

# FCC PART 15.247 TEST REPORT

For

## M5Stack Technology Co., Ltd

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**FCC ID: 2AN3W-M5STACK-TOUGH**

|                                        |                                                                                                                                                                                                                            |
|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Report Type:</b><br>Original Report | <b>Product Type:</b><br>Tough                                                                                                                                                                                              |
| <b>Project Engineer:</b>               | Chao Gao                                                                                                                                                                                                                   |
| <b>Report Number:</b>                  | RSHD210126001-00C                                                                                                                                                                                                          |
| <b>Report Date:</b>                    | 2021-03-11                                                                                                                                                                                                                 |
| <b>Reviewed By:</b>                    | Oscar Ye<br>EMC Manager                                                                                                                                                                                                    |
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## GENERAL INFORMATION

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

|                           |                             |
|---------------------------|-----------------------------|
| Applicant:                | M5Stack Technology Co., Ltd |
| Product Type:             | Tough                       |
| Tested Model:             | M5Tough                     |
| Series Model:             | M5Tough-L                   |
| Model Difference:         | See Declaration Letter      |
| Power Supply:             | DC 5V                       |
| 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:    | 2.00 dBi                    |
| Maximum Output Power:     | 6.56dBm                     |

*Note: The Maximum Antenna Gain was declared by the manufacturer.*

*\*All measurement and test data in this report was gathered from production sample serial number: RSHD210126001-1(Assigned by the BACL. The EUT supplied by the applicant was received on 2020-01-26.)*

### 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: 2AN3W-M5STACK-TOUGH

## 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°C       |
| 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 Tool: ESP 32

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

Note: The power level setting was declared by the applicant.

### Special Accessories

No special accessory.

### Equipment Modifications

No modification was made to the EUT tested.

**Support Equipment List and Details**

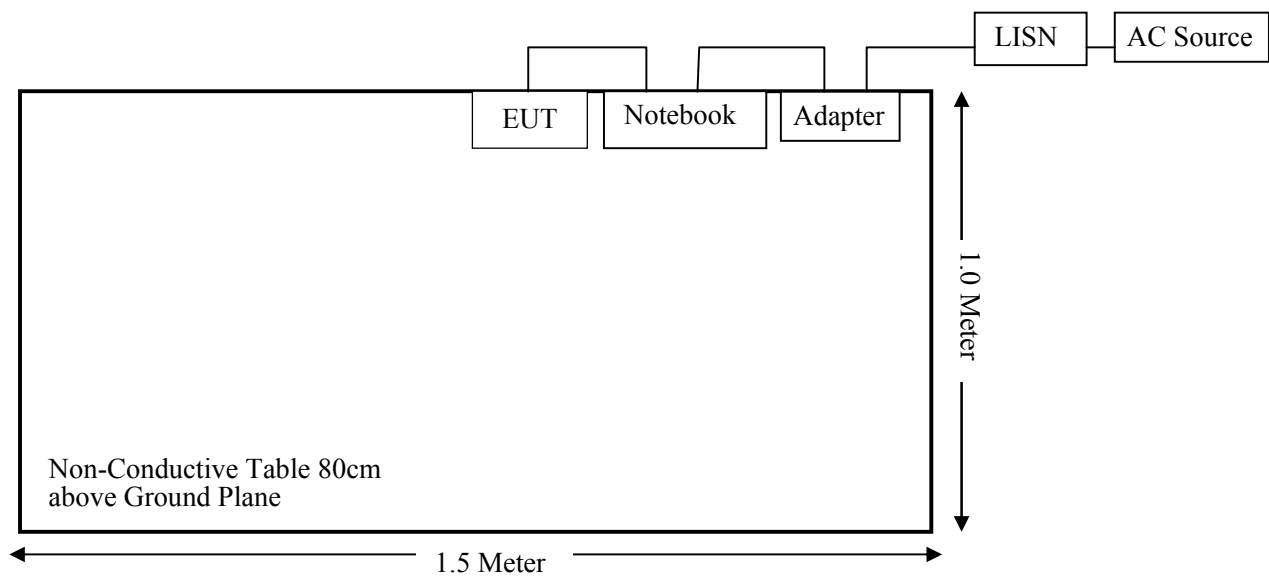
| Manufacturer | Description | Model      | Serial Number |
|--------------|-------------|------------|---------------|
| DELL         | Notebook    | GX620      | D65874152     |
| DELL         | Adapter     | LA65NS0-00 | DF263         |

**External I/O Cable**

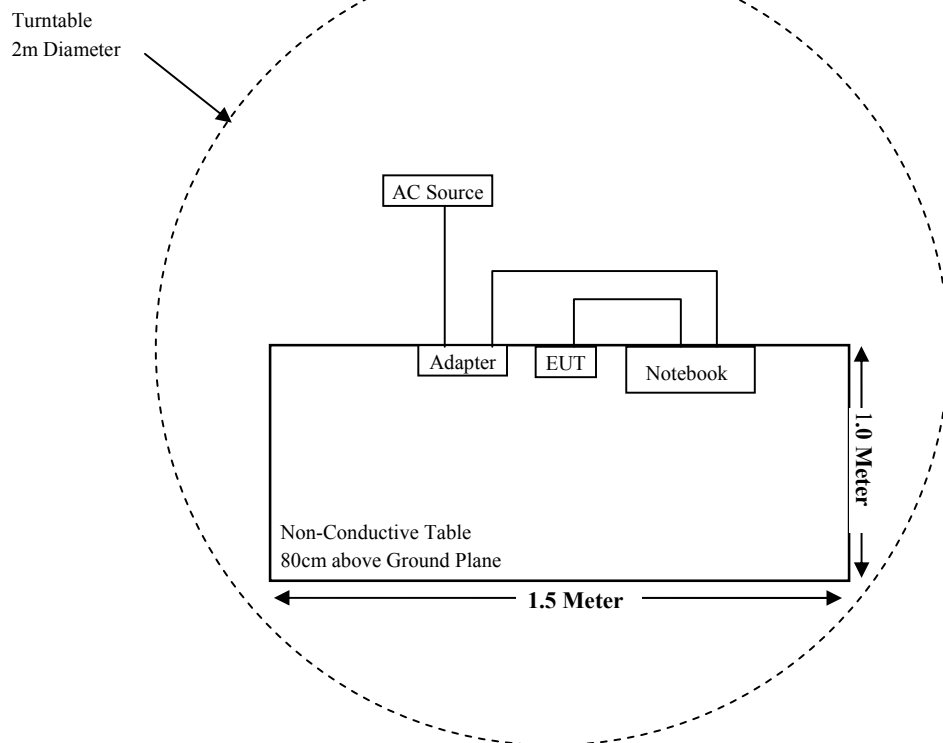
| Cable Description | Length (m) | From Port | To             |
|-------------------|------------|-----------|----------------|
| Power cable1      | 1.0        | EUT       | Notebook       |
| Power cable2      | 1.5        | Notebook  | Adapter        |
| Power cable3      | 1.0        | Adapter   | LISN/AC Source |

**Block Diagram of Test Setup**

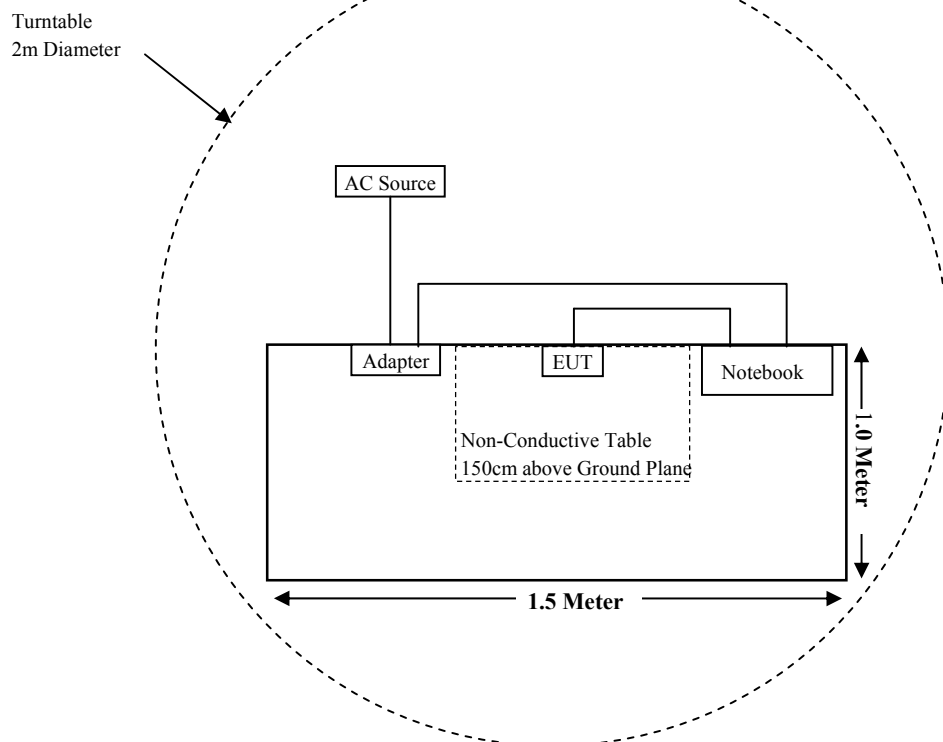
For Conducted Emissions:



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                 | 2020-11-27       | 2021-11-26           |
| Sunol Sciences                             | Broadband Antenna  | JB3                             | A090314-1              | 2020-08-05       | 2023-08-04           |
| Sonoma Instrument                          | Pre-amplifier      | 310N                            | 171205                 | 2020-08-14       | 2021-08-13           |
| Rohde & Schwarz                            | Auto Test Software | EMC32                           | 100361                 | N/A              | N/A                  |
| MICRO-COAX                                 | Coaxial Cable      | Cable-8                         | 008                    | 2020-08-15       | 2021-08-14           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-9                         | 009                    | 2020-08-15       | 2021-08-14           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-10                        | 010                    | 2020-08-15       | 2021-08-14           |
| <b>Radiated Emission Test (Chamber 2#)</b> |                    |                                 |                        |                  |                      |
| Rohde & Schwarz                            | EMI Test Receiver  | ESU40                           | 100207/040             | 2020-04-01       | 2021-03-31           |
| ETS-LINDGREN                               | Horn Antenna       | 3115                            | 9311-4159              | 2020-07-15       | 2023-07-14           |
| ETS-LINDGREN                               | Horn Antenna       | 3116                            | 2516                   | 2020-01-17       | 2023-01-16           |
| A.H.Systems, inc                           | Amplifier          | PAM-0118P                       | 512                    | 2021-02-20       | 2022-02-19           |
| SELECTOR                                   | Amplifier          | EM18G40G                        | 060726                 | 2020-03-22       | 2021-03-21           |
| MICRO-TRONICS                              | Band Reject Filter | BRM50702                        | G024                   | 2020-08-05       | 2021-08-04           |
| Narda                                      | Attenuator         | 10dB                            | 010                    | 2020-08-15       | 2021-08-14           |
| Rohde & Schwarz                            | Auto Test Software | EMC32                           | 100361                 | N/A              | N/A                  |
| MICRO-COAX                                 | Coaxial Cable      | Cable-6                         | 006                    | 2020-08-15       | 2021-08-14           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-11                        | 011                    | 2020-08-15       | 2021-08-14           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-12                        | 012                    | 2020-08-15       | 2021-08-14           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-13                        | 013                    | 2020-08-15       | 2021-08-14           |
| <b>RF Conducted Test</b>                   |                    |                                 |                        |                  |                      |
| Rohde & Schwarz                            | Signal Analyzer    | ESIB26                          | 100146                 | 2020-11-27       | 2021-11-26           |
| Rohde & Schwarz                            | Signal Analyzer    | FSV40                           | 101116                 | 2020-07-08       | 2021-07-27           |
| Narda                                      | Attenuator         | 10dB                            | 010                    | 2020-08-15       | 2021-08-14           |
| M5Stack Technology Co., Ltd                | RF Cable           | M5Stack Technology Co., Ltd C01 | C01                    | Each Time        | /                    |
| <b>Conducted Emission Test</b>             |                    |                                 |                        |                  |                      |
| Rohde & Schwarz                            | EMI Test Receiver  | ESR                             | 1316.3003K03-101746-zn | 2020-08-05       | 2021-08-04           |
| Rohde & Schwarz                            | LISN               | ENV216                          | 3560655016             | 2020-11-27       | 2021-11-26           |
| Audix                                      | Test Software      | e3                              | V9                     | N/A              | N/A                  |
| Rohde & Schwarz                            | Pulse limiter      | ESH3-Z2                         | 0357.8810.54           | 2020-08-10       | 2021-08-09           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-15                        | 015                    | 2020-08-15       | 2021-08-14           |

\* **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):**

| Mode               | Frequency Range (MHz) | Maximum Antenna Gain |           | Tune-up Conducted Power |       | Evaluation Distance (cm) | Power Density (mW/cm <sup>2</sup> ) | MPE Limit (mW/cm <sup>2</sup> ) |
|--------------------|-----------------------|----------------------|-----------|-------------------------|-------|--------------------------|-------------------------------------|---------------------------------|
|                    |                       | (dBi)                | (numeric) | (dBm)                   | (mW)  |                          |                                     |                                 |
| Wi-Fi 802.11b      | 2412-2462             | 2.0                  | 1.58      | 19.00                   | 79.43 | 20                       | 0.0250                              | 1.0                             |
| Wi-Fi 802.11g      |                       | 2.0                  | 1.58      | 18.50                   | 70.79 | 20                       | 0.0222                              | 1.0                             |
| Wi-Fi 802.11n-HT20 |                       | 2.0                  | 1.58      | 18.00                   | 63.10 | 20                       | 0.0198                              | 1.0                             |
| Wi-Fi 802.11n-HT40 | 2422-2452             | 2.0                  | 1.58      | 15.50                   | 35.48 | 20                       | 0.0112                              | 1.0                             |
| BLE                | 2402-2480             | 2.0                  | 1.58      | 4.50                    | 2.82  | 20                       | 0.0009                              | 1.0                             |
| BT                 | 2402-2480             | 2.0                  | 1.58      | 7.00                    | 5.01  | 20                       | 0.0016                              | 1.0                             |

Note 1: Wi-Fi and BT /BLE cannot transmit simultaneously.

Note 2: The tune-up is declared by manufacturer.

**Conclusion:** The device meets MPE at distance 20cm.

**FCC §15.203 – ANTENNA REQUIREMENT**

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**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.

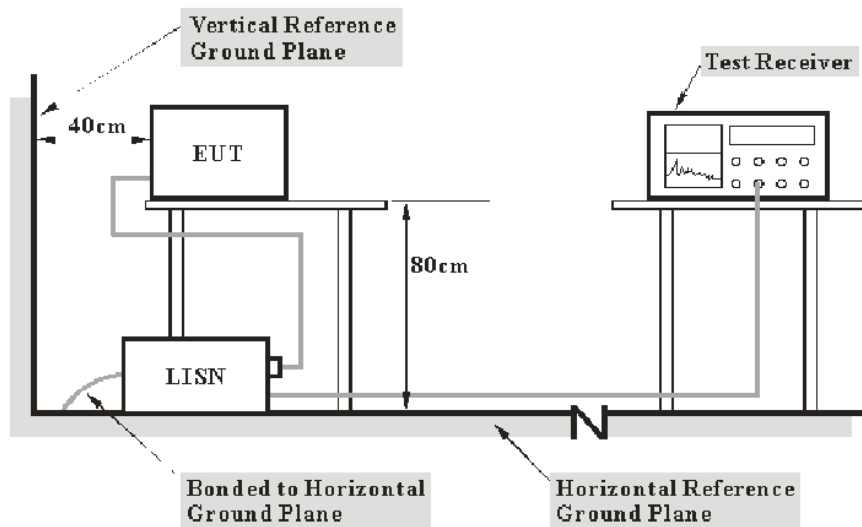
**Antenna Connector Construction**

The EUT has a PIFA antenna for BT3.0 which the antenna gain is 2.00dBi which permanently attached to the unit, 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 notebook adapter was connected to the outlet of the LISN.

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

## 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

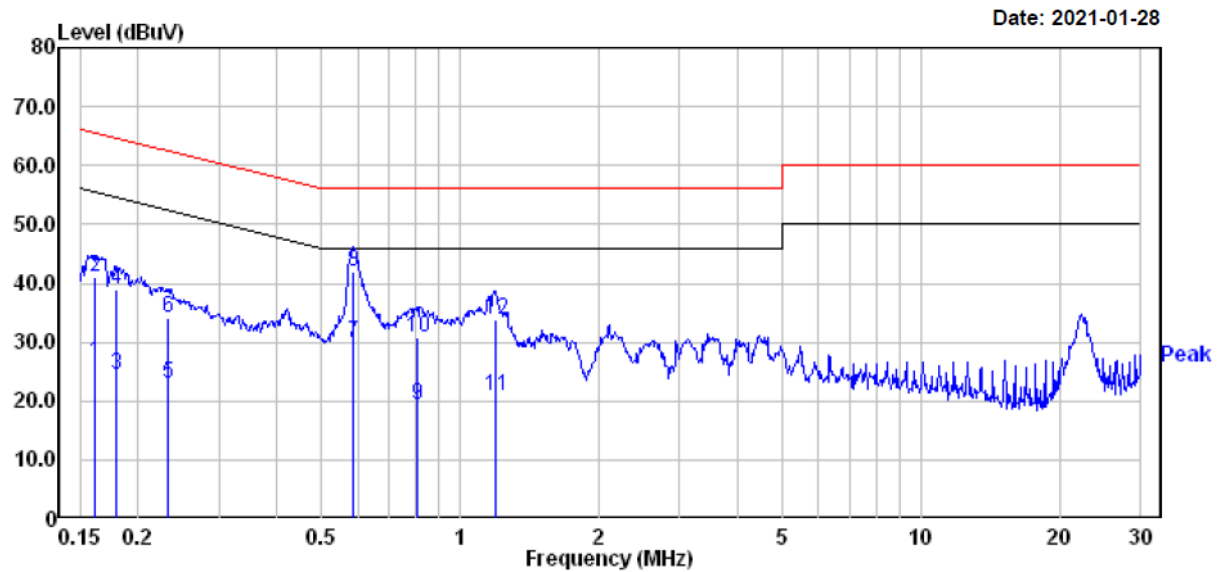
### Environmental Conditions

|                    |           |
|--------------------|-----------|
| Temperature:       | 24.6 °C   |
| Relative Humidity: | 49 %      |
| ATM Pressure:      | 101.2 kPa |

*The testing was performed by Chao Gao on 2021-01-28.*

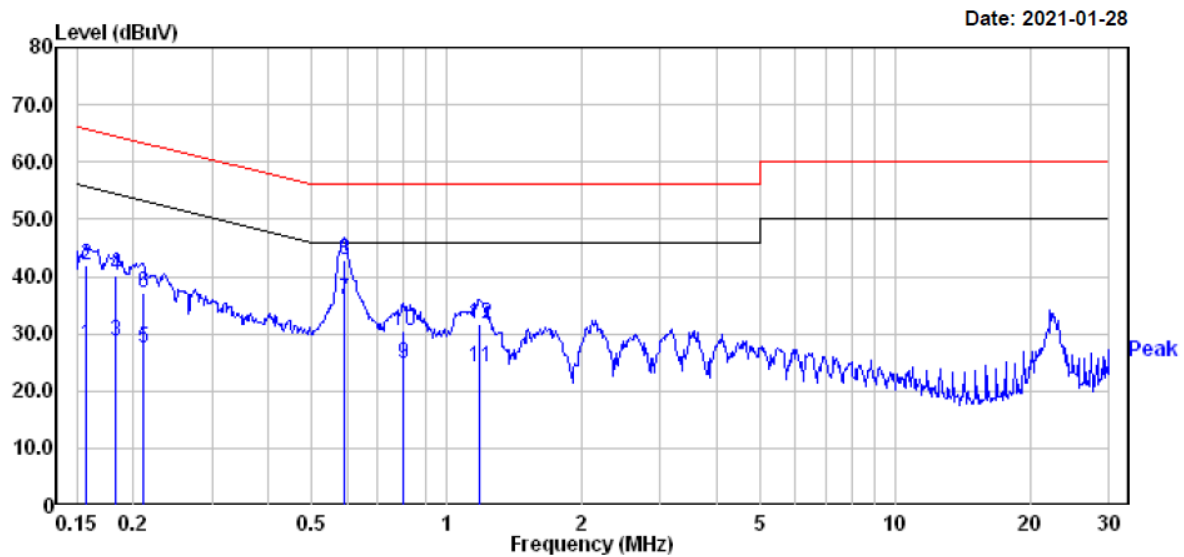
*EUT operation mode: Transmitting in low channel of 8DPSKmode (Worst case)*

