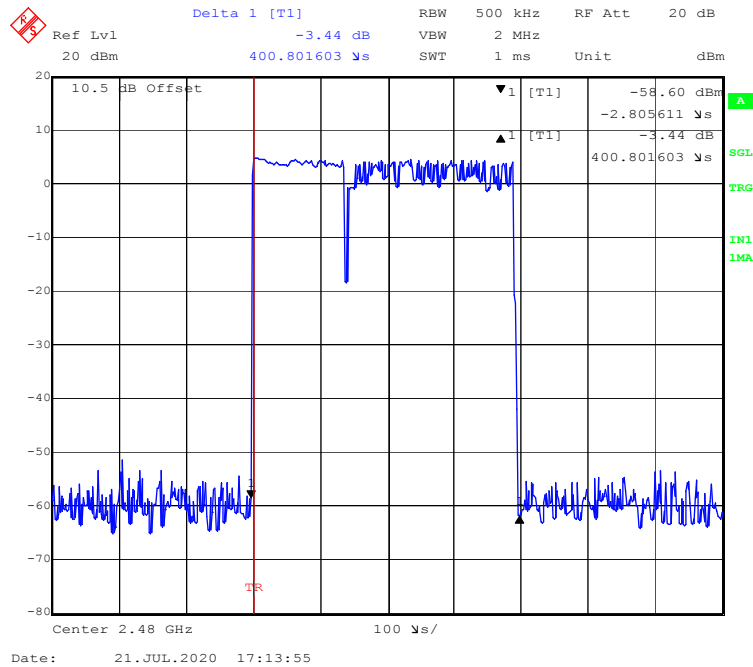
### EDR ( $\pi/4$ -DQPSK): Pulse time, Low Channel, 2DH1

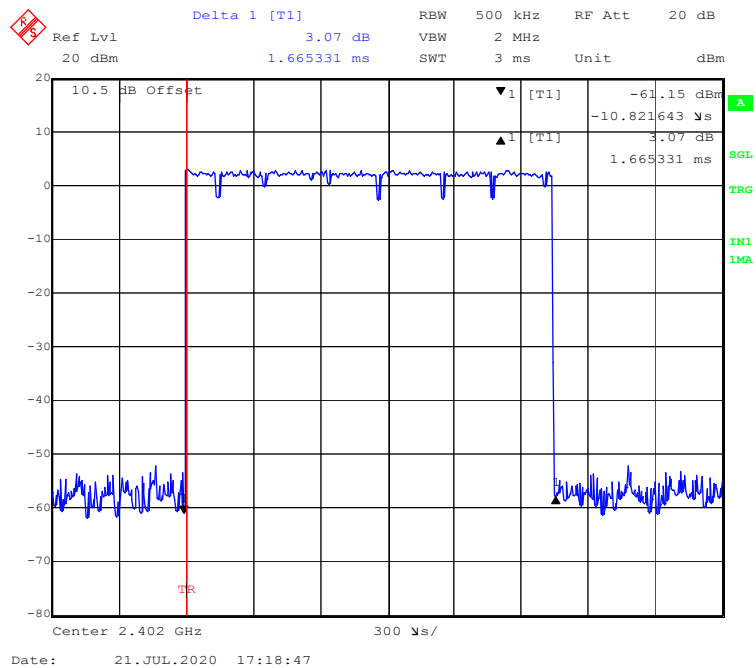
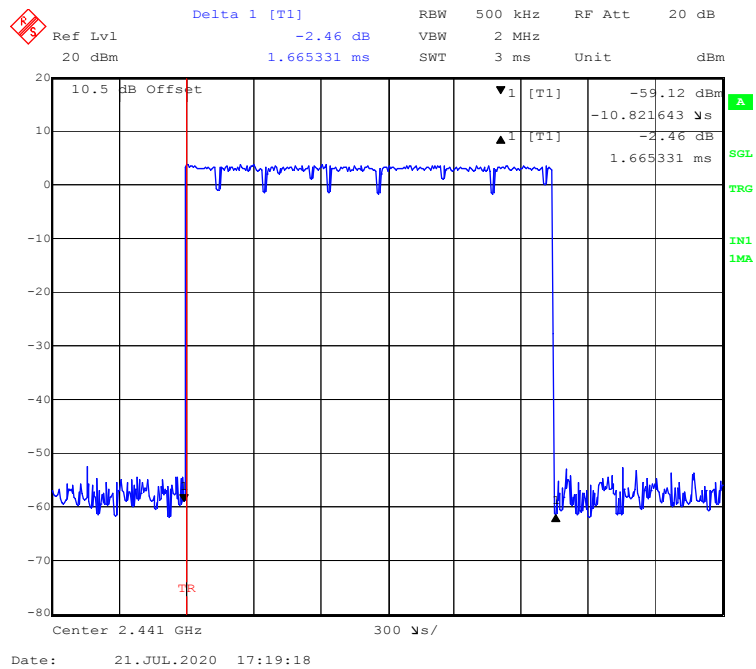


