

# FCC PART 15.247 TEST REPORT

For

**Shanghai HowayGIS Co., Ltd**

RM230, Fawkes Building, No. 1985, Road Chunshen, Shanghai, China

**FCC ID: 2AAZD-TGU1-S3**

|                                                                                                                                                                                                                                                |                                                             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| <b>Report Type:</b><br>Original Report                                                                                                                                                                                                         | <b>Product Type:</b><br>High Precision Mobile GNSS Receiver |
| <b>Test Engineer:</b> Hope Zhang                                                                                                                                                                                                               | Hope Zhang                                                  |
| <b>Report Number:</b> RKSA171222002-00A                                                                                                                                                                                                        |                                                             |
| <b>Report Date:</b> 2018-10-17                                                                                                                                                                                                                 |                                                             |
| <b>Reviewed By:</b> Oscar Ye<br>RF Leader                                                                                                                                                                                                      | Oscar Ye                                                    |
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FINAL

## GENERAL INFORMATION

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

|              |                                                     |
|--------------|-----------------------------------------------------|
| Applicant    | Shanghai HowayGIS Co., Ltd                          |
| Tested Model | TG-U2                                               |
| Series Model | TG-U1, TG-U3, X1                                    |
| Product Type | High Precision Mobile GNSS Receiver                 |
| Dimension    | 210 mm(L)×60 mm(W)×110 mm(H)                        |
| Power Supply | DC 7.2V from battery and DC 12V charging by adapter |

#### Adapter Information:

Model: A122-1201000ID

Input: AC100-240 V 50/60Hz 0.4A

Output: 12V, 1000mA

Note: The differences between the tested model and series models were explained in the declaration letter.

\*All measurement and test data in this report was gathered from production sample serial number: 20171222002.  
(Assigned by the BACL. The EUT supplied by the applicant was received on 2017-12-22)

### Objective

This test report is prepared on behalf of *Shanghai HowayGIS 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 and Part 15B JBP submittals with FCC ID: 2AAZD-TGU1-S3.

### 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 FCC 558074 D01 15.247 Meas Guidance v05.

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) and the FCC designation No. CN1185 under the FCC KDB 974614 D01. 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 for Bluetooth V3.0:

| 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: Blue Test 3

GFSK Power level: 50

$\pi/4$ -DQPSK Power level: 50

8DPSK Power level: 50

### Special Accessories

No special accessory.

### Equipment Modifications

No modification was made to the EUT tested.

**Support Equipment List and Details**

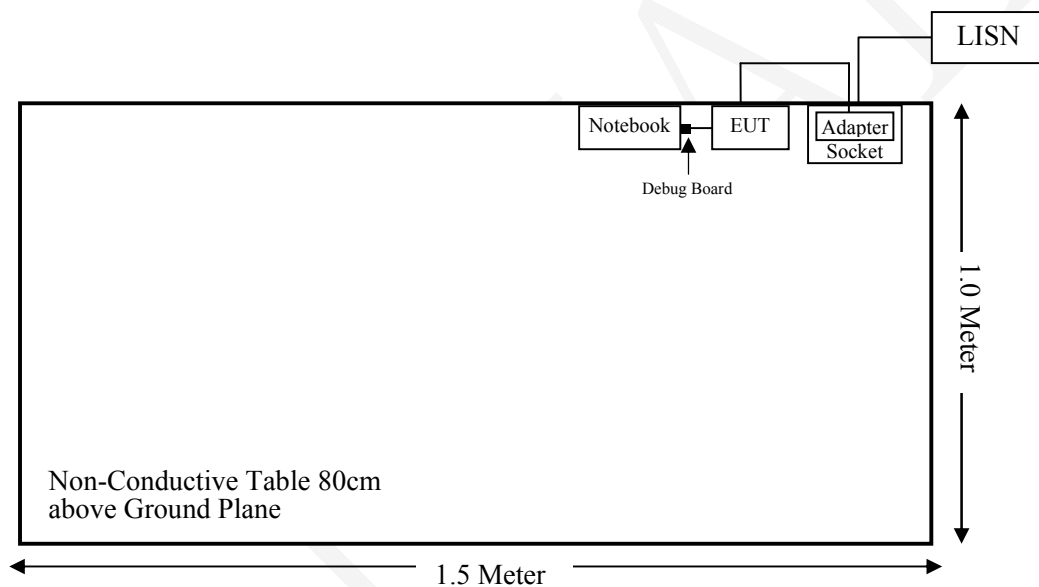
| Manufacturer      | Description | Model | Serial Number |
|-------------------|-------------|-------|---------------|
| DELL              | Notebook    | GX620 | D65874152     |
| Shanghai HowayGIS | Debug Board | /     | /             |

**External I/O Cable**

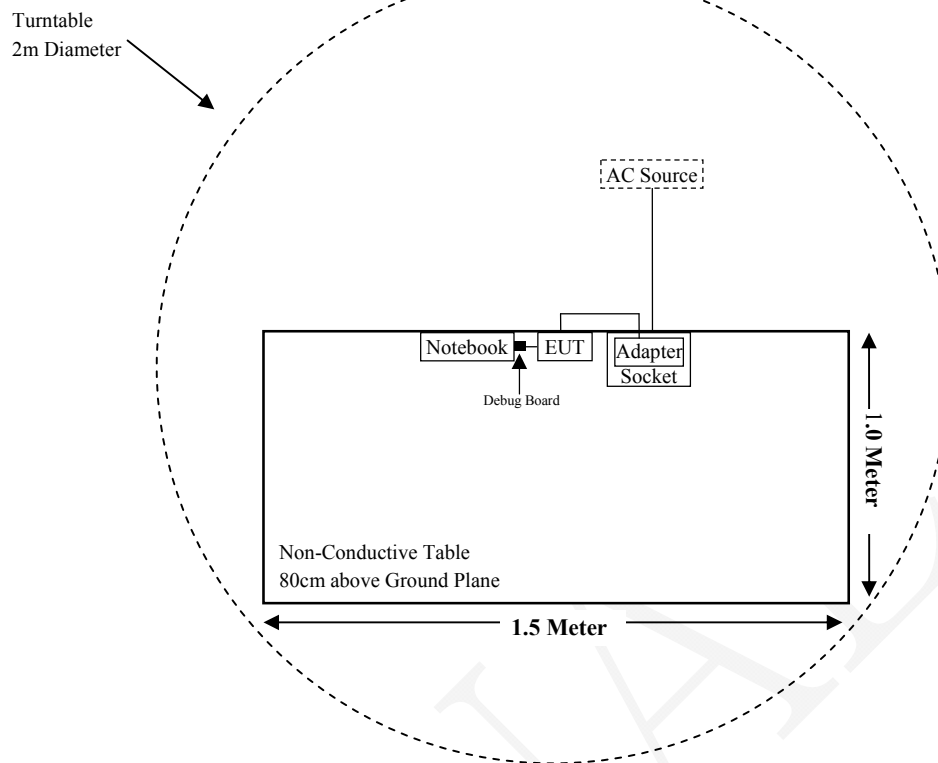
| Cable Description | Length (m) | From Port   | To      |
|-------------------|------------|-------------|---------|
| Data Cable        | 0.2        | Debug Board | EUT     |
| Power Cable       | 1.5        | EUT         | Adapter |

**Block Diagram of Test Setup**

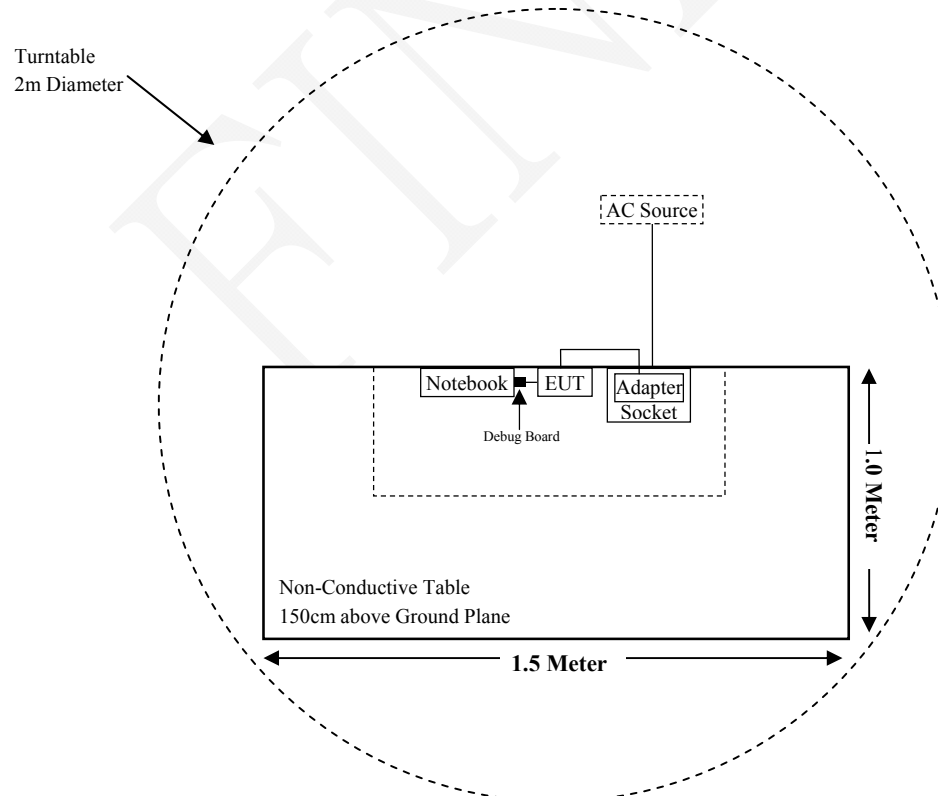
For Conducted Emissions:



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> |
|-------------------------------|-------------------------------------------------|---------------|
| §1.1310 & §2.1093             | RF EXPOSURE                                     | 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        | 2017-11-12       | 2018-11-11           |
| Sunol Sciences                             | Broadband Antenna  | JB3         | A090413-1     | 2016-12-26       | 2019-12-25           |
| Sonoma Instrunent                          | Pre-amplifier      | 310N        | 171205        | 2018-08-15       | 2019-08-14           |
| Rohde & Schwarz                            | Auto test Software | EMC32       | 100361        | /                | /                    |
| MICRO-COAX                                 | Coaxial Cable      | Cable-8     | 008           | 2018-08-15       | 2019-08-14           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-9     | 009           | 2018-08-15       | 2019-08-14           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-10    | 010           | 2018-08-15       | 2019-08-14           |
| <b>Radiated Emission Test (Chamber 2#)</b> |                    |             |               |                  |                      |
| Rohde & Schwarz                            | EMI Test Receiver  | ESU40       | 100207        | 2018-08-27       | 2019-08-26           |
| ETS-LINDGREN                               | Horn Antenna       | 3115        | 6229          | 2016-01-11       | 2019-01-10           |
| ETS-LINDGREN                               | Horn Antenna       | 3116        | 00084159      | 2016-10-18       | 2019-10-17           |
| Mini-Circuits                              | Amplifier          | ZVA-183W-S+ | 220701818     | 2018-05-20       | 2019-05-19           |
| EM Electronics Corporation                 | Amplifier          | EM18G40G    | 060726        | 2018-03-22       | 2019-03-21           |
| MICRO-TRONICS                              | Band notch Filter  | BRM50702    | G024          | 2018-08-05       | 2019-08-04           |
| Narda                                      | Attenuator/10dB    | 10dB        | 010           | 2018-08-15       | 2019-08-14           |
| Rohde & Schwarz                            | Auto test Software | EMC32       | 100361        | /                | /                    |
| MICRO-COAX                                 | Coaxial Cable      | Cable-6     | 006           | 2018-08-15       | 2019-08-14           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-11    | 011           | 2018-08-15       | 2019-08-14           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-12    | 012           | 2018-08-15       | 2019-08-14           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-13    | 013           | 2018-08-15       | 2019-08-14           |
| <b>RF Conducted Test</b>                   |                    |             |               |                  |                      |
| Rohde & Schwarz                            | Signal Analyzer    | FSV40       | 101116        | 2018-07-23       | 2019-07-22           |
| Rohde & Schwarz                            | Signal Analyzer    | FSIQ26      | 836131/009    | 2017-09-21       | 2018-09-20           |
| Narda                                      | Attenuator/10dB    | 10dB        | 010           | 2018-08-15       | 2019-08-14           |
| Shanghai HowayGIS                          | RF Cable           | HowayGISC01 | C01           | Each Time        | /                    |
| <b>Conducted Emission Test</b>             |                    |             |               |                  |                      |
| Rohde & Schwarz                            | EMI Test Receiver  | ESCS30      | 834115/007    | 2017-11-12       | 2018-11-11           |
| Rohde & Schwarz                            | LISN               | ESH3-Z5     | 862770/011    | 2017-11-12       | 2018-11-11           |
| BACL                                       | Auto test Software | BACL-EMC    | CE001         | /                | /                    |
| Narda                                      | Attenuator/6dB     | 10690812-2  | 26850-6       | 2018-01-10       | 2019-01-09           |
| MICRO-COAX                                 | Coaxial Cable      | Cable-15    | 015           | 2018-08-15       | 2019-08-14           |

\* **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 §15.247 (I) & §1.1310 & §2.1093 - RF EXPOSURE

### Applicable Standard

According to §15.247(i) and §1.1310, systems operating under the provisions of this section shall be operated in a manner that ensure that the public is not exposed to radio frequency energy level in excess of the Commission's guideline.

According to KDB447498 D01 General RF Exposure Guidance v06:

The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances  $\leq 50$  mm are determined by:

$[(\text{max. power of channel, including tune-up tolerance, mW})/(\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})}] \leq 3.0$  for 1-g SAR and  $\leq 7.5$  for 10-g extremity SAR, where

- $f(\text{GHz})$  is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison
- 3.0 and 7.5 are referred to as the numeric thresholds in the step 2 below

The test exclusions are applicable only when the minimum test separation distance is  $\leq 50$  mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is  $< 5$  mm, a distance of 5 mm according to 5) in section 4.1 is applied to determine SAR test exclusion.

### Measurement Result

| Mode  | Frequency Range (MHz) | Target Output Power |      | Minimum test separation distance required for the exposure conditions (mm) |
|-------|-----------------------|---------------------|------|----------------------------------------------------------------------------|
|       |                       | (dBm)               | (mW) |                                                                            |
| BT3.0 | 2402-2480             | 4.50                | 2.82 | 5.00                                                                       |
| BLE   | 2402-2480             | 4.60                | 2.88 | 5.00                                                                       |

**Note:** The target output power was declared by the manufacturer.

### Result:

**BT3.0:**  $[(\text{max. power of channel, including tune-up tolerance, mW})/(\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})}] = 2.82/5 \cdot \sqrt{2.48} = 0.9 < 3.0$

**BLE:**  $[(\text{max. power of channel, including tune-up tolerance, mW})/(\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})}] = 2.88/5 \cdot \sqrt{2.48} = 0.9 < 3.0$

**So the stand-alone SAR evaluation is not necessary.**

## **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 ceramic antenna for Bluetooth and the antenna gain is 1dBi, which was permanently attached; fulfill the requirement of this section. Please refer to the EUT photos.

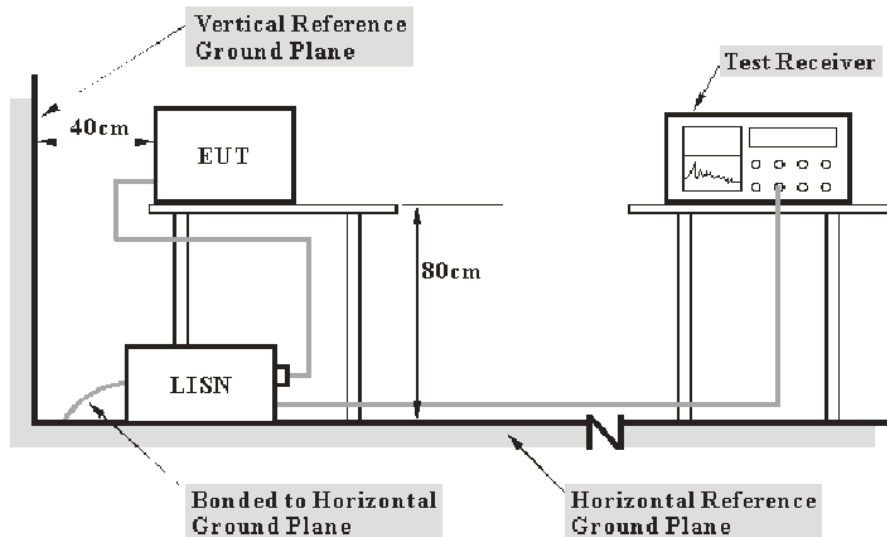
**Result:** Compliance.

## 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

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.

## Corrected Factor & Margin Calculation

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

$$\text{Corrected Factor (dB)} = \text{LISN VDF (dB)} + \text{Cable Loss (dB)} + \text{Transient Limiter Attenuation (dB)}$$

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

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

## Test Results Summary

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

### Test Data

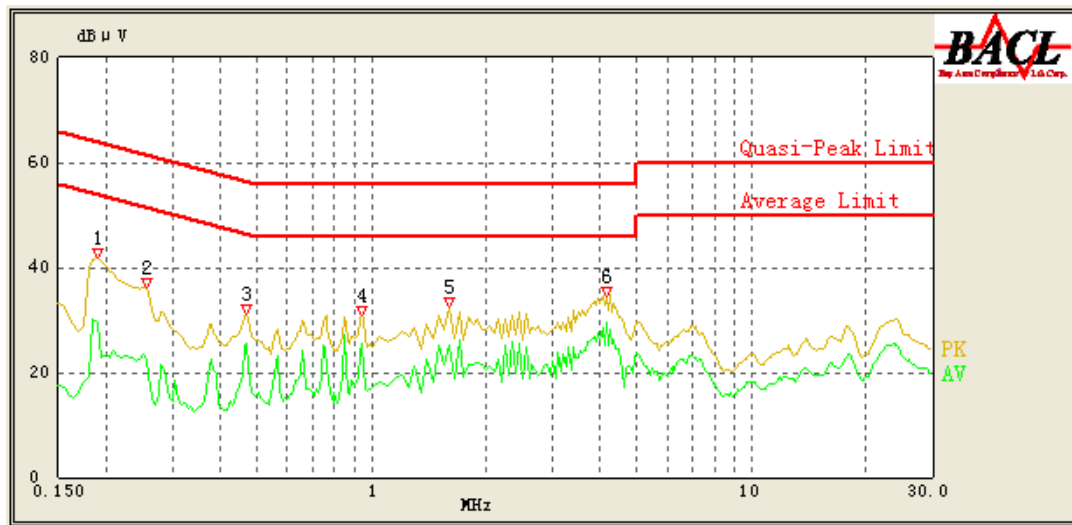
#### Environmental Conditions

|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 23.4 °C   |
| <b>Relative Humidity:</b> | 49 %      |
| <b>ATM Pressure:</b>      | 101.1 kPa |

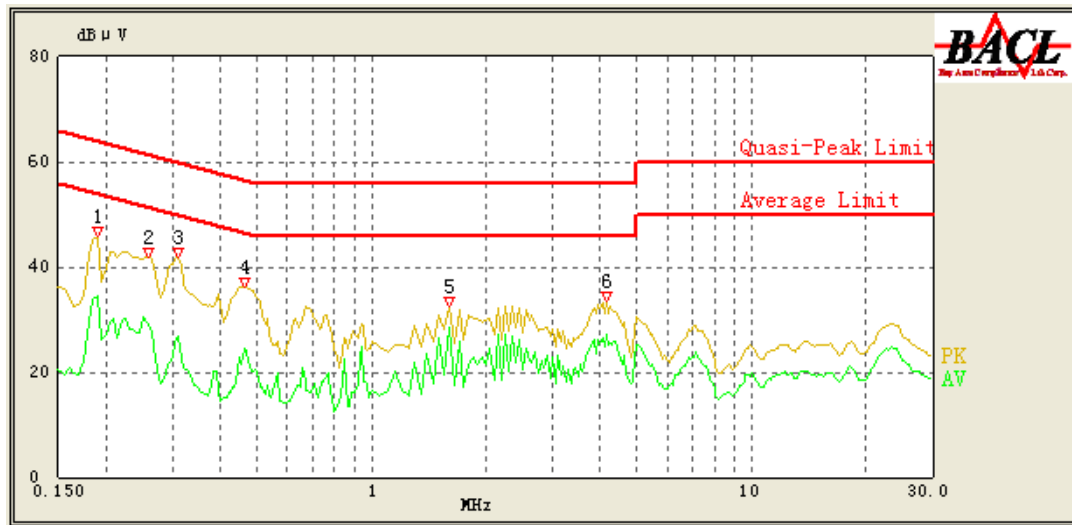
*The testing was performed by Hope Zhang on 2018-09-09.*

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

## AC 120V/60 Hz, Line



| Frequency (MHz) | Corrected Amplitude (dBμV) | Detector (PK/AV/QP) | Bandwidth (kHz) | Line | Corrected Factor (dB) | Limit (dBμV) | Margin (dB) | Comment    |
|-----------------|----------------------------|---------------------|-----------------|------|-----------------------|--------------|-------------|------------|
| 0.190           | 41.98                      | QP                  | 9.000           | L1   | 16.02                 | 64.04        | 22.06       | Compliance |
| 0.190           | 29.50                      | AV                  | 9.000           | L1   | 16.02                 | 54.04        | 24.54       | Compliance |
| 0.255           | 36.33                      | QP                  | 9.000           | L1   | 16.02                 | 61.59        | 25.26       | Compliance |
| 0.255           | 22.56                      | AV                  | 9.000           | L1   | 16.02                 | 51.59        | 29.03       | Compliance |
| 0.470           | 31.19                      | QP                  | 9.000           | L1   | 16.07                 | 56.51        | 25.32       | Compliance |
| 0.470           | 25.46                      | AV                  | 9.000           | L1   | 16.07                 | 46.51        | 21.05       | Compliance |
| 0.945           | 30.77                      | QP                  | 9.000           | L1   | 15.89                 | 56.00        | 25.23       | Compliance |
| 0.940           | 25.49                      | AV                  | 9.000           | L1   | 15.89                 | 46.00        | 20.51       | Compliance |
| 1.600           | 32.41                      | QP                  | 9.000           | L1   | 15.86                 | 56.00        | 23.59       | Compliance |
| 1.600           | 25.33                      | AV                  | 9.000           | L1   | 15.86                 | 46.00        | 20.67       | Compliance |
| 4.150           | 34.66                      | QP                  | 9.000           | L1   | 15.85                 | 56.00        | 21.34       | Compliance |
| 4.150           | 29.41                      | AV                  | 9.000           | L1   | 15.85                 | 46.00        | 16.59       | Compliance |