## AC 120V/60 Hz, Line



|    |       | Read  |        |       | Limit | Over   |         |
|----|-------|-------|--------|-------|-------|--------|---------|
|    | Freq  | Level | Factor | Level | Line  | Limit  | Remark  |
|    | MHz   | dBuV  | dB     | dBuV  | dBuV  | dB     |         |
| 1  | 0.162 | 6.70  | 19.83  | 26.53 | 55.38 | -28.85 | Average |
| 2  | 0.162 | 21.10 | 19.83  | 40.93 | 65.38 | -24.45 | QP      |
| 3  | 0.179 | 4.70  | 19.83  | 24.53 | 54.55 | -30.02 | Average |
| 4  | 0.179 | 19.20 | 19.83  | 39.03 | 64.55 | -25.52 | QP      |
| 5  | 0.232 | 3.10  | 19.82  | 22.92 | 52.39 | -29.47 | Average |
| 6  | 0.232 | 14.30 | 19.82  | 34.12 | 62.39 | -28.27 | QP      |
| 7  | 0.585 | 10.10 | 19.75  | 29.85 | 46.00 | -16.15 | Average |
| 8  | 0.585 | 22.10 | 19.75  | 41.85 | 56.00 | -14.15 | QP      |
| 9  | 0.809 | -0.39 | 19.70  | 19.31 | 46.00 | -26.69 | Average |
| 10 | 0.809 | 11.01 | 19.70  | 30.71 | 56.00 | -25.29 | QP      |
| 11 | 1.191 | 0.90  | 19.81  | 20.71 | 46.00 | -25.29 | Average |
| 12 | 1.191 | 13.90 | 19.81  | 33.71 | 56.00 | -22.29 | QP      |

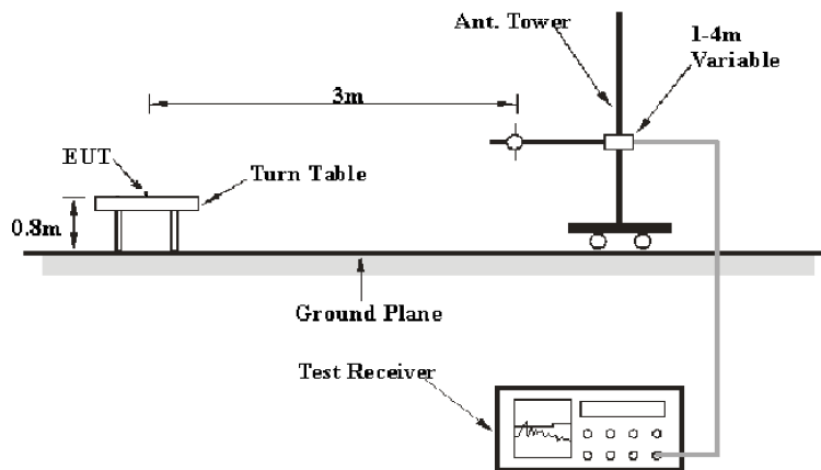
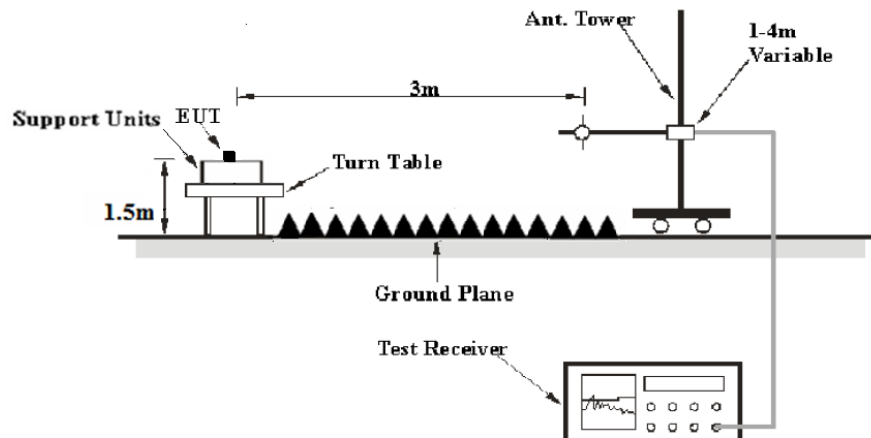
## AC 120V/60 Hz, Neutral



|    |       | Read  |        |       | Limit | Over   |         |
|----|-------|-------|--------|-------|-------|--------|---------|
|    | Freq  | Level | Factor | Level | Line  | Limit  | Remark  |
|    | MHz   | dBuV  | dB     | dBuV  | dBuV  | dB     |         |
| 1  | 0.156 | 8.20  | 19.82  | 28.02 | 55.65 | -27.63 | Average |
| 2  | 0.156 | 22.00 | 19.82  | 41.82 | 65.65 | -23.83 | QP      |
| 3  | 0.182 | 8.90  | 19.83  | 28.73 | 54.37 | -25.64 | Average |
| 4  | 0.182 | 20.30 | 19.83  | 40.13 | 64.37 | -24.24 | QP      |
| 5  | 0.211 | 7.70  | 19.82  | 27.52 | 53.18 | -25.66 | Average |
| 6  | 0.211 | 17.30 | 19.82  | 37.12 | 63.18 | -26.06 | QP      |
| 7  | 0.592 | 16.30 | 19.75  | 36.05 | 46.00 | -9.95  | Average |
| 8  | 0.592 | 23.10 | 19.75  | 42.85 | 56.00 | -13.15 | QP      |
| 9  | 0.800 | 5.00  | 19.70  | 24.70 | 46.00 | -21.30 | Average |
| 10 | 0.800 | 10.80 | 19.70  | 30.50 | 56.00 | -25.50 | QP      |
| 11 | 1.184 | 4.30  | 19.81  | 24.11 | 46.00 | -21.89 | Average |
| 12 | 1.184 | 11.90 | 19.81  | 31.71 | 56.00 | -24.29 | 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.

## 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

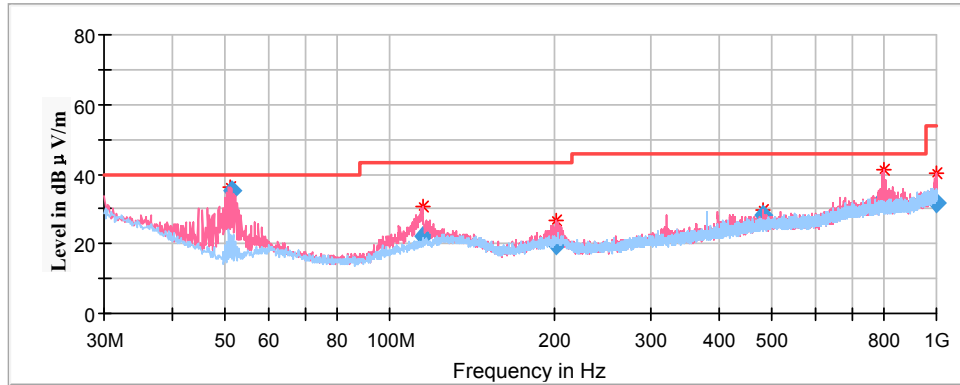
|                    |                 |
|--------------------|-----------------|
| Temperature:       | 24.8~25 °C      |
| Relative Humidity: | 49~50 %         |
| ATM Pressure:      | 101.1~101.2 kPa |

*The testing was performed by Chao Gao from 2021-02-03 to 2021-03-02.*

*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 highchannel of 8DPSK Mode in Y-axis of orientation was recorded*



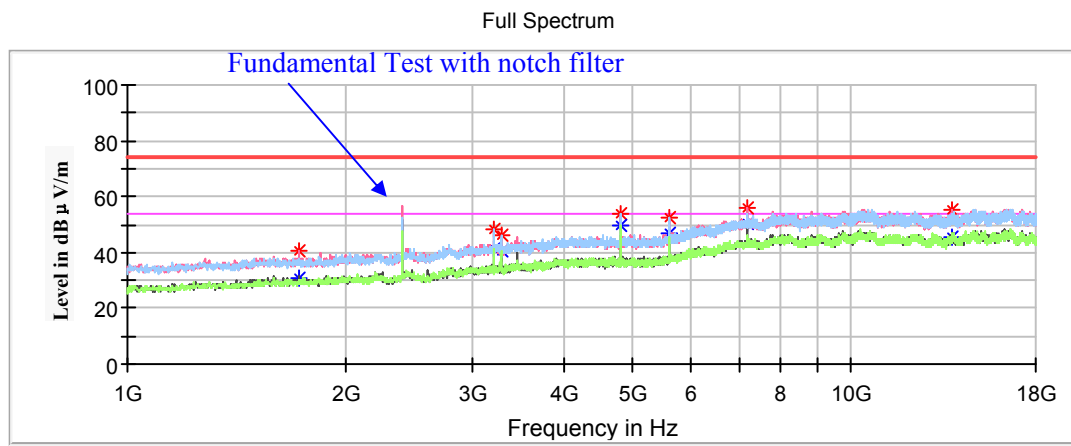
| Frequency (MHz) | Corrected Amplitude | Rx Antenna  |             | Turntable Degree | Corrected Factor (dB/m) | Limit (dBμV/m) | Margin (dB) |
|-----------------|---------------------|-------------|-------------|------------------|-------------------------|----------------|-------------|
|                 | Quasi-peak (dBμV/m) | Height (cm) | Polar (H/V) |                  |                         |                |             |
| 51.313100       | 34.97               | 100.0       | V           | 310.0            | -16.8                   | 40.00          | 5.03        |
| 114.656800      | 22.34               | 100.0       | V           | 0.0              | -12.0                   | 43.50          | 21.16       |
| 200.767900      | 19.64               | 100.0       | V           | 310.0            | -10.8                   | 43.50          | 23.86       |
| 480.008900      | 28.03               | 100.0       | V           | 298.0            | -6.0                    | 46.00          | 17.97       |
| 799.857900      | 33.27               | 100.0       | V           | 207.0            | -0.7                    | 46.00          | 12.73       |
| 999.071250      | 31.57               | 200.0       | V           | 29.0             | 2.7                     | 54.00          | 22.43       |

**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 Y-axis of orientation was recorded*

Note:

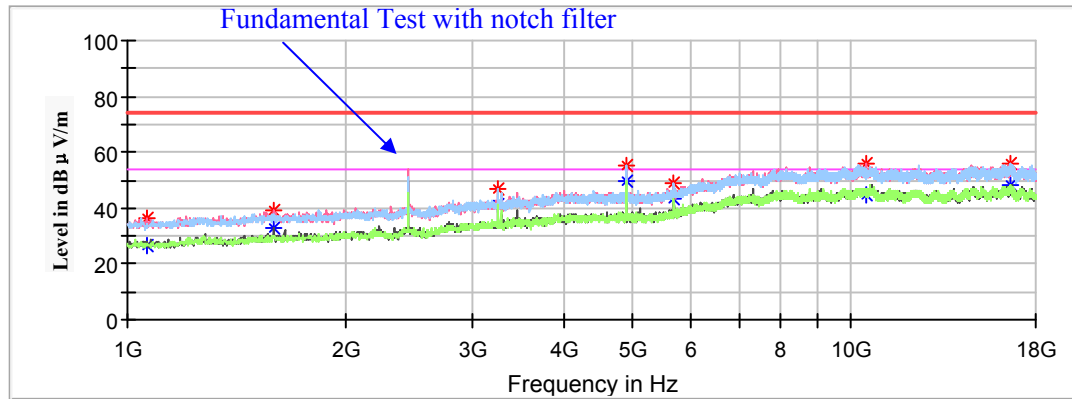
1. This test was performed with the 2.4-2.5 GHz notch filter.
2. Corrected Factor (dB/m) = Antenna factor (RX) (dB/m) + Cable Loss (dB) – Amplifier Factor (dB)  
 Corrected Amplitude (dB $\mu$ V/m) = Corrected Factor (dB/m) + Reading (dB $\mu$ V)  
 Margin (dB) = Limit (dB $\mu$ V/m) – Corrected Amplitude (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) |                  |                         |                      |             |
| 1727.600000     | ---                    | 30.45                  | 200.0       | V           | 181.0            | -8.6                    | 54.00                | 23.55       |
| 1727.600000     | 40.75                  | ---                    | 200.0       | V           | 181.0            | -8.6                    | 74.00                | 33.25       |
| 3201.500000     | 48.58                  | ---                    | 150.0       | H           | 336.0            | -2.6                    | 74.00                | 25.42       |
| 3201.500000     | ---                    | 41.49                  | 150.0       | H           | 336.0            | -2.6                    | 54.00                | 12.51       |
| 3281.400000     | ---                    | 40.31                  | 150.0       | H           | 196.0            | -2.4                    | 54.00                | 13.69       |
| 3281.400000     | 46.33                  | ---                    | 150.0       | H           | 196.0            | -2.4                    | 74.00                | 27.67       |
| 4804.000000     | ---                    | 49.62                  | 150.0       | H           | 183.0            | 1.0                     | 54.00                | 4.38        |
| 4804.000000     | 53.81                  | ---                    | 150.0       | H           | 183.0            | 1.0                     | 74.00                | 20.19       |
| 5603.600000     | 52.30                  | ---                    | 200.0       | H           | 345.0            | 2.7                     | 74.00                | 21.70       |
| 5603.600000     | ---                    | 47.05                  | 200.0       | H           | 345.0            | 2.7                     | 54.00                | 6.95        |
| 7206.000000     | ---                    | 50.44                  | 200.0       | V           | 346.0            | 9.0                     | 54.00                | 3.56        |
| 7206.000000     | 55.74                  | ---                    | 200.0       | V           | 346.0            | 9.0                     | 74.00                | 18.26       |
| 13761.900000    | ---                    | 45.35                  | 150.0       | V           | 109.0            | 11.2                    | 54.00                | 8.65        |
| 13761.900000    | 55.38                  | ---                    | 150.0       | V           | 109.0            | 11.2                    | 74.00                | 18.62       |

**Middle Channel: 2441MHz**

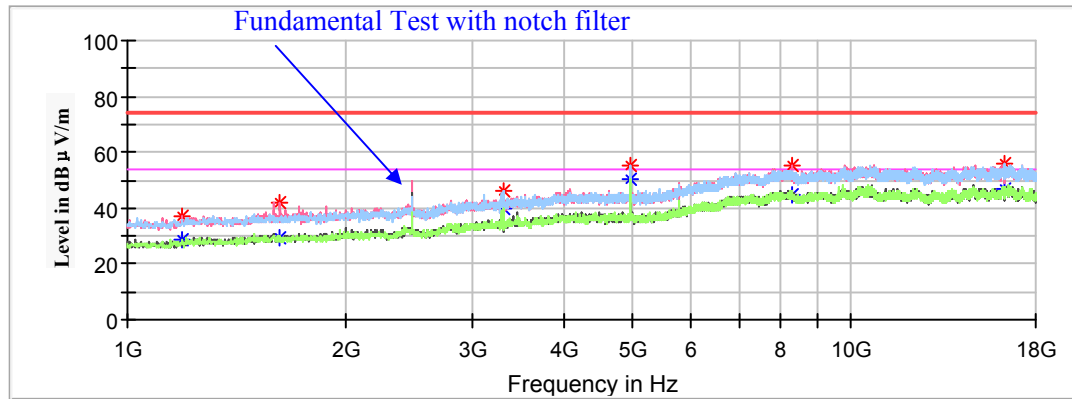
Full Spectrum



| 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) |                  |                         |                      |             |
| 1061.200000     | ---                    | 26.60                  | 150.0       | H           | 162.0            | -12.1                   | 54.00                | 27.40       |
| 1061.200000     | 36.46                  | ---                    | 150.0       | H           | 162.0            | -12.1                   | 74.00                | 37.54       |
| 1591.600000     | 39.11                  | ---                    | 150.0       | V           | 283.0            | -9.1                    | 74.00                | 34.89       |
| 1591.600000     | ---                    | 33.12                  | 150.0       | V           | 283.0            | -9.1                    | 54.00                | 20.88       |
| 3254.200000     | ---                    | 41.17                  | 150.0       | H           | 315.0            | -2.5                    | 54.00                | 12.83       |
| 3254.200000     | 46.89                  | ---                    | 150.0       | H           | 315.0            | -2.5                    | 74.00                | 27.11       |
| 4882.000000     | 55.13                  | ---                    | 150.0       | H           | 226.0            | 1.1                     | 74.00                | 18.87       |
| 4882.000000     | ---                    | 49.39                  | 150.0       | H           | 226.0            | 1.1                     | 54.00                | 4.61        |
| 5695.400000     | ---                    | 43.70                  | 150.0       | H           | 0.0              | 3.2                     | 54.00                | 10.30       |
| 5695.400000     | 49.19                  | ---                    | 150.0       | H           | 0.0              | 3.2                     | 74.00                | 24.81       |
| 10520.000000    | 55.88                  | ---                    | 200.0       | V           | 226.0            | 12.9                    | 74.00                | 18.12       |
| 10520.000000    | ---                    | 45.06                  | 200.0       | V           | 226.0            | 12.9                    | 54.00                | 8.94        |
| 16599.200000    | ---                    | 48.11                  | 150.0       | H           | 162.0            | 11.9                    | 54.00                | 5.89        |
| 16599.200000    | 55.95                  | ---                    | 150.0       | H           | 162.0            | 11.9                    | 74.00                | 18.05       |

**High Channel: 2480MHz**

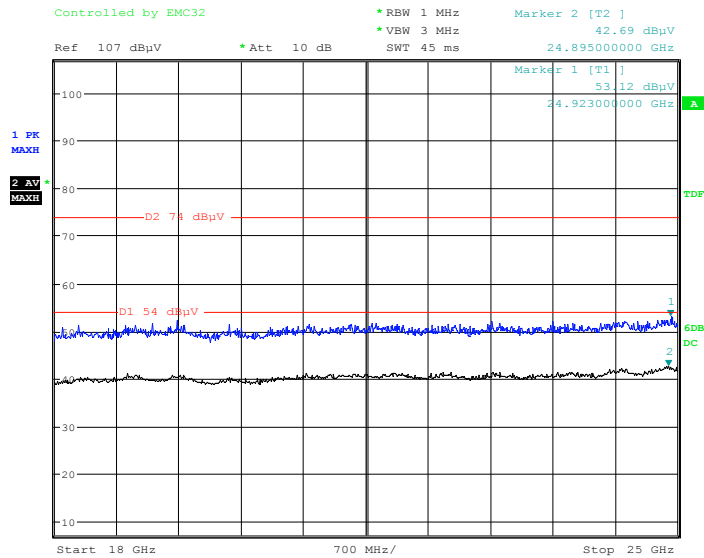
Full Spectrum



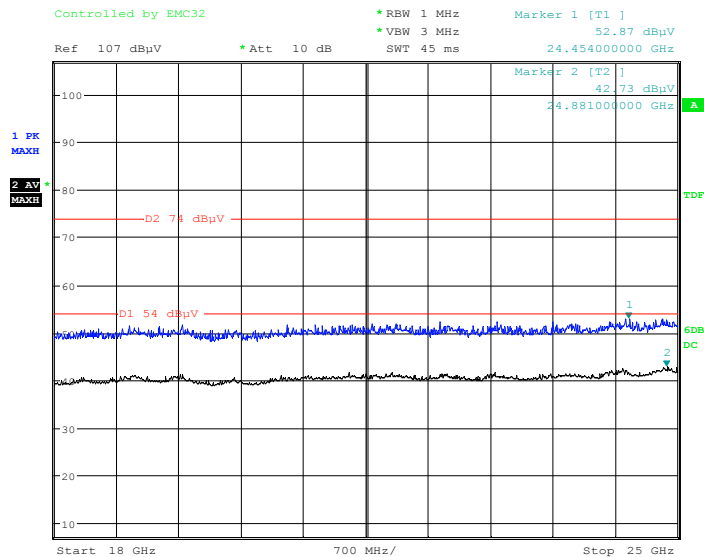
| Frequency (MHz) | Corrected Amplitude |                  | Rx Antenna  |             | Turntable Degree | Corrected Factor (dB/m) | Limit (dBµV/m) | Margin (dB) |
|-----------------|---------------------|------------------|-------------|-------------|------------------|-------------------------|----------------|-------------|
|                 | MaxPeak (dBµV/m)    | Average (dBµV/m) | Height (cm) | Polar (H/V) |                  |                         |                |             |
| 1188.700000     | ---                 | 28.98            | 200.0       | V           | 300.0            | -11.3                   | 54.00          | 25.02       |
| 1188.700000     | 37.04               | ---              | 200.0       | V           | 300.0            | -11.3                   | 74.00          | 36.96       |
| 1625.600000     | ---                 | 29.35            | 200.0       | V           | 275.0            | -9.0                    | 54.00          | 24.65       |
| 1625.600000     | 41.92               | ---              | 200.0       | V           | 275.0            | -9.0                    | 74.00          | 32.08       |
| 3308.600000     | ---                 | 39.56            | 200.0       | H           | 189.0            | -2.3                    | 54.00          | 14.44       |
| 3308.600000     | 46.19               | ---              | 200.0       | H           | 189.0            | -2.3                    | 74.00          | 27.81       |
| 4960.000000     | ---                 | 50.53            | 150.0       | H           | 15.0             | 1.1                     | 54.00          | 3.47        |
| 4960.000000     | 55.39               | ---              | 150.0       | H           | 15.0             | 1.1                     | 74.00          | 18.61       |
| 8270.900000     | ---                 | 44.85            | 150.0       | V           | 62.0             | 10.8                    | 54.00          | 9.15        |
| 8270.900000     | 54.90               | ---              | 150.0       | V           | 62.0             | 10.8                    | 74.00          | 19.10       |
| 16254.100000    | ---                 | 46.63            | 200.0       | H           | 88.0             | 12.2                    | 54.00          | 7.37        |
| 16254.100000    | 55.81               | ---              | 200.0       | H           | 88.0             | 12.2                    | 74.00          | 18.19       |

