TESTING LABORATORY
CERTIFICATE#4323.01

# FCC PART 15.247
# TEST REPORT

For

## DANLAW Inc

41131 Vincenti Court, Novi, Michigan, United States 48375

**FCC ID: 2AD9I-DL910**

| **Report Type:** | **Product Type:** |
|---|---|
| Original Report | PicoLogger |

| | |
|---|---|
| **Test Engineer:** | HopeDD Zhang |
| **Report Number:** | RKSA180514001-00B |
| **Report Date:** | 2018-06-06 |
| **Reviewed By:** | Oscar Ye<br>RF Leader |
| **Prepared By:** | Bay Area Compliance Laboratories Corp. (Kunshan)<br>No.248 Chenghu Road,Kunshan,Jiangsu province,China<br>Tel: +86-0512-86175000<br>Fax: +86-0512-88934268<br>www.baclcorp.com.cn |

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# GENERAL INFORMATION

## Product Description for Equipment under Test (EUT)

| | |
|---|---|
| Applicant | DANLAW Inc |
| Tested Model | DL910 |
| Product Type | PicoLogger |
| Dimension | 43mm (L)* 22 mm (W)*18 mm(H) |
| Power Supply | DC 12V |

**All measurement and test data in this report was gathered from production sample serial number: 20180514001. (Assigned by the BACL. The EUT supplied by the applicant was received on 2018-05-14)*

## Objective

This test report is prepared on behalf of *DANLAW Inc* 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, 15.209 and 15.247 rules.

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

FCC Part 15.247 DTS submission with FCC ID: 2AD9I-DL910.

## 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.

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

## Measurement Uncertainty

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

## Test Facility

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

Bay Area Compliance Laboratories Corp. (Kunshan) Lab is accredited to ISO/IEC 17025 by A2LA (Lab code: 4323.01) 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 | … | … |
| … | … | … | … |
| … | … | 77 | 2479 |
| 39 | 2441 | 78 | 2480 |

EUT was tested with Channel 0, 39 and 78.

## EUT Exercise Software

RF test tool: SecureCRT

GFSK Power level: 5
π/4-DQPSK Power level: 5
8DPSK Power level: 5

## Special Accessories

No special accessory.

## Equipment Modifications

No modification was made to the EUT tested.

## Support Equipment List and Details

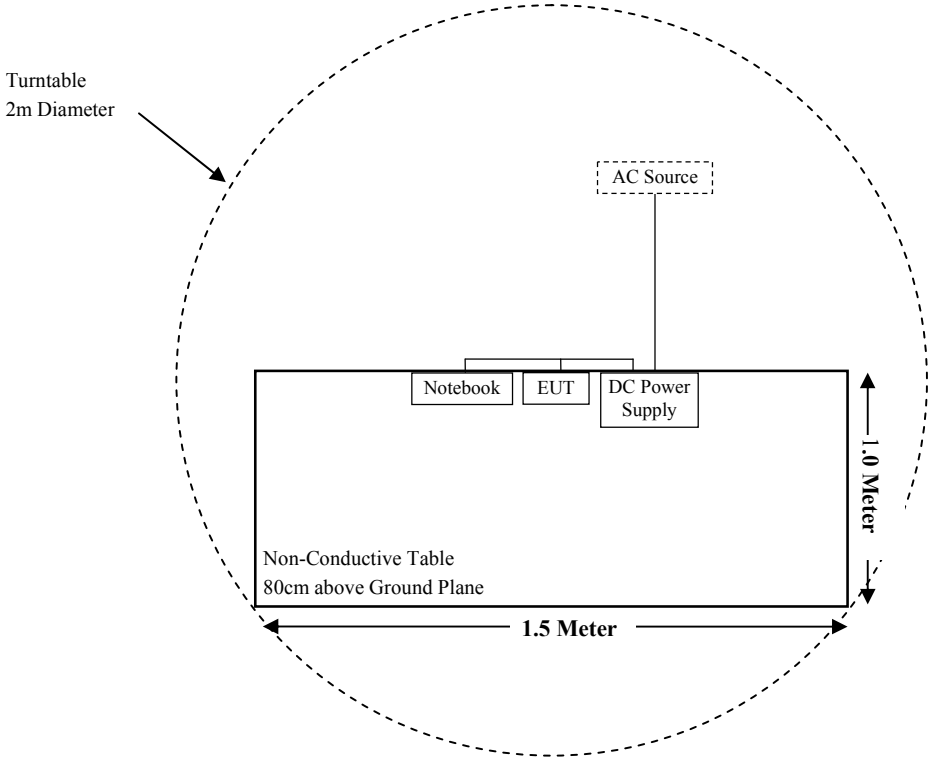
| Manufacturer | Description | Model | Serial Number |
|---|---|---|---|
| DELL | Notebook | GX620 | D65874152 |
| BEST | DC Power Supply | PS-1502D+ | / |