### EDR ( $\pi/4$ -DQPSK):Pulse time, Middle Channel, 2DH1

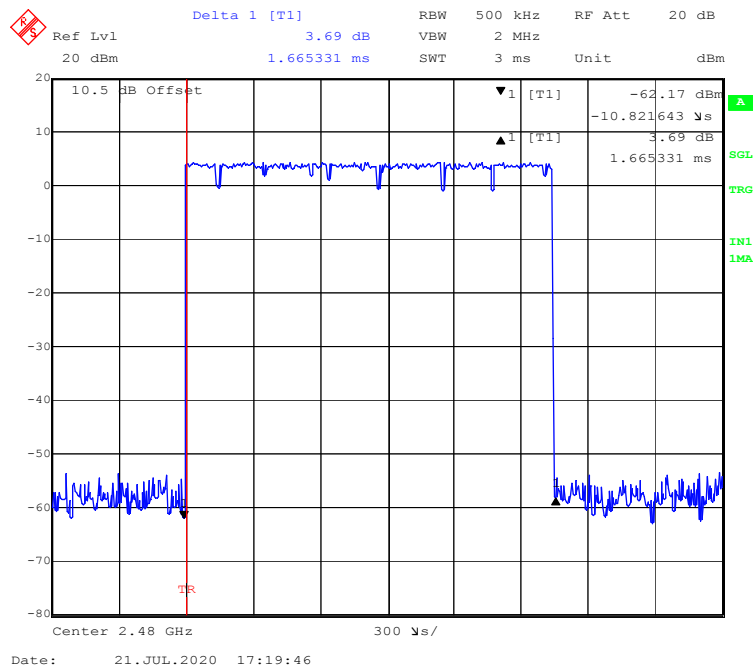


### EDR ( $\pi/4$ -DQPSK):Pulse time, High Channel, 2DH1

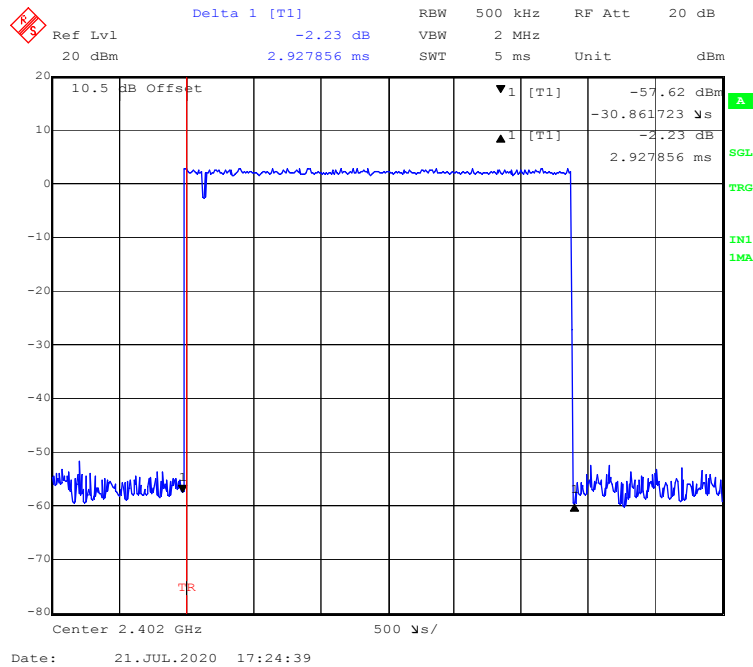


**EDR ( $\pi/4$ -DQPSK):Pulse time, Low Channel, 2DH3****EDR ( $\pi/4$ -DQPSK):Pulse time, Middle Channel, 2DH3**

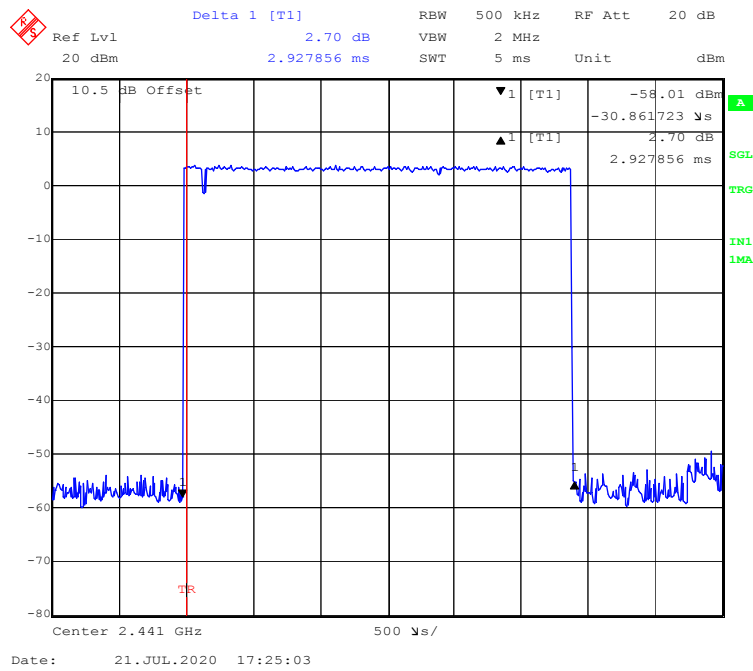
### EDR ( $\pi/4$ -DQPSK):Pulse time, High Channel, 2DH3



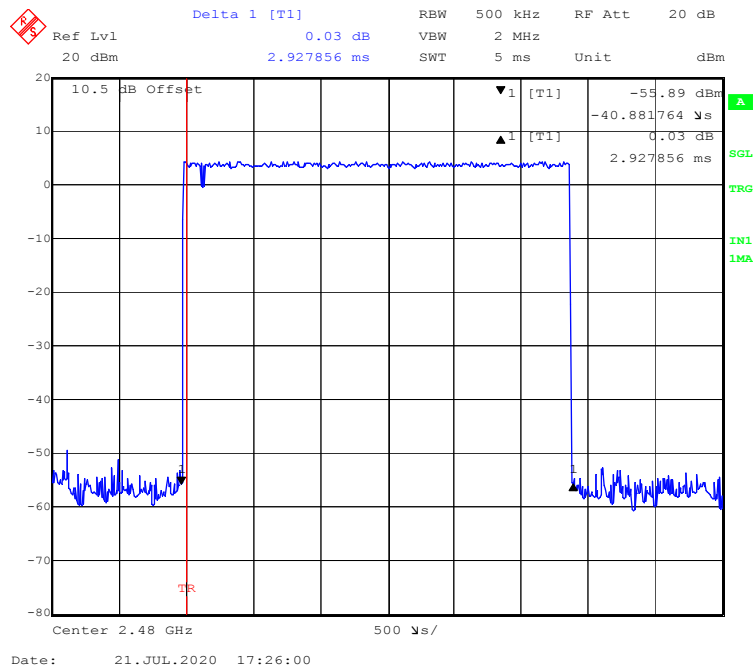
### EDR ( $\pi/4$ -DQPSK):Pulse time, Low Channel, 2DH5

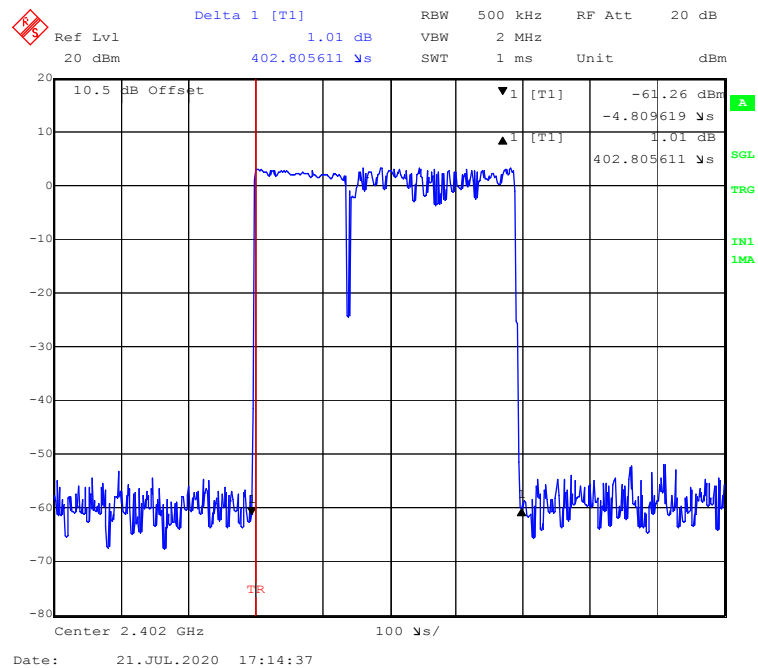
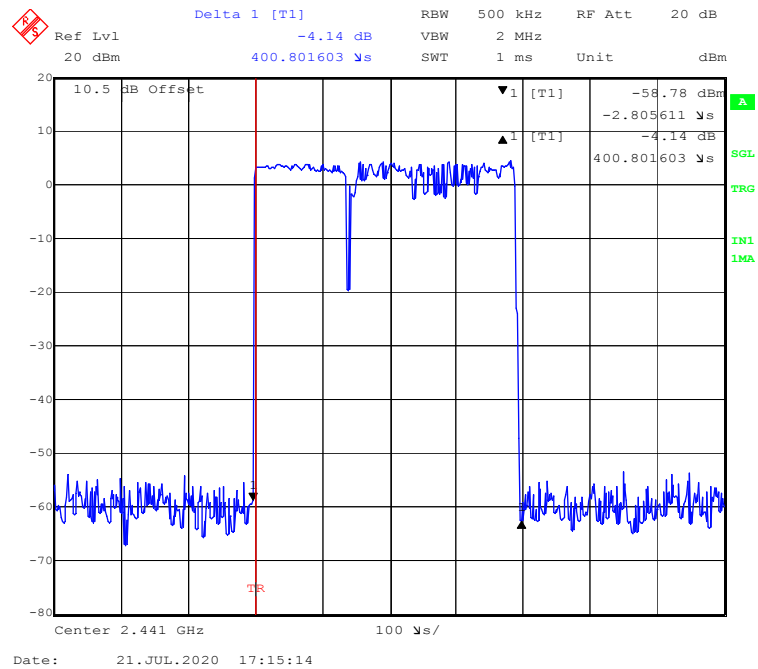