**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 Y-axis of orientation was recorded*

**Horizontal**

Date: 3.FEB.2021 19:22:34

**Vertical**

Date: 3.FEB.2021 19:23:57

**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 Y-axis of orientation was recorded*

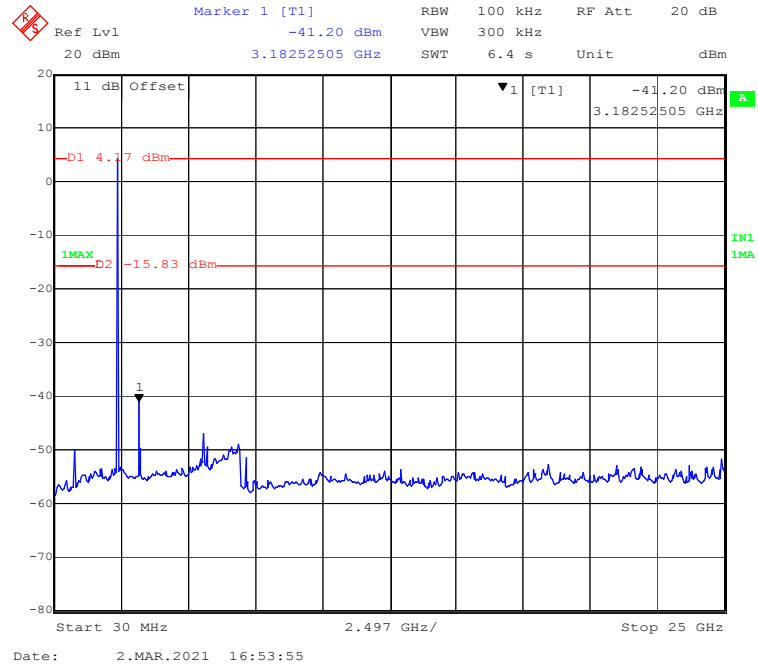
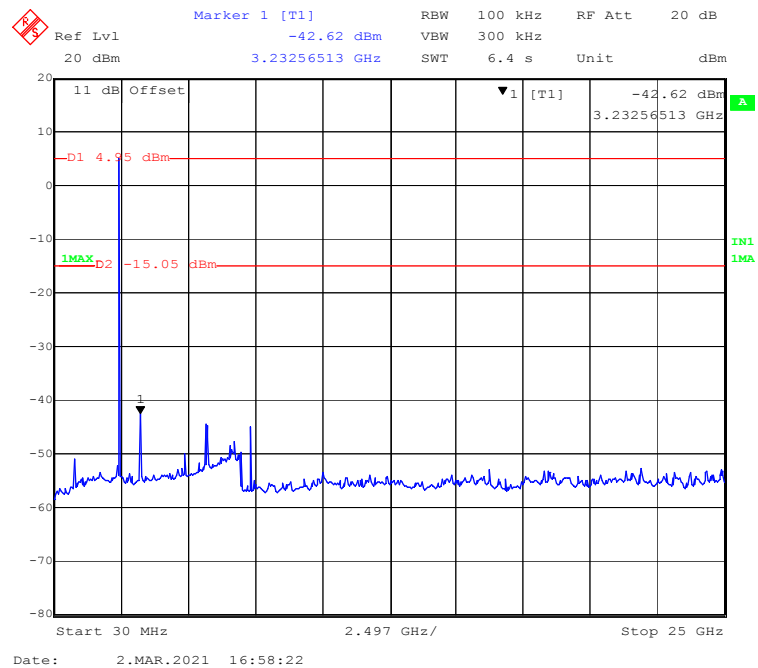
Note:

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

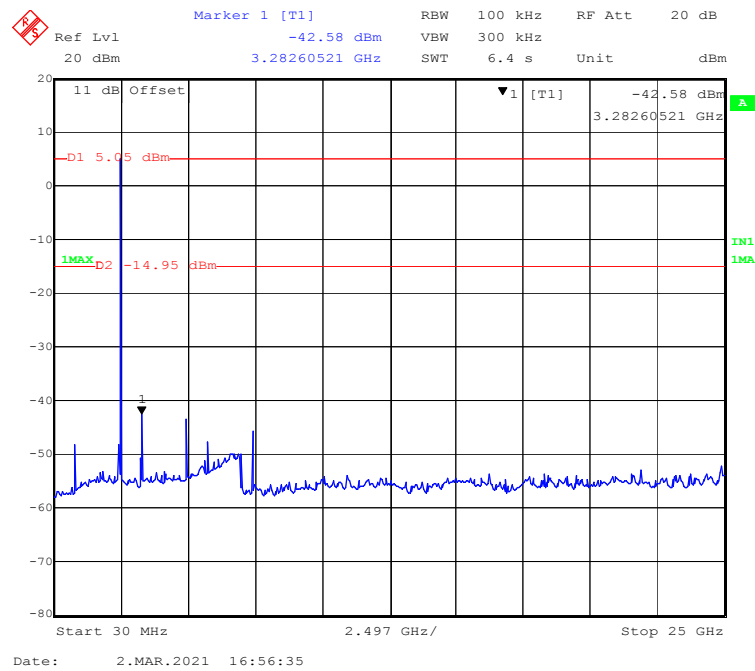
Corrected Amplitude (dB $\mu$ V /m) = Corrected Factor (dB/m) + Reading (dB $\mu$ V)

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

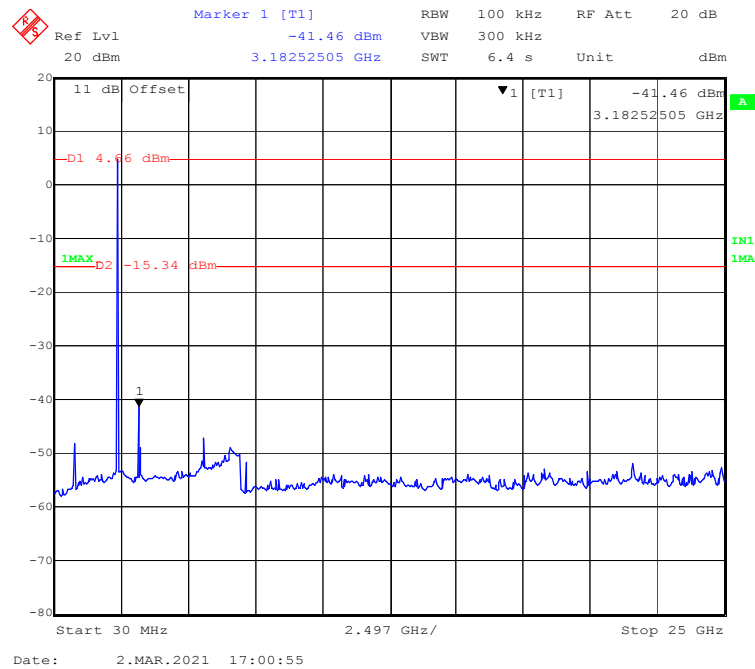
| Frequency<br>(MHz)    | Corrected Amplitude |                     | Rx Antenna     |                | Turntable<br>Degree | Corrected<br>Factor<br>(dB/m) | Limit<br>(dBμV/m) | Margin<br>(dB) |
|-----------------------|---------------------|---------------------|----------------|----------------|---------------------|-------------------------------|-------------------|----------------|
|                       | MaxPeak<br>(dBμV/m) | Average<br>(dBμV/m) | Height<br>(cm) | Polar<br>(H/V) |                     |                               |                   |                |
| Low Channel: 2402MHz  |                     |                     |                |                |                     |                               |                   |                |
| 2390.00               | 51.64               | ---                 | 200.0          | V              | 278.0               | 3.8                           | 74.00             | 22.36          |
| 2390.00               | ---                 | 46.35               | 200.0          | V              | 278.0               | 3.8                           | 54.00             | 7.65           |
| High Channel: 2480MHz |                     |                     |                |                |                     |                               |                   |                |
| 2483.50               | 57.60               | ---                 | 200.0          | V              | 0.0                 | 4.1                           | 74.00             | 16.40          |
| 2483.50               | ---                 | 52.49               | 200.0          | V              | 0.0                 | 4.1                           | 54.00             | 1.51           |

**Conducted Spurious Emissions at Antenna Port****BDR (GFSK): Low Channel****BDR (GFSK): Middle Channel**

### BDR (GFSK): High Channel



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



Marker 1 [T1]

|         |                |      |         |        |       |
|---------|----------------|------|---------|--------|-------|
| Ref Lvl | -42.12 dBm     | RBW  | 100 kHz | RF Att | 20 dB |
| 20 dBm  | 3.23256513 GHz | VBW  | 300 kHz | SWT    | 6.4 s |
|         |                | Unit |         |        | dBm   |

11 dB Offset

▼1 [T1]

-42.12 dBm

3.23256513 GHz

-14.99 dBm

1

Start 30 MHz

2.497 GHz/

Stop 25 GHz

Date: 2.MAR.2021 17:04:41

Ref Lvl 20 dBm  
 Marker 1 [T1] -41.69 dBm  
 RBW 100 kHz  
 RF Att 20 dB  
 VBW 300 kHz  
 SWT 6.4 s  
 Unit dBm

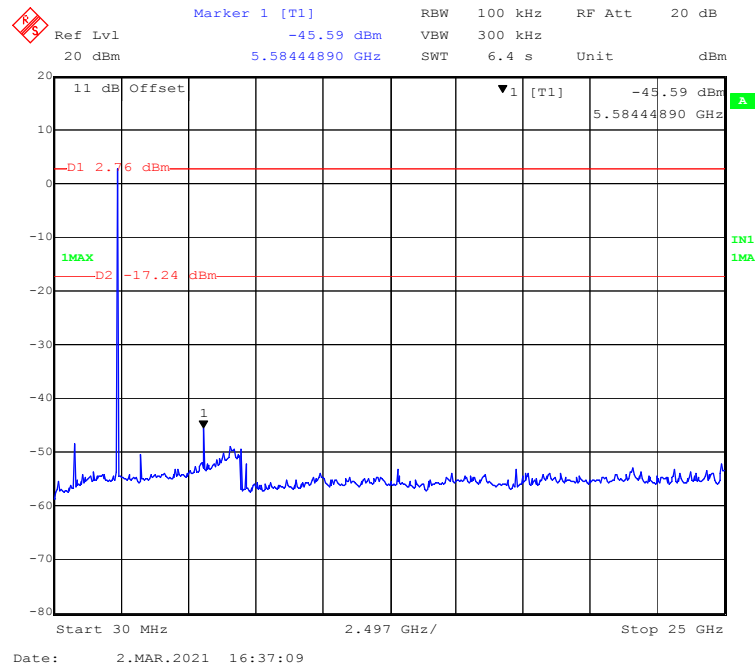
11 dB Offset  
 -41.69 dBm  
 3.28260521 GHz

D1 5.38 dBm  
 D2 -14.62 dBm

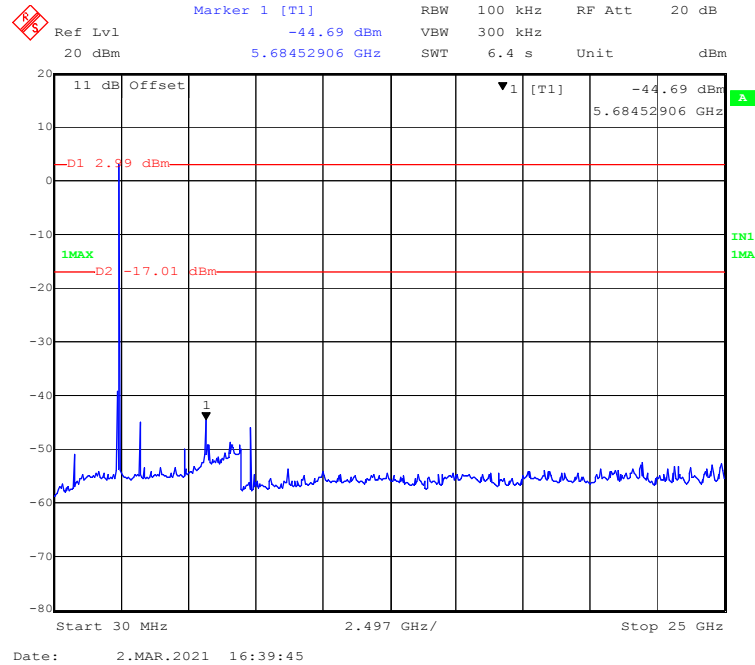
Start 30 MHz  
 2.497 GHz/  
 Stop 25 GHz

Date: 2.MAR.2021 17:06:26

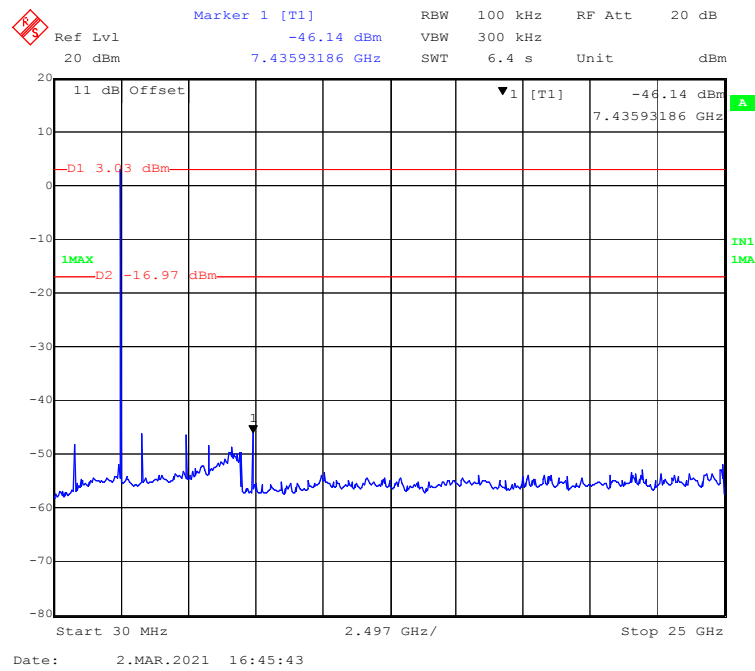
### EDR (8DPSK): Low Channel



### EDR (8DPSK): Middle Channel



### 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:

- a. Span: Wide enough to capture the peaks of two adjacent channels.
- b. 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.
- c. Video (or average) bandwidth (VBW)  $\geq$  RBW.
- d. Sweep: Auto.
- e. Detector function: Peak.
- f. Trace: Max hold.
- g. 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**

|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 24.5 °C   |
| <b>Relative Humidity:</b> | 50 %      |
| <b>ATM Pressure:</b>      | 101.3 kPa |

*The testing was performed by Chao Gao on 2021-03-08.*

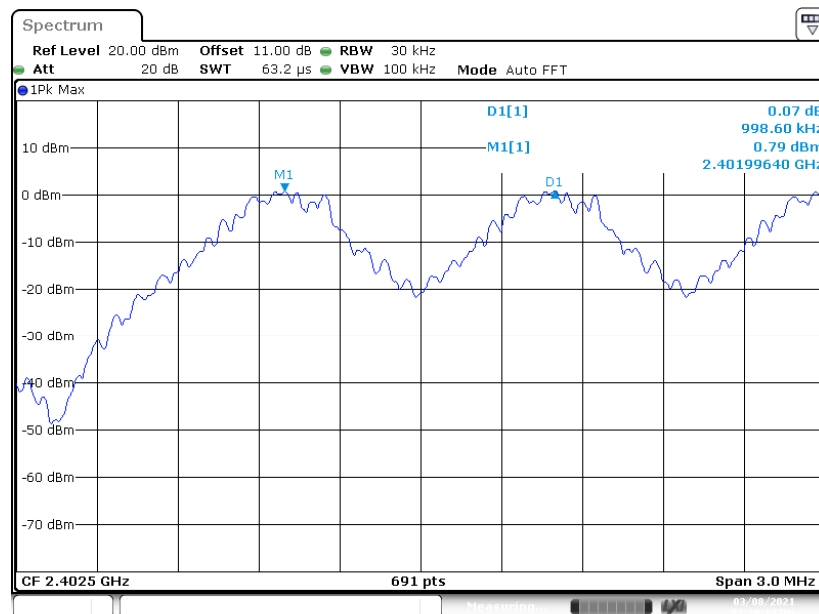
*EUT operation mode: Transmitting*

*Test Result: Compliant.*

| Mode                  | Channel  | Frequency (MHz) | Channel Separation (MHz) | Limit (MHz) | Result |
|-----------------------|----------|-----------------|--------------------------|-------------|--------|
| BDR (GFSK)            | Low      | 2402            | 0.999                    | 0.950       | Pass   |
|                       | Adjacent | 2403            |                          |             |        |
|                       | Middle   | 2441            | 0.999                    | 0.950       | Pass   |
|                       | Adjacent | 2442            |                          |             |        |
|                       | High     | 2480            | 0.999                    | 0.950       | Pass   |
|                       | Adjacent | 2479            |                          |             |        |
| EDR ( $\pi/4$ -DQPSK) | Low      | 2402            | 0.999                    | 0.878       | Pass   |
|                       | Adjacent | 2403            |                          |             |        |
|                       | Middle   | 2441            | 1.003                    | 0.882       | Pass   |
|                       | Adjacent | 2442            |                          |             |        |
|                       | High     | 2480            | 1.003                    | 0.882       | Pass   |
|                       | Adjacent | 2479            |                          |             |        |
| EDR (8DPSK)           | Low      | 2402            | 0.999                    | 0.874       | Pass   |
|                       | Adjacent | 2403            |                          |             |        |
|                       | Middle   | 2441            | 1.003                    | 0.874       | Pass   |
|                       | Adjacent | 2442            |                          |             |        |
|                       | High     | 2480            | 0.999                    | 0.870       | Pass   |
|                       | Adjacent | 2479            |                          |             |        |

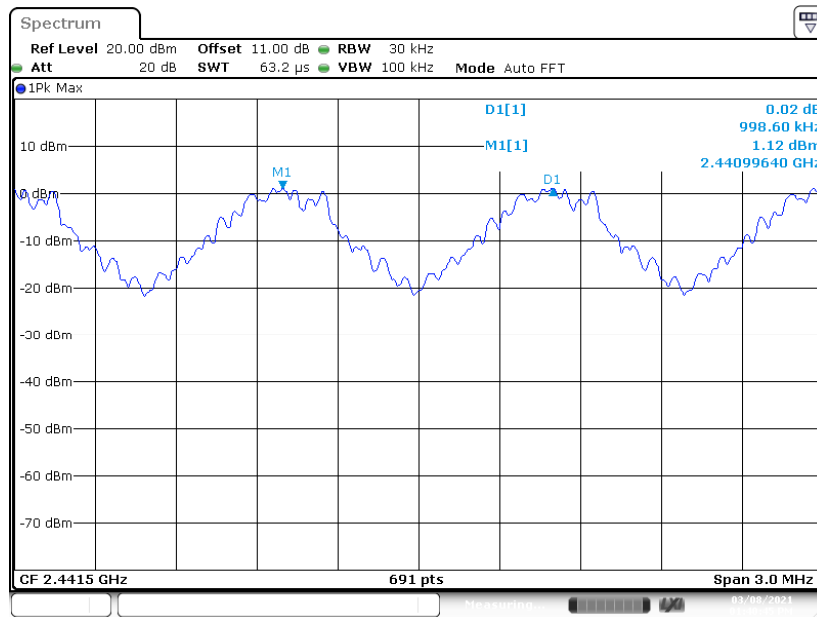
Note: For BDR mode, Limit = 20 dB bandwidth; For EDR mode, Limit = 20 dB bandwidth\*2/3