**AC 120V/60 Hz, Neutral**

| Frequency (MHz) | Corrected Amplitude (dBμV) | Detector (PK/AV/QP) | Bandwidth (kHz) | Line | Corrected Factor (dB) | Limit (dBμV) | Margin (dB) | Comment    |
|-----------------|----------------------------|---------------------|-----------------|------|-----------------------|--------------|-------------|------------|
| 0.190           | 45.84                      | QP                  | 9.000           | N    | 16.05                 | 64.04        | 18.20       | Compliance |
| 0.190           | 34.52                      | AV                  | 9.000           | N    | 16.05                 | 54.04        | 19.52       | Compliance |
| 0.260           | 41.97                      | QP                  | 9.000           | N    | 16.06                 | 61.43        | 19.46       | Compliance |
| 0.260           | 29.16                      | AV                  | 9.000           | N    | 16.06                 | 51.43        | 22.27       | Compliance |
| 0.310           | 41.82                      | QP                  | 9.000           | N    | 16.07                 | 59.97        | 18.15       | Compliance |
| 0.310           | 26.88                      | AV                  | 9.000           | N    | 16.07                 | 49.97        | 23.09       | Compliance |
| 0.465           | 36.33                      | QP                  | 9.000           | N    | 16.10                 | 56.60        | 20.27       | Compliance |
| 0.465           | 24.36                      | AV                  | 9.000           | N    | 16.10                 | 46.60        | 22.24       | Compliance |
| 1.600           | 32.46                      | QP                  | 9.000           | N    | 15.92                 | 56.00        | 23.54       | Compliance |
| 1.600           | 28.41                      | AV                  | 9.000           | N    | 15.92                 | 46.00        | 17.59       | Compliance |
| 4.150           | 33.45                      | QP                  | 9.000           | N    | 15.88                 | 56.00        | 22.55       | Compliance |
| 4.150           | 27.05                      | AV                  | 9.000           | N    | 15.88                 | 46.00        | 18.95       | Compliance |

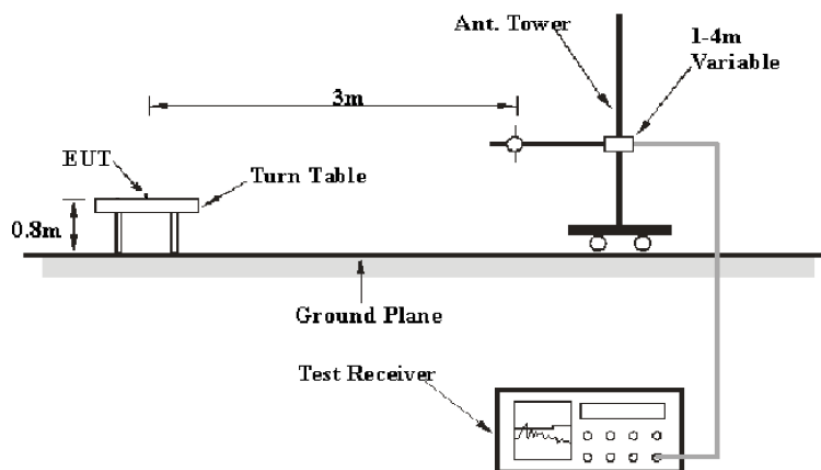
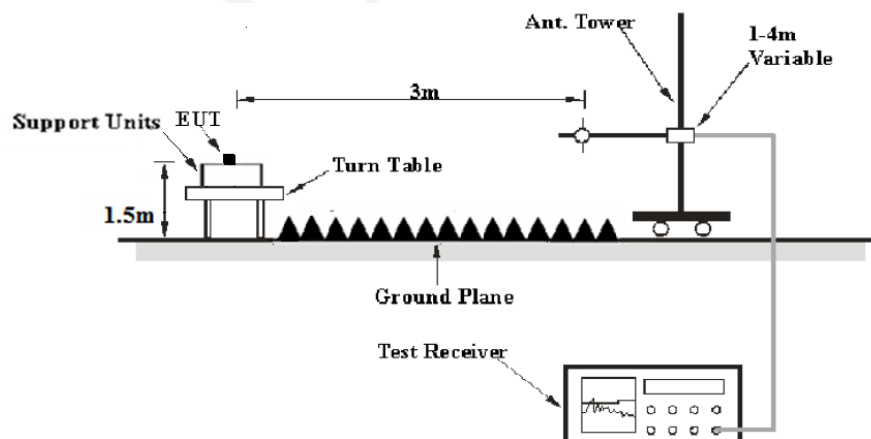
**Note:**

1) Corrected Factor (dB) = LISN VDF (dB) + Cable Loss (dB) + Transient Limiter Attenuation (dB)

2) Margin (dB) = Limit (dBμV) - Corrected Amplitude (dBμV)

**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:       | 23.3-23.5 °C    |
| Relative Humidity: | 49-50 %         |
| ATM Pressure:      | 101.1-101.2 kPa |

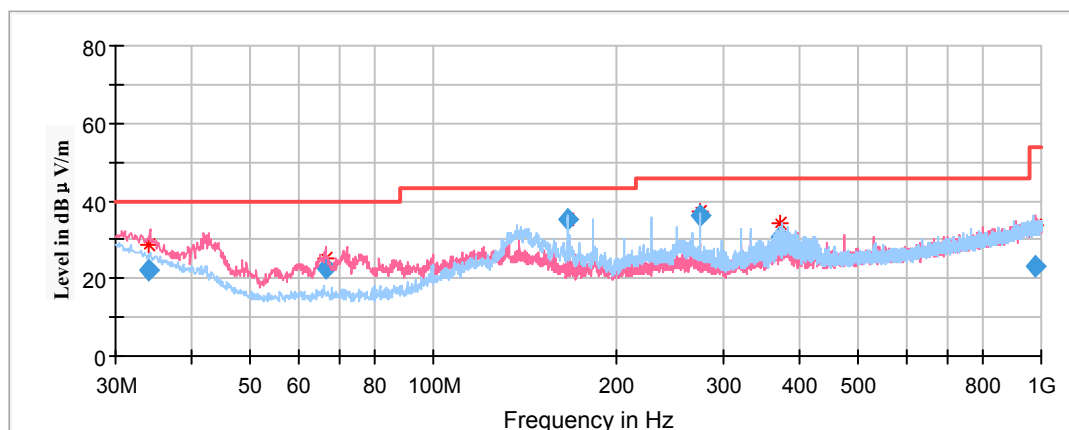
Radiated emission test was performed by Hope Zhang on 2018-09-14 & 2018-10-17;  
RF conducted test was performed by Hope Zhang on 2018-08-24.

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 GFSK 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) |                  |                         |                |             |
| 34.125850       | 28.87               | 100.0       | V           | 98.0             | -6.8                    | 40.00          | 11.13       |
| 66.562500       | 24.98               | 100.0       | V           | 175.0            | -17.5                   | 40.00          | 15.02       |
| 166.491550      | 35.23               | 200.0       | H           | 0.0              | -13.0                   | 43.50          | 8.27        |
| 274.691450      | 37.19               | 100.0       | H           | 0.0              | -11.3                   | 46.00          | 8.81        |
| 373.112000      | 34.34               | 100.0       | H           | 176.0            | -8.7                    | 46.00          | 11.66       |
| 976.303700      | 33.75               | 100.0       | V           | 353.0            | 1.8                     | 53.90          | 20.15       |

**1GHz-18GHz:**

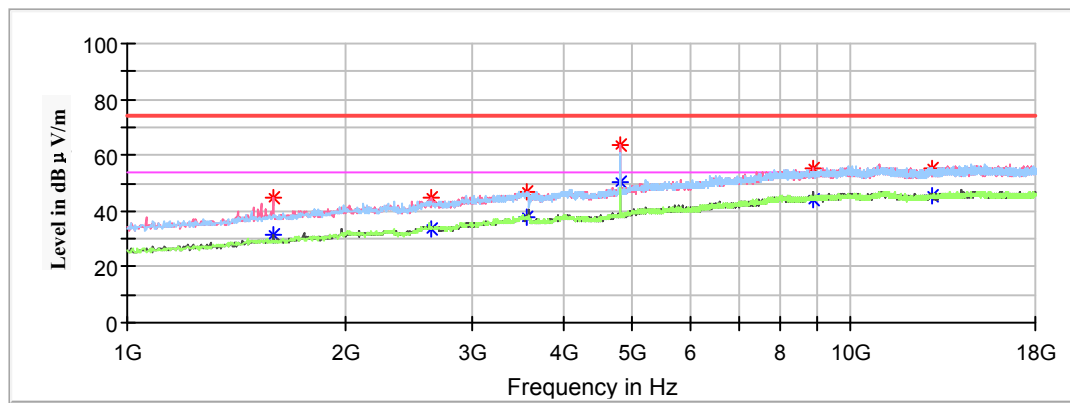
*Pre-Scan with GFSK,  $\pi/4$ -DQPSK, 8DPSK modes of operation in the X,Y and Z axes of orientation, the worst case GFSK Mode in Y-axis of orientation was recorded*

Note:

1. This test was performed with the 2.4 - 2.5GHz 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**

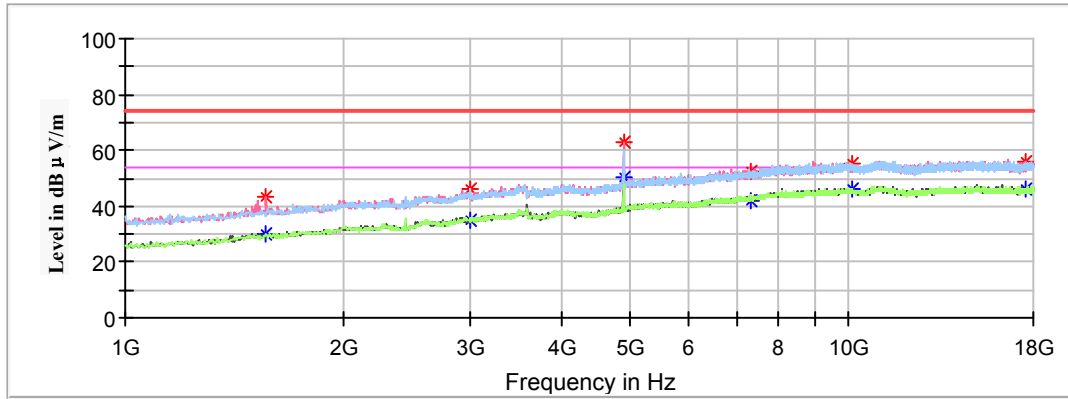
Full Spectrum



| 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) |                  |                         |                      |             |
| 1591.600000     | ---                     | 31.73                   | 100.0       | V           | 99.0             | -0.6                    | 54.00                | 22.27       |
| 1591.600000     | 45.01                   | ---                     | 100.0       | V           | 99.0             | -0.6                    | 74.00                | 28.99       |
| 2638.800000     | 44.63                   | ---                     | 100.0       | V           | 88.0             | 3.9                     | 74.00                | 29.37       |
| 2638.800000     | ---                     | 33.70                   | 100.0       | V           | 88.0             | 3.9                     | 54.00                | 20.30       |
| 3563.600000     | ---                     | 37.43                   | 200.0       | V           | 103.0            | 7.5                     | 54.00                | 16.57       |
| 3563.600000     | 47.14                   | ---                     | 200.0       | V           | 103.0            | 7.5                     | 74.00                | 26.86       |
| 4804.000000     | ---                     | 50.42                   | 100.0       | V           | 64.0             | 10.7                    | 54.00                | 3.58        |
| 4804.000000     | 63.71                   | ---                     | 100.0       | V           | 64.0             | 10.7                    | 74.00                | 10.29       |
| 8860.800000     | ---                     | 44.06                   | 200.0       | V           | 98.0             | 17.4                    | 54.00                | 9.94        |
| 8860.800000     | 55.28                   | ---                     | 200.0       | V           | 98.0             | 17.4                    | 74.00                | 18.72       |
| 12940.800000    | 55.30                   | ---                     | 100.0       | V           | 251.0            | 17.7                    | 74.00                | 18.70       |
| 12940.800000    | ---                     | 45.56                   | 100.0       | V           | 251.0            | 17.7                    | 54.00                | 8.44        |

**Middle Channel: 2441MHz**

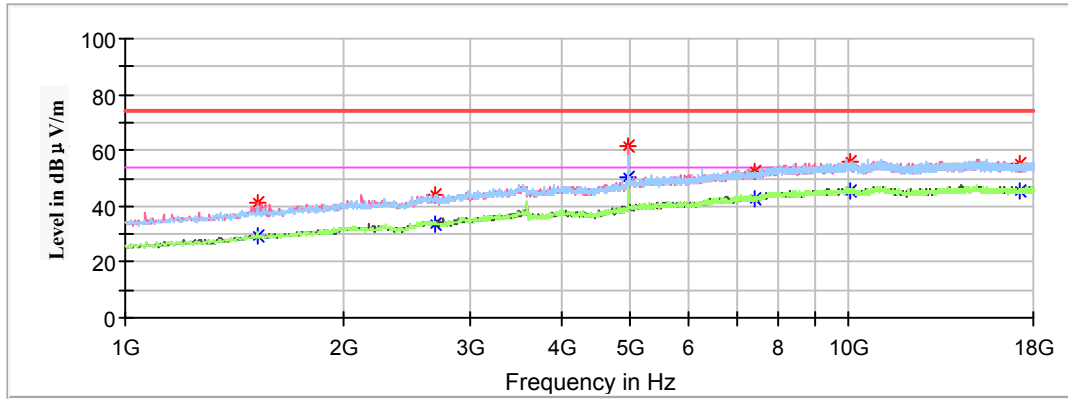
Full Spectrum



| 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) |                  |                         |                      |             |
| 1567.800000     | ---                     | 29.98                   | 200.0       | V           | 293.0            | -0.8                    | 54.00                | 24.02       |
| 1567.800000     | 43.35                   | ---                     | 200.0       | V           | 293.0            | -0.8                    | 74.00                | 30.65       |
| 2992.400000     | ---                     | 35.06                   | 150.0       | H           | 246.0            | 6.0                     | 54.00                | 18.94       |
| 2992.400000     | 45.99                   | ---                     | 150.0       | H           | 246.0            | 6.0                     | 74.00                | 28.01       |
| 4882.000000     | ---                     | 50.30                   | 100.0       | V           | 254.0            | 11.1                    | 54.00                | 3.70        |
| 4882.000000     | 63.21                   | ---                     | 100.0       | V           | 254.0            | 11.1                    | 74.00                | 10.79       |
| 7323.000000     | ---                     | 42.09                   | 200.0       | V           | 217.0            | 15.4                    | 54.00                | 11.91       |
| 7323.000000     | 52.26                   | ---                     | 200.0       | V           | 217.0            | 15.4                    | 74.00                | 21.74       |
| 10105.200000    | ---                     | 45.87                   | 150.0       | V           | 144.0            | 18.2                    | 54.00                | 8.13        |
| 10105.200000    | 55.34                   | ---                     | 150.0       | V           | 144.0            | 18.2                    | 74.00                | 18.66       |
| 17558.000000    | ---                     | 45.93                   | 250.0       | V           | 330.0            | 18.5                    | 54.00                | 8.07        |
| 17558.000000    | 55.87                   | ---                     | 250.0       | V           | 330.0            | 18.5                    | 74.00                | 18.13       |

**High Channel: 2480MHz**

Full Spectrum

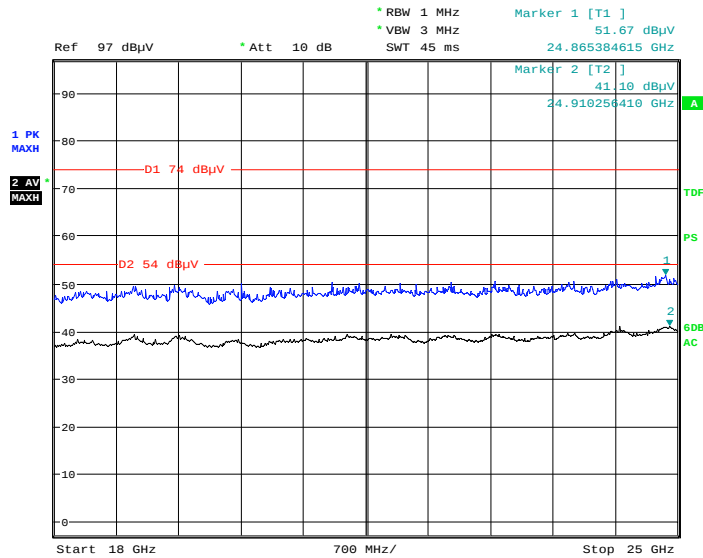


| Frequency (MHz) | Corrected Amplitude     |                         | Rx Antenna  |             | Turntable Degree | Corrected Factor (dB/m) | Limit (dB $\mu$ V/m) | Margin (dB) |
|-----------------|-------------------------|-------------------------|-------------|-------------|------------------|-------------------------|----------------------|-------------|
|                 | MaxPeak (dB $\mu$ V /m) | Average (dB $\mu$ V /m) | Height (cm) | Polar (H/V) |                  |                         |                      |             |
| 1527.000000     | ---                     | 29.10                   | 250.0       | V           | 243.0            | -1.1                    | 54.00                | 24.90       |
| 1527.000000     | 41.51                   | ---                     | 250.0       | V           | 243.0            | -1.1                    | 74.00                | 32.49       |
| 2676.200000     | ---                     | 33.40                   | 100.0       | H           | 30.0             | 4.2                     | 54.00                | 20.60       |
| 2676.200000     | 44.11                   | ---                     | 100.0       | H           | 30.0             | 4.2                     | 74.00                | 29.89       |
| 4960.000000     | 61.37                   | ---                     | 200.0       | V           | 299.0            | 11.5                    | 74.00                | 12.63       |
| 4960.000000     | ---                     | 50.40                   | 200.0       | V           | 299.0            | 11.5                    | 54.00                | 3.60        |
| 7440.000000     | 52.67                   | ---                     | 200.0       | V           | 259.0            | 15.6                    | 74.00                | 21.33       |
| 7440.000000     | ---                     | 42.77                   | 200.0       | V           | 259.0            | 15.6                    | 54.00                | 11.23       |
| 10071.200000    | ---                     | 45.27                   | 100.0       | V           | 70.0             | 18.2                    | 54.00                | 8.73        |
| 10071.200000    | 55.60                   | ---                     | 100.0       | V           | 70.0             | 18.2                    | 74.00                | 18.40       |
| 17218.000000    | ---                     | 45.69                   | 250.0       | V           | 293.0            | 18.3                    | 54.00                | 8.31        |
| 17218.000000    | 55.16                   | ---                     | 250.0       | V           | 293.0            | 18.3                    | 74.00                | 18.84       |

# 18GHz-25GHz:

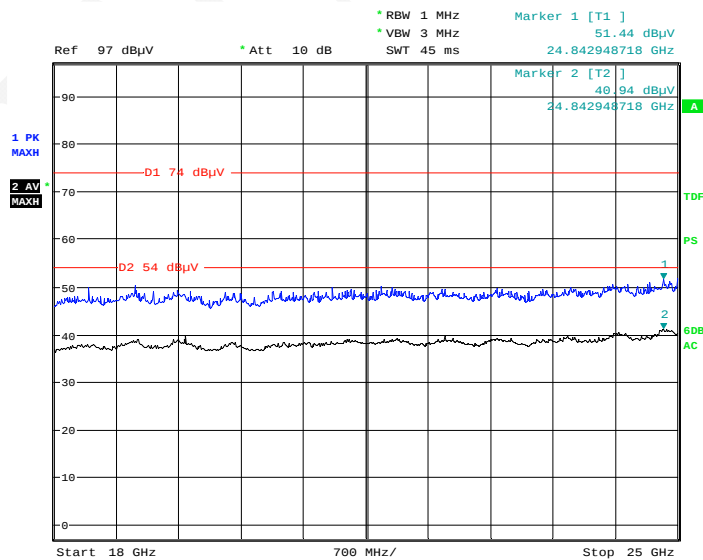
Pre-Scan with GFSK,  $\pi/4$ -DQPSK, 8DPSK modes of operation in the X, Y and Z axes of orientation, the worst case GFSK Mode in Y-axis of orientation was recorded

## Horizontal



Date: 17.OCT.2018 16:01:43

## Vertical



Date: 17.OCT.2018 16:23:21

**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 GFSK Mode in Y-axis of orientation was recorded*

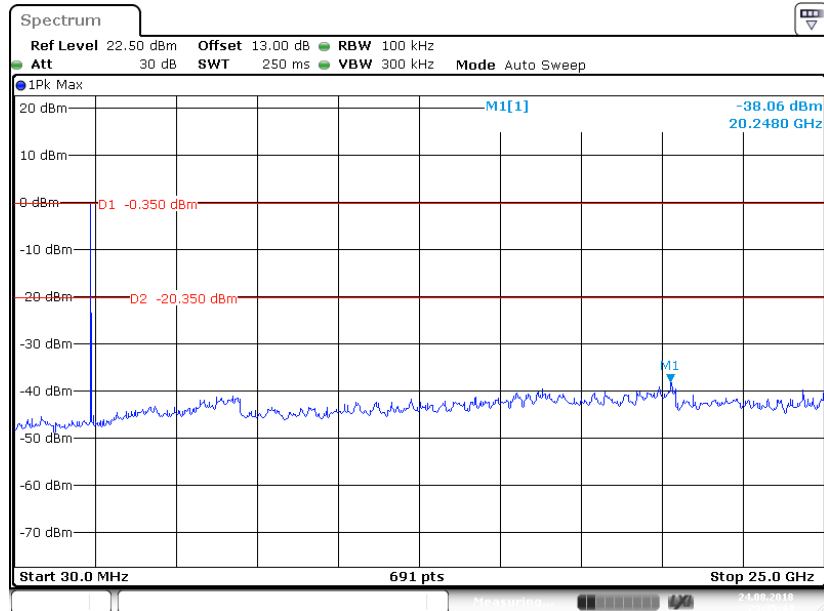
Note:

- 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<br>/m) | Average<br>(dBμV /m) | Height<br>(cm) | Polar<br>(H/V) |                     |                               |                   |                |
| Low Channel: 2402MHz    |                         |                      |                |                |                     |                               |                   |                |
| 2402.000000             | 95.35                   | ---                  | 250.0          | V              | 171.0               | 2.9                           | /                 | /              |
| 2402.000000             | ---                     | 92.83                | 250.0          | V              | 171.0               | 2.9                           | /                 | /              |
| 2402.000000             | 93.30                   | ---                  | 200.0          | H              | 233.0               | 2.9                           | /                 | /              |
| 2402.000000             | ---                     | 90.91                | 200.0          | H              | 233.0               | 2.9                           | /                 | /              |
| 2390.000000             | 49.72                   | ---                  | 200.0          | V              | 119.0               | 2.8                           | 74.00             | 24.28          |
| 2390.000000             | ---                     | 39.21                | 200.0          | V              | 119.0               | 2.8                           | 54.00             | 14.79          |
| Middle Channel: 2441MHz |                         |                      |                |                |                     |                               |                   |                |
| 2441.000000             | 98.39                   | ---                  | 250.0          | V              | 113.0               | 3.0                           | /                 | /              |
| 2441.000000             | ---                     | 95.88                | 250.0          | V              | 113.0               | 3.0                           | /                 | /              |
| 2441.000000             | 96.30                   | ---                  | 150.0          | H              | 210.0               | 3.0                           | /                 | /              |
| 2441.000000             | ---                     | 93.87                | 150.0          | H              | 210.0               | 3.0                           | /                 | /              |
| High Channel: 2480MHz   |                         |                      |                |                |                     |                               |                   |                |
| 2480.000000             | 100.10                  | ---                  | 200.0          | V              | 90.0                | 3.0                           | /                 | /              |
| 2480.000000             | ---                     | 97.64                | 200.0          | V              | 90.0                | 3.0                           | /                 | /              |
| 2480.000000             | 98.15                   | ---                  | 250.0          | H              | 347.0               | 3.0                           | /                 | /              |
| 2480.000000             | ---                     | 95.54                | 250.0          | H              | 347.0               | 3.0                           | /                 | /              |
| 2483.500000             | 51.26                   | ---                  | 150.0          | V              | 25.0                | 3.0                           | 74.00             | 22.74          |
| 2483.500000             | ---                     | 40.37                | 150.0          | V              | 25.0                | 3.0                           | 54.00             | 13.63          |