## External I/O Cable

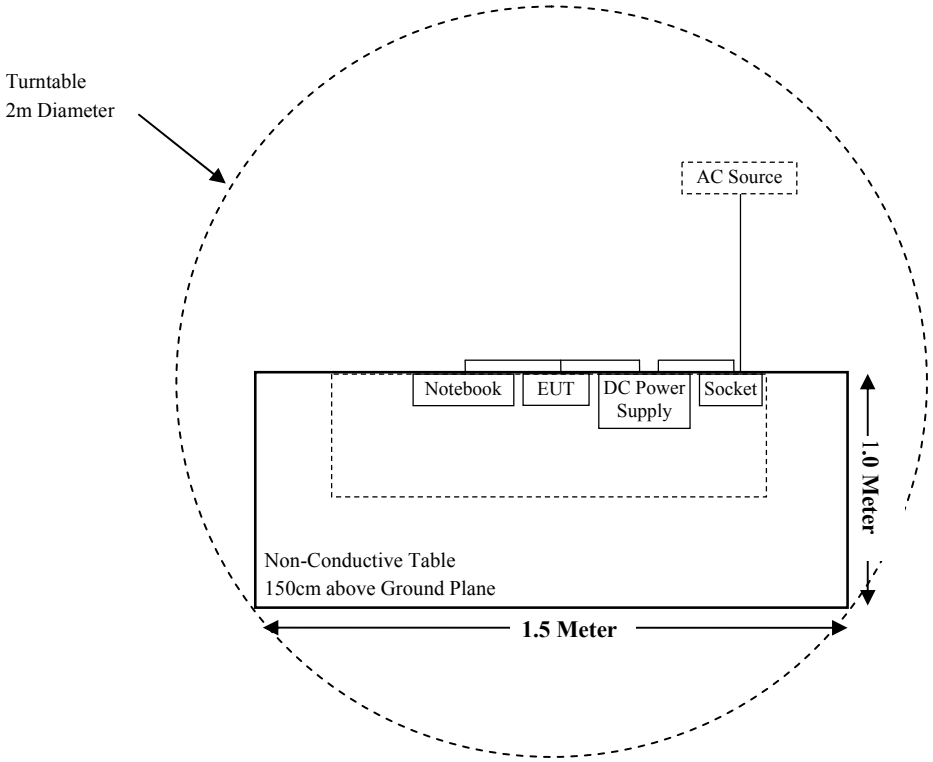
| Cable Description | Length (m) | From Port | To |
|---|---|---|---|
| Date Cable | 1.0 | EUT | Notebook |
| Power Cable | 0.8 | EUT | DC Power Supply |

## Block Diagram of Test Setup

For Radiated Emissions(Below 1GHz):



For Radiated Emissions(Above 1GHz):



# SUMMARY OF TEST RESULTS

| FCC Rules | Description of Test | Result |
|---|---|---|
| §1.1310 & §2.1091 | Maximum Permissible Exposure (MPE) | Compliant |
| §15.203 | Antenna Requirement | Compliant |
| §15.207(a) | AC Line Conducted Emissions | Not Applicable (See Note) |
| §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 |

Note: The EUT is a vehicle device.

# TEST EQUIPMENT LIST

| Manufacturer | Description | Model | Serial Number | Calibration Date | Calibration Due Date |
|---|---|---|---|---|---|
| **Radiated Emission Test（Chamber 1#）** | | | | | |
| 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 | 2017-08-15 | 2018-08-14 |
| Rohde & Schwarz | Auto test Software | EMC32 | 100361 | / | / |
| MICRO-COAX | Coaxial Cable | Cable-8 | 008 | 2017-08-15 | 2018-08-14 |
| MICRO-COAX | Coaxial Cable | Cable-9 | 009 | 2017-08-15 | 2018-08-14 |
| MICRO-COAX | Coaxial Cable | Cable-10 | 010 | 2017-08-15 | 2018-08-14 |
| BEST | DC Power Supply | PS-1502D+ | / | 2017-10-10 | 2018-10-09 |
| **Radiated Emission Test（Chamber 2#）** | | | | | |
| Rohde & Schwarz | EMI Test Receiver | ESU40 | 100207 | 2017-08-27 | 2018-08-26 |
| 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 | / | 2017-08-05 | 2018-08-04 |
| Narda | Attenuator/10dB | 10dB | / | 2017-08-15 | 2018-08-14 |
| Rohde & Schwarz | Auto test Software | EMC32 | 100361 | / | / |
| MICRO-COAX | Coaxial Cable | Cable-6 | 006 | 2017-08-15 | 2018-08-14 |
| MICRO-COAX | Coaxial Cable | Cable-11 | 011 | 2017-08-15 | 2018-08-14 |
| MICRO-COAX | Coaxial Cable | Cable-12 | 012 | 2017-08-15 | 2018-08-14 |
| MICRO-COAX | Coaxial Cable | Cable-13 | 013 | 2017-08-15 | 2018-08-14 |
| BEST | DC Power Supply | PS-1502D+ | / | 2017-10-10 | 2018-10-09 |
| **RF Conducted Test** | | | | | |
| Rohde & Schwarz | Signal Analyzer | FSIQ26 | 836131/009 | 2017-09-21 | 2018-09-20 |
| Narda | Attenuator/10dB | 10dB | / | 2017-08-15 | 2018-08-14 |
| DANLAW Inc | RF Cable | / | / | Each Time | / |

*** 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 §2.1091 and subpart §1.1310, systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.