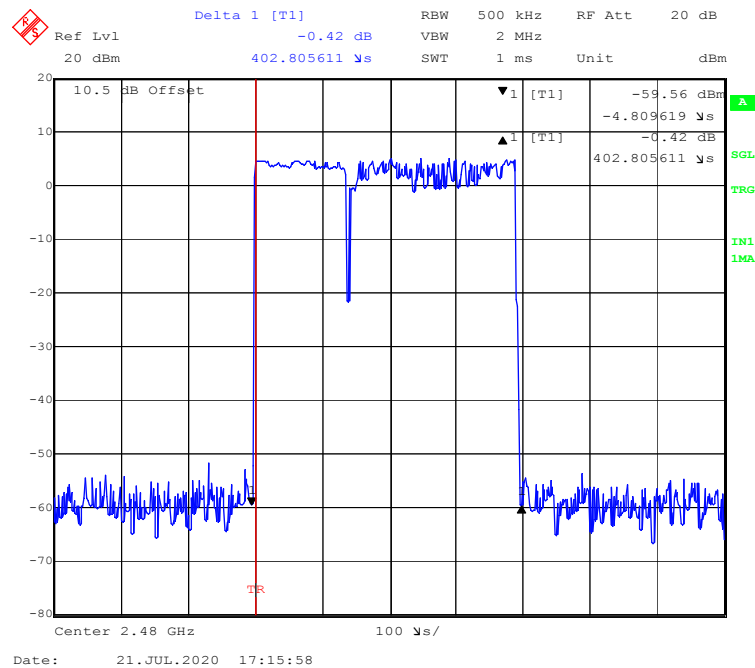
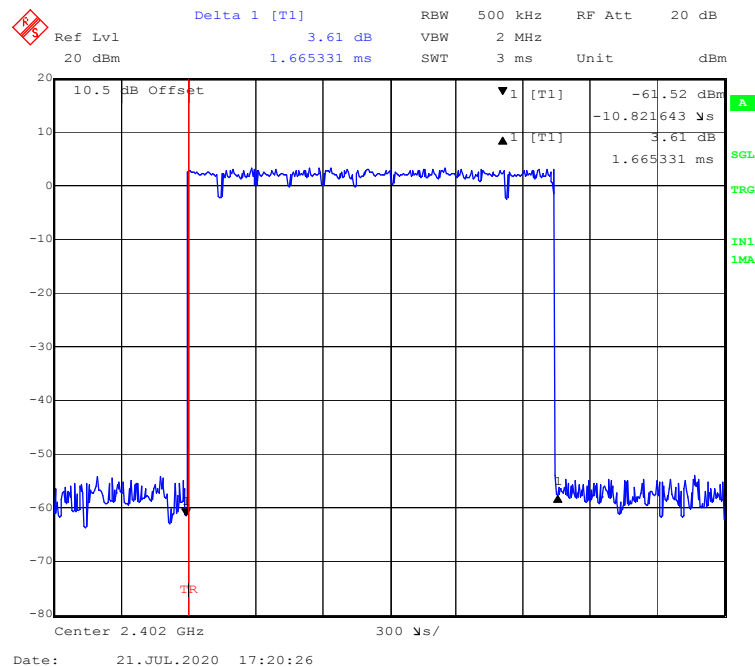
### EDR ( $\pi/4$ -DQPSK):Pulse time, Middle Channel, 2DH5



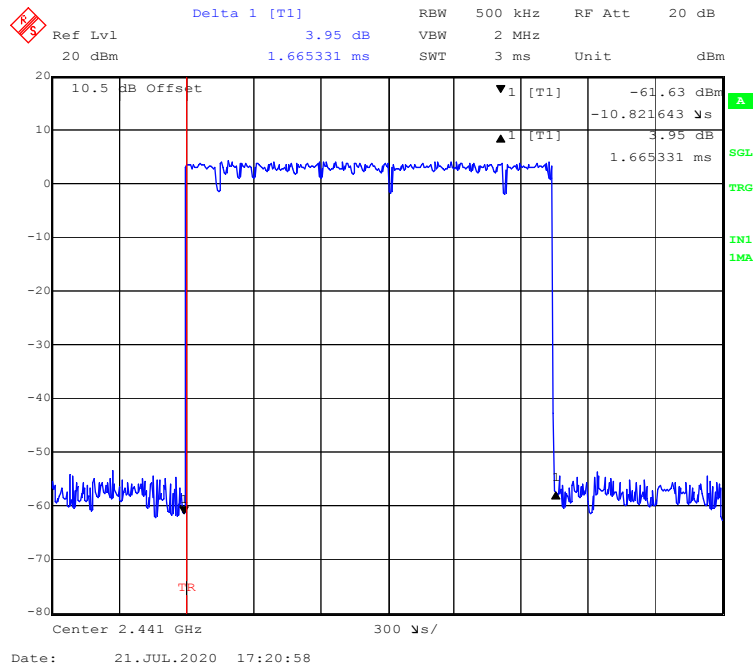
### EDR ( $\pi/4$ -DQPSK):Pulse time, High Channel, 2DH5



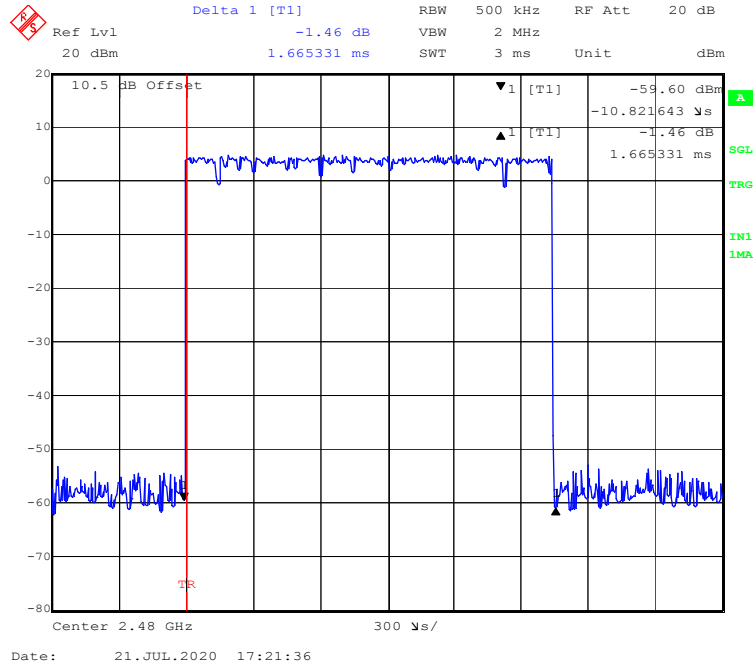
**EDR (8DPSK): Pulse time, Low Channel, 3DH1****EDR (8DPSK): Pulse time, Middle Channel, 3DH1**

**EDR (8DPSK): Pulse time, High Channel, 3DH1****EDR (8DPSK): Pulse time, Low Channel, 3DH3**

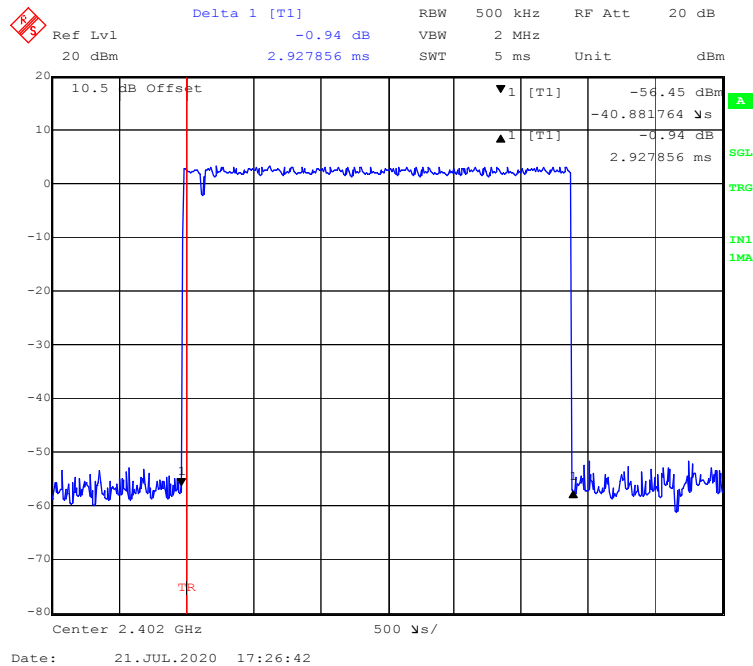
### EDR (8DPSK): Pulse time, Middle Channel, 3DH3