### BDR (GFSK): Low Channel

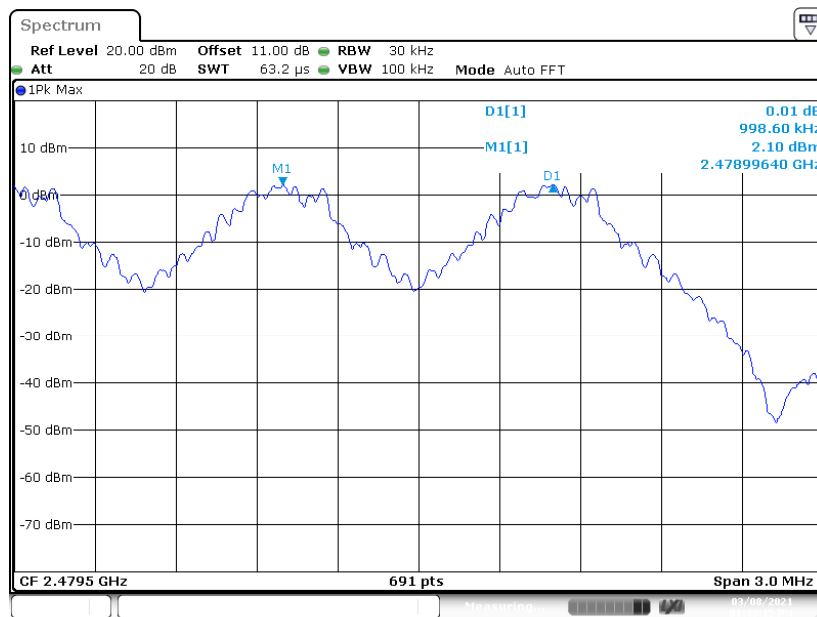


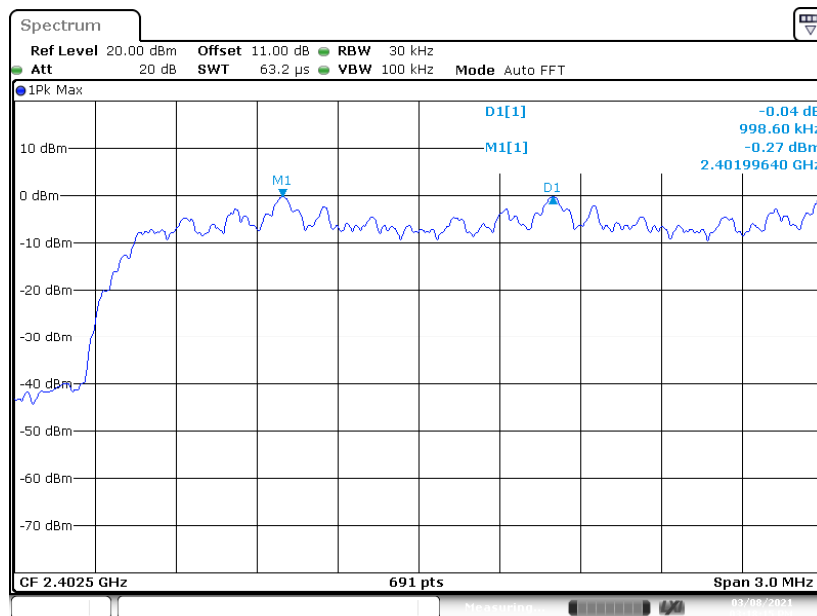
Date: 8.MAR.2021 13:39:14

### BDR (GFSK): Middle Channel

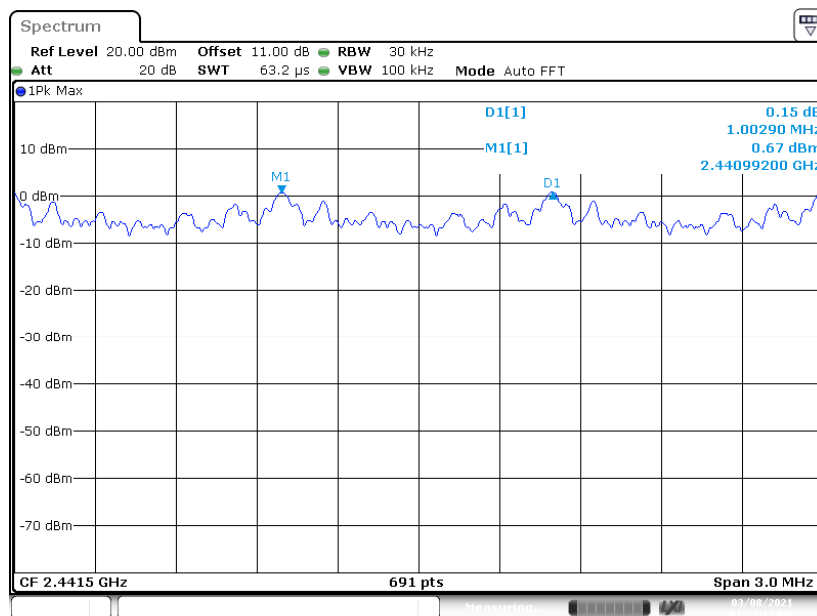


### BDR (GFSK): High Channel

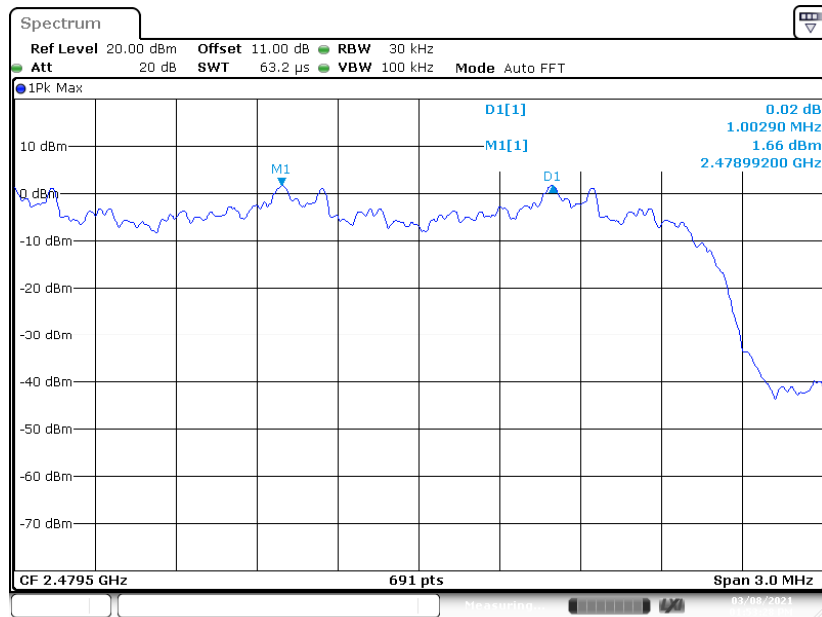


**EDR ( $\pi/4$ -DQPSK): Low Channel**

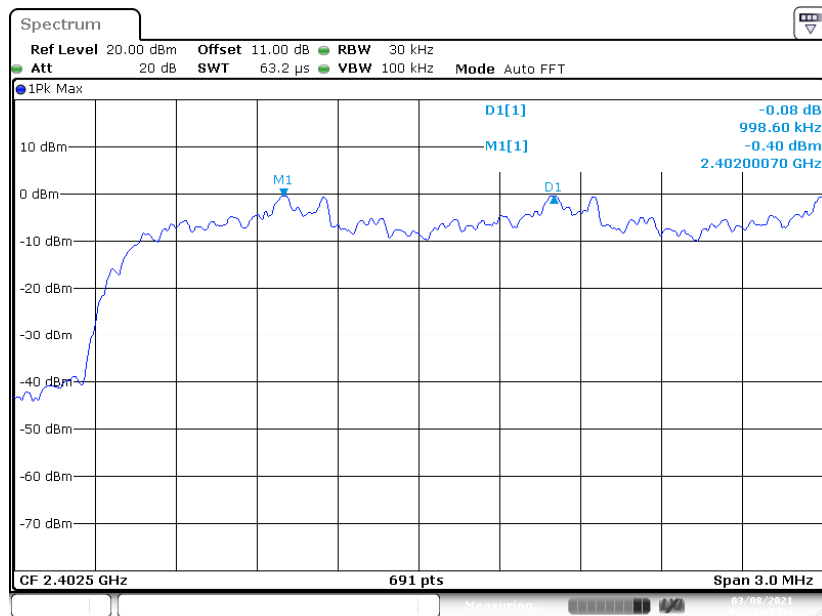
Date: 8.MAR.2021 15:18:16

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

Date: 8.MAR.2021 13:57:15

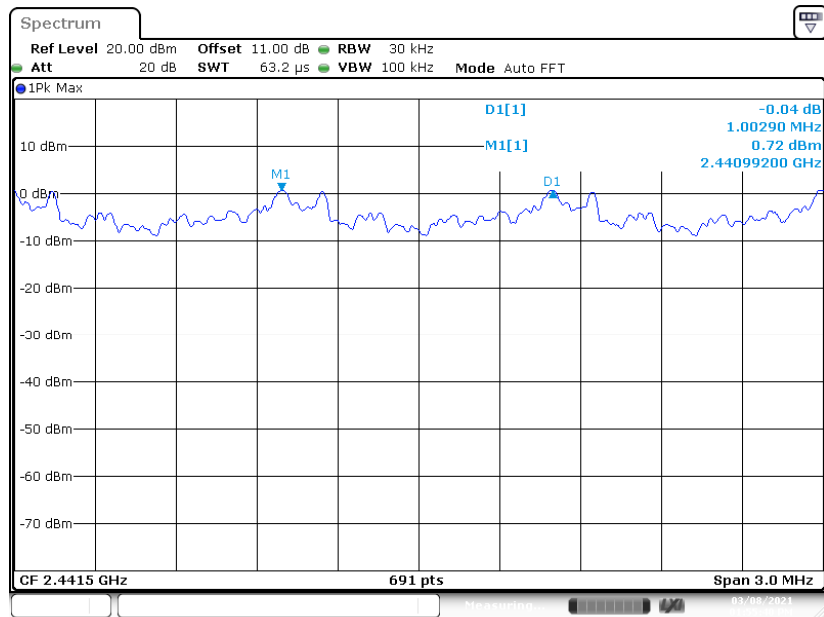
**EDR ( $\pi/4$ -DQPSK): High Channel**

Date: 8.MAR.2021 13:53:29

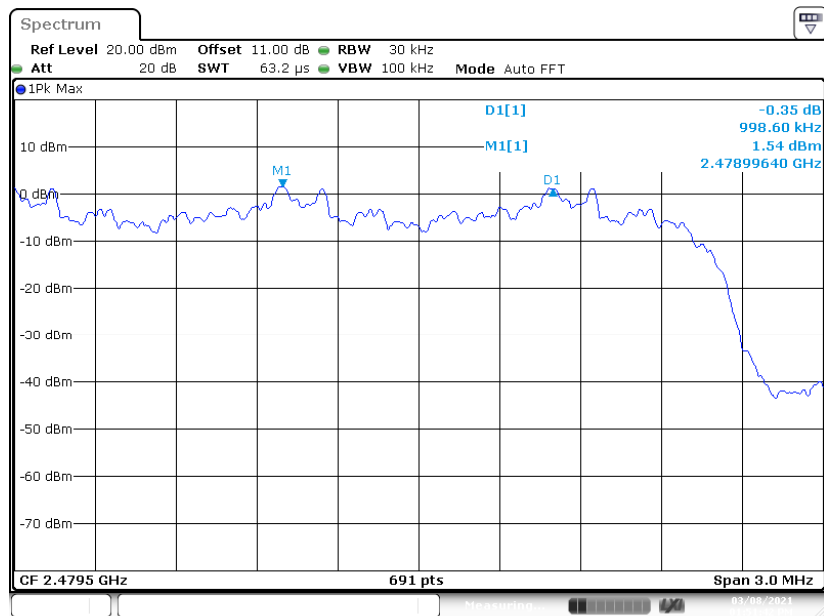
**EDR (8DPSK): Low Channel**

Date: 8.MAR.2021 15:23:08

### 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**

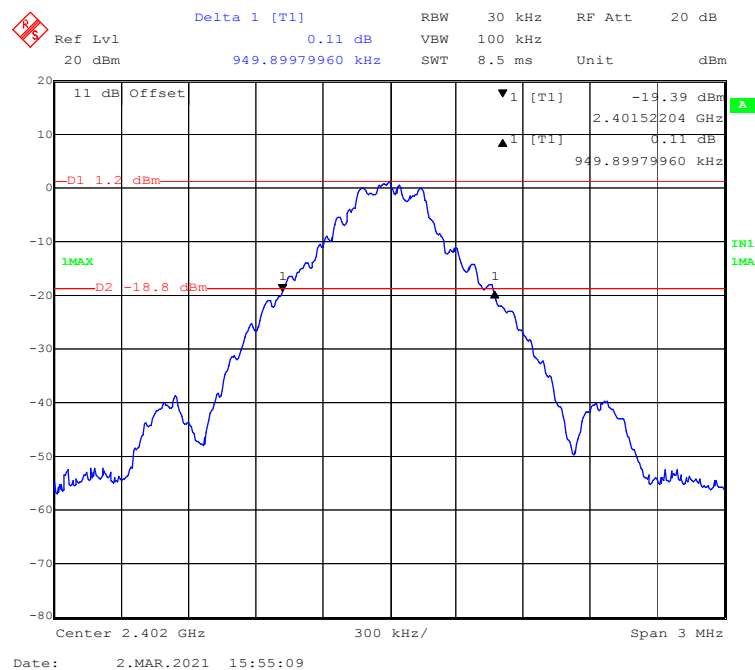
|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 23.7 °C   |
| <b>Relative Humidity:</b> | 50 %      |
| <b>ATM Pressure:</b>      | 101.3 kPa |

*The testing was performed by Chao Gao on 2021-03-02.*

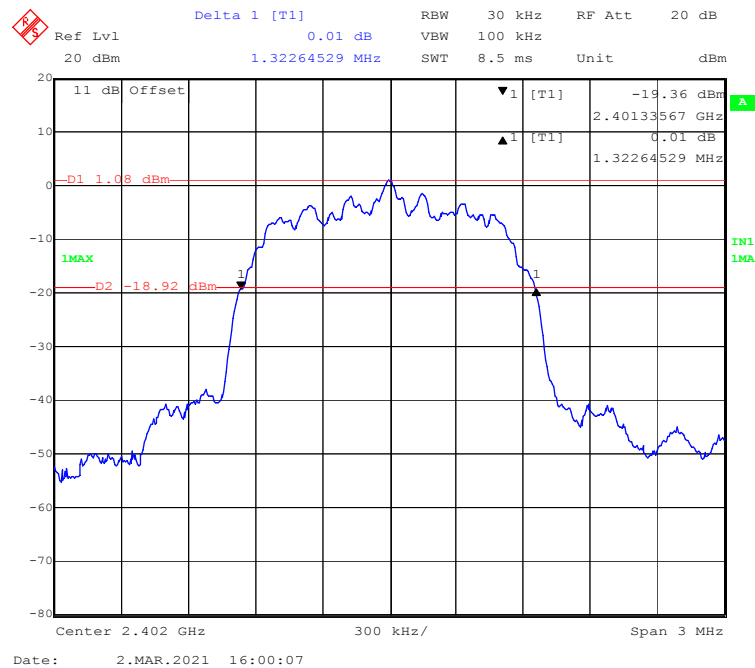
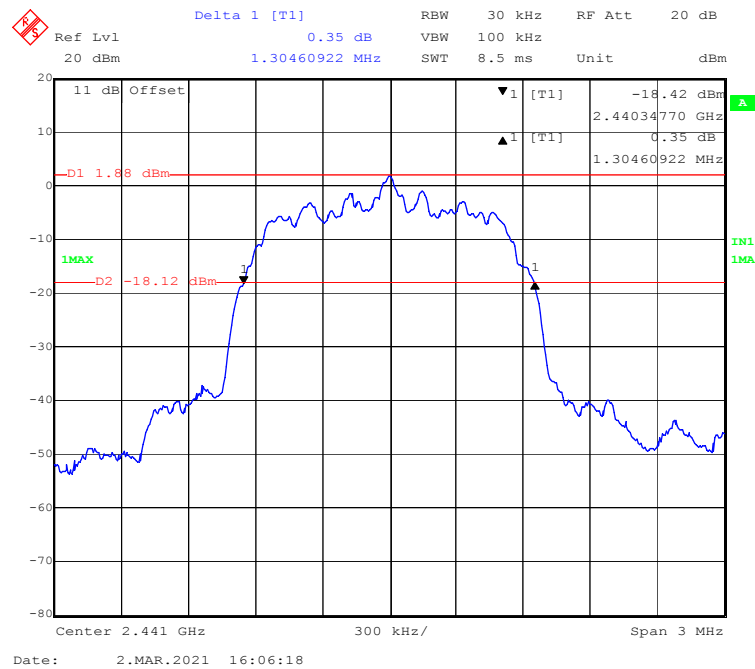
*EUT operation mode: Transmitting*

*Test Result: Compliant.*

| Mode                                  | Channel | Frequency (MHz) | 20 dB Emission Bandwidth (MHz) |
|---------------------------------------|---------|-----------------|--------------------------------|
| <b>BDR (GFSK)</b>                     | Low     | 2402            | 0.950                          |
|                                       | Middle  | 2441            | 0.950                          |
|                                       | High    | 2480            | 0.950                          |
| <b>EDR (<math>\pi/4</math>-DQPSK)</b> | Low     | 2402            | 1.323                          |
|                                       | Middle  | 2441            | 1.305                          |
|                                       | High    | 2480            | 1.305                          |
| <b>EDR (8DPSK)</b>                    | Low     | 2402            | 1.311                          |
|                                       | Middle  | 2441            | 1.305                          |
|                                       | High    | 2480            | 1.305                          |

**BDR (GFSK): Low Channel**

[illegible][illegible]

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

[illegible]

Delta 1 [T1] -0.02 dB

RBW 30 kHz RF Att 20 dB

Ref Lvl 20 dBm VBW 100 kHz Unit dBm

1.31062124 MHz 8.5 ms

11 dB Offset

-D1 1.15 dBm

1MAX

-D2 -18.85 dBm

▼1 [T1] -19.24 dBm

▲1 [T1] -0.02 dB

1.31062124 MHz

Center 2.402 GHz 300 kHz/ Span 3 MHz

Date: 2.MAR.2021 16:09:53

Delta 1 [T1] 0.49 dB

RBW 30 kHz RF Att 20 dB

Ref Lvl 20 dBm VBW 100 kHz

20 dBm 1.30460922 MHz SWT 8.5 ms Unit dBm

11 dB Offset

▼ 1 [T1] -18.65 dBm

▲ 1 [T1] 0.49 dB

2.44033567 GHz

D1 1.95 dBm

1.30460922 MHz

1MAX

D2 -18.05 dBm

1

IN1 1MAX

Center 2.441 GHz 300 kHz/ Span 3 MHz

Date: 2.MAR.2021 16:11:38

Delta 1 [T1] -0.53 dB  
 RBW 30 kHz RF Att 20 dB  
 Ref Lvl 20 dBm Unit dBm  
 2.47933567 GHz  
 1.30460922 MHz  
 8.5 ms  
 11 dB Offset  
 -18.39 dBm  
 -0.53 dB  
 1.30460922 MHz  
 -17.96 dBm  
 1MAX  
 1MA  
 Center 2.48 GHz 300 kHz/ Span 3 MHz  
 Date: 2.MAR.2021 16:15:57

**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>       | 23.7 °C   |
| <b>Relative Humidity:</b> | 50 %      |
| <b>ATM Pressure:</b>      | 101.3 kPa |

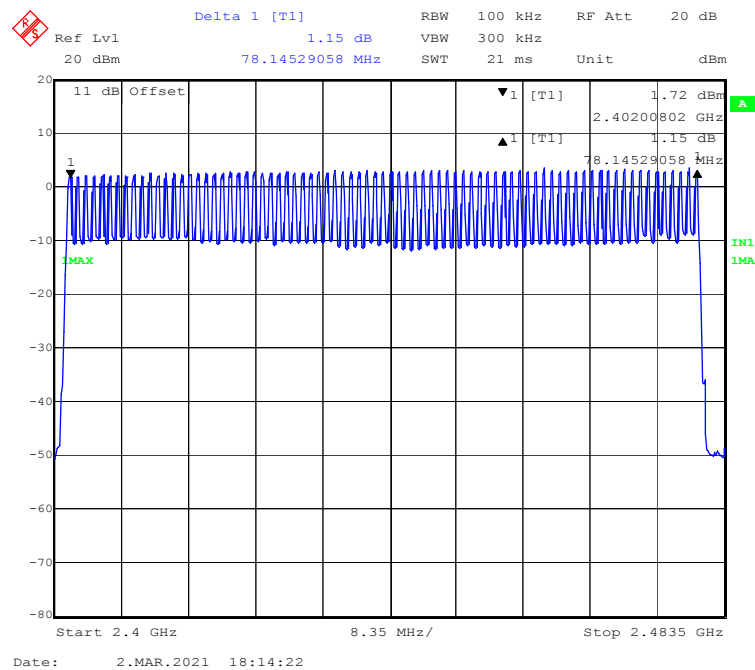
*The testing was performed by Chao Gao on 2021-03-02.*

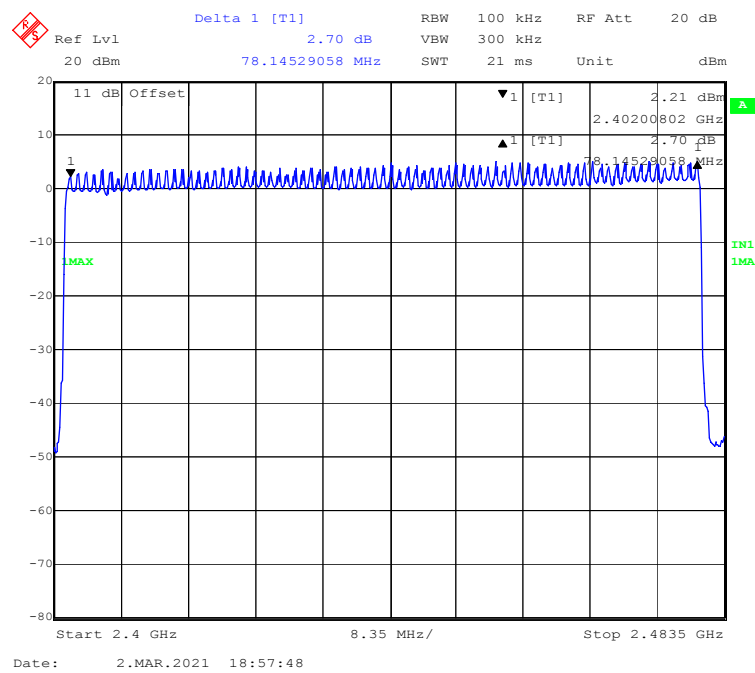
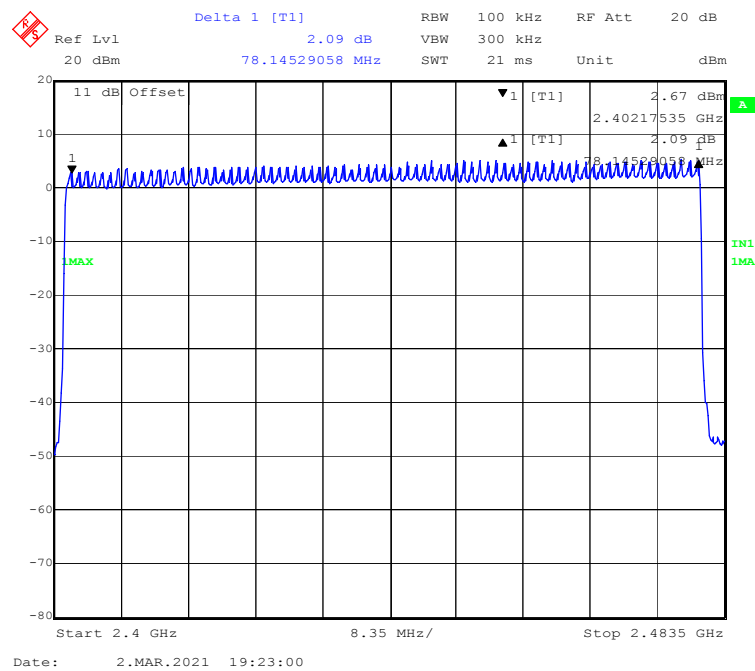
*EUT operation mode: Hopping*

*Test Result: Compliant.*

| Mode                  | Frequency Range (MHz) | Number of Hopping Channel (CH) | Limit (CH) |
|-----------------------|-----------------------|--------------------------------|------------|
| BDR (GFSK)            | 2400-2483.5           | 79                             | ≥15        |
| EDR ( $\pi/4$ -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.