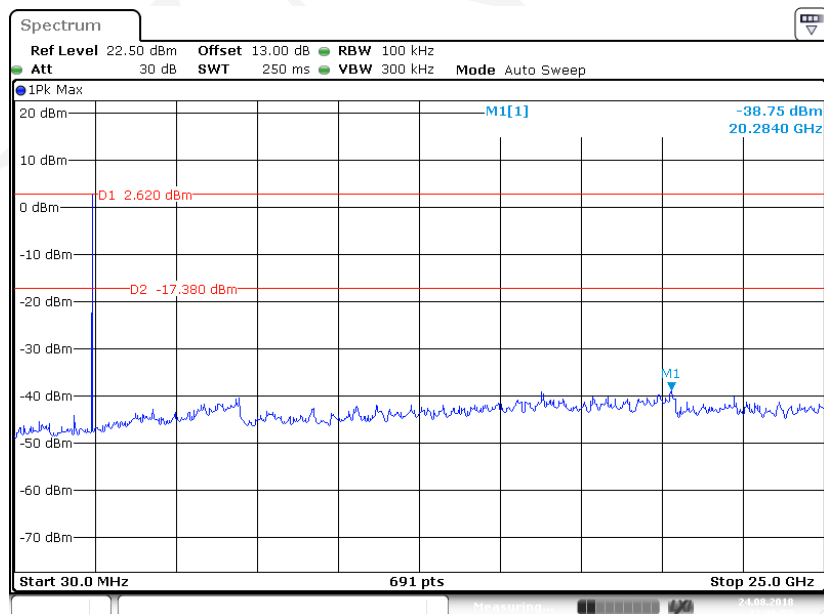
## Conducted Spurious Emissions at Antenna Port

### BDR (GFSK): Low Channel



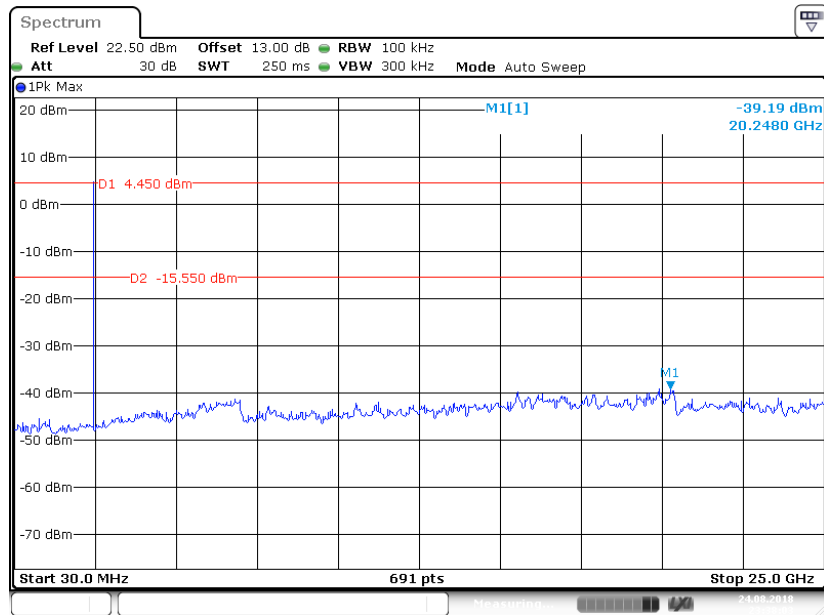
Date: 24 AUG 2018 23:35:44

### BDR (GFSK): Middle Channel



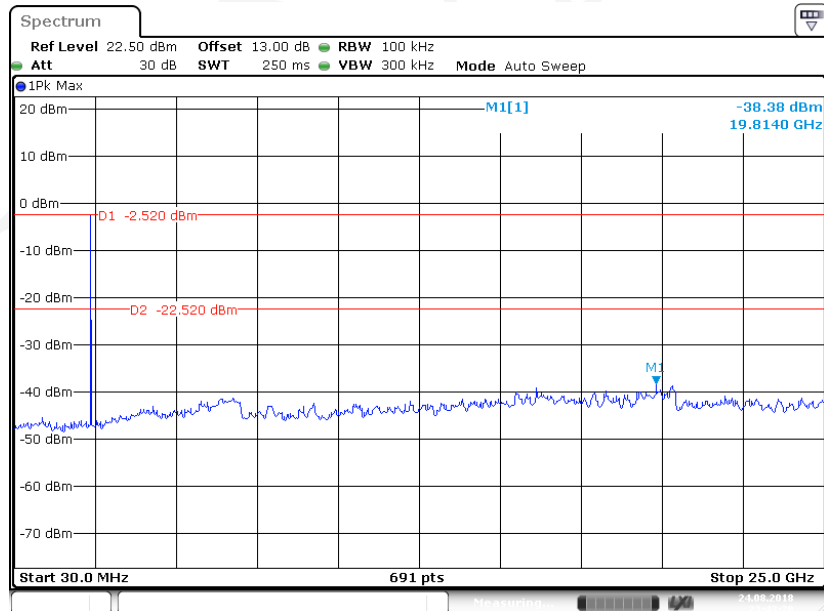
Date: 24 AUG 2018 23:37:00

### BDR (GFSK): High Channel



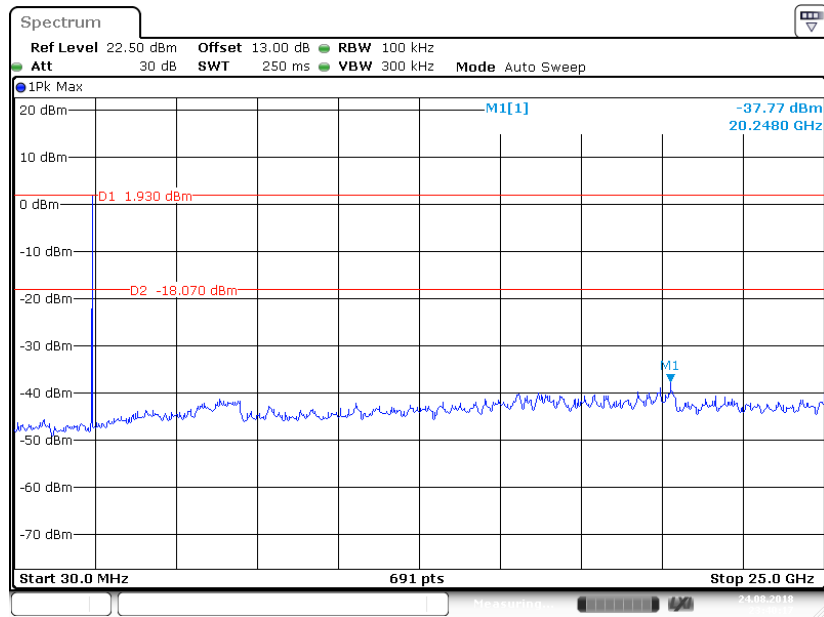
Date: 24 AUG 2018 23:38:34

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



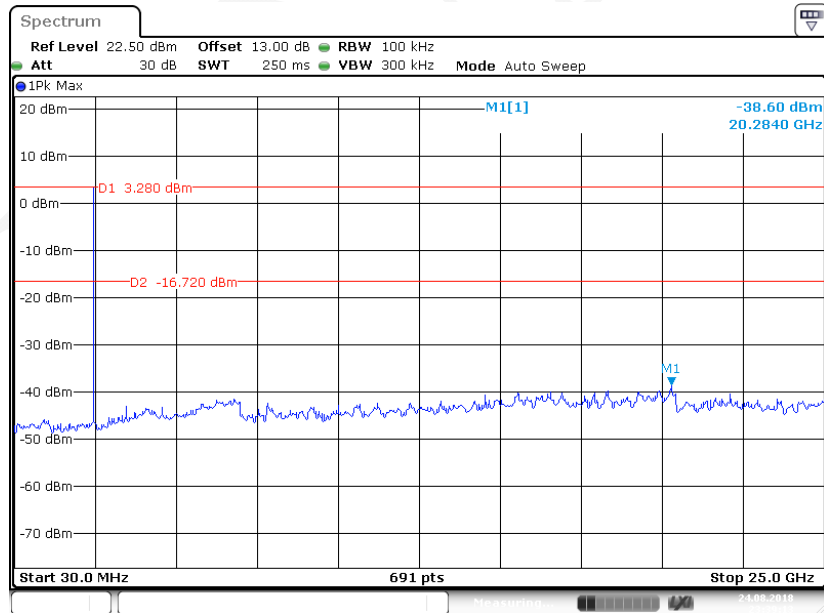
Date: 24 AUG 2018 23:43:20

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



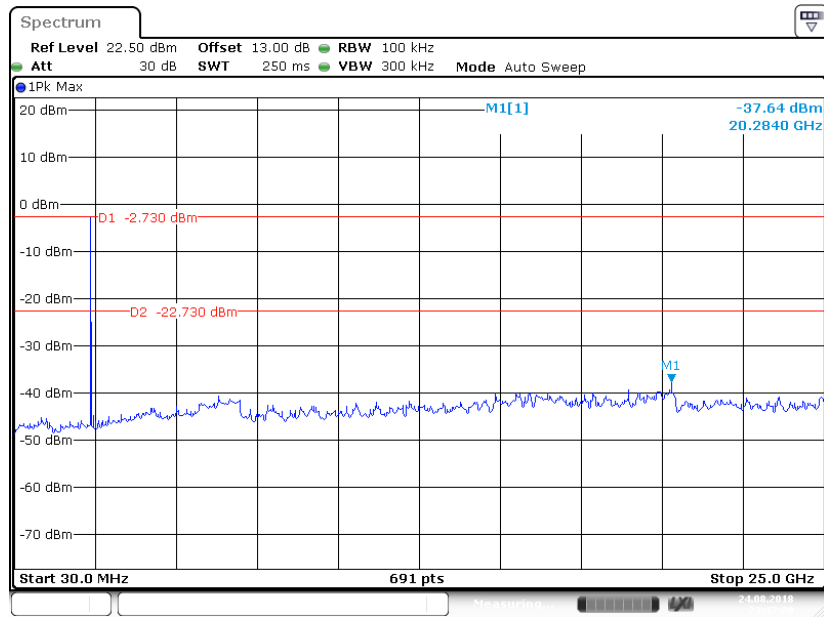
Date: 24 AUG 2018 23:40:17

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



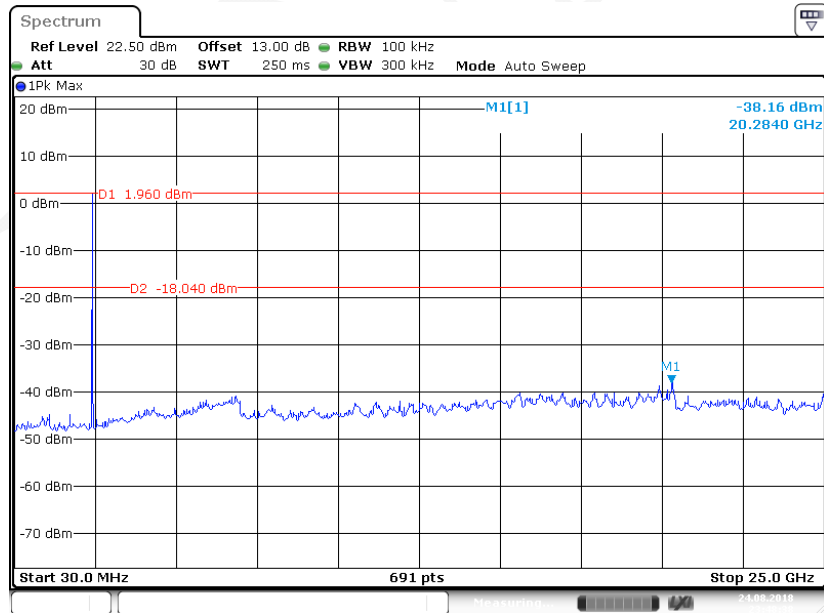
Date: 24 AUG 2018 23:39:14

### EDR (8DPSK): Low Channel



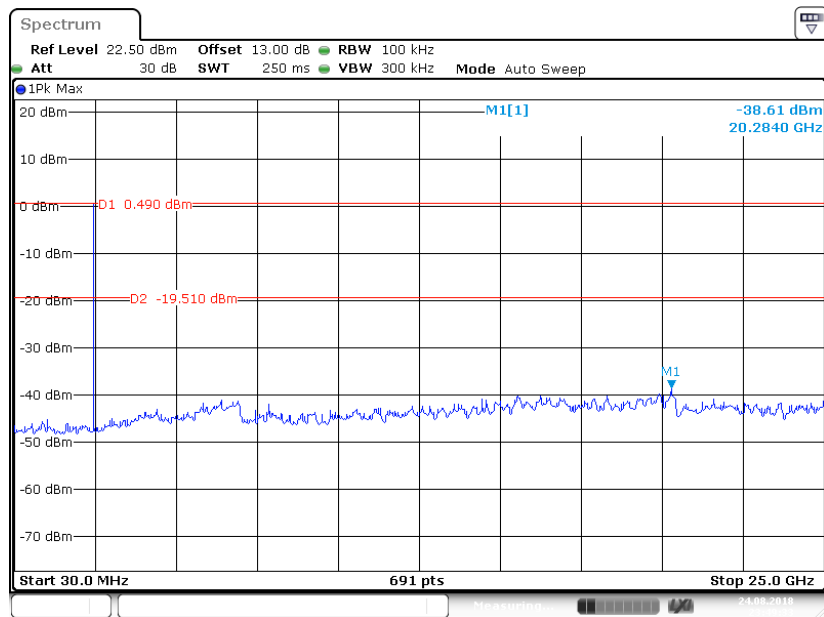
Date: 24 AUG 2018 23:47:20

### EDR (8DPSK): Middle Channel



Date: 24 AUG 2018 23:48:39

# EDR (8DPSK): High Channel



Date: 24 AUG 2018 23:49:33

## 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:       | 23.3-23.5 °C    |
| Relative Humidity: | 49-50 %         |
| ATM Pressure:      | 101.1-101.2 kPa |

*The testing was performed by Hope Zhang on 2018-08-25 & 2018-09-01.*

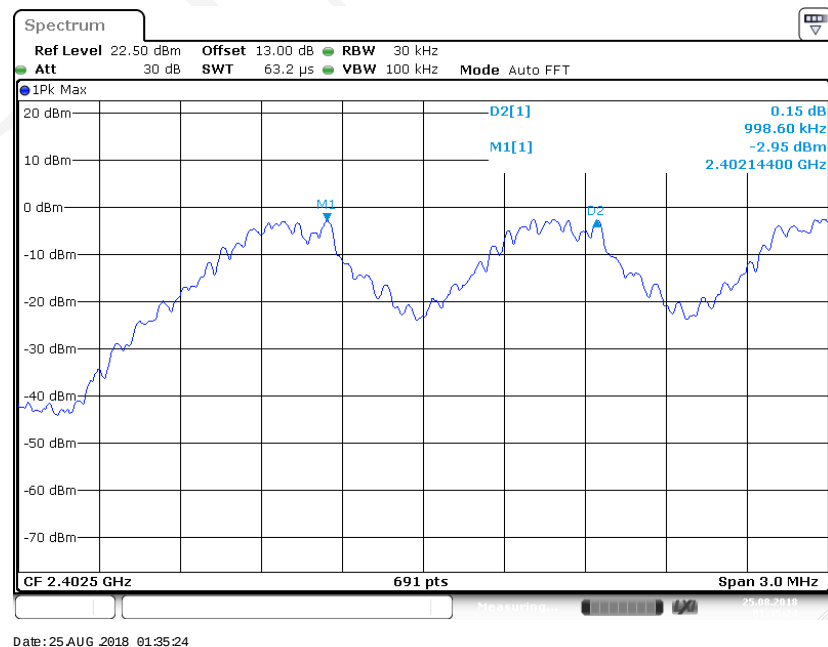
*EUT operation mode: Transmitting*

*Test Result: Compliance.*

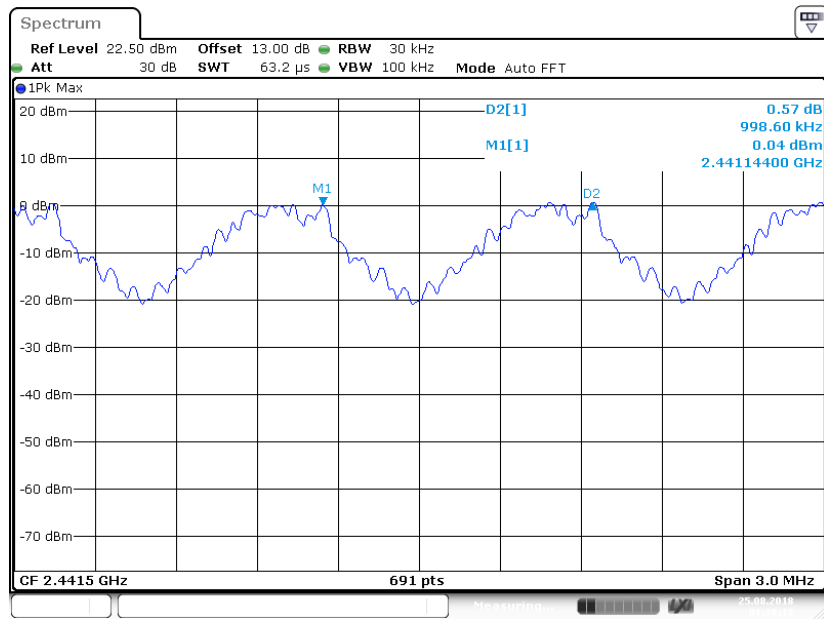
| Mode                                  | Channel  | Frequency (MHz) | Channel Separation (MHz) | Limit (MHz)  | Result |
|---------------------------------------|----------|-----------------|--------------------------|--------------|--------|
| <b>BDR (GFSK)</b>                     | Low      | 2402            | 0.999                    | $\geq 0.955$ | Pass   |
|                                       | Adjacent | 2403            |                          |              |        |
|                                       | Middle   | 2441            | 0.999                    | $\geq 0.955$ | Pass   |
|                                       | Adjacent | 2442            |                          |              |        |
|                                       | High     | 2480            | 0.999                    | $\geq 0.960$ | Pass   |
|                                       | Adjacent | 2479            |                          |              |        |
| <b>EDR (<math>\pi/4</math>-DQPSK)</b> | Low      | 2402            | 0.999                    | $\geq 0.859$ | Pass   |
|                                       | Adjacent | 2403            |                          |              |        |
|                                       | Middle   | 2441            | 1.003                    | $\geq 0.886$ | Pass   |
|                                       | Adjacent | 2442            |                          |              |        |
|                                       | High     | 2480            | 1.003                    | $\geq 0.874$ | Pass   |
|                                       | Adjacent | 2479            |                          |              |        |
| <b>EDR (8DPSK)</b>                    | Low      | 2402            | 0.999                    | $\geq 0.854$ | Pass   |
|                                       | Adjacent | 2403            |                          |              |        |
|                                       | Middle   | 2441            | 0.999                    | $\geq 0.869$ | Pass   |
|                                       | Adjacent | 2442            |                          |              |        |
|                                       | High     | 2480            | 1.003                    | $\geq 0.863$ | Pass   |
|                                       | Adjacent | 2479            |                          |              |        |