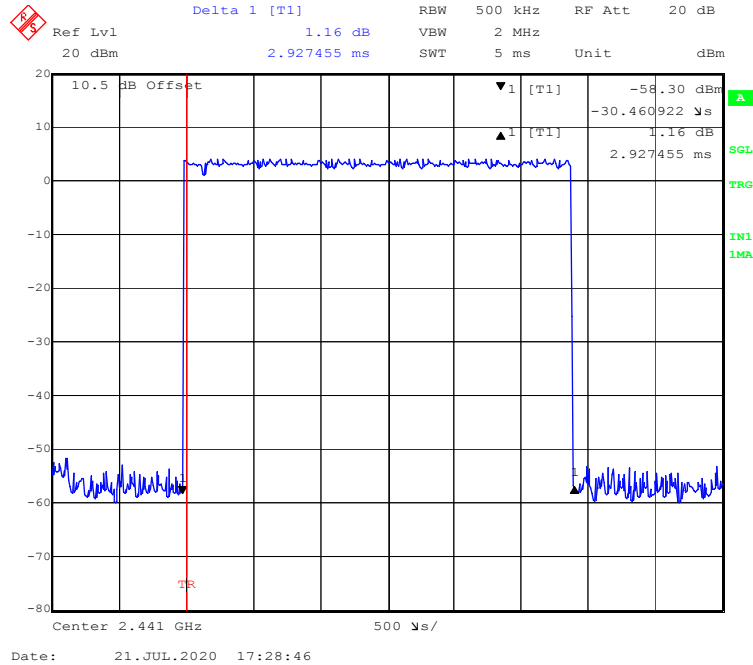
### EDR (8DPSK): Pulse time, High Channel, 3DH3



### EDR (8DPSK): Pulse time, Low Channel, 3DH5



### EDR (8DPSK): Pulse time, Middle Channel, 3DH5



Ref Lvl 20 dBm Delta 1 [T1] 1.07 dB RBW 500 kHz RF Att 20 dB Unit dBm

20 dBm 2.927455 ms

10.5 dB Offset

▼ 1 [T1] -56.36 dBm

▲ 1 [T1] 1.07 dB

2.927455 ms

Center 2.48 GHz 500 us/

Date: 21.JUL.2020 17:29:11

## **FCC §15.247(b) (1) - PEAK OUTPUT POWER MEASUREMENT**

### **Applicable Standard**

According to §15.247(b) (1), for frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 watt. And for all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

### **Test Procedure**

- a. Use the following spectrum analyzer settings:
  - 1) Span: Approximately five times the 20 dB bandwidth, centered on a hopping channel.
  - 2) RBW > 20 dB bandwidth of the emission being measured.
  - 3) VBW  $\geq$  RBW.
  - 4) Sweep: Auto.
  - 5) Detector function: Peak.
  - 6) Trace: Max hold.
- b. Allow trace to stabilize.
- c. Use the marker-to-peak function to set the marker to the peak of the emission.
- d. The indicated level is the peak output power, after any corrections for external attenuators and cables.
- e. A plot of the test results and setup description shall be included in the test report.

### **Test Data**

#### **Environmental Conditions**

|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 21.7 °C   |
| <b>Relative Humidity:</b> | 50 %      |
| <b>ATM Pressure:</b>      | 101.3 kPa |

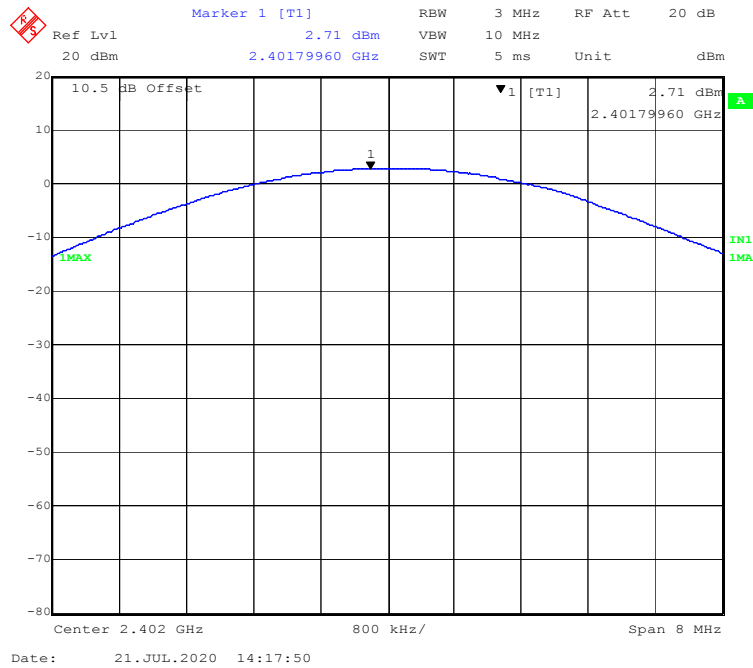
*The testing was performed by Lee Li on 2020-07-21.*

*EUT operation mode: Transmitting*

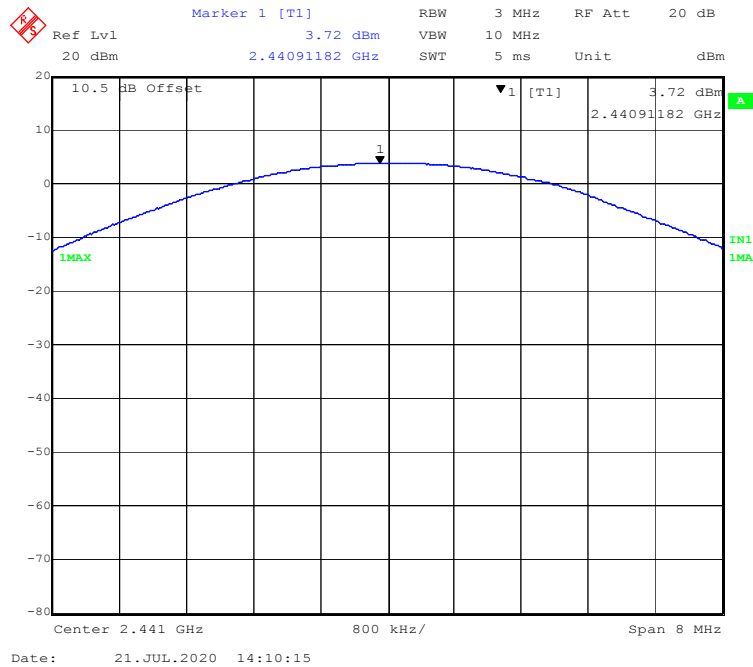
*Test Result: Compliant.*

| Mode                                      | Frequency<br>(MHz) | Output Power |      | Limit<br>(mW) |
|-------------------------------------------|--------------------|--------------|------|---------------|
|                                           |                    | (dBm)        | (mW) |               |
| <b>BDR<br/>(GFSK)</b>                     | 2402               | 2.71         | 1.87 | 1000          |
|                                           | 2441               | 3.72         | 2.36 | 1000          |
|                                           | 2480               | 4.37         | 2.74 | 1000          |
| <b>EDR<br/>(<math>\pi/4</math>-DQPSK)</b> | 2402               | 5.03         | 3.18 | 125           |
|                                           | 2441               | 5.95         | 3.94 | 125           |
|                                           | 2480               | 6.57         | 4.54 | 125           |
| <b>EDR<br/>(8DPSK)</b>                    | 2402               | 5.39         | 3.46 | 125           |
|                                           | 2441               | 6.36         | 4.33 | 125           |
|                                           | 2480               | 6.97         | 4.98 | 125           |