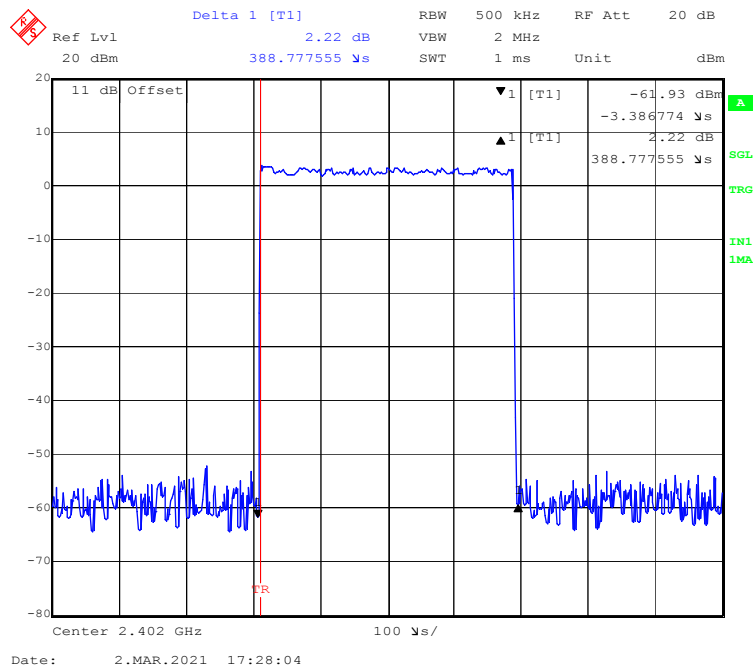
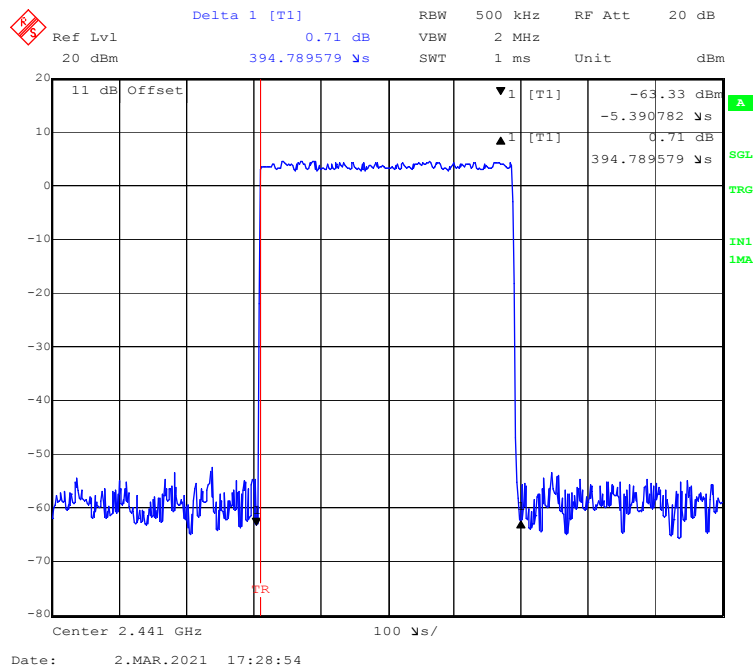
**Test Data****Environmental Conditions**

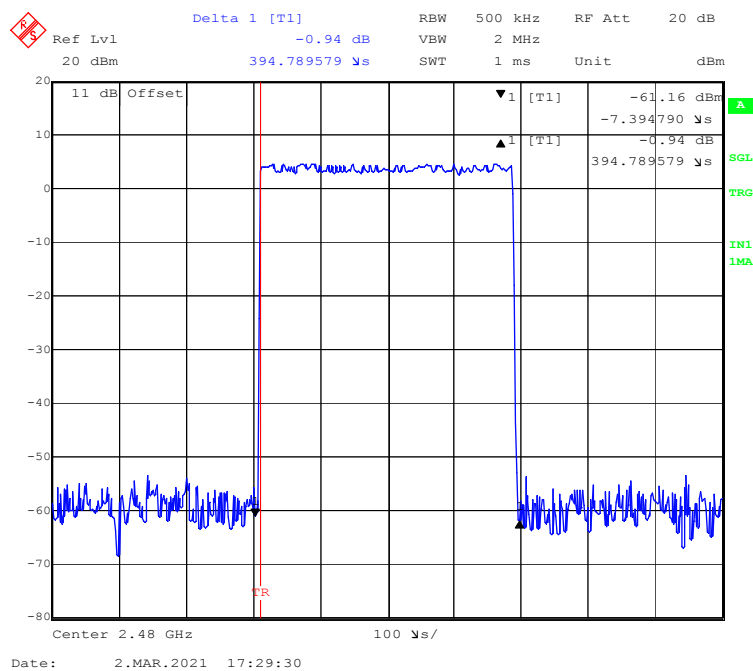
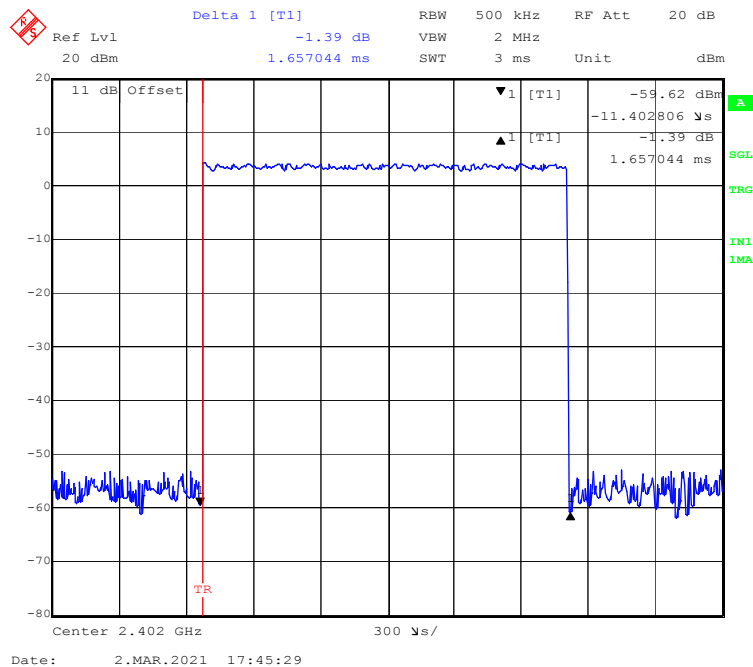
|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 23.7 °C   |
| <b>Relative Humidity:</b> | 50 %      |
| <b>ATM Pressure:</b>      | 101.3 kPa |

*The testing was performed by Chao Gao on 2021-03-02.*

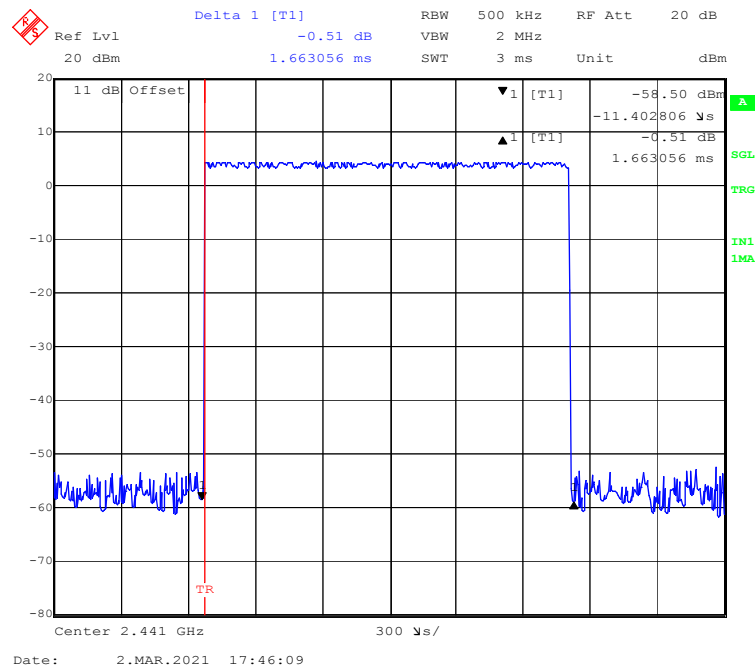
*EUT operation mode: Hopping*

| Mode                  |      | Channel                                                | Pulse Width (ms) | Dwell Time (s) | Limit (s) | Result |
|-----------------------|------|--------------------------------------------------------|------------------|----------------|-----------|--------|
| BDR (GFSK)            | DH1  | Low                                                    | 0.389            | 0.124          | 0.4       | Pass   |
|                       |      | Middle                                                 | 0.395            | 0.126          | 0.4       | Pass   |
|                       |      | High                                                   | 0.395            | 0.126          | 0.4       | Pass   |
|                       |      | Note: DH1: Dwell time = Pulse time*(1600/2/79)*31.6S   |                  |                |           |        |
|                       | DH3  | Low                                                    | 1.657            | 0.265          | 0.4       | Pass   |
|                       |      | Middle                                                 | 1.663            | 0.266          | 0.4       | Pass   |
|                       |      | High                                                   | 1.663            | 0.266          | 0.4       | Pass   |
|                       |      | Note: DH3: Dwell time = Pulse time*(1600/4/79)*31.6S   |                  |                |           |        |
|                       | DH5  | Low                                                    | 2.926            | 0.312          | 0.4       | Pass   |
|                       |      | Middle                                                 | 2.910            | 0.310          | 0.4       | Pass   |
|                       |      | High                                                   | 2.910            | 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                                                   | 0.403            | 0.129          | 0.4       | Pass   |
|                       |      | Note: 2DH1: Dwell time = Pulse time*(1600/2/79)*31.6S  |                  |                |           |        |
|                       | 2DH3 | Low                                                    | 1.669            | 0.267          | 0.4       | Pass   |
|                       |      | Middle                                                 | 1.681            | 0.269          | 0.4       | Pass   |
|                       |      | High                                                   | 1.659            | 0.265          | 0.4       | Pass   |
|                       |      | Note: 2DH3: Dwell time = Pulse time*(1600/4/79)*31.6S  |                  |                |           |        |
|                       | 2DH5 | Low                                                    | 2.981            | 0.318          | 0.4       | Pass   |
|                       |      | Middle                                                 | 2.942            | 0.314          | 0.4       | Pass   |
|                       |      | High                                                   | 2.934            | 0.313          | 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                                                 | 0.405            | 0.130          | 0.4       | Pass   |
|                       |      | High                                                   | 0.409            | 0.131          | 0.4       | Pass   |
|                       |      | Note: 3 DH1: Dwell time = Pulse time*(1600/2/79)*31.6S |                  |                |           |        |
|                       | 3DH3 | Low                                                    | 1.671            | 0.267          | 0.4       | Pass   |
|                       |      | Middle                                                 | 1.671            | 0.267          | 0.4       | Pass   |
|                       |      | High                                                   | 1.659            | 0.265          | 0.4       | Pass   |
|                       |      | Note: 3DH3: Dwell time = Pulse time*(1600/4/79)*31.6S  |                  |                |           |        |
|                       | 3DH5 | Low                                                    | 2.934            | 0.313          | 0.4       | Pass   |
|                       |      | Middle                                                 | 2.942            | 0.314          | 0.4       | Pass   |
|                       |      | High                                                   | 2.934            | 0.313          | 0.4       | Pass   |
|                       |      | Note: 3DH5: Dwell time = Pulse time*(1600/6/79)*31.6S  |                  |                |           |        |

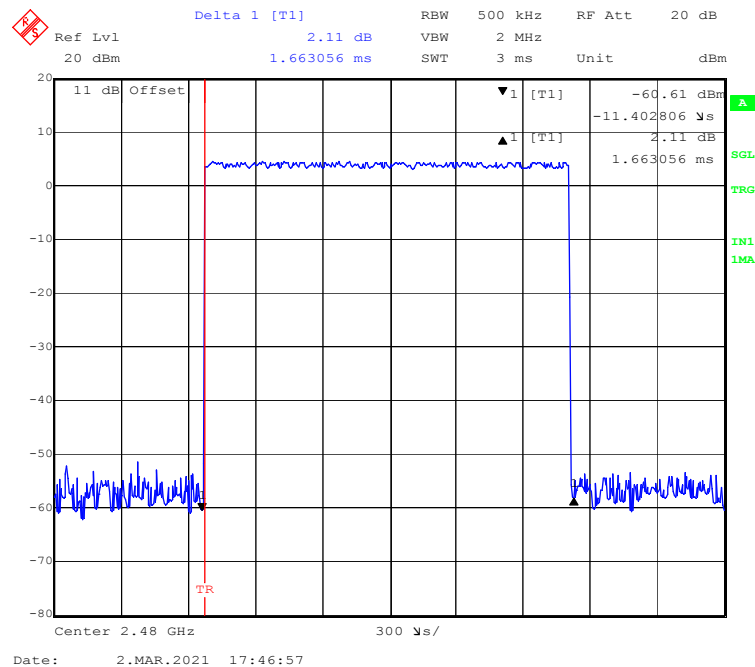
**BDR (GFSK): Pulse time, Low Channel, DH1****BDR (GFSK): Pulse time, Middle Channel, DH1**

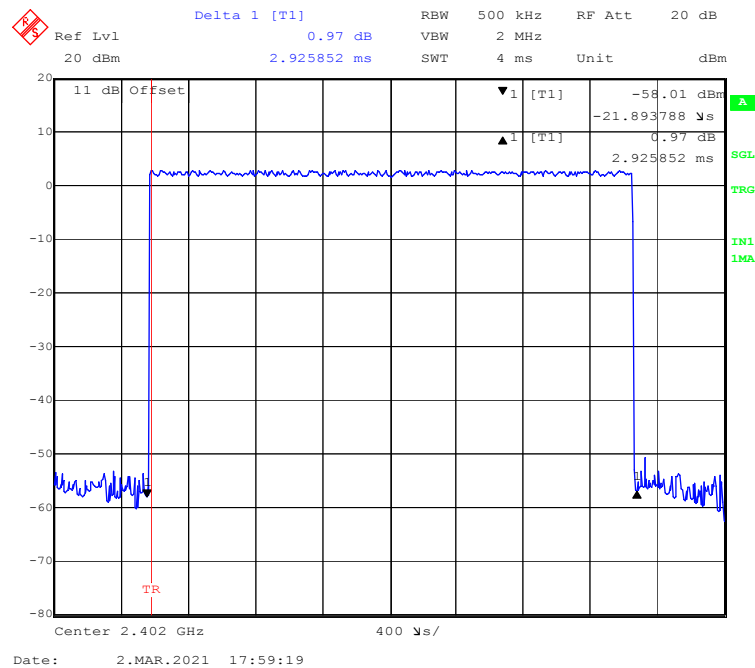
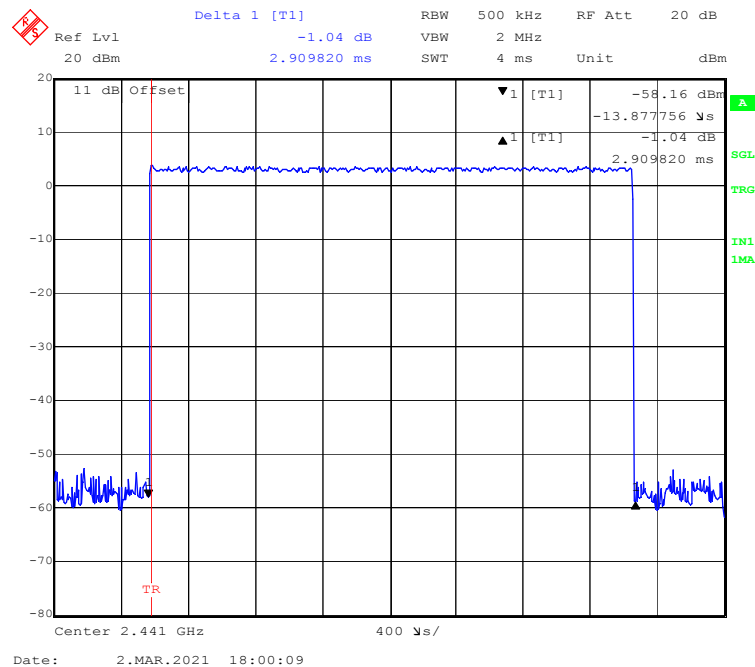
**BDR (GFSK): Pulse time, High Channel, DH1****BDR (GFSK): Pulse time, Low Channel, DH3**

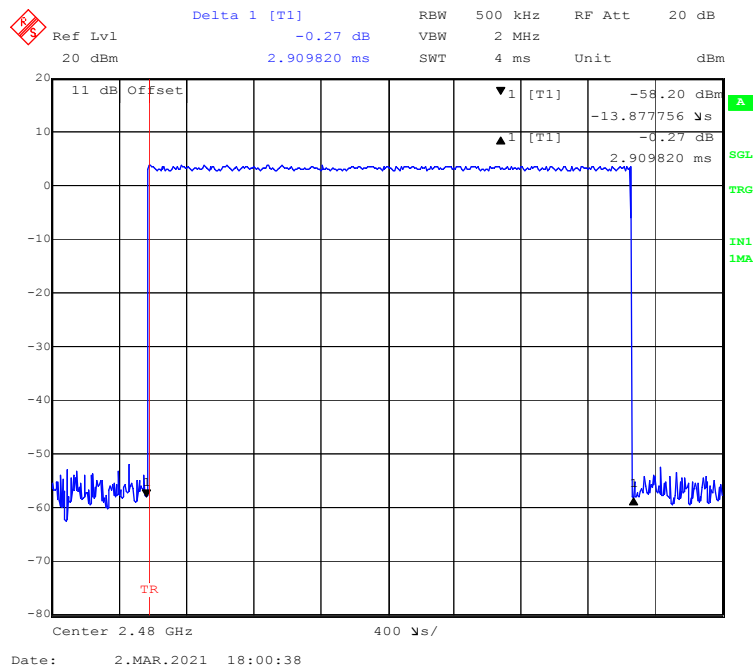
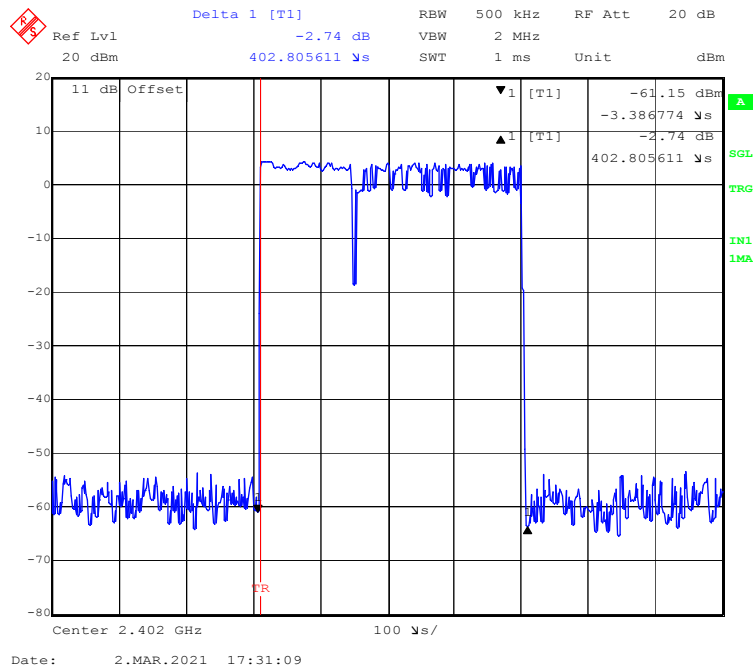
### BDR (GFSK): Pulse time, Middle Channel, DH3