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

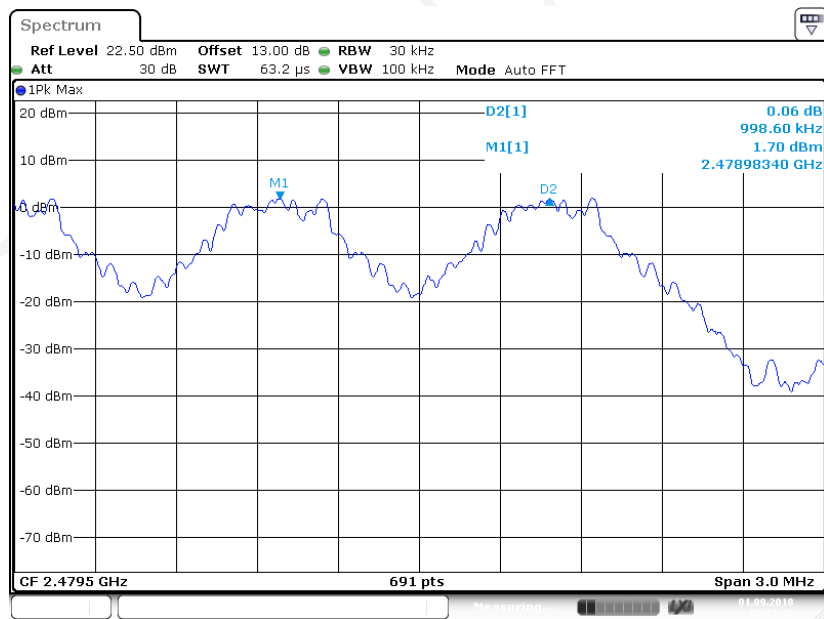
### BDR (GFSK): Low Channel



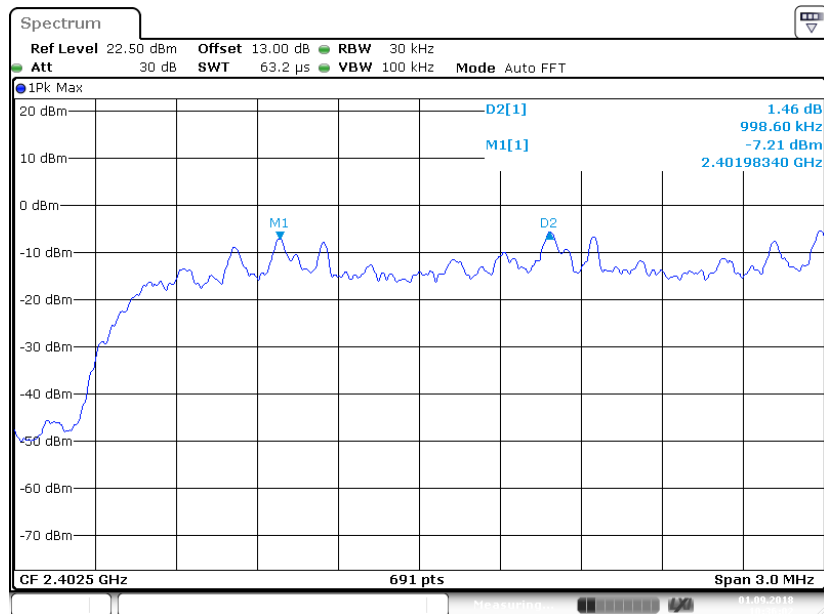
### BDR (GFSK): Middle Channel



### BDR (GFSK): High Channel

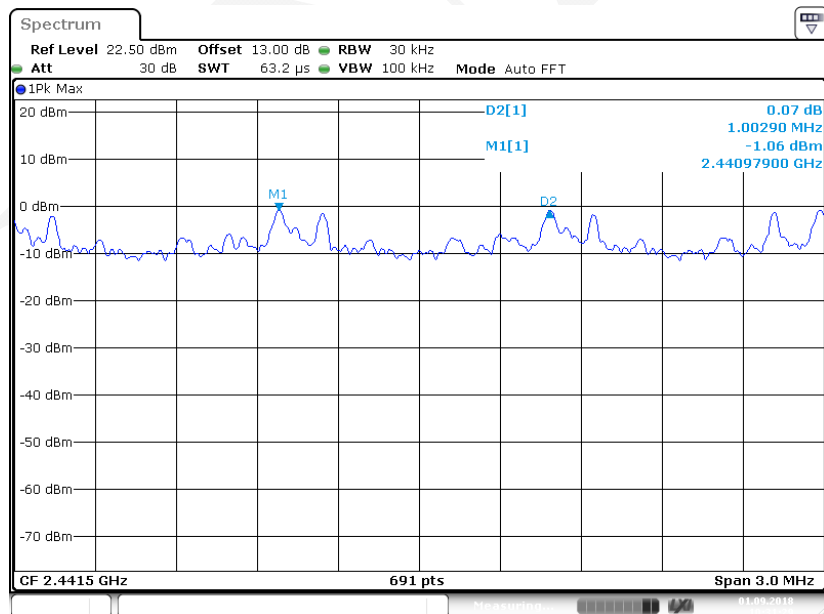


### EDR ( $\pi/4$ -DQPSK): Low Channel

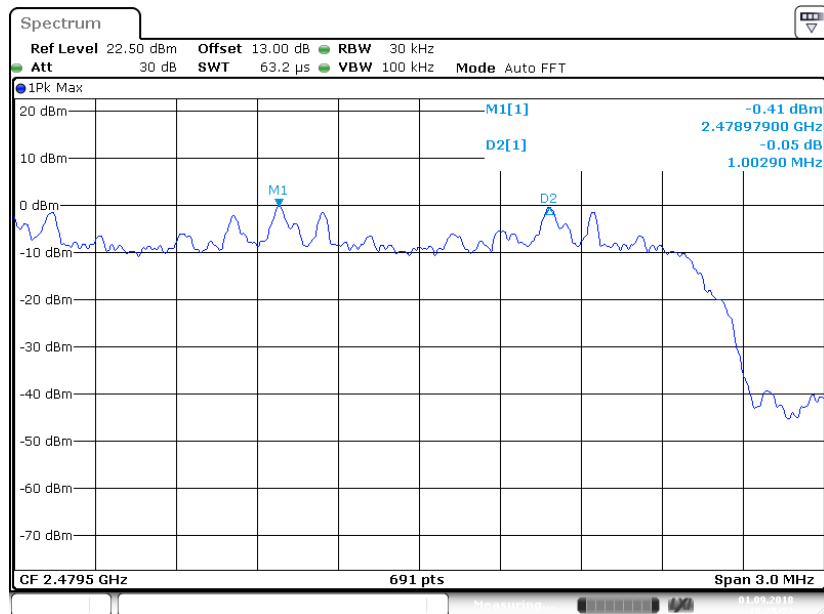


Date: 1 SEP 2018 10:36:02

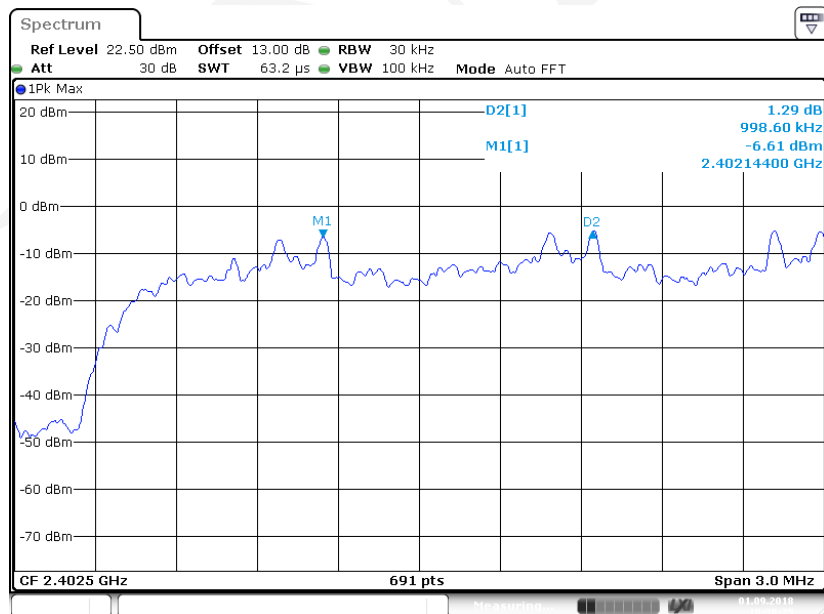
### EDR ( $\pi/4$ -DQPSK): Middle Channel



Date: 1 SEP 2018 10:31:29

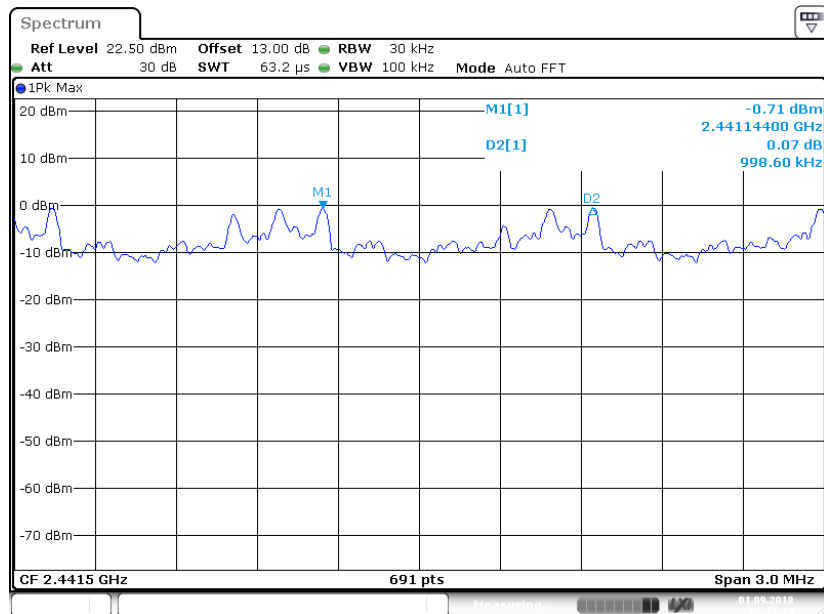
**EDR ( $\pi/4$ -DQPSK): High Channel**

Date: 1 SEP 2018 10:25:23

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

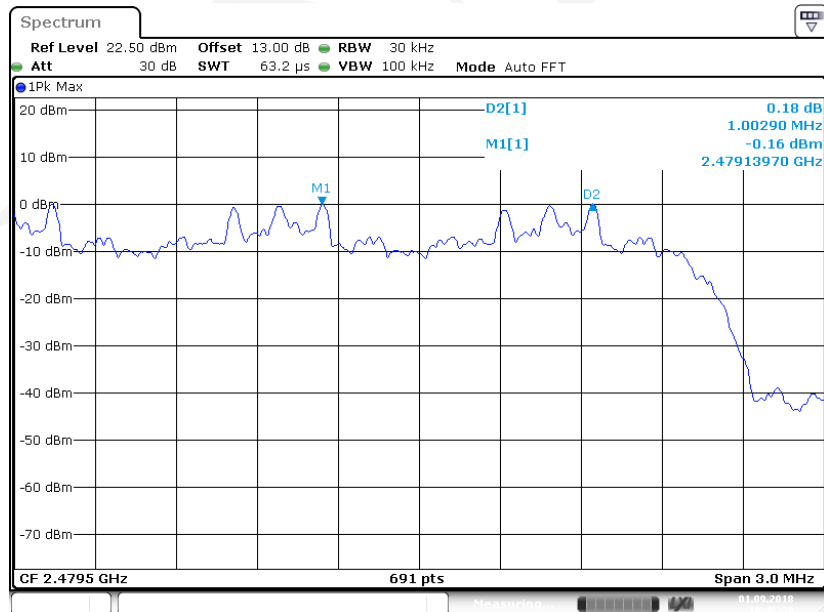
Date: 1 SEP 2018 10:38:26

### EDR (8DPSK): Middle Channel



Date: 1 SEP 2018 10:43:24

### EDR (8DPSK): High Channel



Date: 1 SEP 2018 10:46:36

## 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

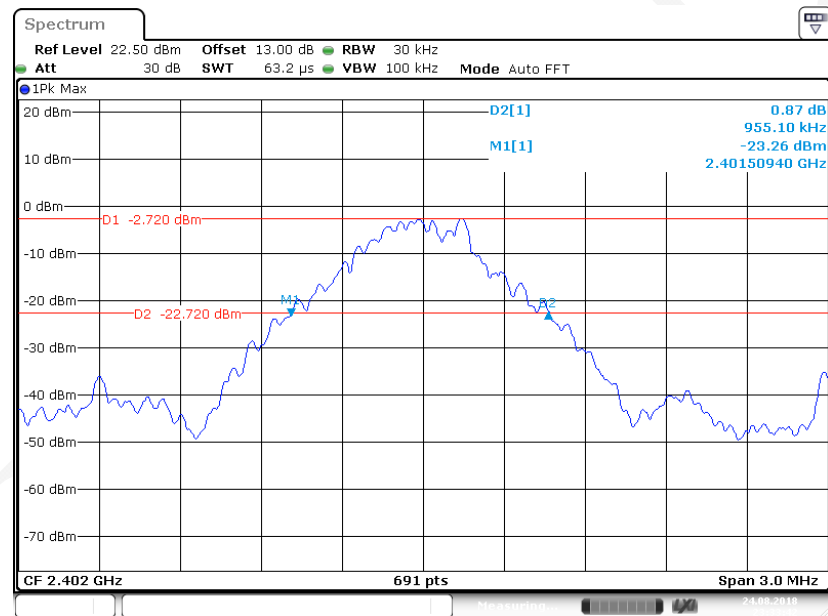
|                    |           |
|--------------------|-----------|
| Temperature:       | 23.2 °C   |
| Relative Humidity: | 50 %      |
| ATM Pressure:      | 101.3 kPa |

*The testing was performed by Hope Zhang on 2018-08-24.*

*EUT operation mode: Transmitting*

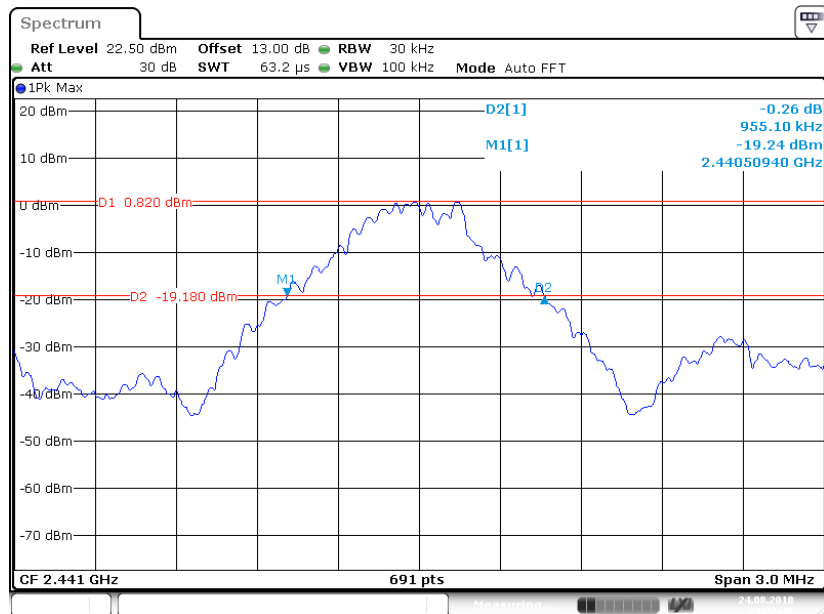
*Test Result: Compliance.*

| Mode                                  | Channel | Frequency (MHz) | 20 dB Emission Bandwidth (MHz) |
|---------------------------------------|---------|-----------------|--------------------------------|
| <b>BDR (GFSK)</b>                     | Low     | 2402            | 0.955                          |
|                                       | Middle  | 2441            | 0.955                          |
|                                       | High    | 2480            | 0.960                          |
| <b>EDR (<math>\pi/4</math>-DQPSK)</b> | Low     | 2402            | 1.289                          |
|                                       | Middle  | 2441            | 1.329                          |
|                                       | High    | 2480            | 1.311                          |
| <b>EDR (8DPSK)</b>                    | Low     | 2402            | 1.281                          |
|                                       | Middle  | 2441            | 1.303                          |
|                                       | High    | 2480            | 1.294                          |

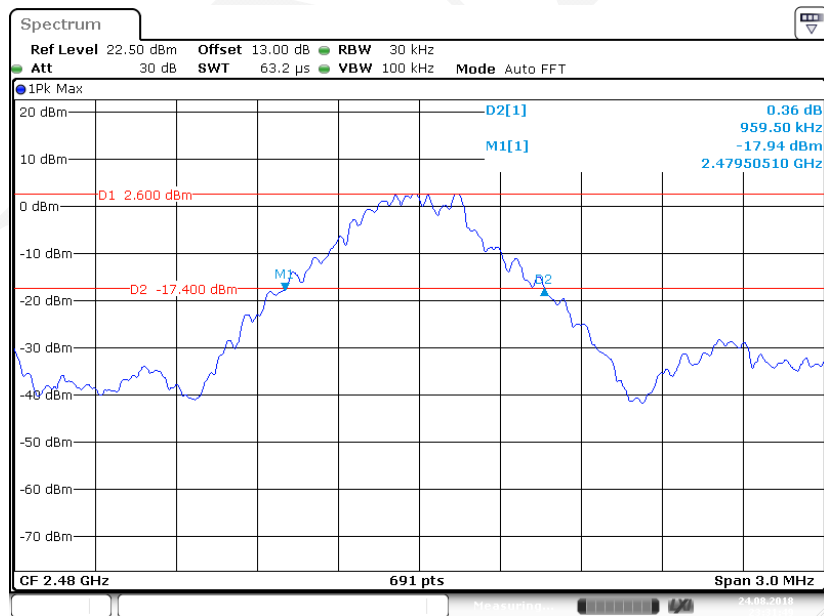
**BDR (GFSK): Low Channel**

Date: 24 AUG 2018 23:33:42

### BDR (GFSK): Middle Channel



### BDR (GFSK): High Channel



**Spectrum**

Ref Level 22.50 dBm Offset 13.00 dB RBW 30 kHz  
Att 30 dB SWT 63.2  $\mu$ s VBW 100 kHz Mode Auto FFT

1Pk Max

0.17 dB  
1.28940 MHz  
-24.70 dBm  
2.40134880 GHz

D1 -4.460 dBm  
D2 -24.460 dBm

M1[1]  
M2

CF 2.402 GHz 691 pts Span 3.0 MHz

Detailed description: This is a screenshot of a spectrum analyzer. The title bar says 'Spectrum'. Below it, various settings are displayed: 'Ref Level 22.50 dBm', 'Offset 13.00 dB', 'RBW 30 kHz', 'Att 30 dB', 'SWT 63.2 μs', 'VBW 100 kHz', and 'Mode Auto FFT'. The main display area shows a blue trace on a grid. The y-axis is labeled from -70 dBm to 20 dBm in 10 dB increments. The x-axis represents frequency. A peak is marked with a blue dot and labeled 'D1 -4.460 dBm'. Another point is marked with a blue dot and labeled 'D2 -24.460 dBm'. There are also labels 'M1[1]' and 'M2' near the trace. In the top right corner, there are several numerical values: '0.17 dB', '1.28940 MHz', '-24.70 dBm', and '2.40134880 GHz'. At the bottom, it says 'CF 2.402 GHz', '691 pts', and 'Span 3.0 MHz'. The bottom of the image shows a portion of the physical device, including a 'Measuring' label and some buttons.

**Spectrum**

Ref Level 22.50 dBm Offset 13.00 dB RBW 30 kHz  
Att 30 dB SWT 63.2  $\mu$ s VBW 100 kHz Mode Auto FFT

1Pk Max

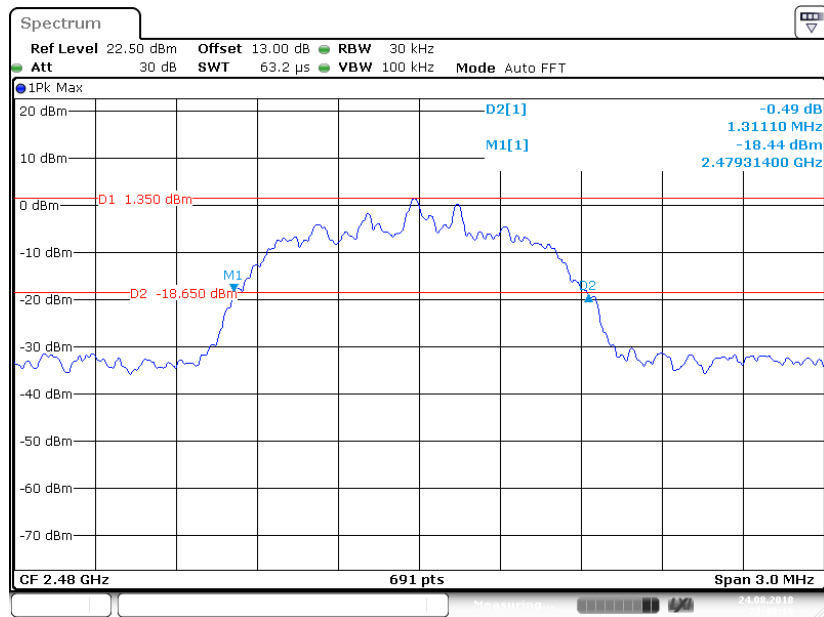
20 dBm -0.06 dB  
10 dBm 1.32850 MHz -19.87 dBm  
0 dBm D1 0.030 dBm 2.44031400 GHz  
-10 dBm  
-20 dBm D2 -19.970 dBm  
-30 dBm  
-40 dBm  
-50 dBm  
-60 dBm  
-70 dBm

D2[1]  
M1[1]

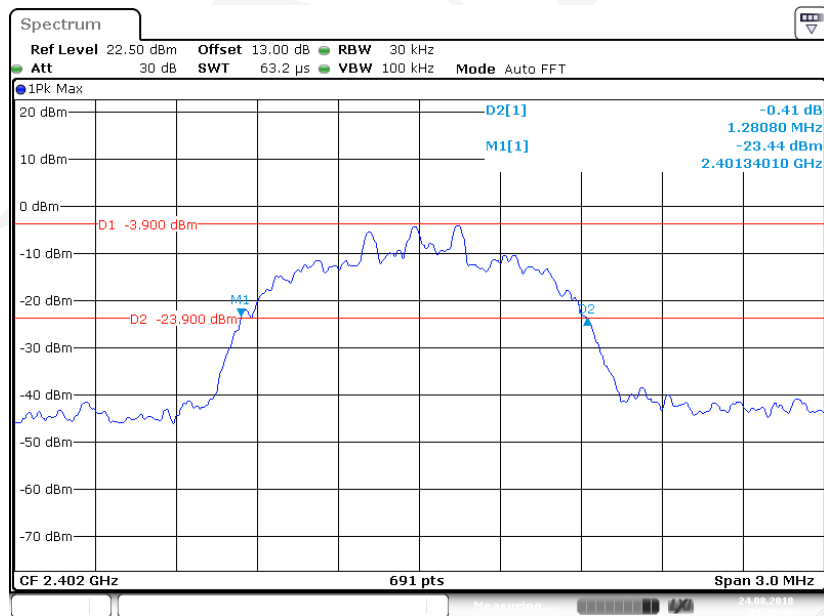
CF 2.441 GHz 691 pts Span 3.0 MHz

2.44031400 GHz

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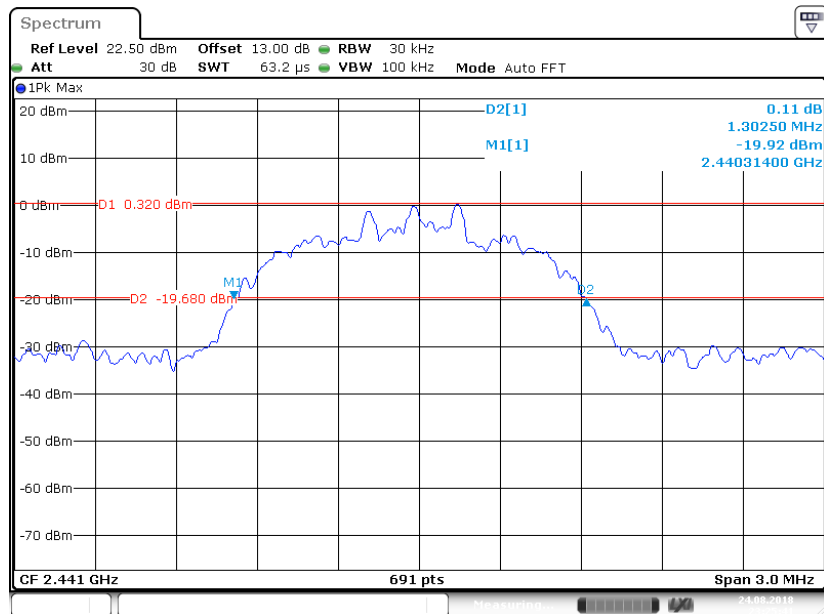
**EDR ( $\pi/4$ -DQPSK): High Channel**

Date: 24 AUG 2018 23:30:16

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

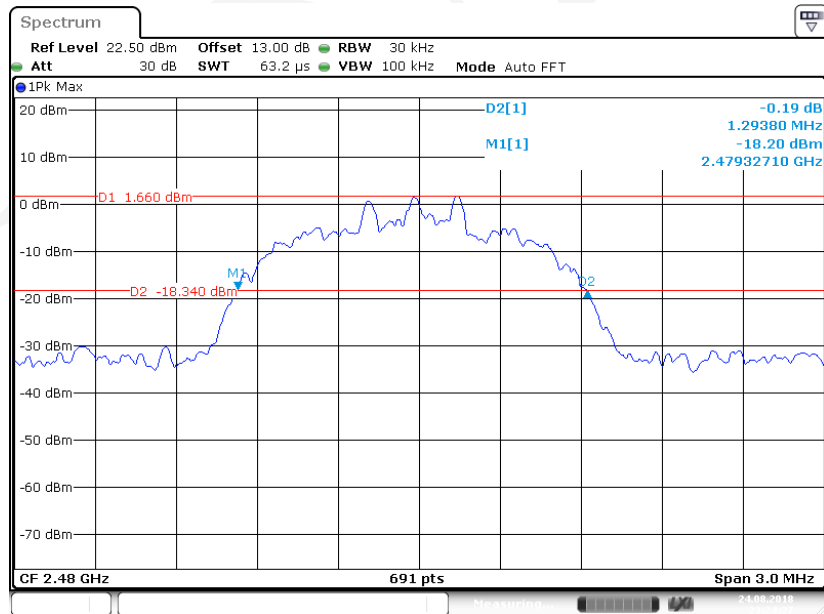
Date: 24 AUG 2018 23:26:40

### EDR (8DPSK): Middle Channel



Date: 24 AUG 2018 23:25:41

### EDR (8DPSK): High Channel



Date: 24 AUG 2018 23:24:27

**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**

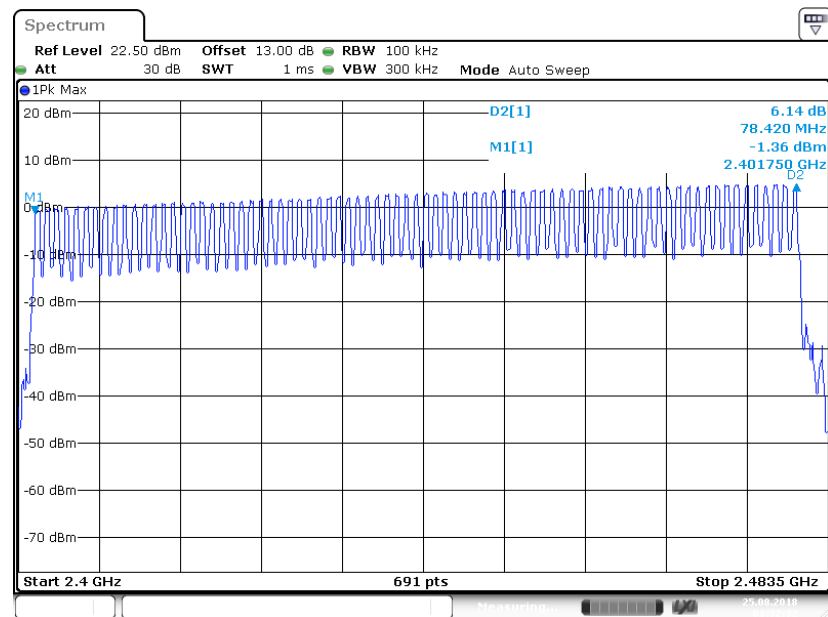
|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 23.2 °C   |
| <b>Relative Humidity:</b> | 50 %      |
| <b>ATM Pressure:</b>      | 101.3 kPa |