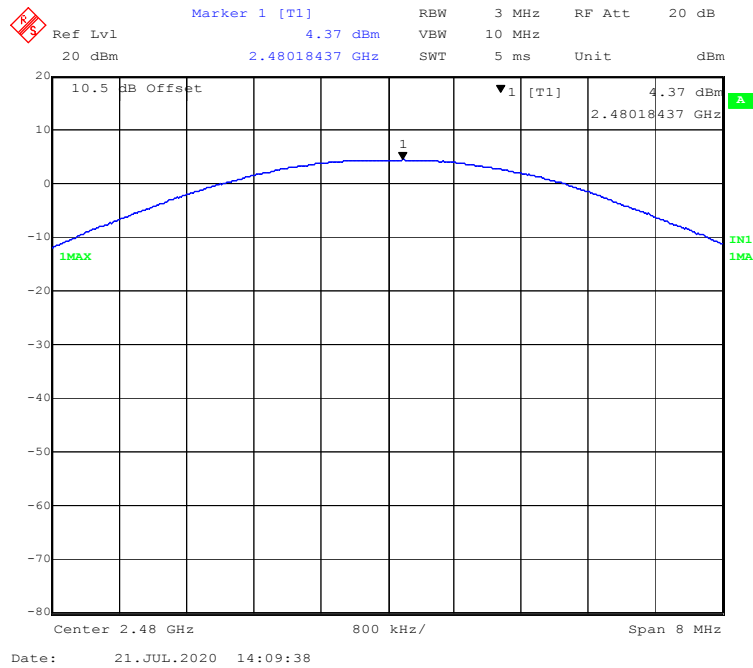
### BDR (GFSK): 2402MHz



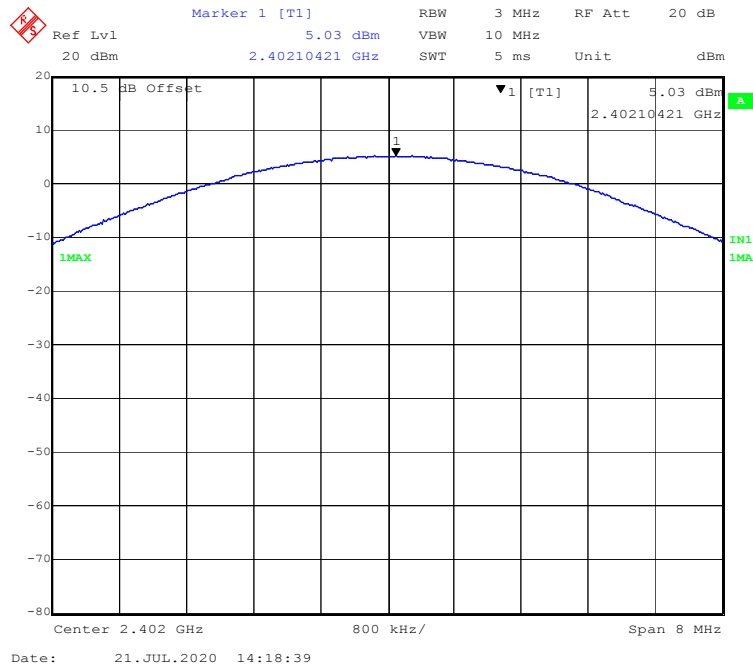
### BDR (GFSK): 2441MHz



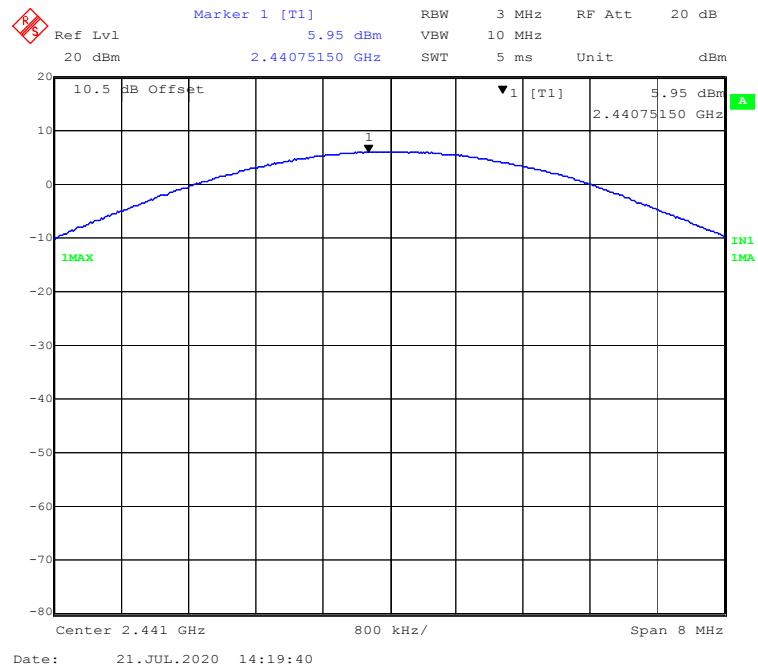
### BDR (GFSK): 2480MHz



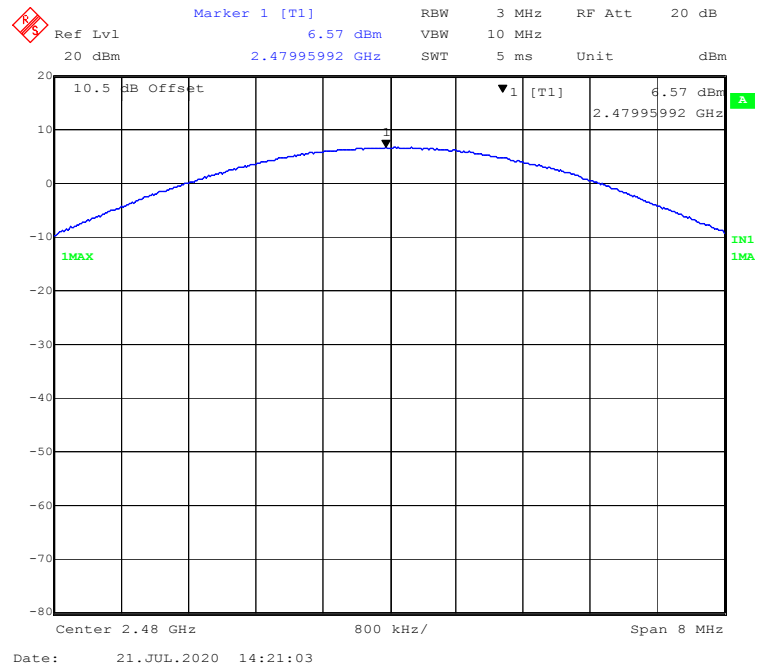
### EDR( $\pi/4$ -DQPSK): 2402MHz



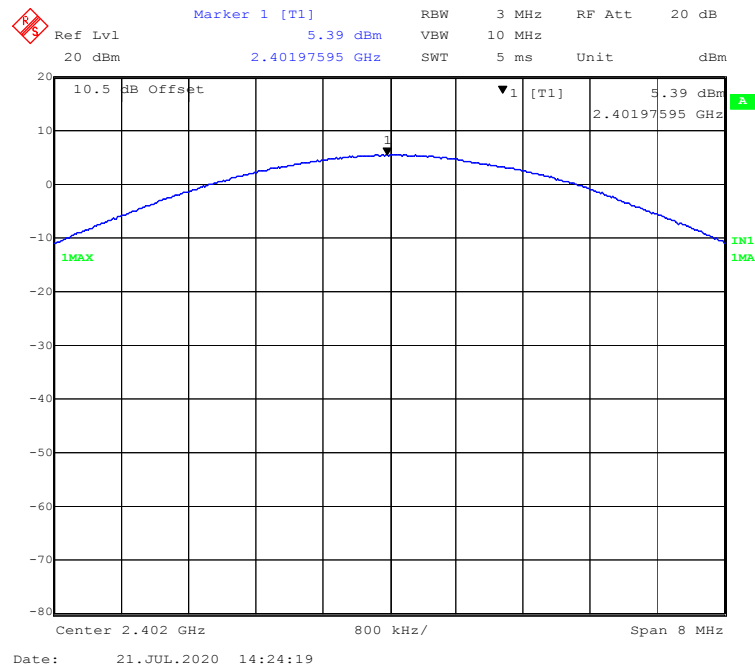
### EDR( $\pi/4$ -DQPSK): 2441MHz



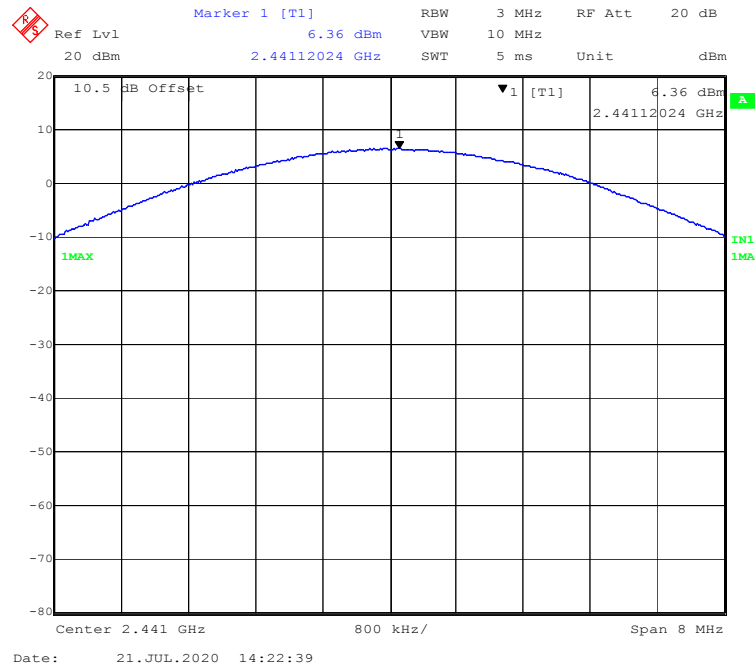
### EDR( $\pi/4$ -DQPSK): 2480MHz



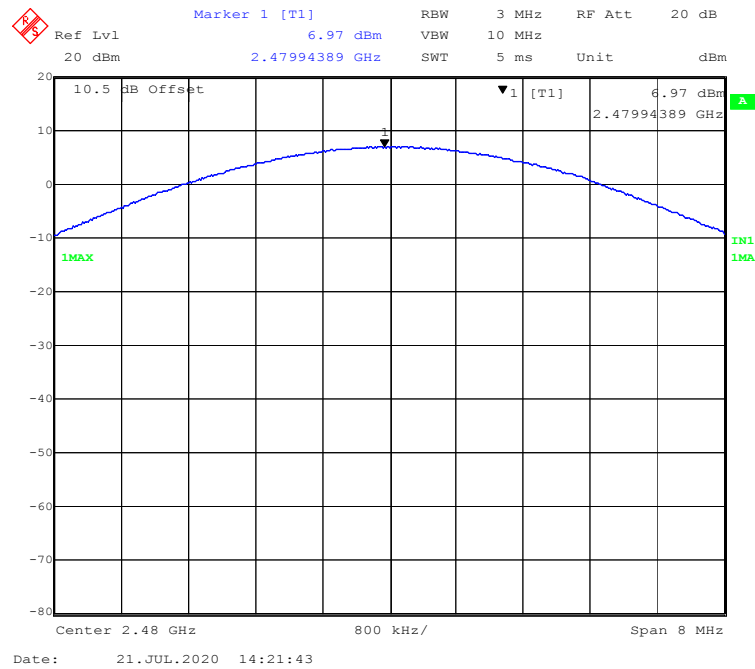
### EDR(8DPSK): 2402MHz



### EDR(8DPSK): 2441MHz



# EDR(8DPSK): 2480MHz



## **FCC §15.247(d) - BAND EDGES TESTING**

### **Applicable Standard**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates Compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

### **Test Procedure**

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to a EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set RBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100 kHz bandwidth from band edge.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.

### **Test Data**

#### **Environmental Conditions**

|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 24.8°C    |
| <b>Relative Humidity:</b> | 50 %      |
| <b>ATM Pressure:</b>      | 101.3 kPa |

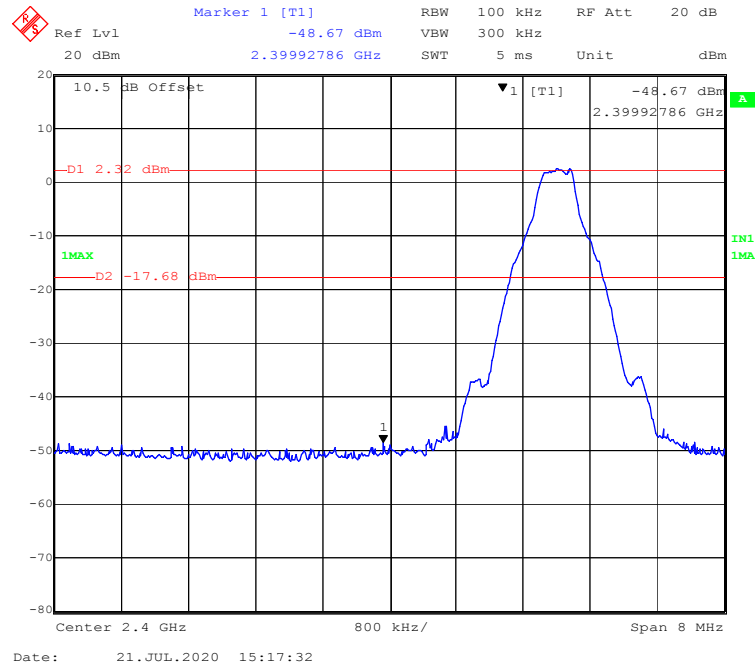
*The testing was performed by Lee Li on 2020-07-21.*