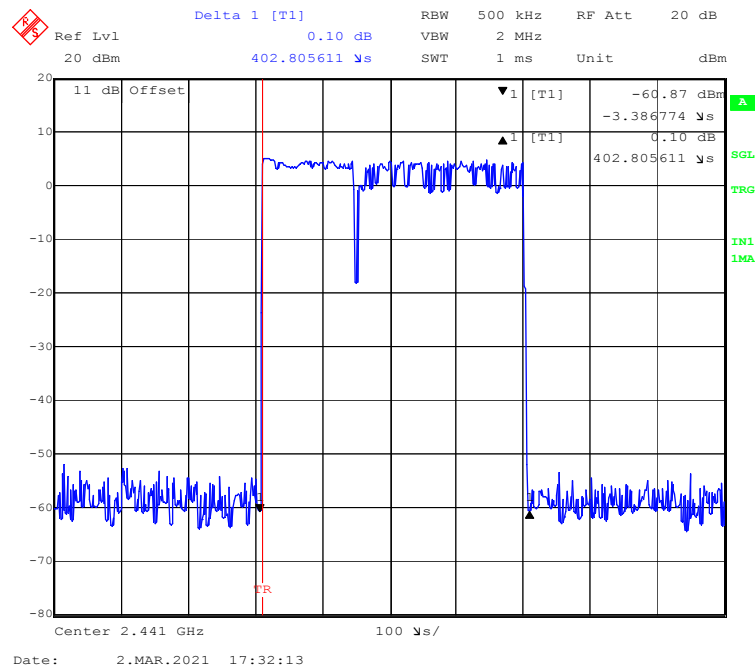
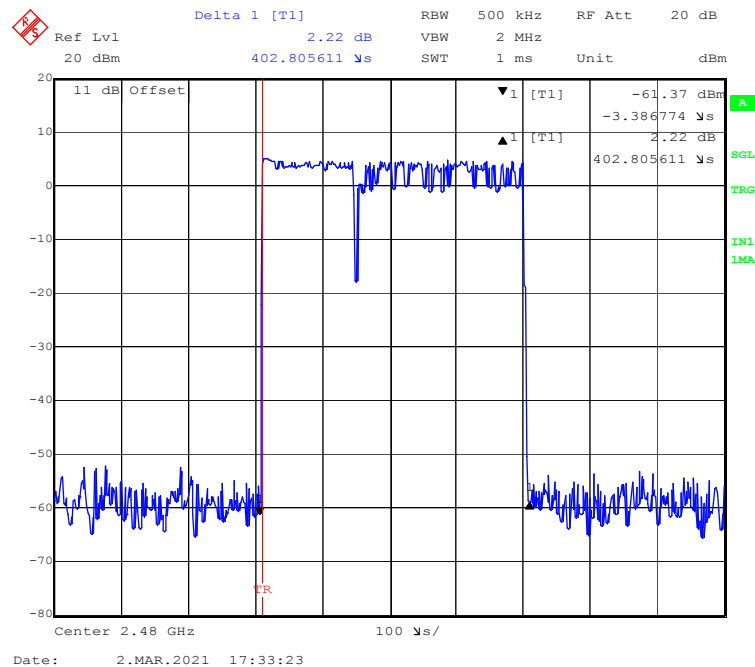


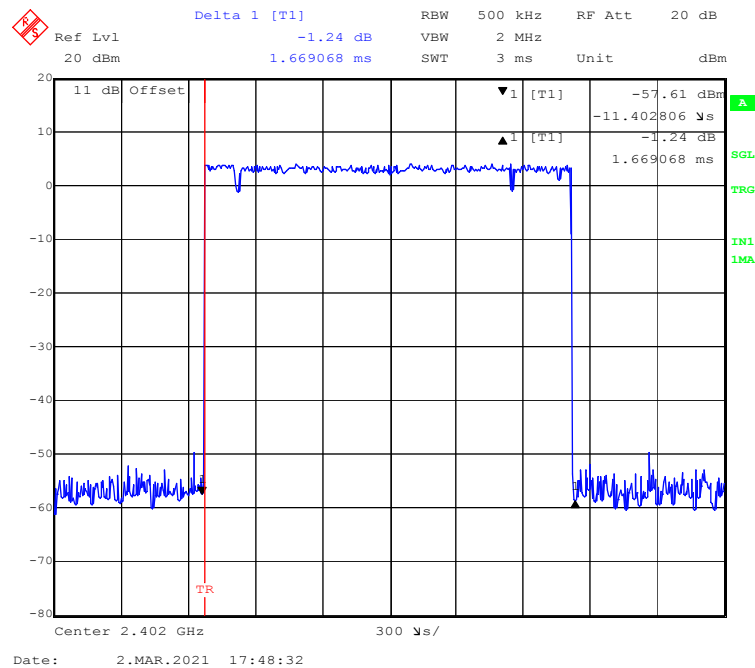
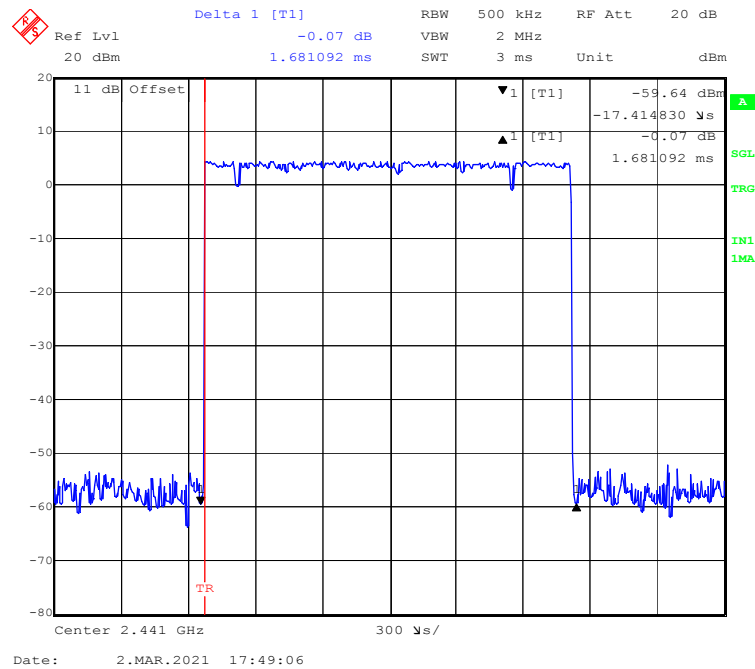
### BDR (GFSK): Pulse time, High Channel, DH3

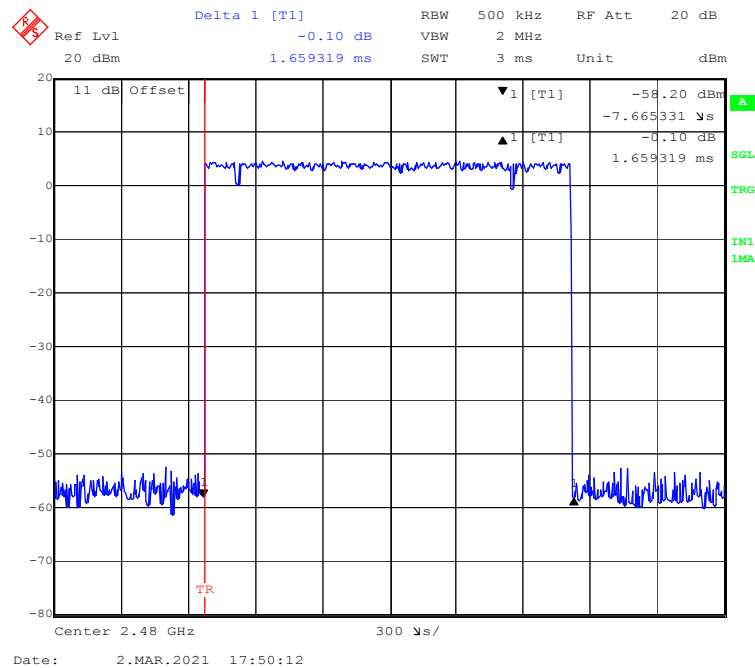
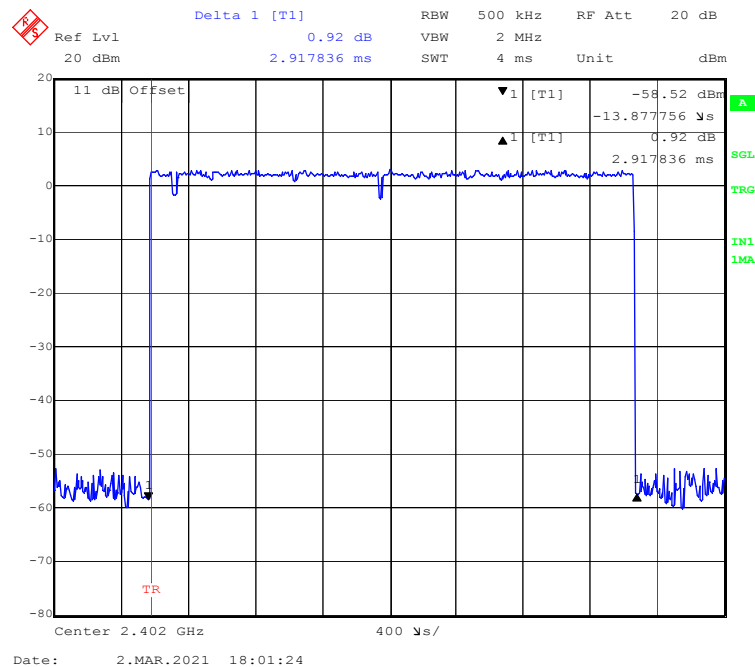


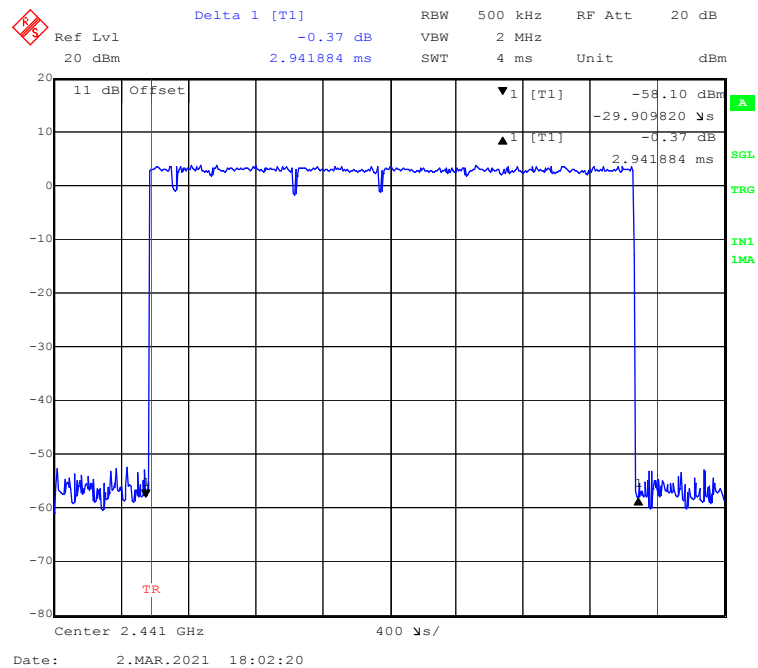
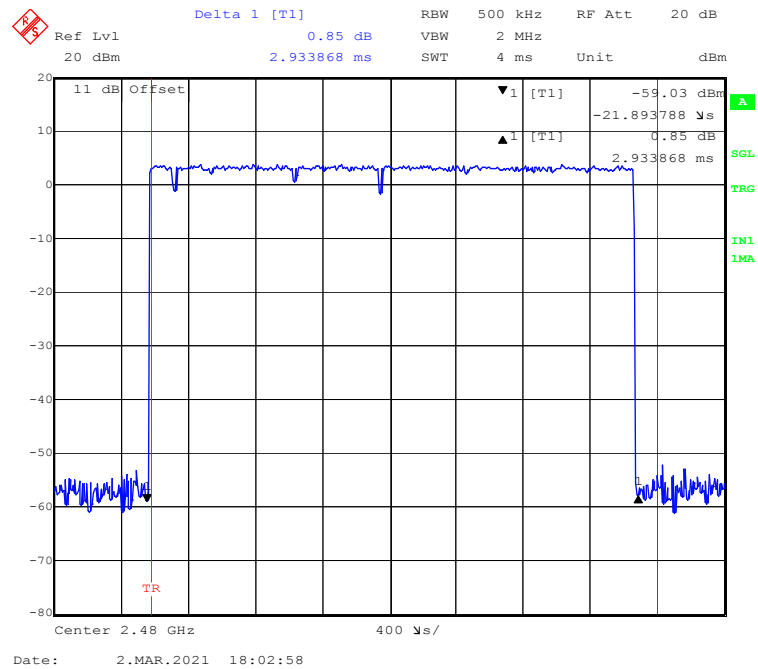
**BDR (GFSK): Pulse time, Low Channel, DH5****BDR (GFSK): Pulse time, Middle Channel, DH5**

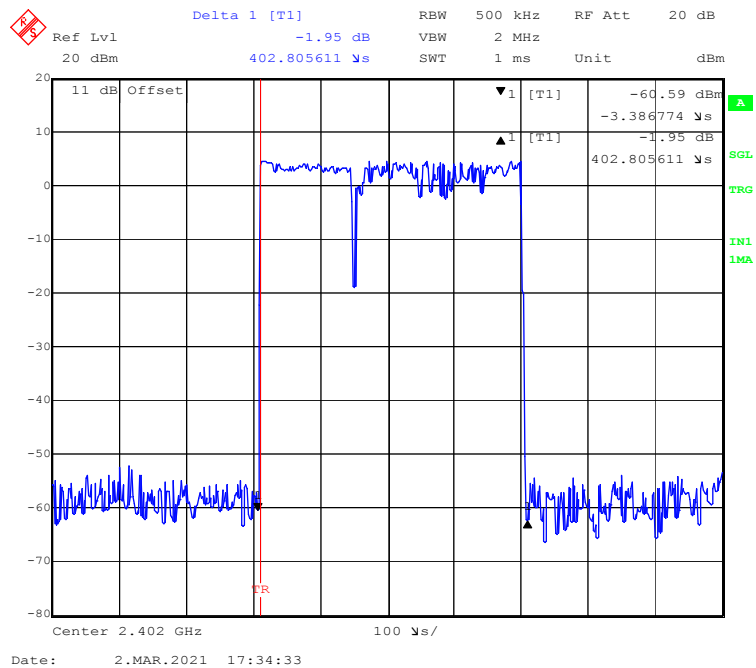
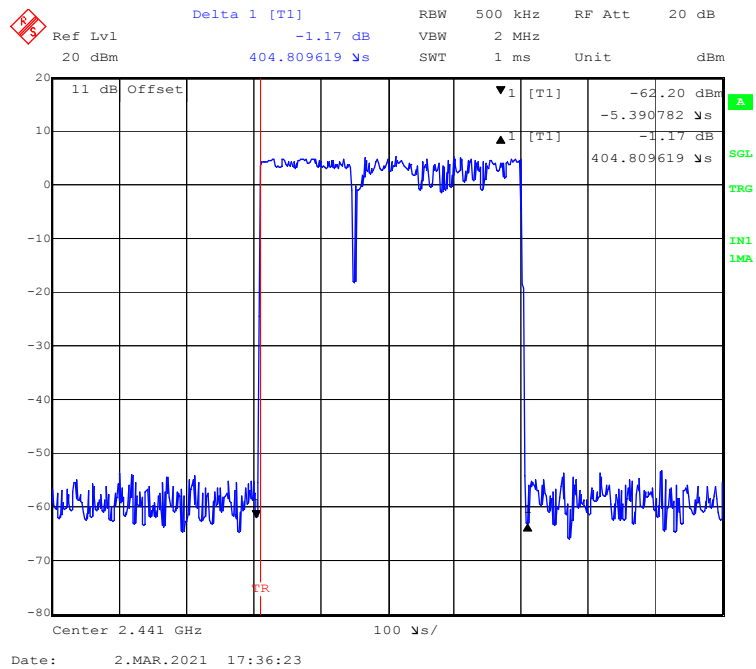
**BDR (GFSK): Pulse time, High Channel, DH5****EDR ( $\pi/4$ -DQPSK): Pulse time, Low Channel, 2DH1**

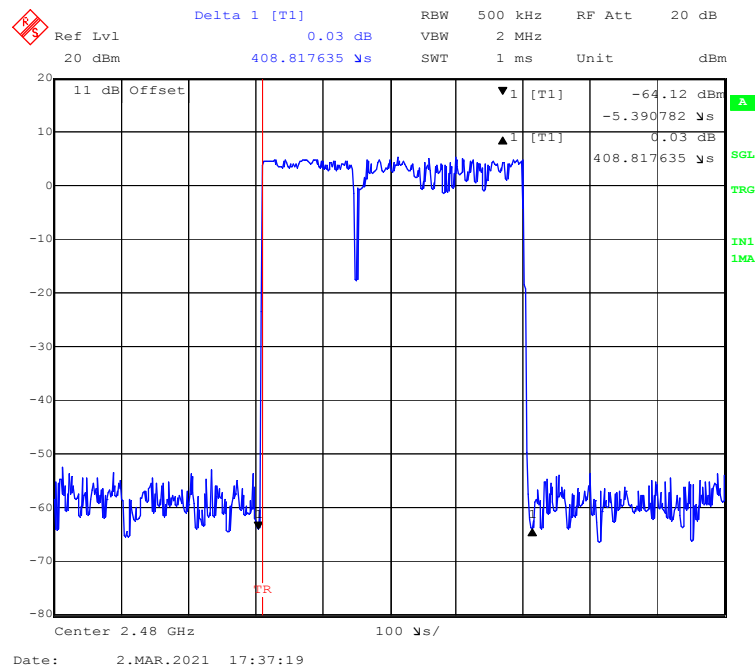
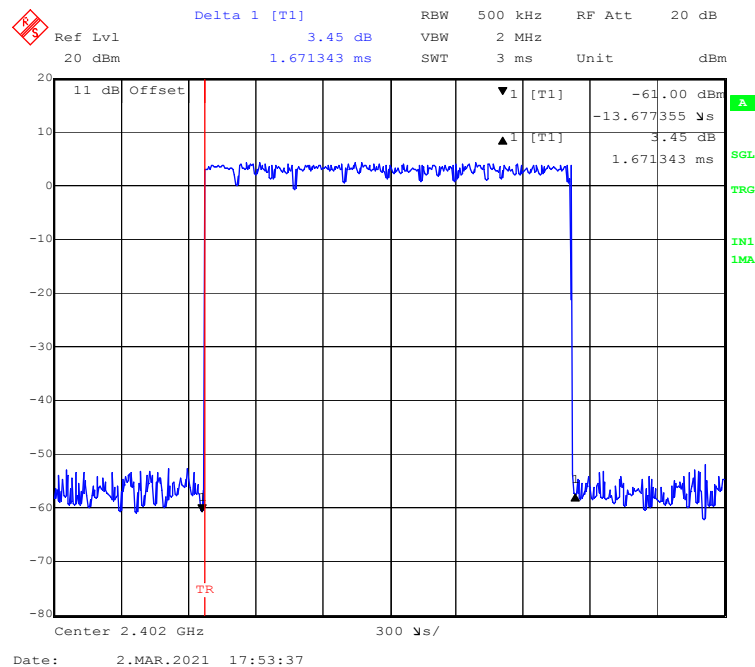
**EDR ( $\pi/4$ -DQPSK):Pulse time, Middle Channel, 2DH1****EDR ( $\pi/4$ -DQPSK):Pulse time, High Channel, 2DH1**

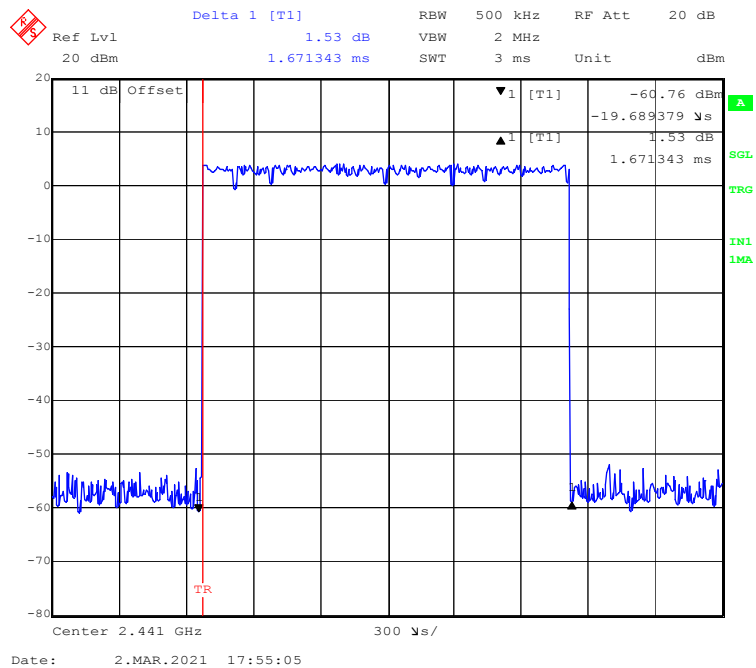
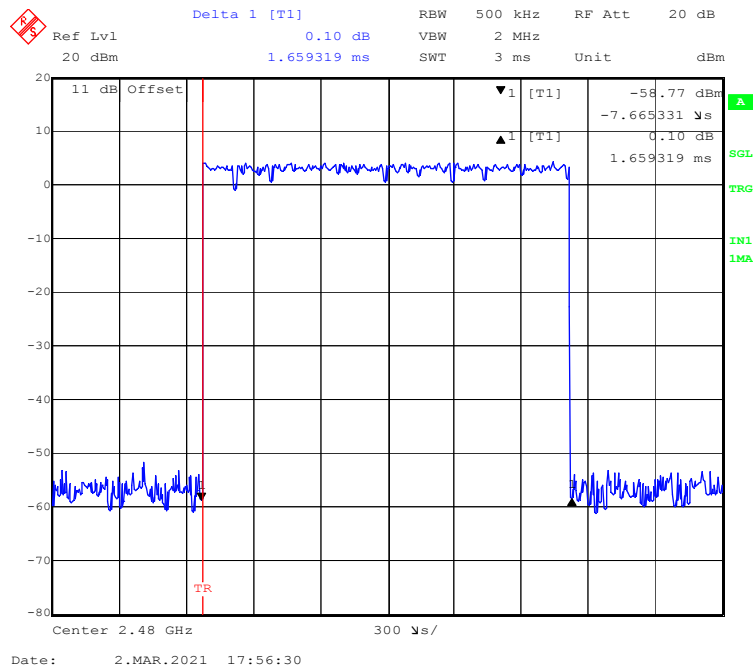
EDR ( $\pi/4$ -DQPSK):Pulse time, Low Channel, 2DH3EDR ( $\pi/4$ -DQPSK):Pulse time, Middle Channel, 2DH3