*The testing was performed by Hope Zhang on 2018-08-25.*

*EUT operation mode: Hopping*

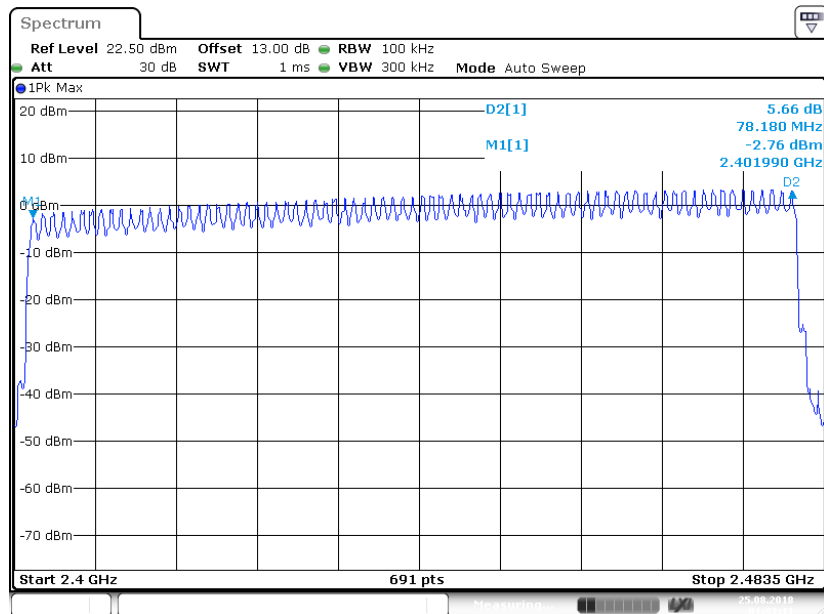
*Test Result: Compliance.*

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

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

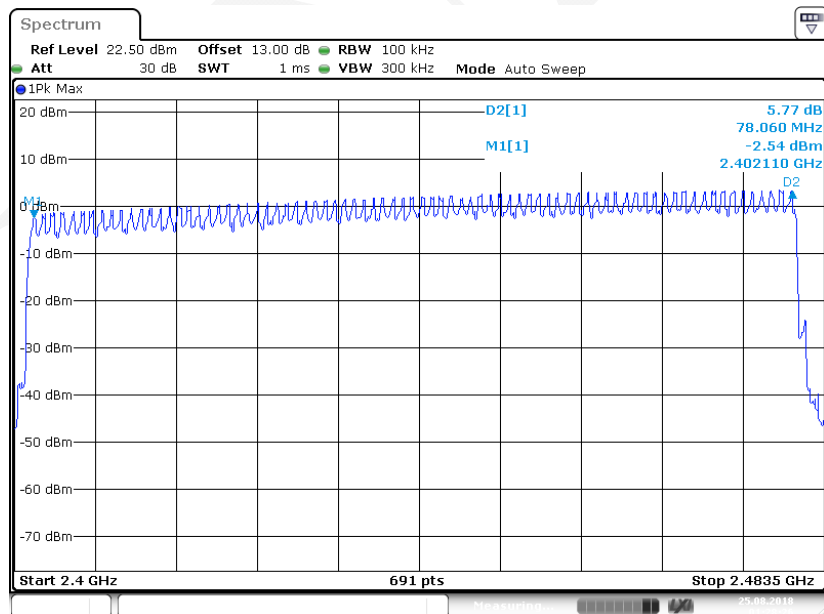
Date: 25 AUG 2018 01:32:33

### EDR ( $\pi/4$ -DQPSK): Number of Hopping Channels



Date: 25 AUG 2018 01:31:11

### EDR (8DPSK): Number of Hopping Channels



Date: 25 AUG 2018 01:28:26

**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**

1 Span: Zero span, centered on a hopping channel.

2 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.

3 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.

4 Detector function: Peak.

5 Trace: Max hold.

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

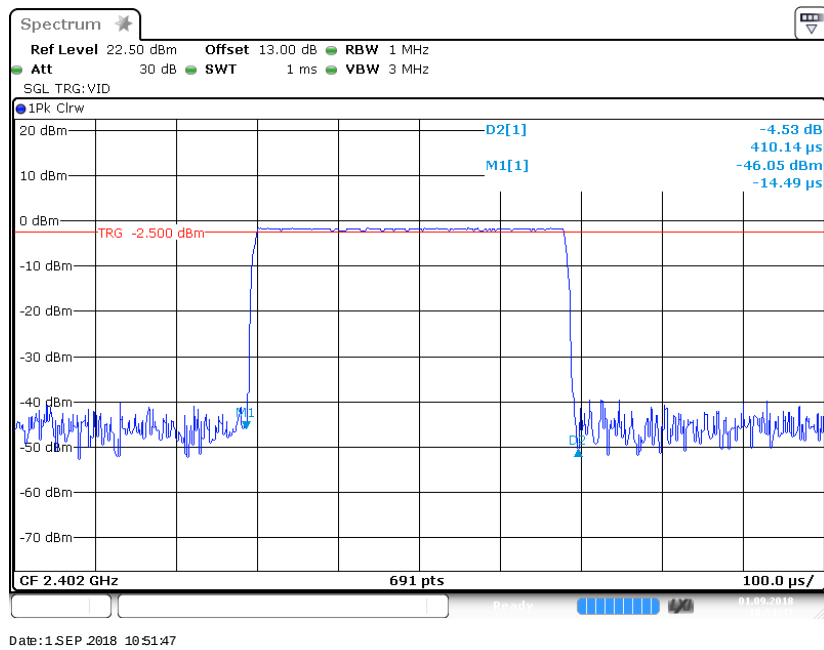
|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 23.4 °C   |
| <b>Relative Humidity:</b> | 51 %      |
| <b>ATM Pressure:</b>      | 101.2 kPa |

*The testing was performed by Hope Zhang on 2018-09-01.*

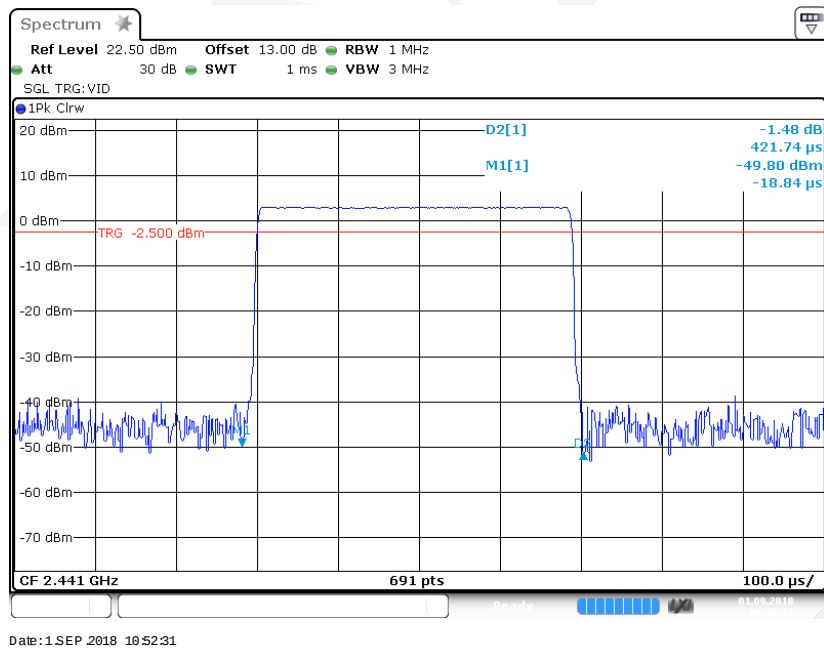
*EUT operation mode: Hopping*

| Mode                  |      | Channel                                              | Pulse Width (ms) | Dwell Time (s) | Limit (s) | Result |
|-----------------------|------|------------------------------------------------------|------------------|----------------|-----------|--------|
| BDR (GFSK)            | DH1  | Low                                                  | 0.410            | 0.131          | 0.4       | Pass   |
|                       |      | Middle                                               | 0.422            | 0.135          | 0.4       | Pass   |
|                       |      | High                                                 | 0.419            | 0.134          | 0.4       | Pass   |
|                       |      | Note: DH1:Dwell time = Pulse time*(1600/2/79)*31.6S  |                  |                |           |        |
|                       | DH3  | Low                                                  | 1.701            | 0.272          | 0.4       | Pass   |
|                       |      | Middle                                               | 1.683            | 0.269          | 0.4       | Pass   |
|                       |      | High                                                 | 1.712            | 0.274          | 0.4       | Pass   |
|                       |      | Note: DH3:Dwell time = Pulse time*(1600/4/79)*31.6S  |                  |                |           |        |
|                       | DH5  | Low                                                  | 2.940            | 0.314          | 0.4       | Pass   |
|                       |      | Middle                                               | 2.991            | 0.319          | 0.4       | Pass   |
|                       |      | High                                                 | 2.954            | 0.315          | 0.4       | Pass   |
|                       |      | Note: DH5:Dwell time = Pulse time*(1600/6/79)*31.6S  |                  |                |           |        |
| EDR ( $\pi/4$ -DQPSK) | 2DH1 | Low                                                  | 0.430            | 0.138          | 0.4       | Pass   |
|                       |      | Middle                                               | 0.432            | 0.138          | 0.4       | Pass   |
|                       |      | High                                                 | 0.435            | 0.139          | 0.4       | Pass   |
|                       |      | Note: 2DH1:Dwell time = Pulse time*(1600/2/79)*31.6S |                  |                |           |        |
|                       | 2DH3 | Low                                                  | 1.704            | 0.273          | 0.4       | Pass   |
|                       |      | Middle                                               | 1.693            | 0.271          | 0.4       | Pass   |
|                       |      | High                                                 | 1.697            | 0.272          | 0.4       | Pass   |
|                       |      | Note: 2DH3:Dwell time = Pulse time*(1600/4/79)*31.6S |                  |                |           |        |
|                       | 2DH5 | Low                                                  | 2.947            | 0.314          | 0.4       | Pass   |
|                       |      | Middle                                               | 2.952            | 0.315          | 0.4       | Pass   |
|                       |      | High                                                 | 2.952            | 0.315          | 0.4       | Pass   |
|                       |      | Note: 2DH5:Dwell time = Pulse time*(1600/6/79)*31.6S |                  |                |           |        |
| EDR (8DPSK)           | 3DH1 | Low                                                  | 0.425            | 0.136          | 0.4       | Pass   |
|                       |      | Middle                                               | 0.442            | 0.141          | 0.4       | Pass   |
|                       |      | High                                                 | 0.436            | 0.140          | 0.4       | Pass   |
|                       |      | Note:3 DH1:Dwell time = Pulse time*(1600/2/79)*31.6S |                  |                |           |        |
|                       | 3DH3 | Low                                                  | 1.697            | 0.272          | 0.4       | Pass   |
|                       |      | Middle                                               | 1.690            | 0.270          | 0.4       | Pass   |
|                       |      | High                                                 | 1.722            | 0.276          | 0.4       | Pass   |
|                       |      | Note: 3DH3:Dwell time = Pulse time*(1600/4/79)*31.6S |                  |                |           |        |
|                       | 3DH5 | Low                                                  | 3.003            | 0.320          | 0.4       | Pass   |
|                       |      | Middle                                               | 2.959            | 0.316          | 0.4       | Pass   |
|                       |      | High                                                 | 2.952            | 0.315          | 0.4       | Pass   |
|                       |      | Note: 3DH5:Dwell time = Pulse time*(1600/6/79)*31.6S |                  |                |           |        |

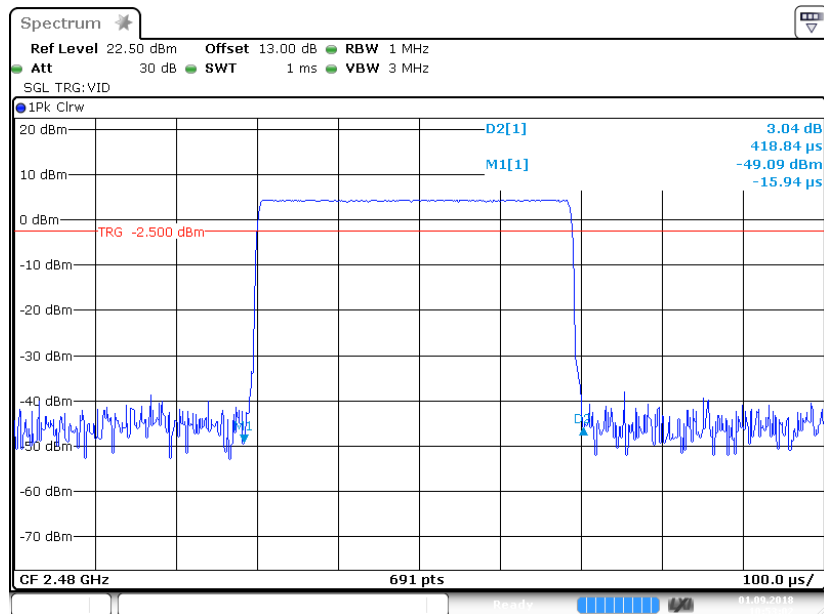
### BDR (GFSK): Pulse time, Low Channel, DH1



### BDR (GFSK): Pulse time, Middle Channel, DH1

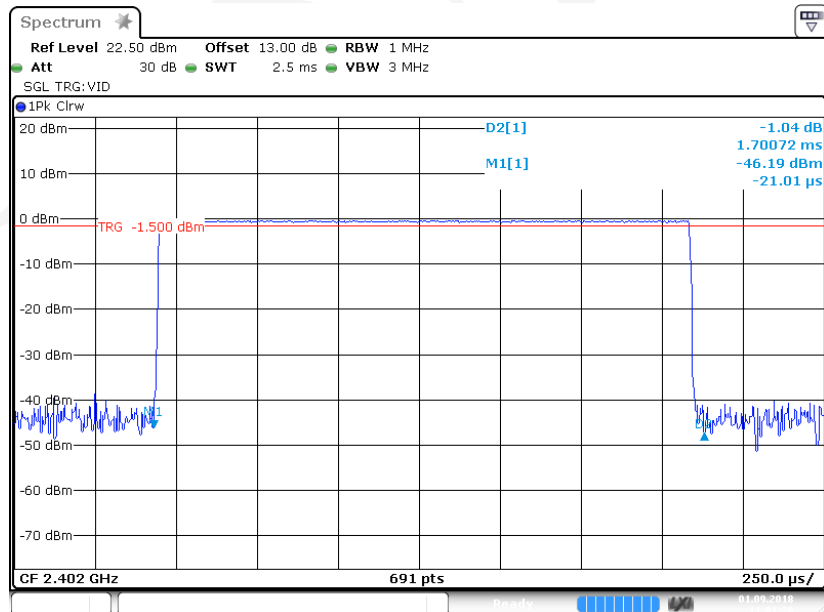


### BDR (GFSK): Pulse time, High Channel, DH1



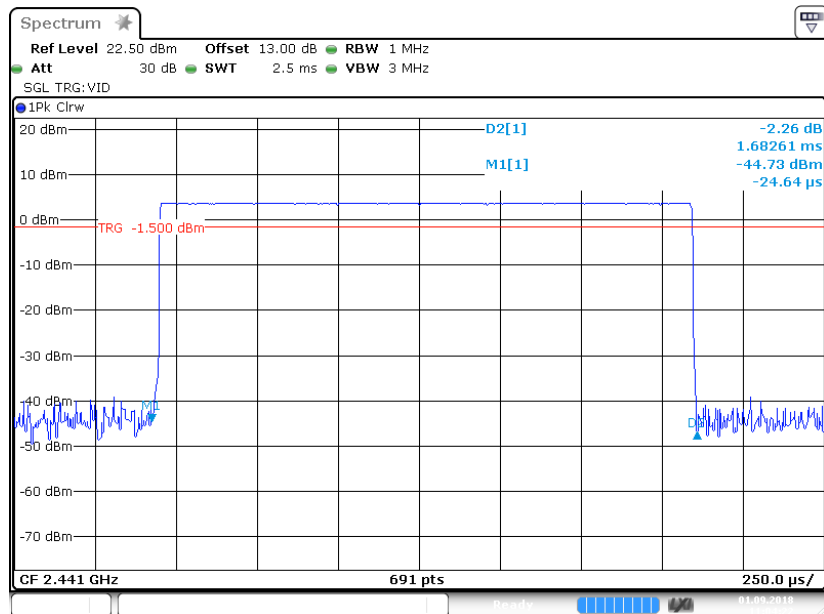
Date: 1 SEP 2018 10:53:02

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



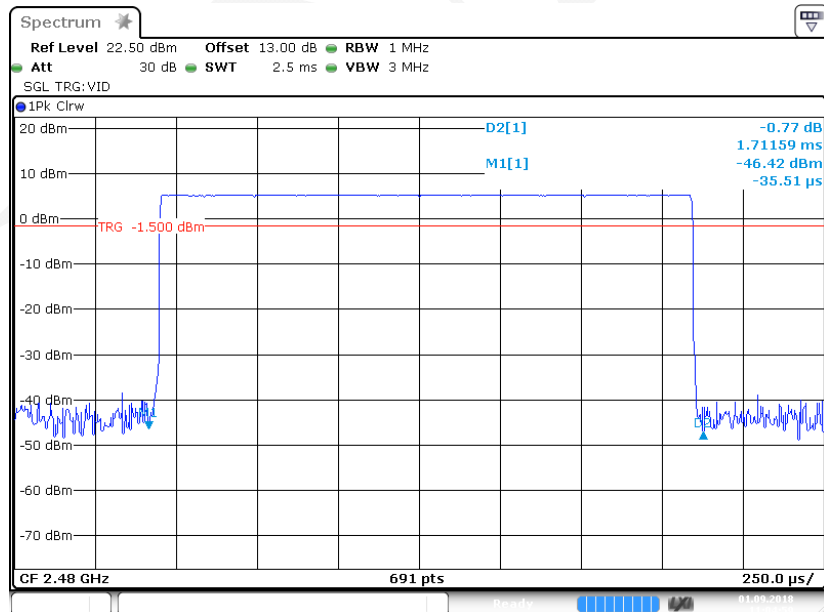
Date: 1 SEP 2018 11:01:26

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



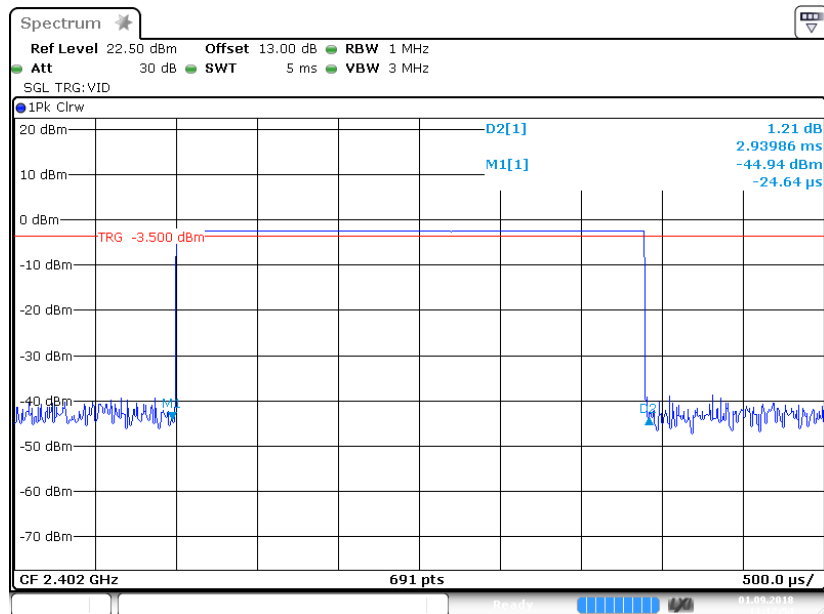
Date: 1 SEP 2018 11:04:22

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



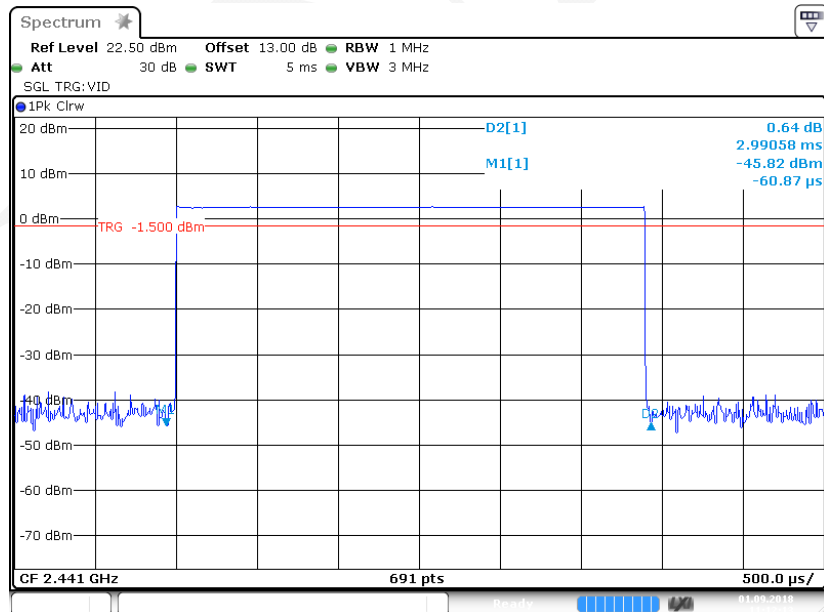
Date: 1 SEP 2018 11:04:59

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

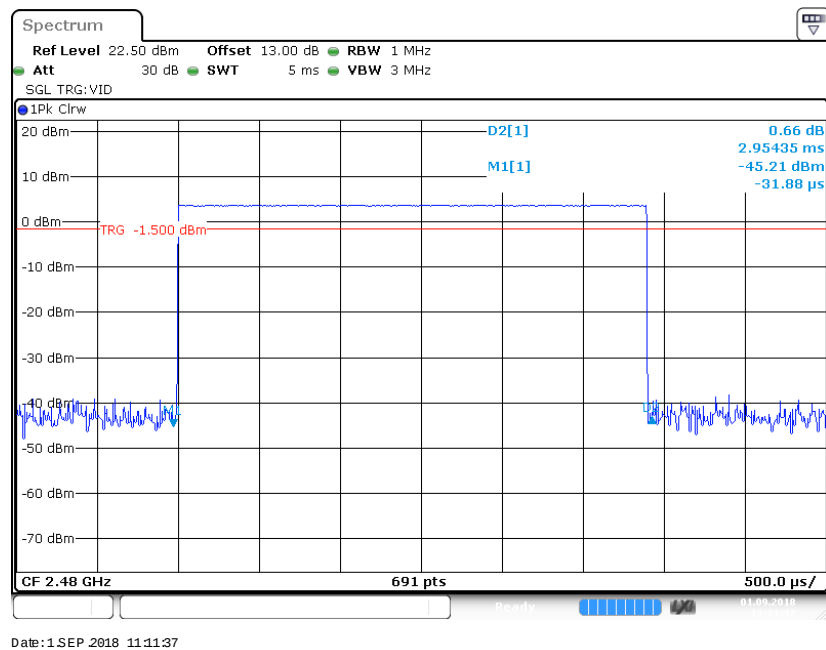
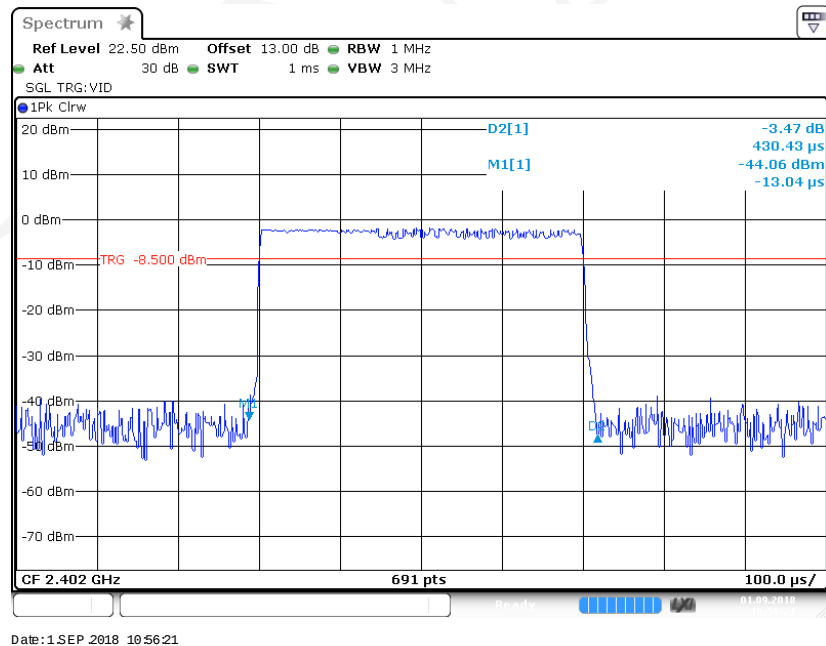