*EUT operation mode: Transmitting & Hopping*

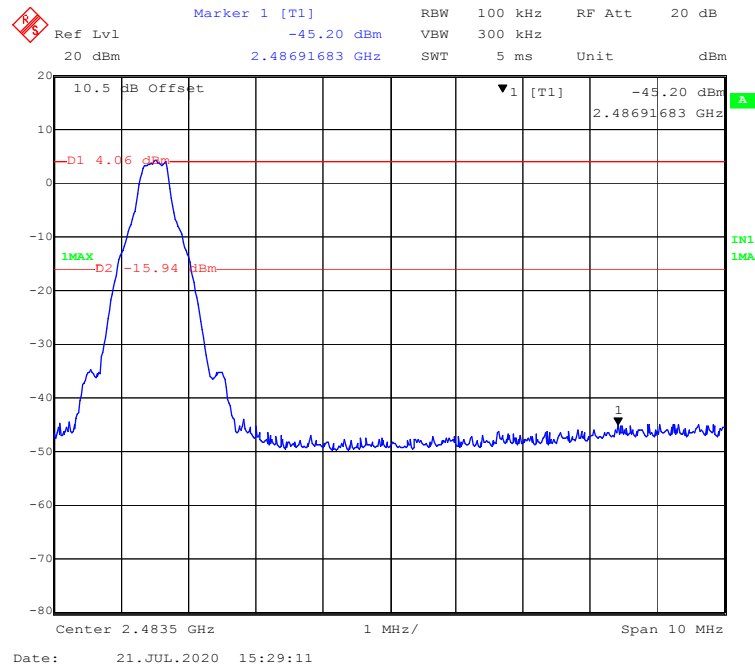
*Test Result: Compliant.*

# Band Edge

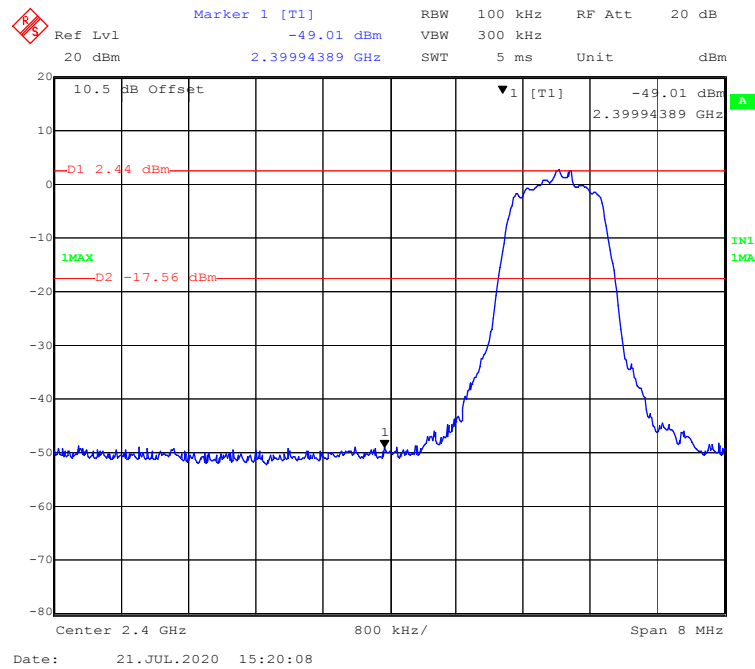
## BDR (GFSK): Left Side - Transmitting



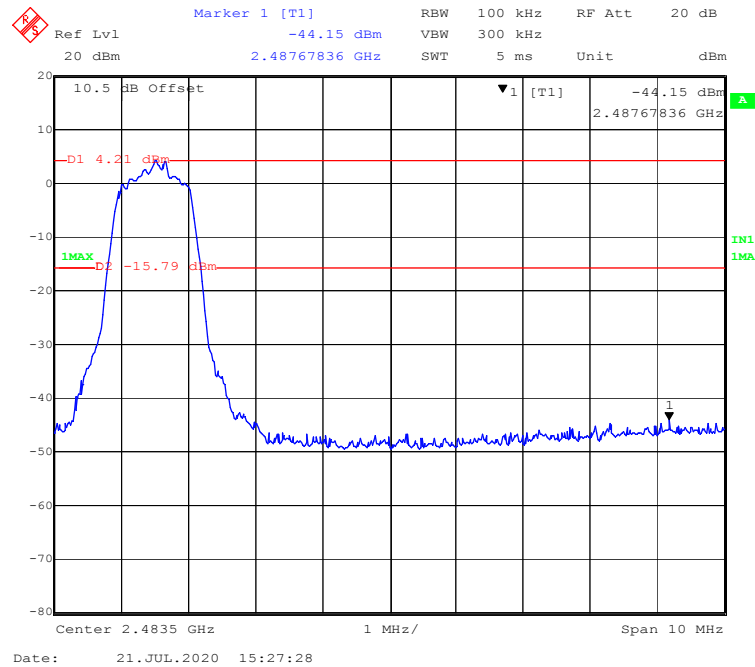
## BDR (GFSK): Right Side - Transmitting



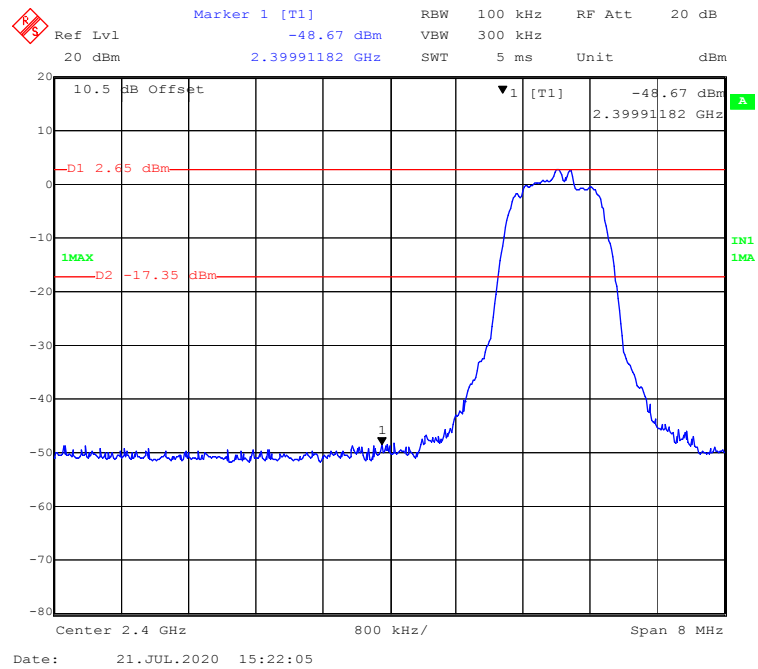
### EDR ( $\pi/4$ -DQPSK): Left Side - Transmitting



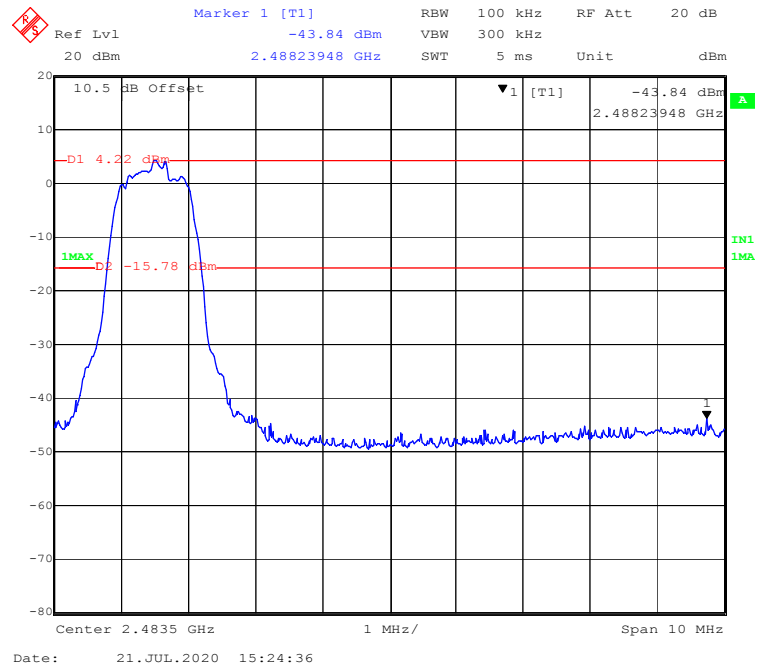
### EDR ( $\pi/4$ -DQPSK): Right Side - Transmitting



### EDR (8DPSK): Left Side - Transmitting



### EDR (8DPSK): Right Side - Transmitting



Ref Lvl 20 dBm RBW 100 kHz VBW 300 kHz SWT 5 ms RF Att 20 dB Unit dBm

Marker 1 [T1] -47.53 dBm 2.39672345 GHz

10.5 dB Offset

▼ 1 [T1] -47.53 dBm 2.39672345 GHz

D1 2.63 dBm

1MAX

D2 -17.37 dBm

IN1 1MAX

Center 2.4 GHz 1 MHz/ Span 10 MHz

Date: 21.JUL.2020 15:55:07

Ref Lvl 20 dBm

Marker 1 [T1] -44.73 dBm

2.48704709 GHz

RBW 100 kHz

VBW 300 kHz

SWT 5 ms

RF Att 20 dB

Unit dBm

10.5 dB Offset

▼1 [T1]