**EDR ( $\pi/4$ -DQPSK):Pulse time, High Channel, 2DH3****EDR ( $\pi/4$ -DQPSK):Pulse time, Low Channel, 2DH5**

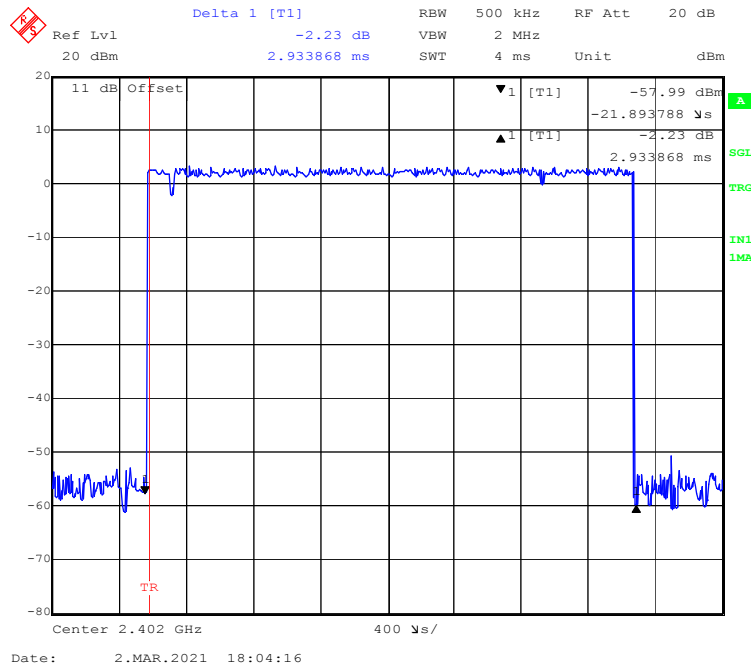
**EDR ( $\pi/4$ -DQPSK):Pulse time, Middle Channel, 2DH5****EDR ( $\pi/4$ -DQPSK):Pulse time, High Channel, 2DH5**

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

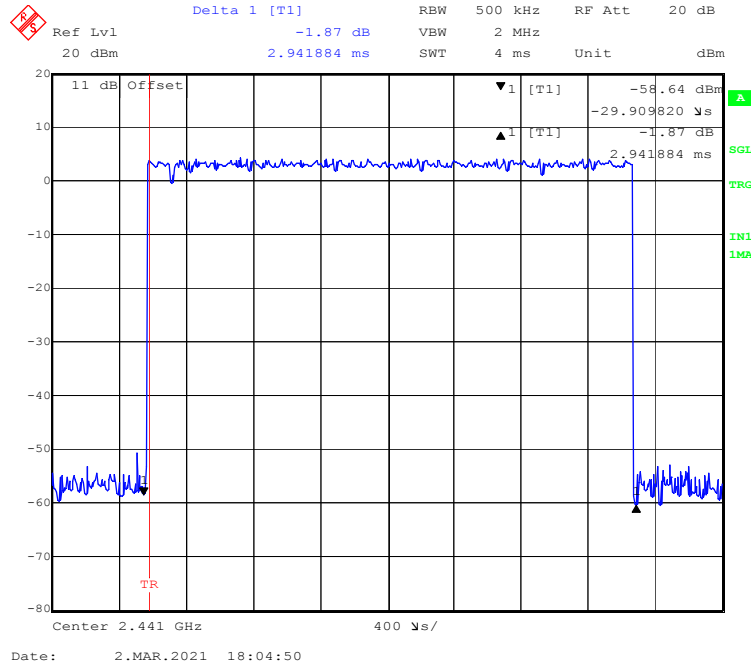
**EDR (8DPSK): Pulse time, High Channel, 3DH1****EDR (8DPSK): Pulse time, Low Channel, 3DH3**

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

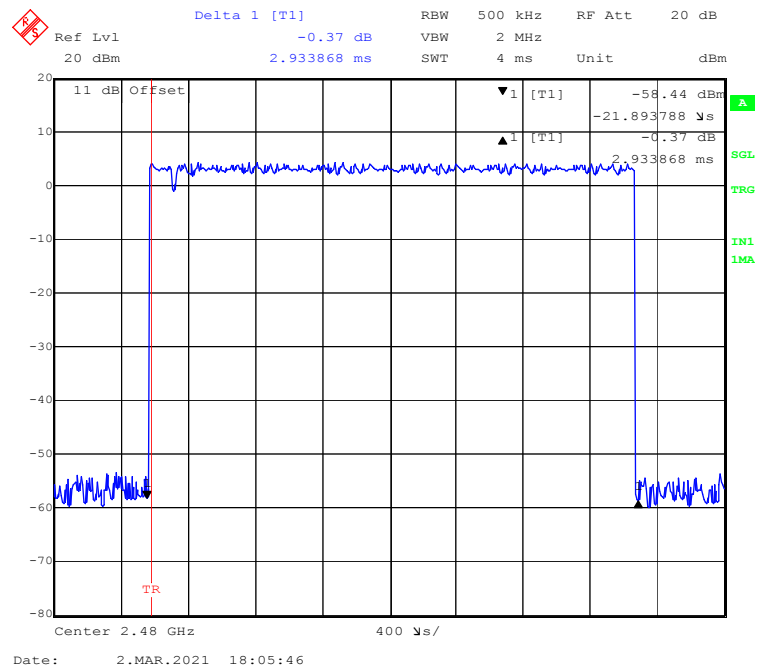
### EDR (8DPSK): Pulse time, Low Channel, 3DH5



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



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



## **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>       | 23.7 °C   |
| <b>Relative Humidity:</b> | 50 %      |
| <b>ATM Pressure:</b>      | 101.3 kPa |

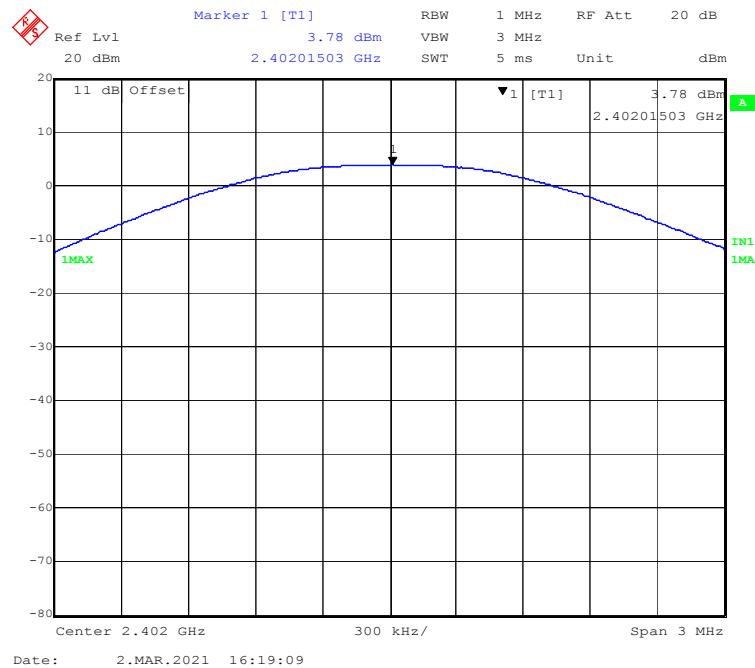
*The testing was performed by Chao Gao on 2021-03-02.*

*EUT operation mode: Transmitting*

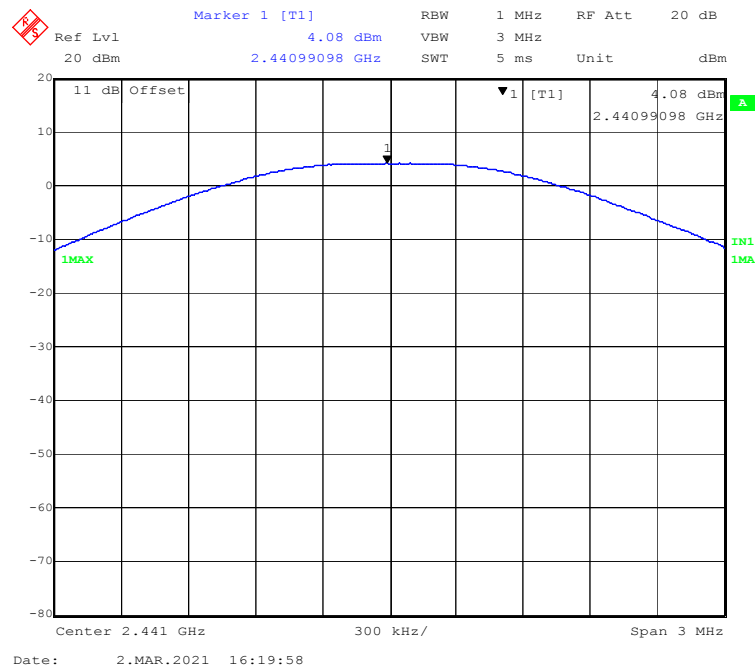
*Test Result: Compliant.*

| Mode                                      | Frequency<br>(MHz) | Output Power |      | Limit<br>(mW) |
|-------------------------------------------|--------------------|--------------|------|---------------|
|                                           |                    | (dBm)        | (mW) |               |
| <b>BDR<br/>(GFSK)</b>                     | 2402               | 3.78         | 2.39 | 1000          |
|                                           | 2441               | 4.08         | 2.56 | 1000          |
|                                           | 2480               | 4.10         | 2.57 | 1000          |
| <b>EDR<br/>(<math>\pi/4</math>-DQPSK)</b> | 2402               | 5.82         | 3.82 | 125           |
|                                           | 2441               | 6.03         | 4.01 | 125           |
|                                           | 2480               | 6.16         | 4.13 | 125           |
| <b>EDR<br/>(8DPSK)</b>                    | 2402               | 6.03         | 4.01 | 125           |
|                                           | 2441               | 6.44         | 4.41 | 125           |
|                                           | 2480               | 6.56         | 4.53 | 125           |

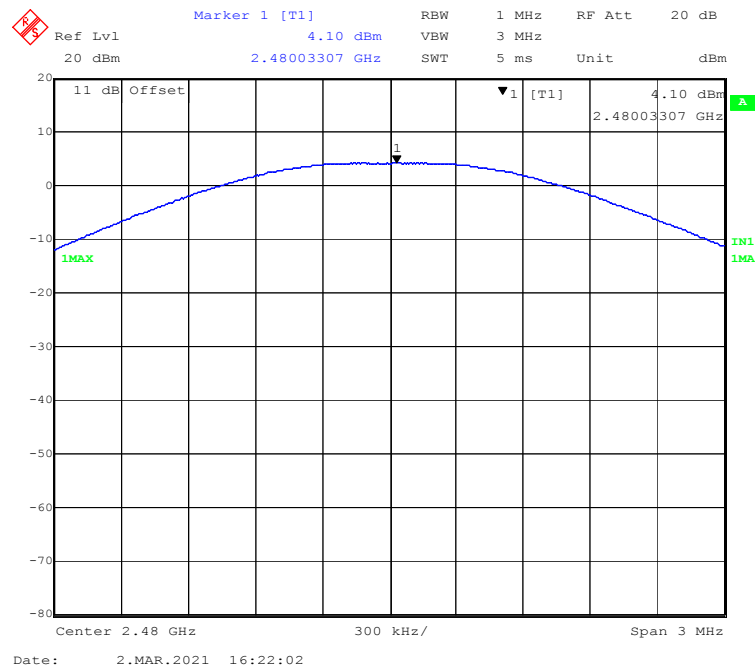
### BDR (GFSK): 2402MHz



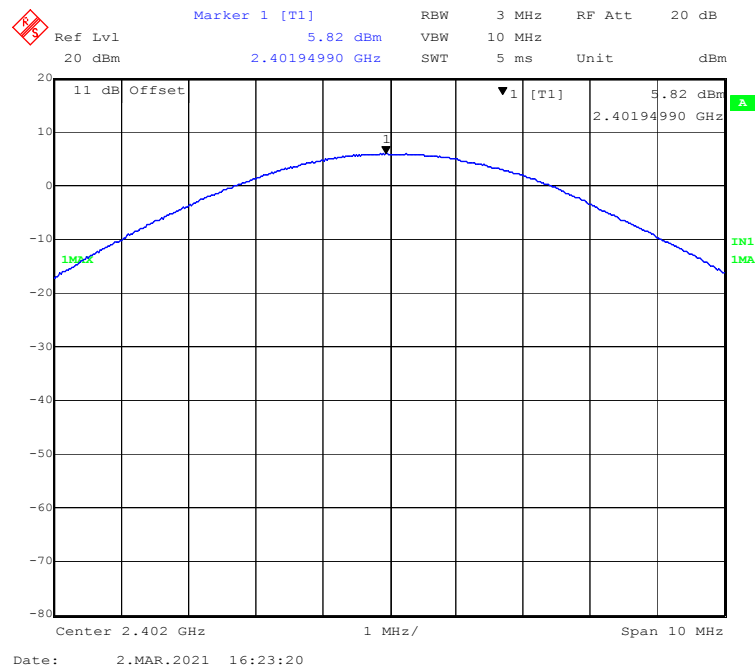
### BDR (GFSK): 2441MHz



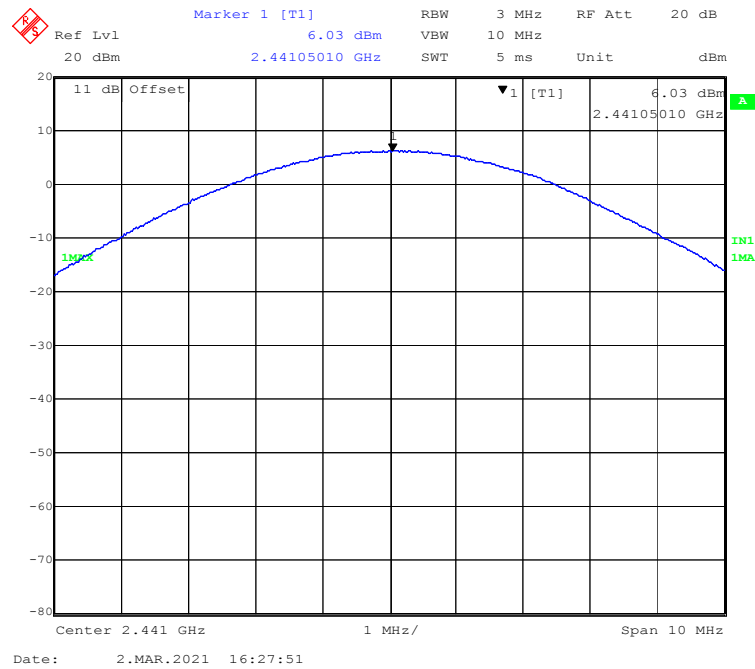
### BDR (GFSK): 2480MHz



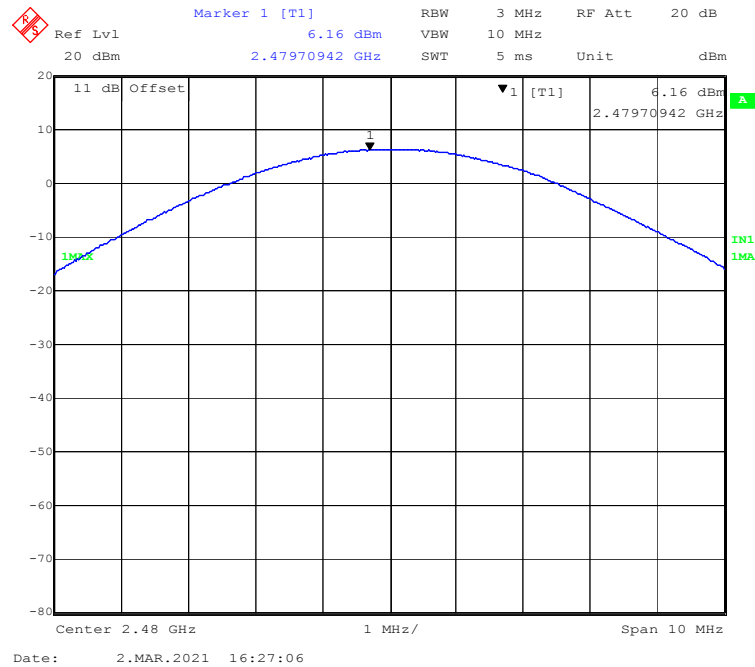
### EDR( $\pi/4$ -DQPSK): 2402MHz



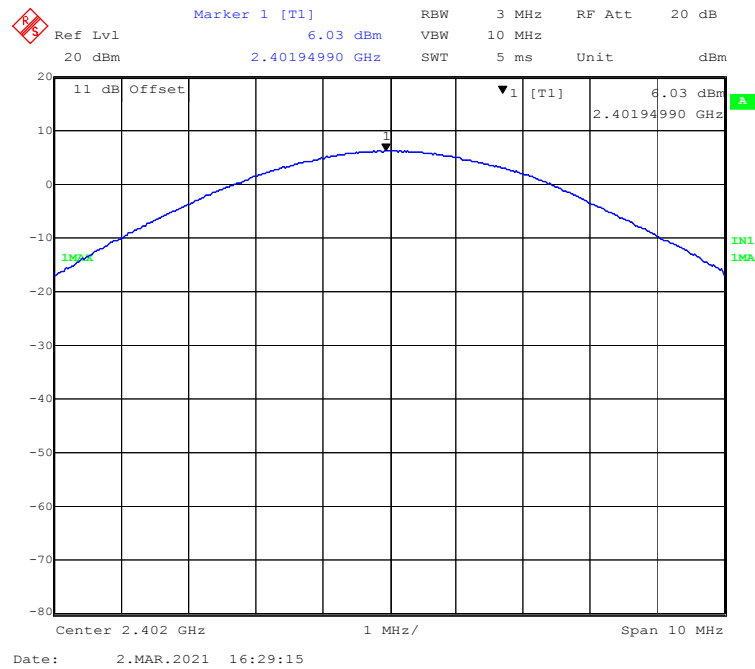
### EDR( $\pi/4$ -DQPSK): 2441MHz



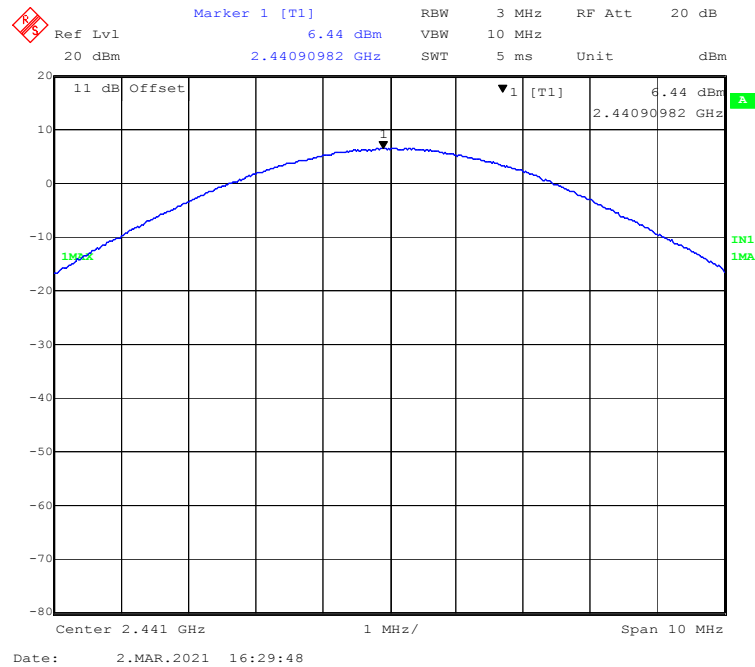
### EDR( $\pi/4$ -DQPSK): 2480MHz

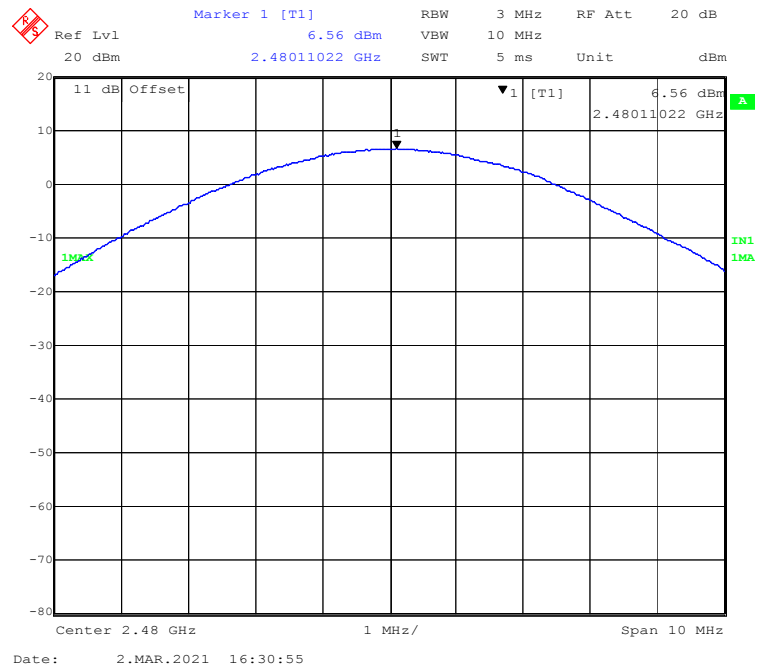


### EDR(8DPSK): 2402MHz



### 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>       | 23.4~24.8℃      |
| <b>Relative Humidity:</b> | 49~52 %         |
| <b>ATM Pressure:</b>      | 100.9~101.1 kPa |