Date:1 SEP 2018 11:12:54

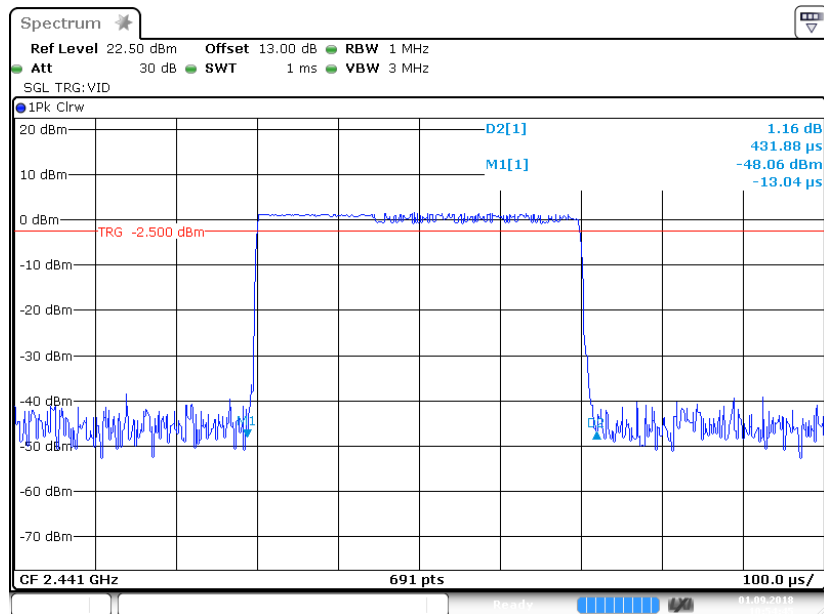
### BDR (GFSK): Pulse time, Middle Channel, DH5



Date:1 SEP 2018 11:12:14

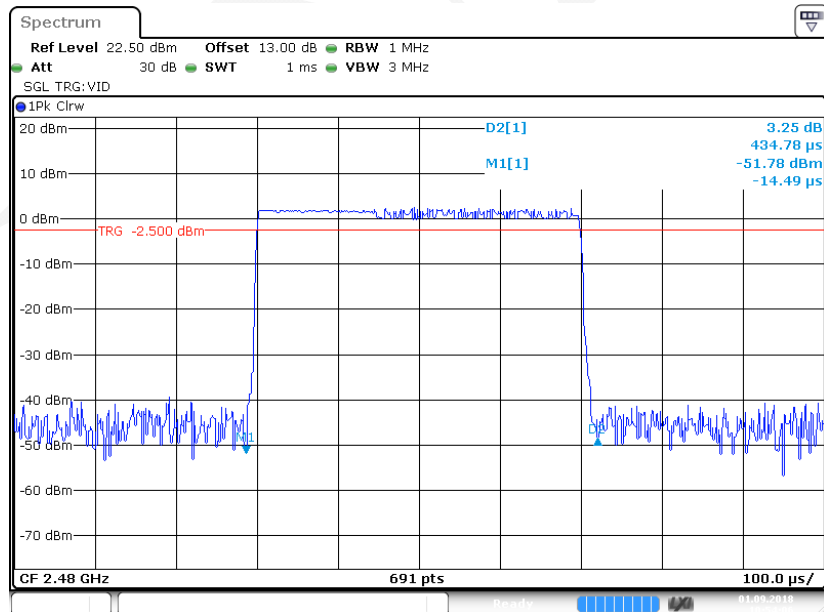
**BDR (GFSK): Pulse time, High Channel, DH5****EDR ( $\pi/4$ -DQPSK): Pulse time, Low Channel, 2DH1**

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



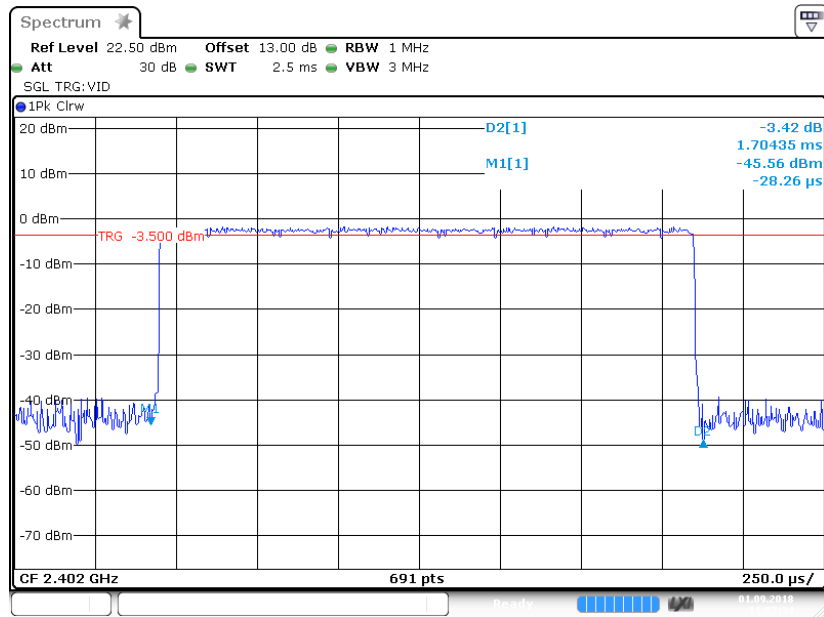
Date:1 SEP 2018 10:54:45

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



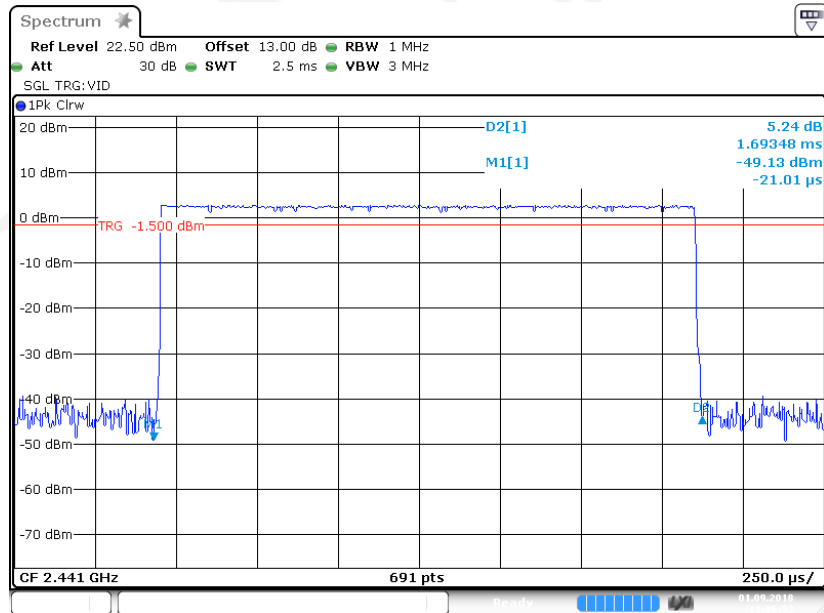
Date:1 SEP 2018 10:54:06

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



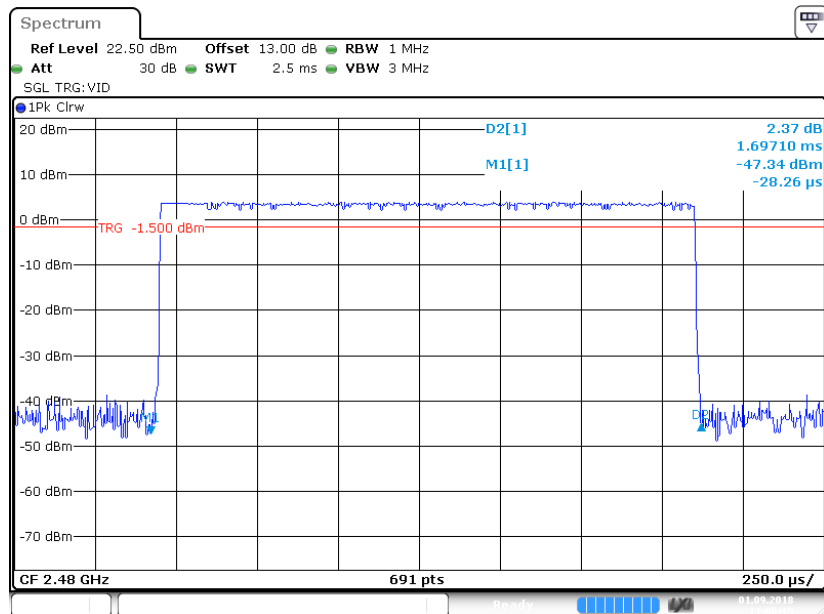
Date:1 SEP 2018 11:07:34

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



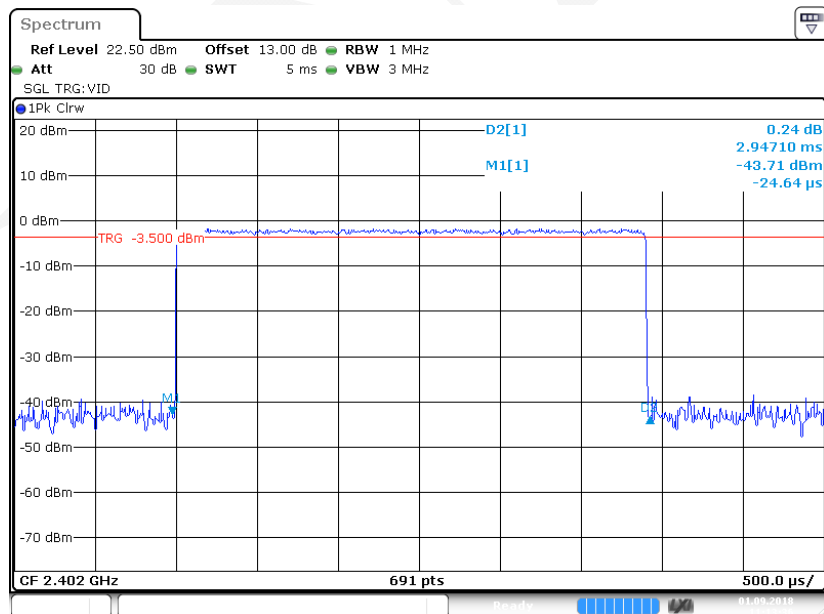
Date:1 SEP 2018 11:06:52

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



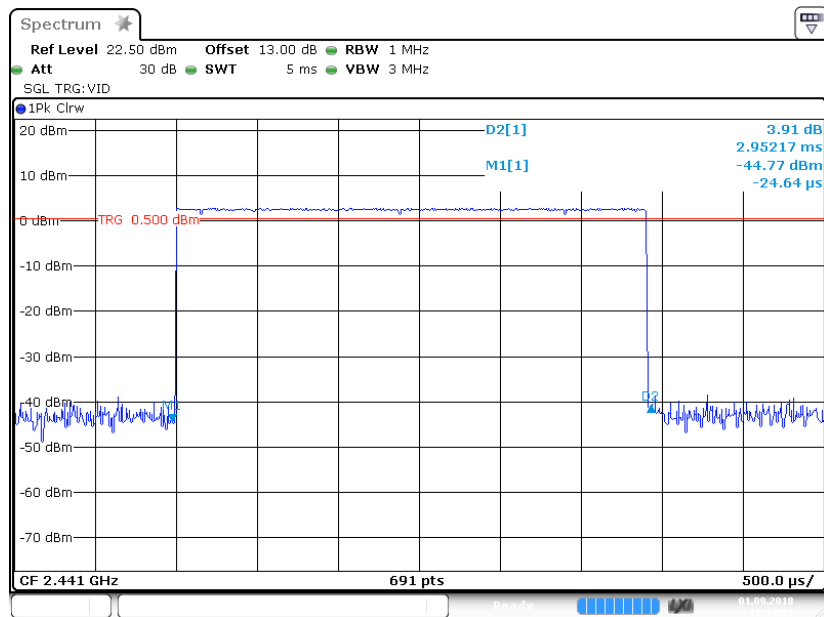
Date:1 SEP 2018 11:06:16

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

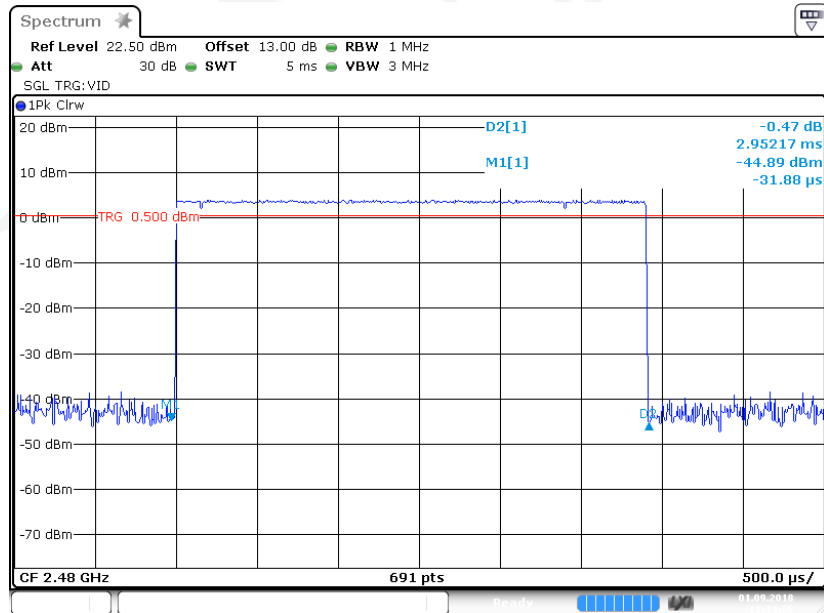


Date:1 SEP 2018 11:13:36

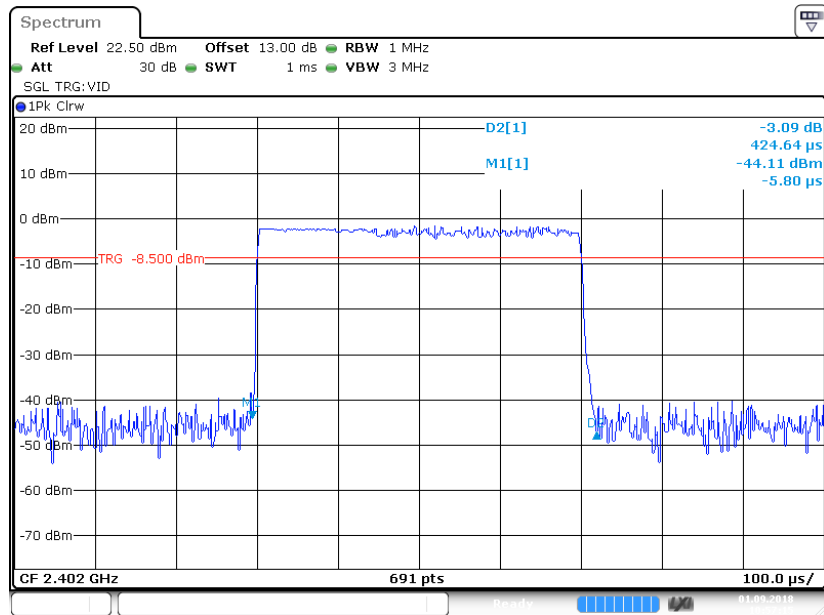
### EDR ( $\pi/4$ -DQPSK): Pulse time, Middle Channel, 2DH5