-44.73 dBm

2.48704709 GHz

D1 4.11 dBm

D2 -15.89 dBm

1MAX

IN1

1MA

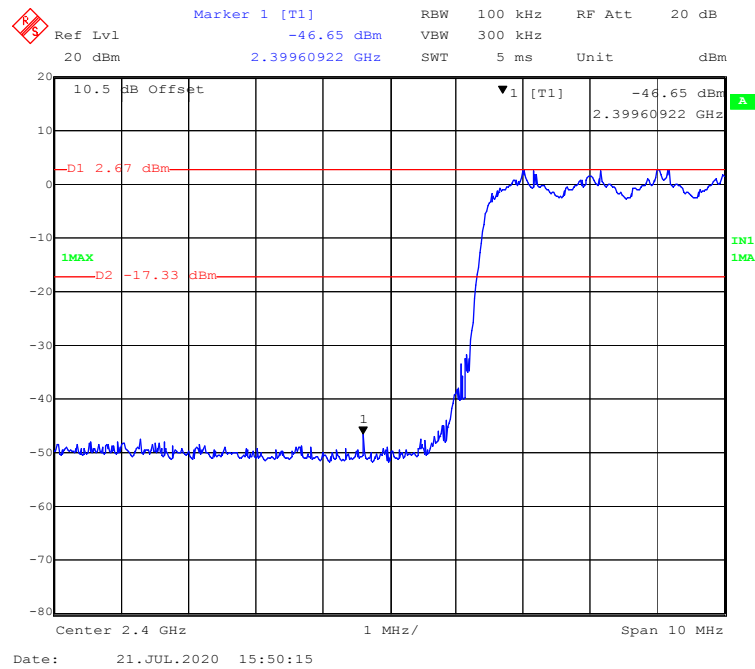
Center 2.4835 GHz

1.2 MHz/

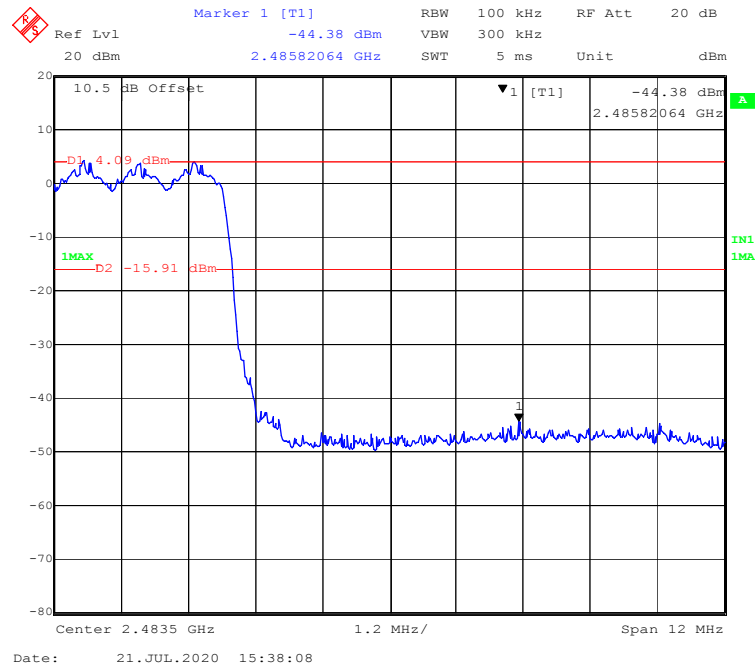
Span 12 MHz

Date: 21. JUL. 2020 15:34:59

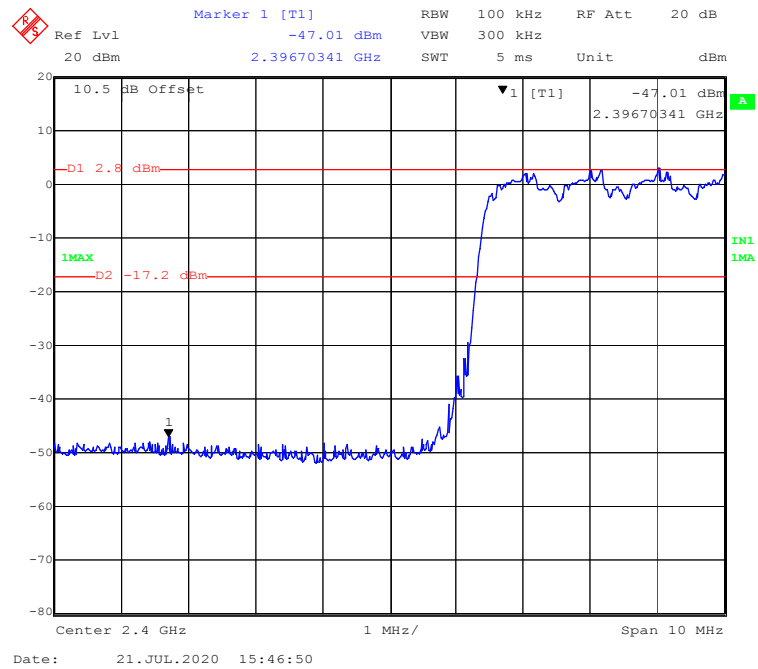
### EDR ( $\pi/4$ -DQPSK): Left Side- Hopping



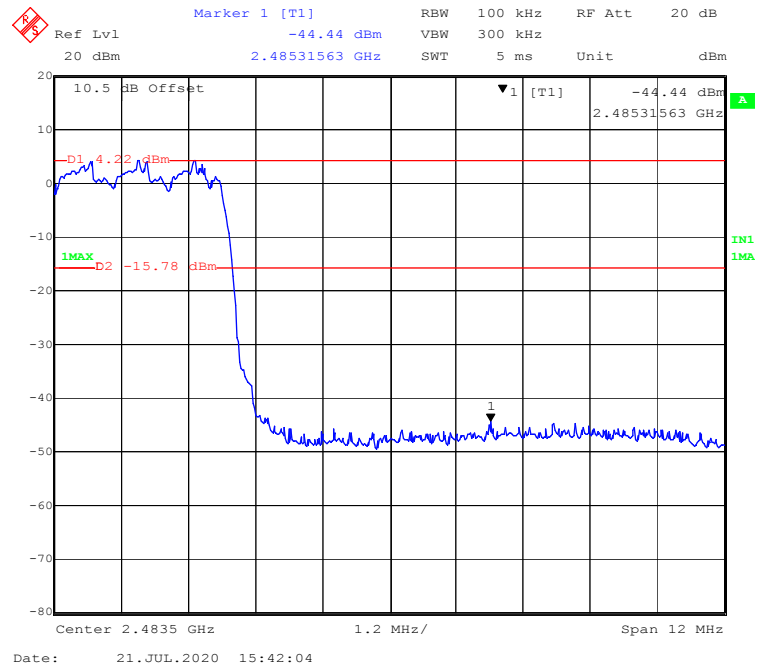
### EDR ( $\pi/4$ -DQPSK): Right Side- Hopping



### EDR (8DPSK): Left Side- Hopping



### EDR (8DPSK): Right Side- Hopping



### **Declarations**

- 1: BACL is not responsible for the authenticity of any test data provided by the applicant. Data included from the applicant that may affect test results are marked with an asterisk '\*'. Customer model name, addresses, names, trademarks etc. are not considered data.
- 2: Unless otherwise stated the results shown in this test report refer only to the sample(s) tested.
- 3: Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.
- 4: The extended uncertainty given in this report is obtained by combining the standard uncertainty times the coverage factor K with the 95% confidence interval.
- 5: This report cannot be reproduced except in full, without prior written approval of the Company.
- 6: This report is valid only with a valid digital signature. The digital signature may be available only under the Adobe software above version 7.0.

**\*\*\*\*\* END OF REPORT \*\*\*\*\***