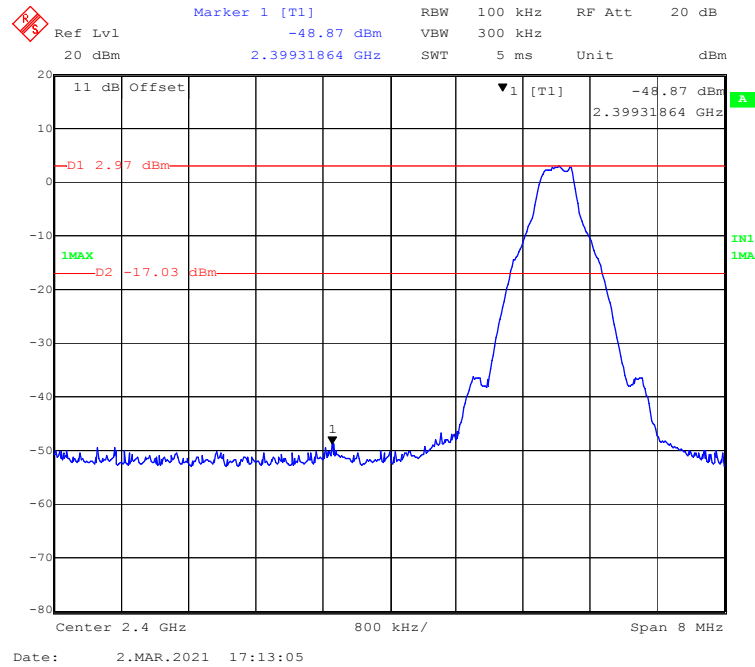
*The testing was performed by Chao Gao from 2021-03-02 to 2021-03-08.*

*EUT operation mode: Transmitting & Hopping*

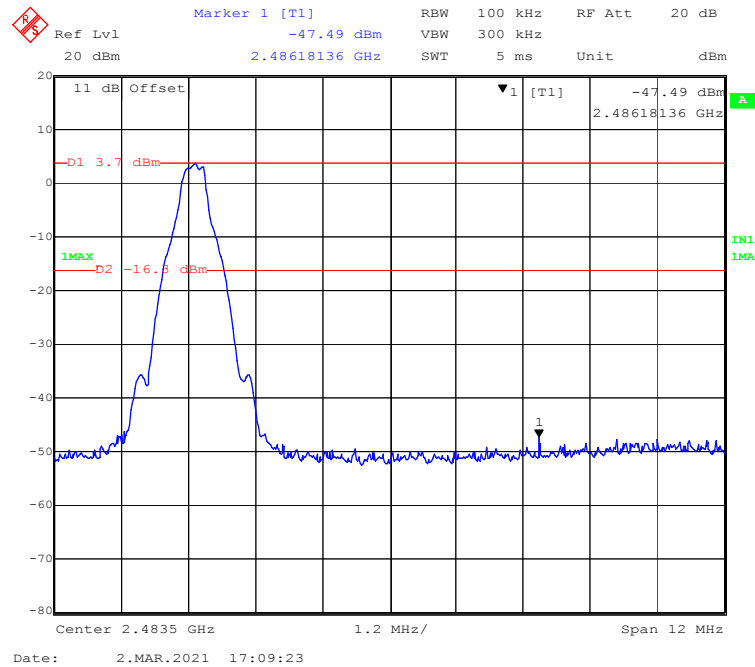
*Test Result: Compliant.*

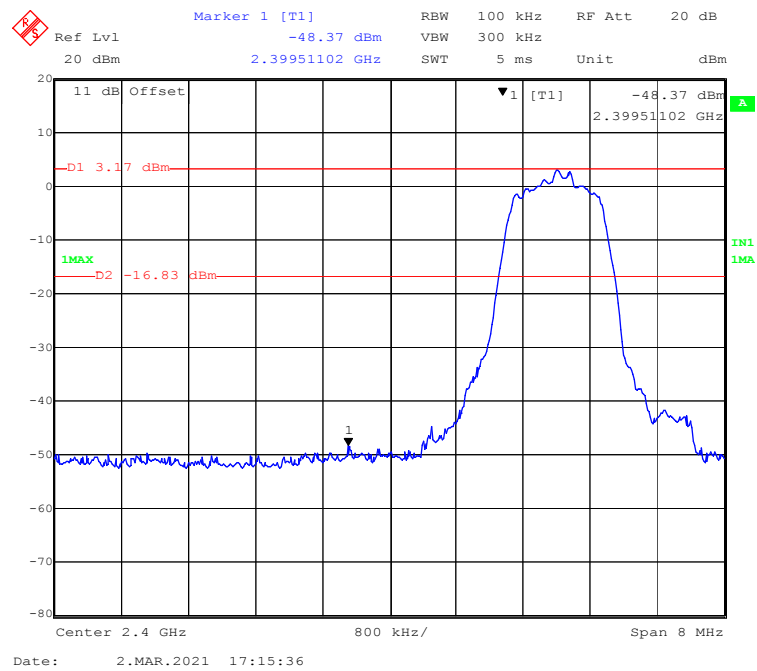
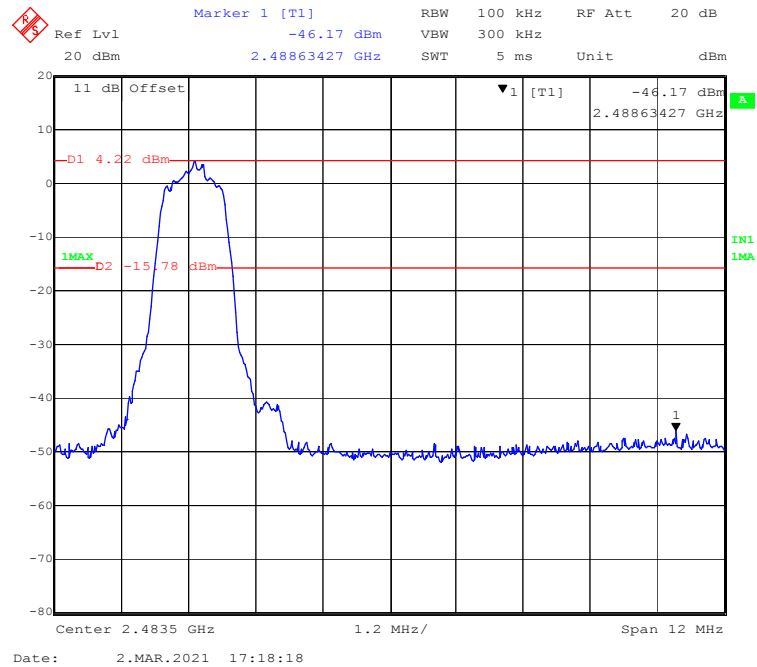
# Band Edge

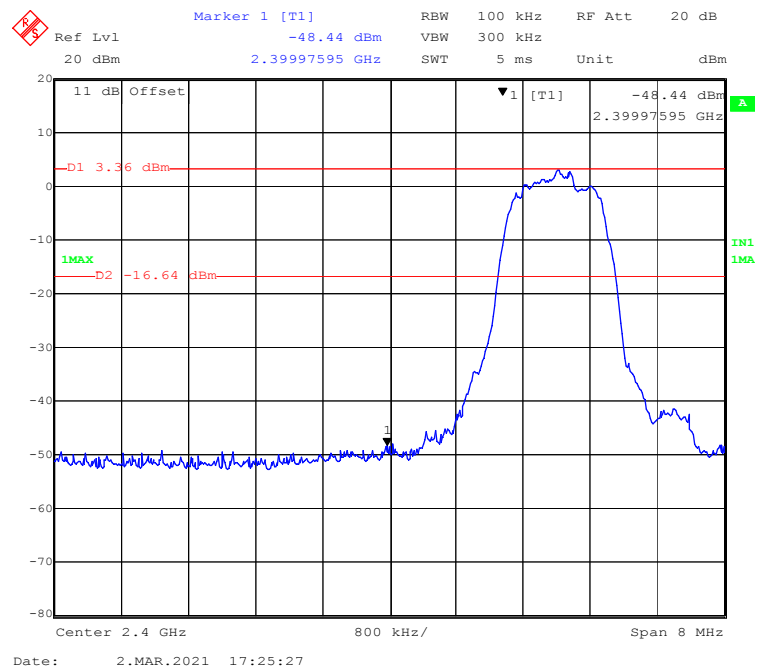
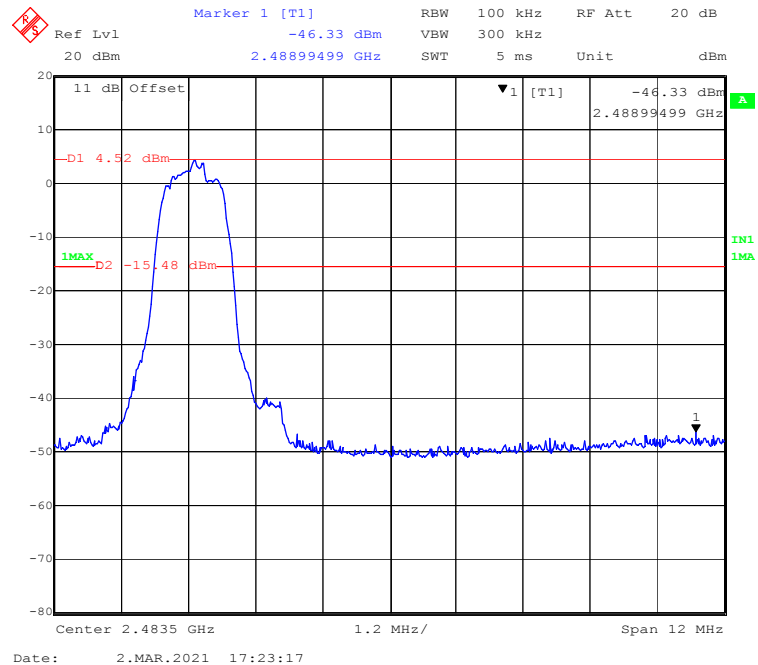
## BDR (GFSK): Left Side - Transmitting



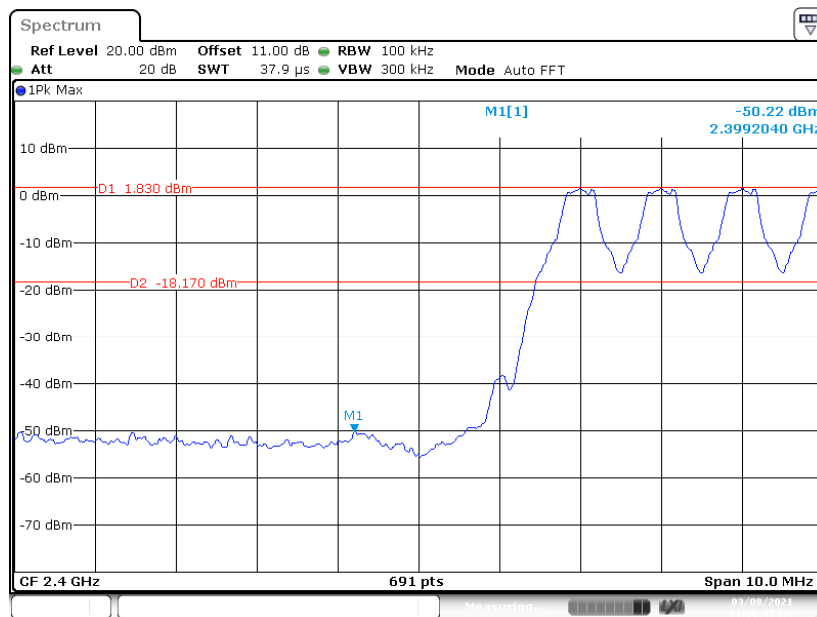
## BDR (GFSK): Right Side - Transmitting



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

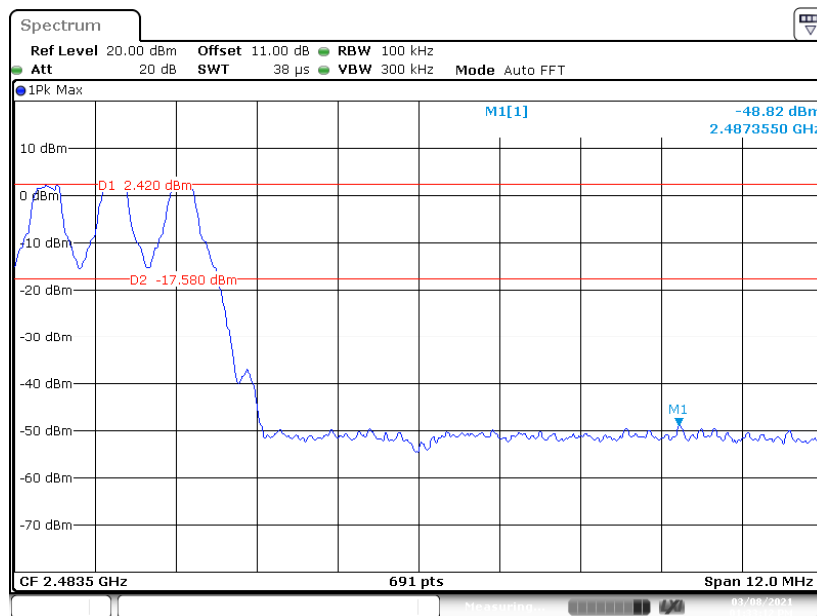
**EDR (8DPSK): Left Side - Transmitting****EDR (8DPSK): Right Side - Transmitting**

### BDR (GFSK): Left Side - Hopping

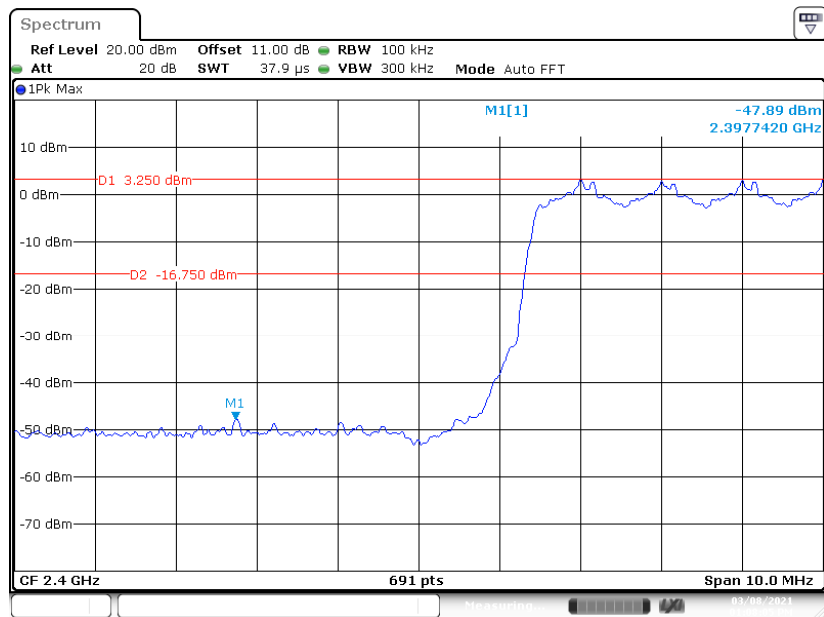


Date: 8.MAR.2021 13:36:46

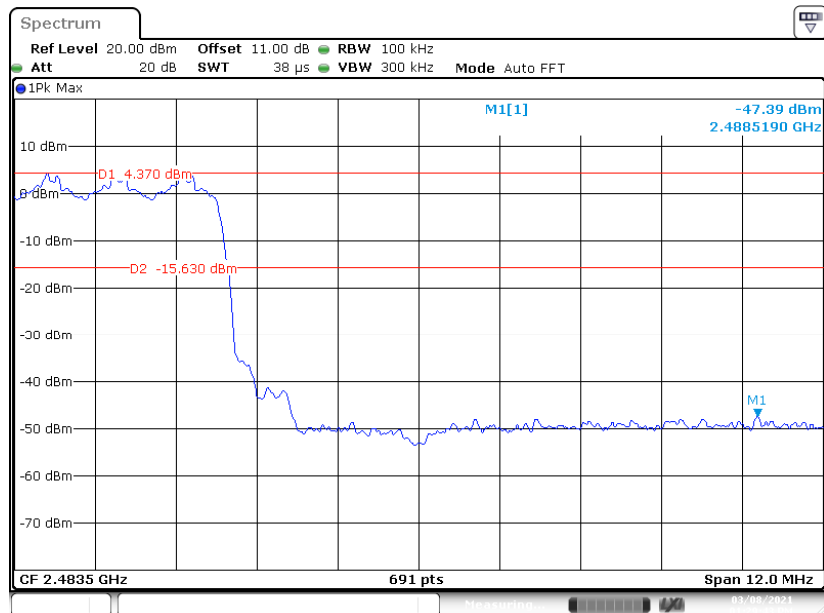
### BDR (GFSK): Right Side- Hopping



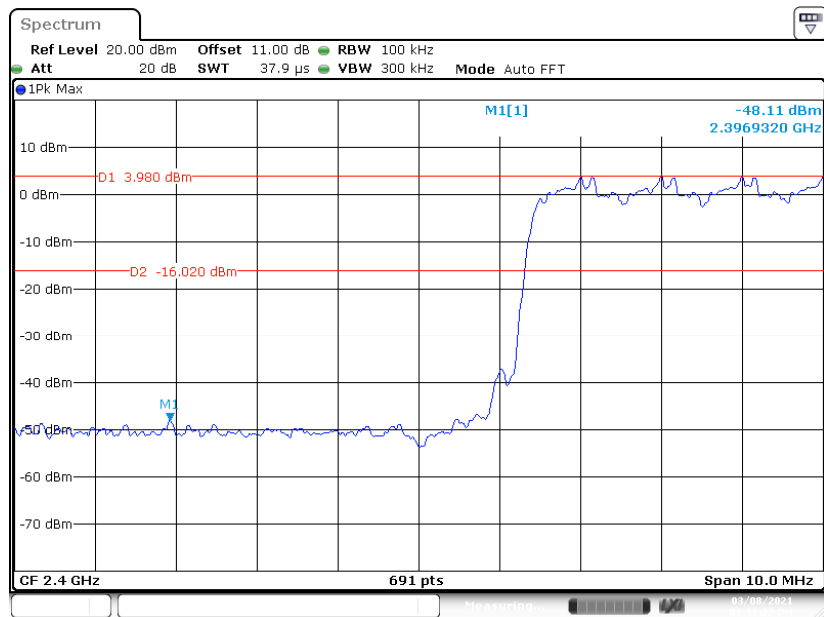
Date: 8.MAR.2021 13:33:12

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

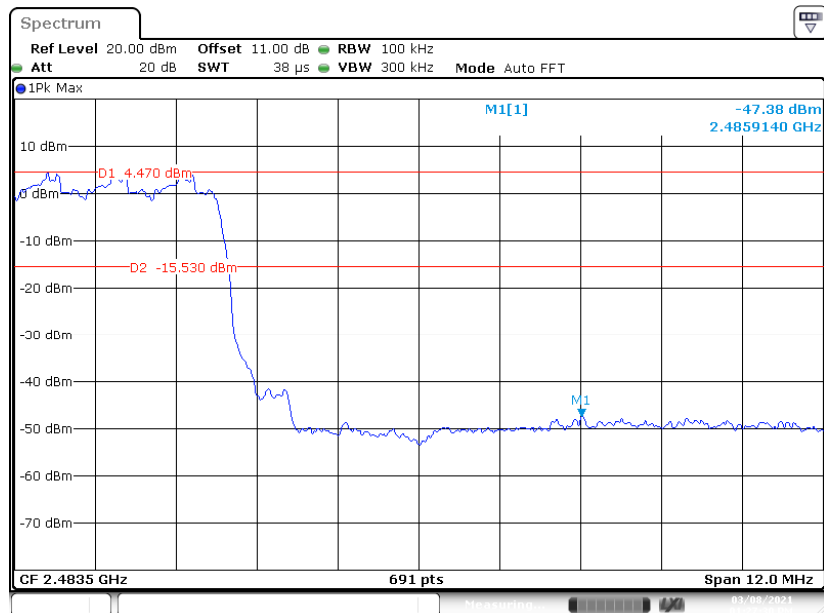
Date: 8.MAR.2021 13:08:05

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

Date: 8.MAR.2021 13:29:44

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

Date: 8.MAR.2021 13:16:27

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

Date: 8.MAR.2021 13:27:30

### **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 \*\*\*\*\***