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

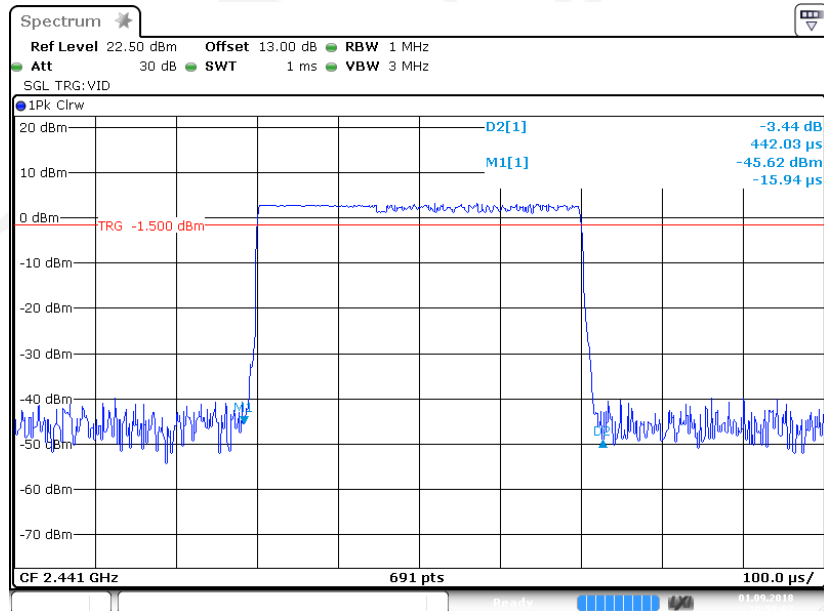


### EDR (8DPSK): Pulse time, Low Channel, 3DH1



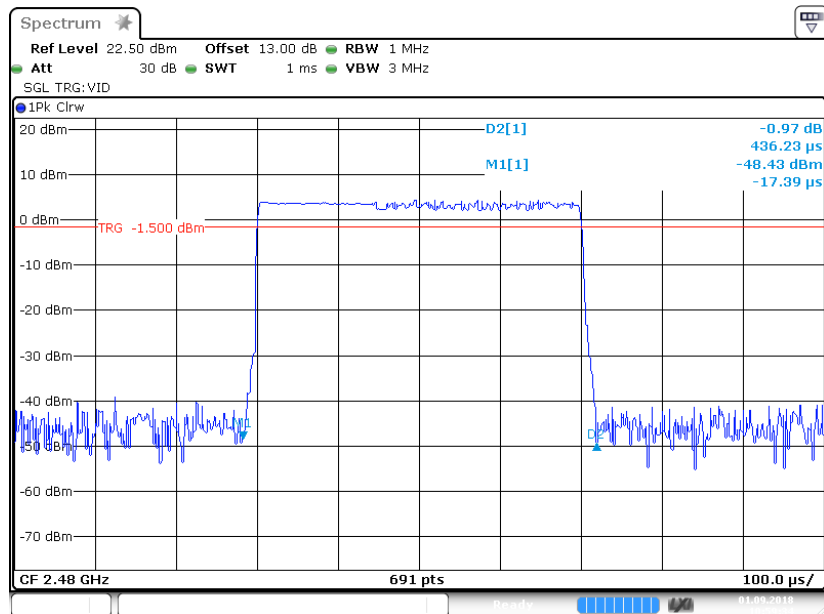
Date: 1 SEP 2018 10:57:15

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



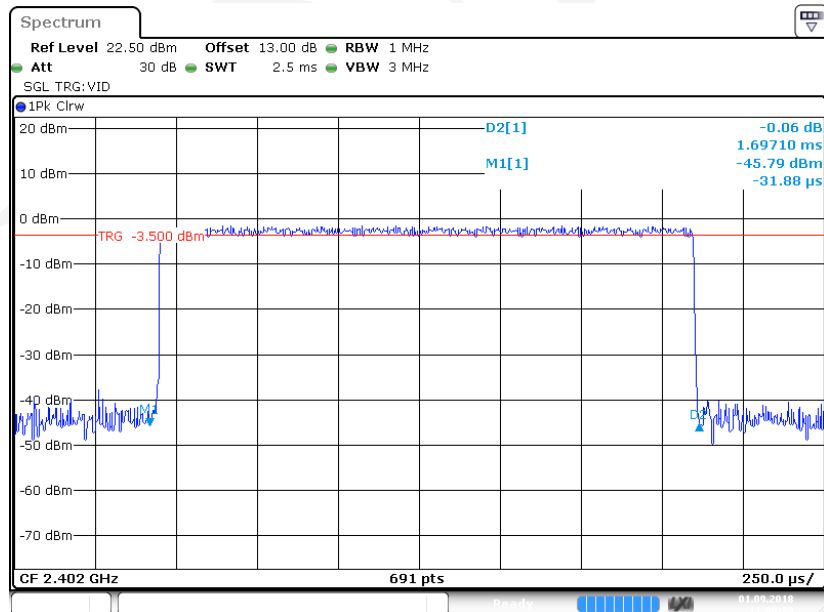
Date: 1 SEP 2018 10:59:07

### EDR (8DPSK): Pulse time, High Channel, 3DH1



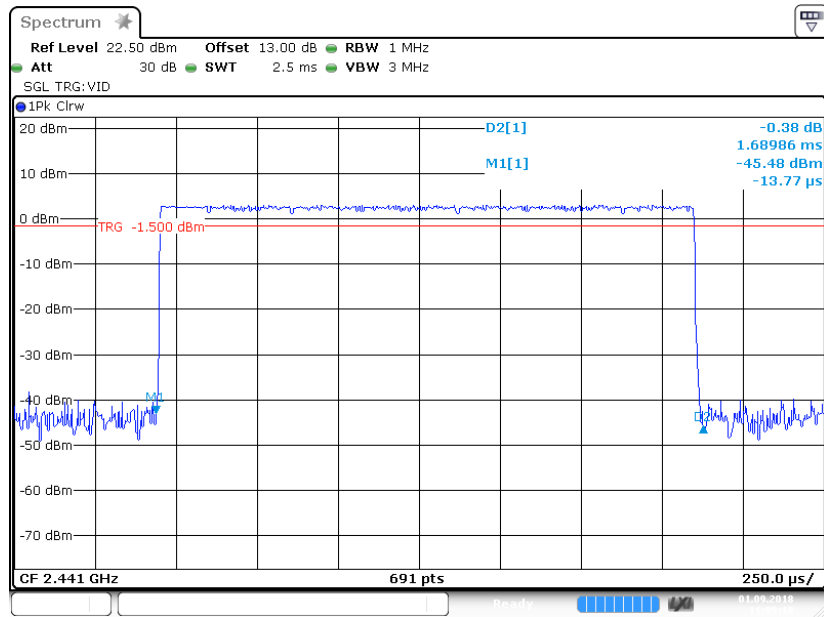
Date: 1 SEP 2018 10:59:34

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



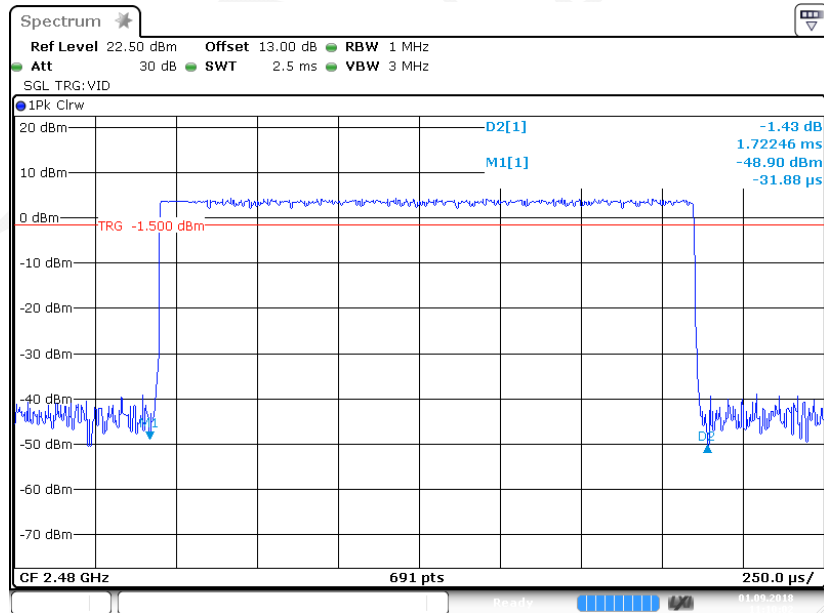
Date: 1 SEP 2018 11:08:29

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



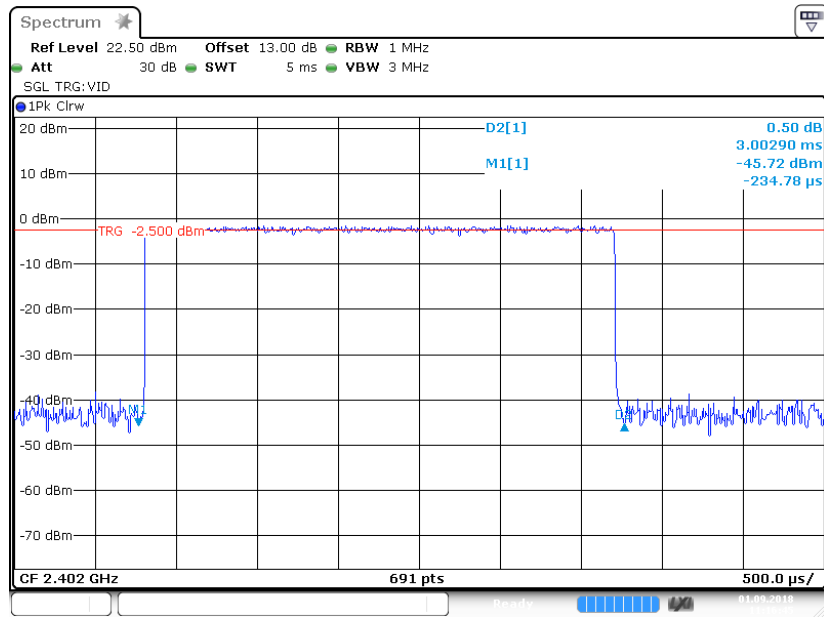
Date:1 SEP 2018 11:09:18

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



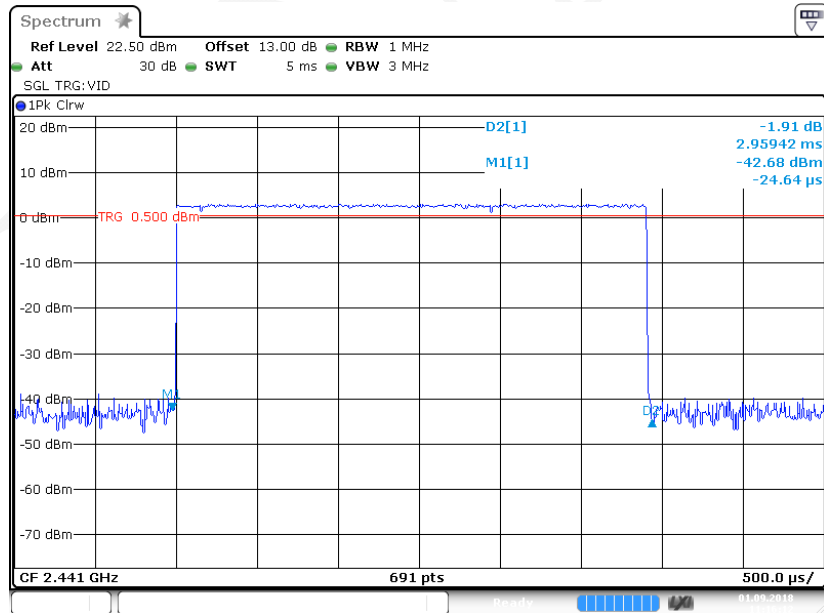
Date:1 SEP 2018 11:10:03

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



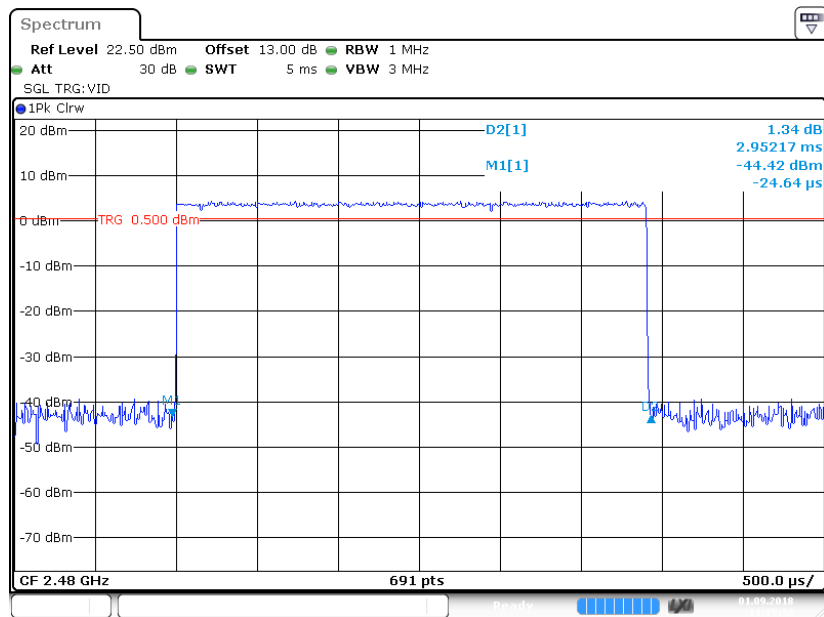
Date: 1 SEP 2018 11:16:45

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



Date: 1 SEP 2018 11:16:13

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



Date: 1 SEP 2018 11:15:32

## **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**

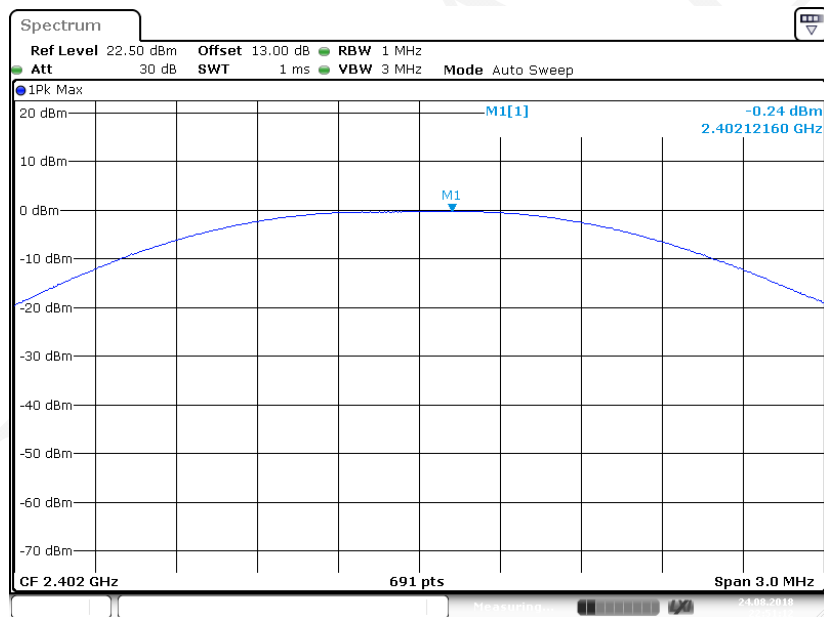
|                           |                 |
|---------------------------|-----------------|
| <b>Temperature:</b>       | 23.3-23.5 °C    |
| <b>Relative Humidity:</b> | 49-50 %         |
| <b>ATM Pressure:</b>      | 101.1-101.2 kPa |

*The testing was performed by Hope Zhang on 2018-08-24 & 2018-09-14.*

*EUT operation mode: Transmitting*

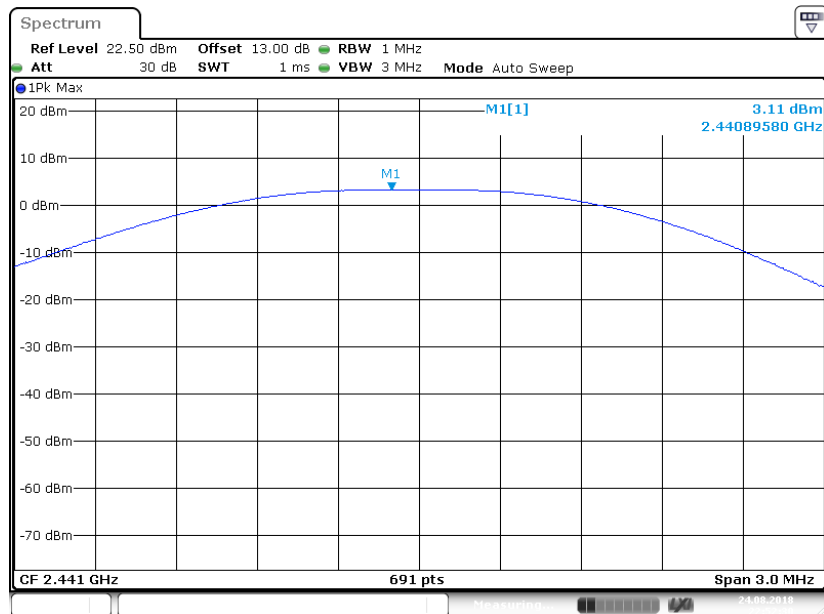
*Test Result: Compliance.*

| Mode                                  | Frequency (MHz) | Output Power |      | Limit (mW) |
|---------------------------------------|-----------------|--------------|------|------------|
|                                       |                 | (dBm)        | (mW) |            |
| <b>BDR (GFSK)</b>                     | 2402            | -0.24        | 0.95 | ≤ 1000     |
|                                       | 2441            | 3.11         | 2.05 | ≤ 1000     |
|                                       | 2480            | 4.42         | 2.77 | ≤ 1000     |
| <b>EDR (<math>\pi/4</math>-DQPSK)</b> | 2402            | -1.19        | 0.76 | ≤ 125      |
|                                       | 2441            | 2.69         | 1.86 | ≤ 125      |
|                                       | 2480            | 4.37         | 2.74 | ≤ 125      |
| <b>EDR (8DPSK)</b>                    | 2402            | -0.75        | 0.84 | ≤ 125      |
|                                       | 2441            | 2.82         | 1.91 | ≤ 125      |
|                                       | 2480            | 4.37         | 2.74 | ≤ 125      |

**BDR (GFSK): 2402MHz**

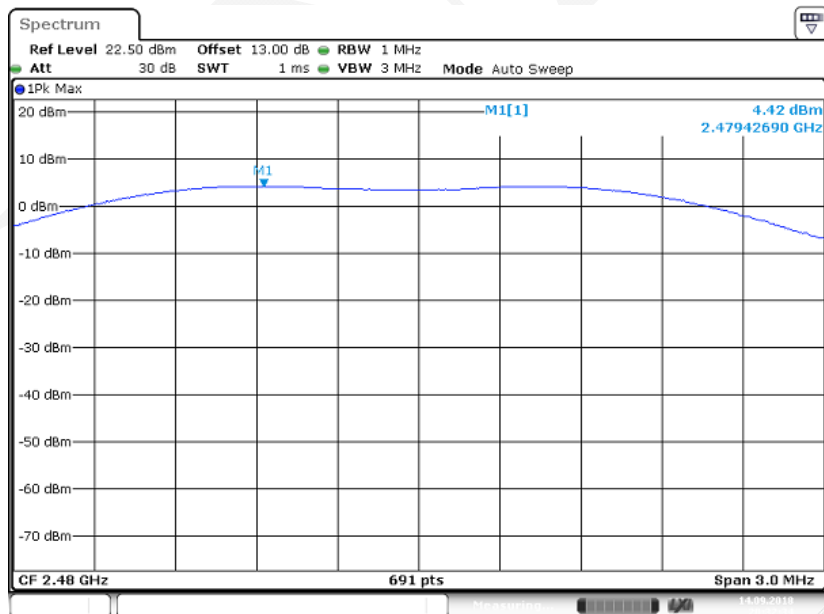
Date: 24 AUG 2018 22:51:11

### BDR (GFSK): 2441MHz



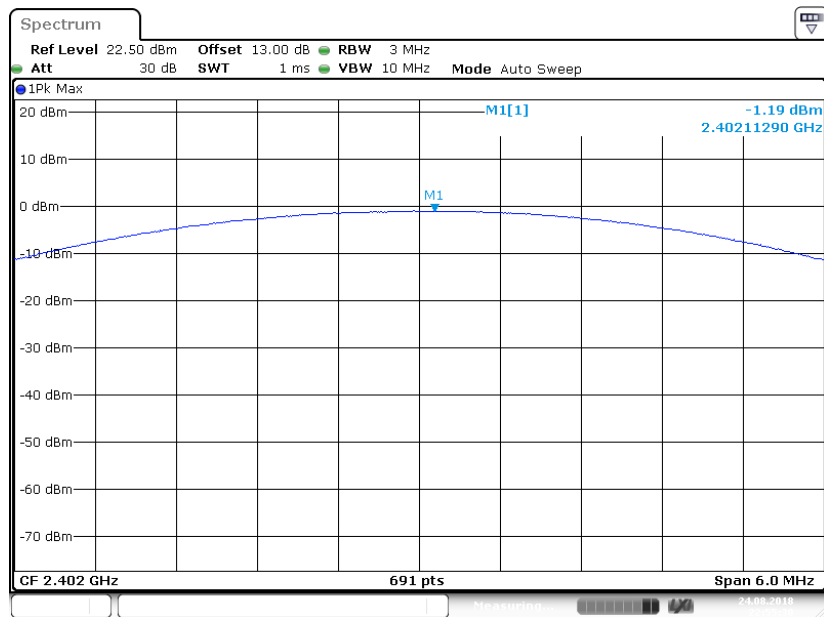
Date: 24 AUG 2018 22:52:30

### BDR (GFSK): 2480MHz



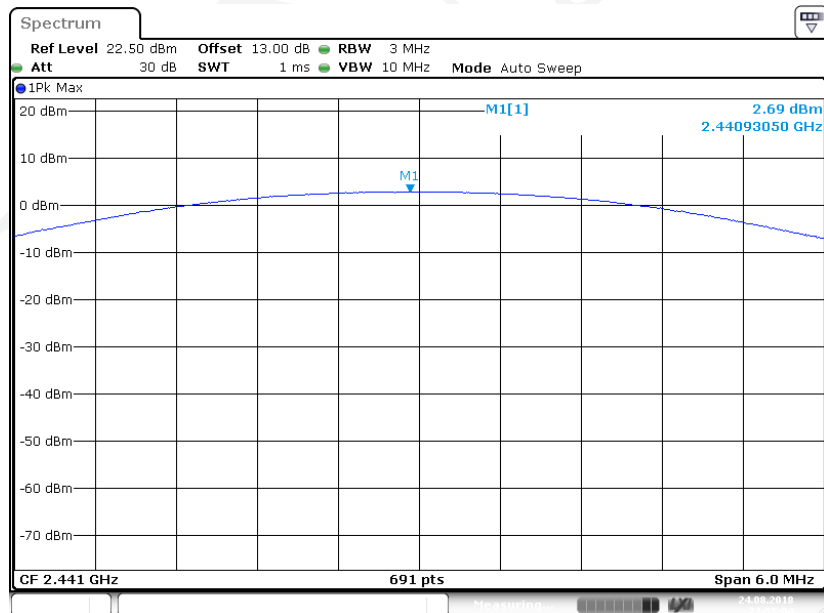
Date: 14 SEP 2018 20:22:24

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



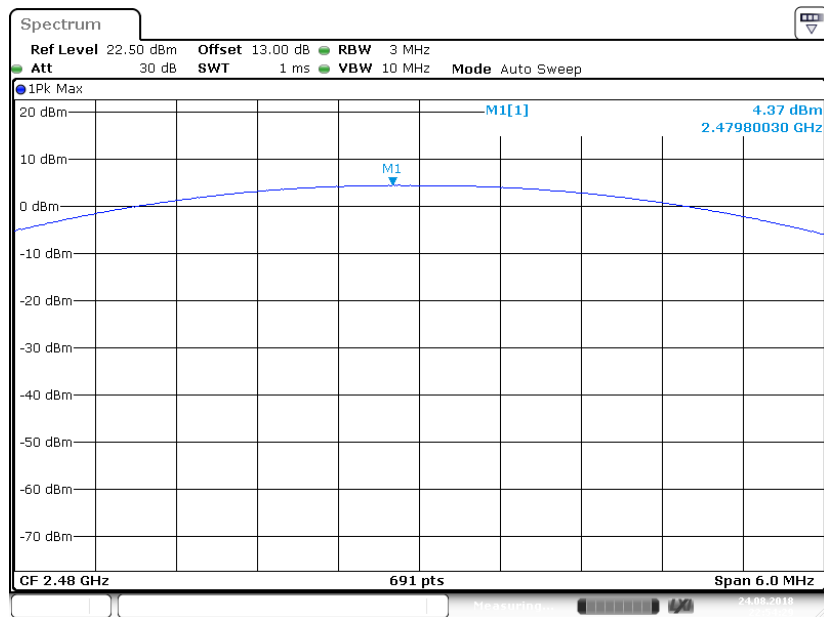
Date: 24 AUG 2018 22:55:30

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



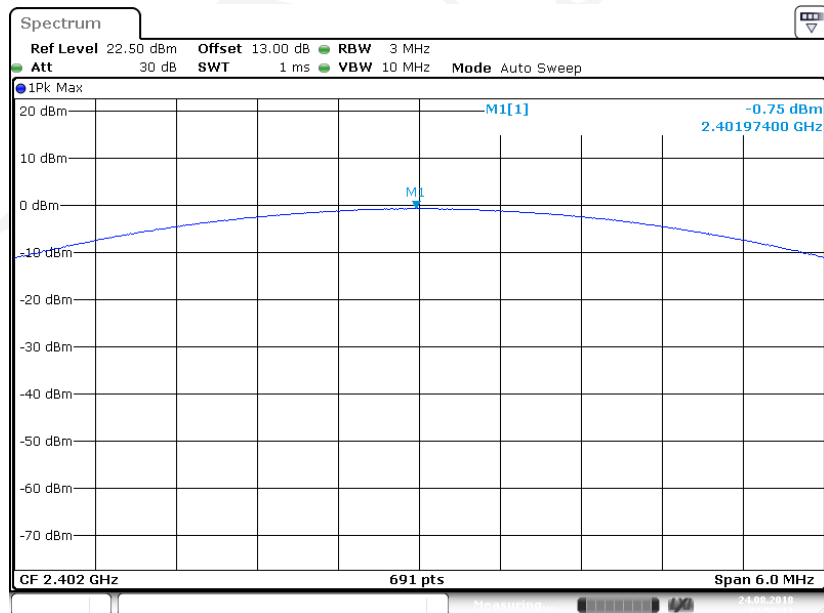
Date: 24 AUG 2018 22:55:33

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



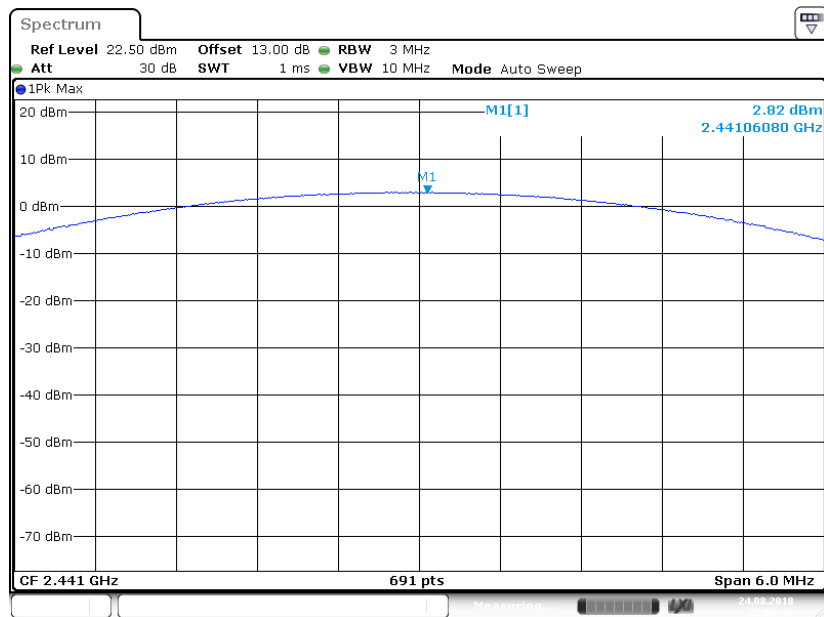
Date: 24 AUG 2018 22:54:29

**EDR(8DPSK): 2402MHz**



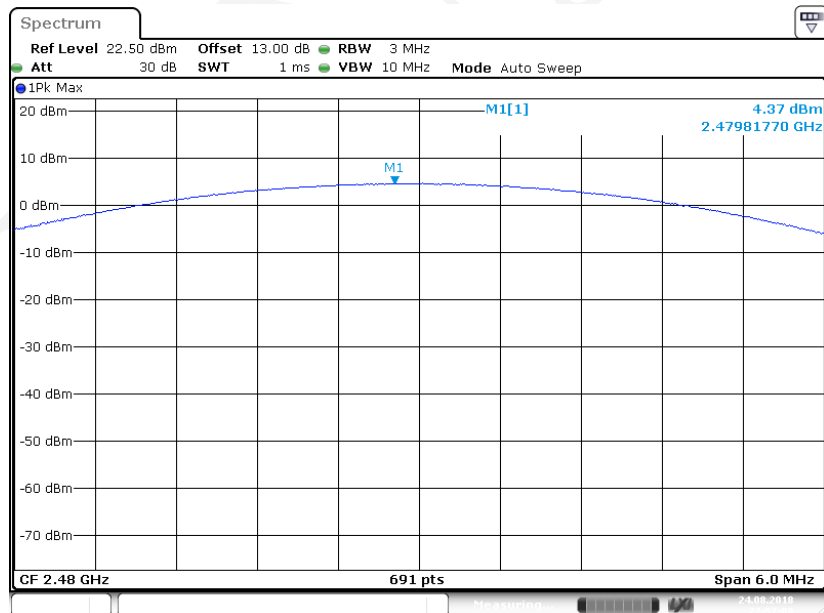
Date: 24 AUG 2018 22:56:11

### EDR(8DPSK): 2441MHz



Date: 24 AUG 2018 22:56:49

### EDR(8DPSK): 2480MHz



Date: 24 AUG 2018 22:57:09

## 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

|                    |           |
|--------------------|-----------|
| Temperature:       | 23.2 °C   |
| Relative Humidity: | 50 %      |
| ATM Pressure:      | 101.3 kPa |

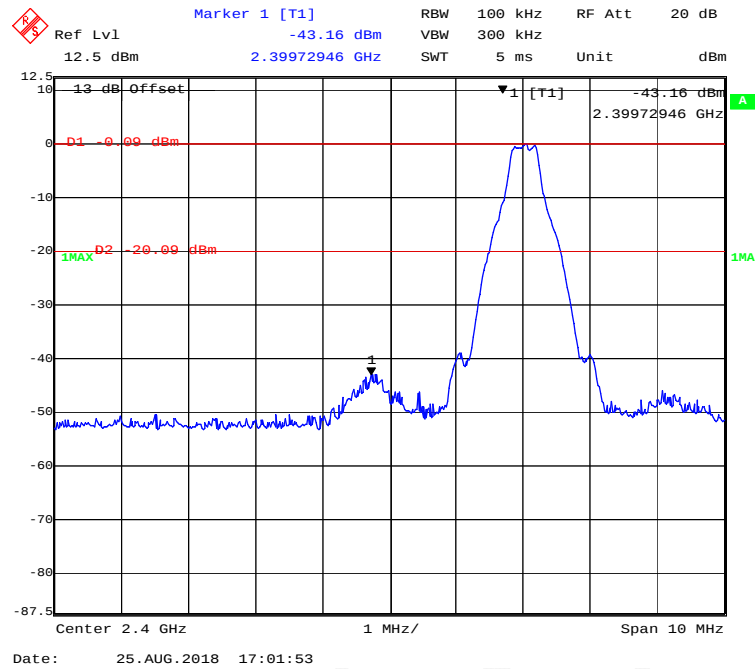
*The testing was performed by Hope Zhang on 2018-08-25.*

*EUT operation mode: Transmitting & Hopping*

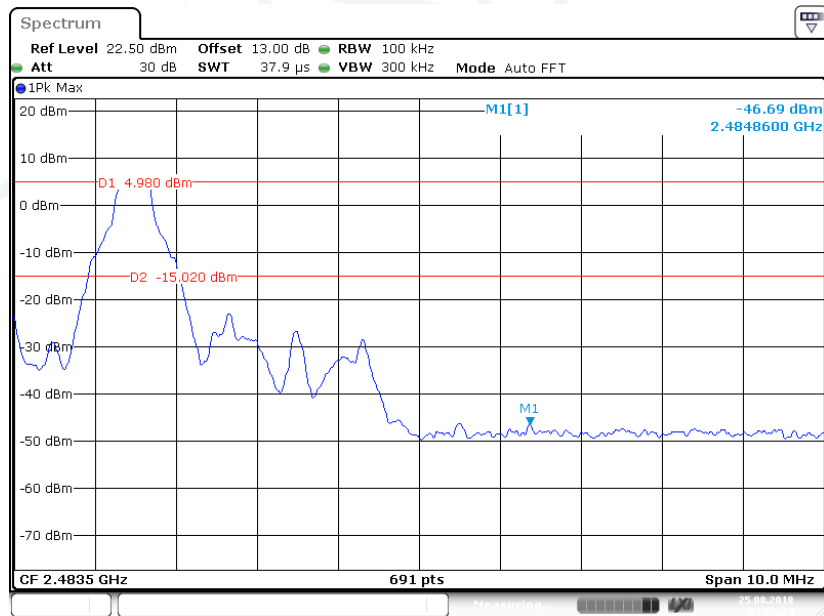
*Test Result: Compliance.*

## Band Edge

## BDR (GFSK): Left Side

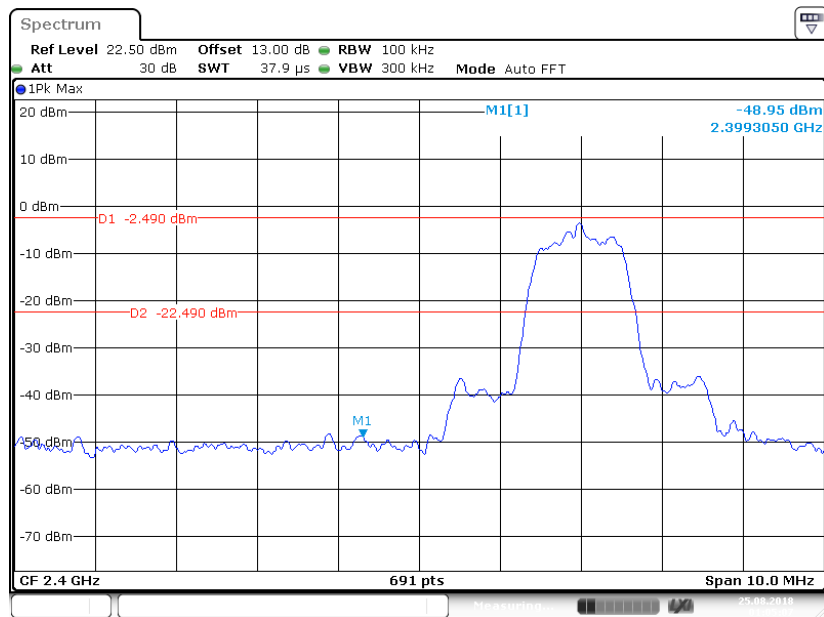


## BDR (GFSK): Right Side



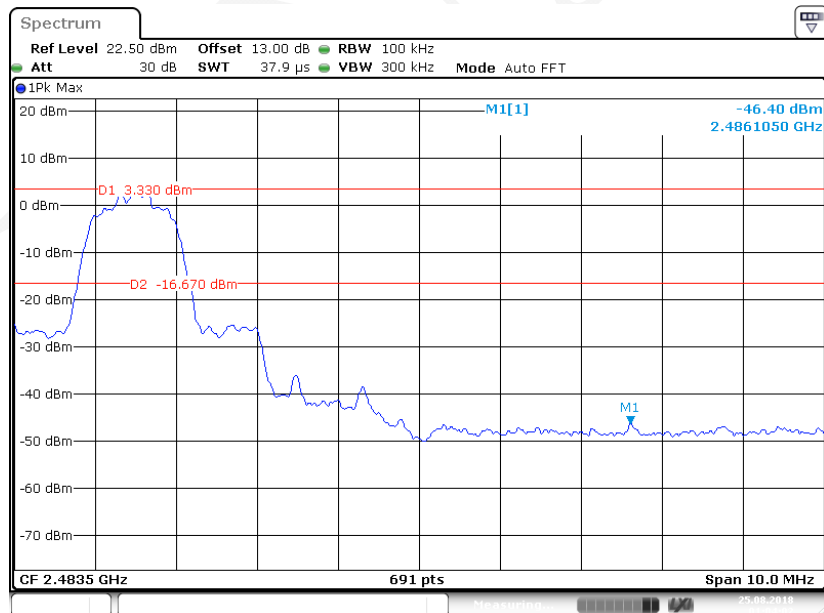
Date: 25 AUG 2018 01:02:14

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



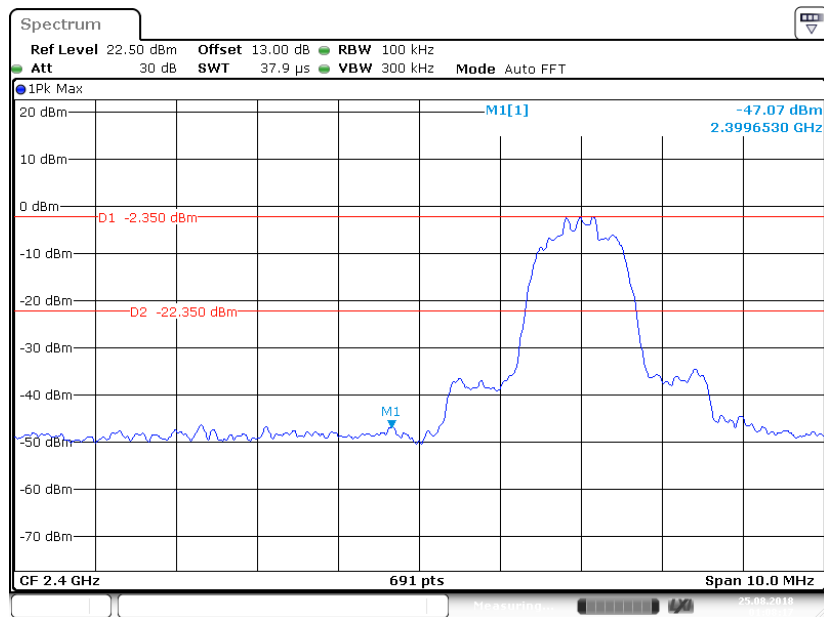
Date: 25 AUG 2018 01:05:06

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



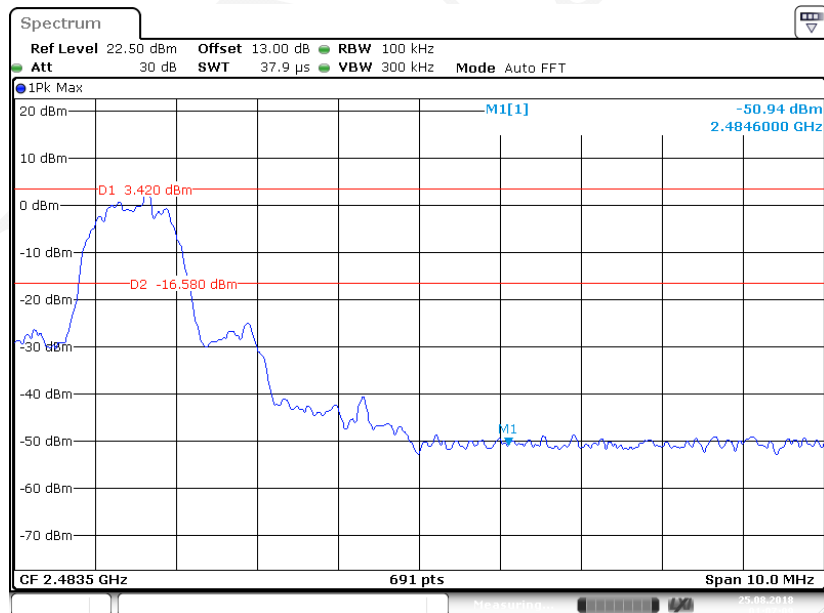
Date: 25 AUG 2018 01:04:02

### EDR (8DPSK): Left Side



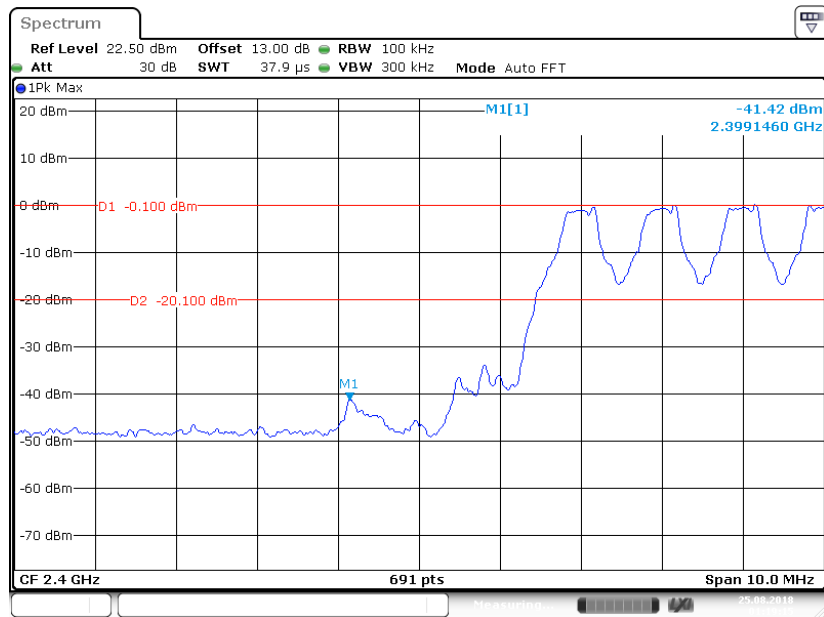
Date: 25 AUG 2018 01:08:17

### EDR (8DPSK): Right Side

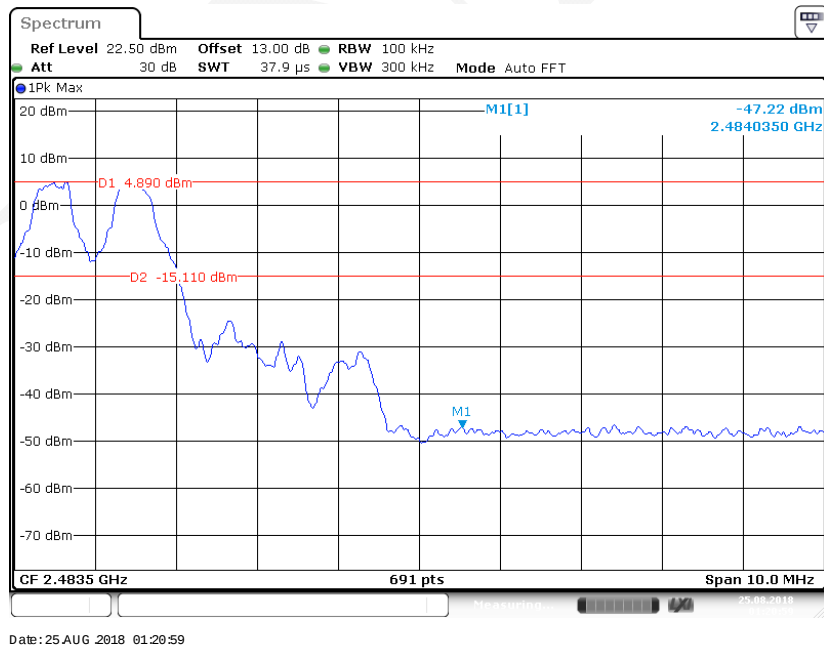


Date: 25 AUG 2018 01:07:09

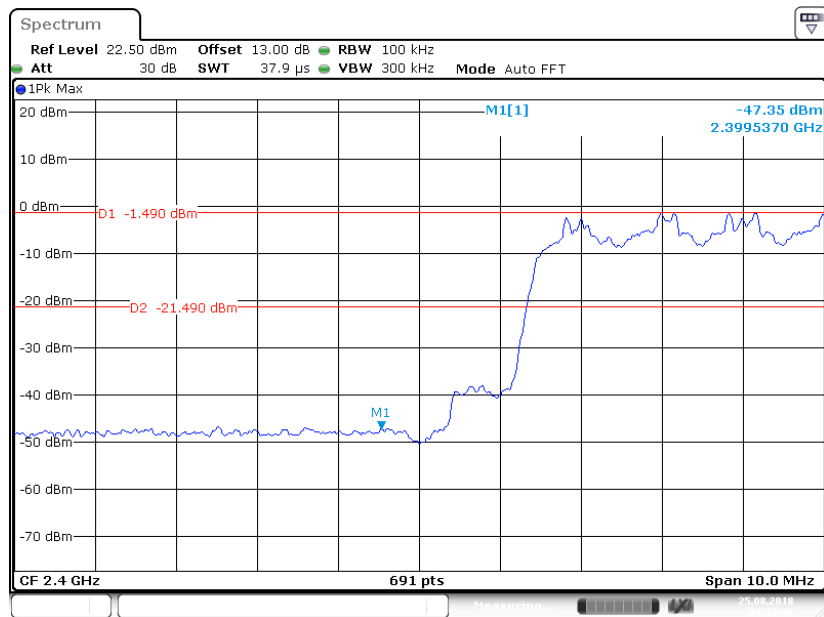
### BDR (GFSK): Left Side - Hopping



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

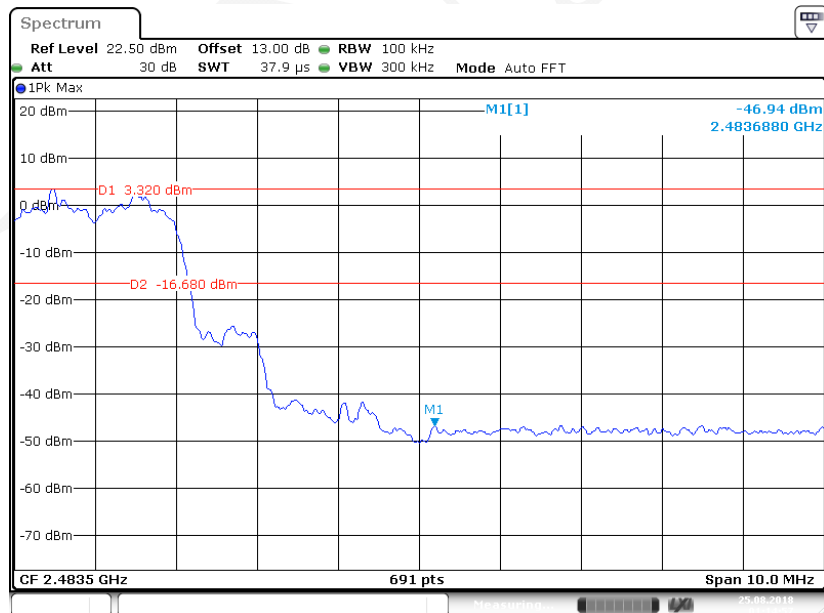


### EDR ( $\pi/4$ -DQPSK): Left Side- Hopping



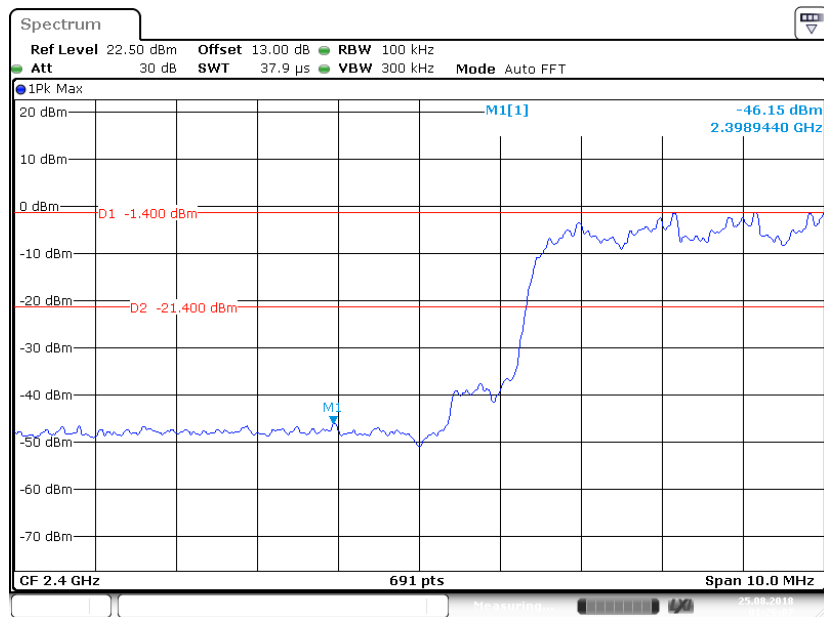
Date: 25 AUG 2018 01:17:48

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



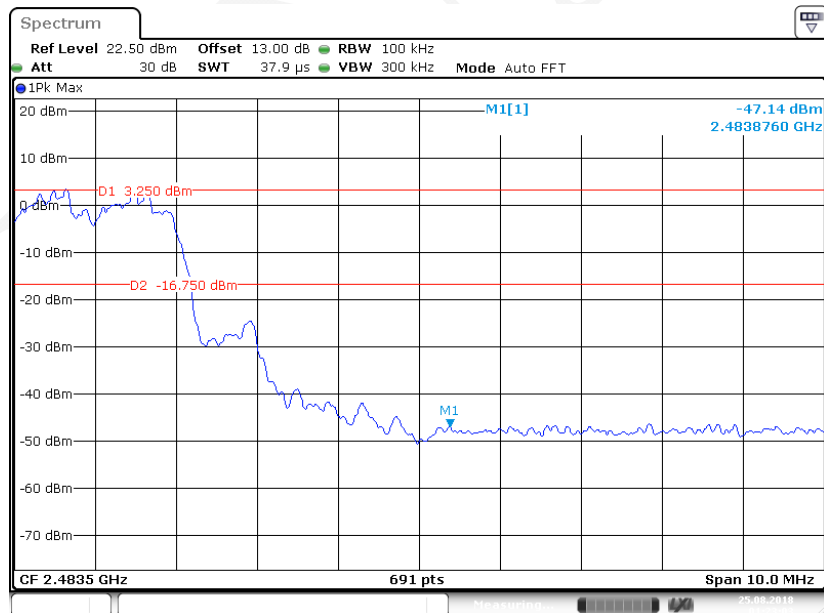
Date: 25 AUG 2018 01:14:56

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



Date: 25 AUG 2018 01:26:37

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



Date: 25 AUG 2018 01:23:34

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