Limits for Maximum Permissible Exposure (MPE) (§1.1310, §2.1091)

| (B) Limits for General Population/Uncontrolled Exposure | | | | |
|---|---|---|---|---|
| **Frequency Range (MHz)** | **Electric Field Strength (V/m)** | **Magnetic Field Strength (A/m)** | **Power Density ($mW/cm^2$)** | **Averaging Time (minutes)** |
| 0.3-1.34 | 614 | 1.63 | *(100) | 30 |
| 1.34-30 | 824/f | 2.19/f | *(180/f²) | 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;

According to §1.1310 and §2.1091 RF exposure is calculated.

Calculated Formulary:
Predication of MPE limit at a given distance
$S = PG/4\pi R^2$ = power density (in appropriate units, e.g. $mW/cm^2$);
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:

| **Mode** | **Frequency Range (MHz)** | **Antenna Gain** | | **Tune-up Conducted Power** | | **Evaluation Distance (cm)** | **Power Density ($mW/cm^2$)** | **MPE Limit ($mW/cm^2$)** |
|---|---|---|---|---|---|---|---|---|
| | | **(dBi)** | **(numeric)** | **(dBm)** | **(mW)** | | | |
| BT 3.0 | 2402~2480 | 0.00 | 1.00 | 1.0 | 1.26 | 20 | 0.0003 | 1.0000 |

**Note**: For the above target output power were all declared by the manufacturer.

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

# FCC §15.203 – ANTENNA REQUIREMENT

## Applicable Standard

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

## Antenna Connector Construction

The EUT has a built-in trace antenna for Bluetooth and the antenna gain is 0dBi, which was permanently attached, fulfill the requirement of this section. Please refer to the EUT photos.

**Result:** Compliance.

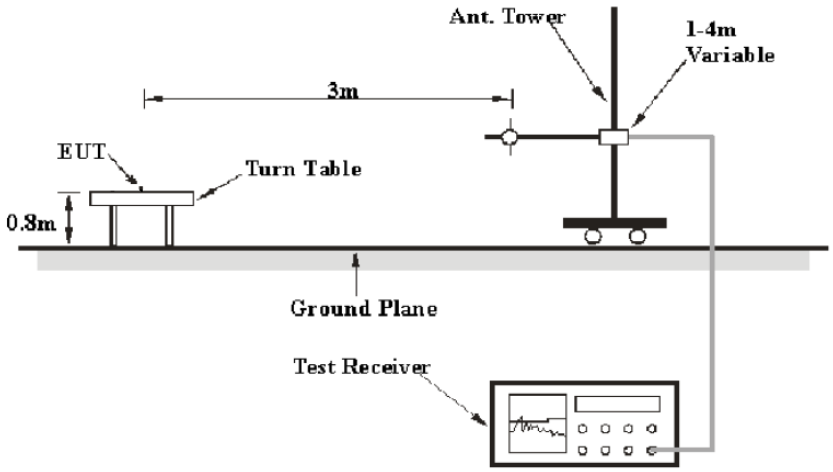
# FCC §15.205, §15.209 & §15.247(d) – RADIATED EMISSIONS

## Applicable Standard

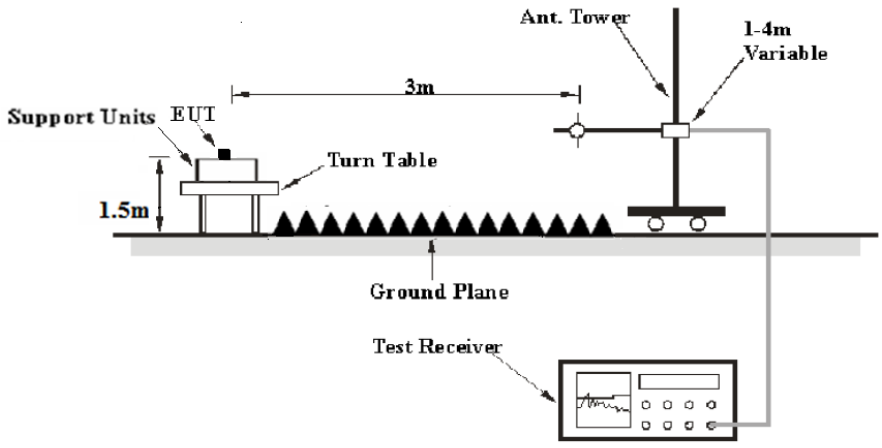
FCC §15.205; §15.209; §15.247(d)

## 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:

Corrected Amplitude = Meter Reading + Antenna Factor + Cable Loss - Amplifier Gain

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:

Margin = Limit – Corrected Amplitude

## 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:** | 23.4 ℃ |
| **Relative Humidity:** | 49 % |
| **ATM Pressure:** | 101.1 kPa |

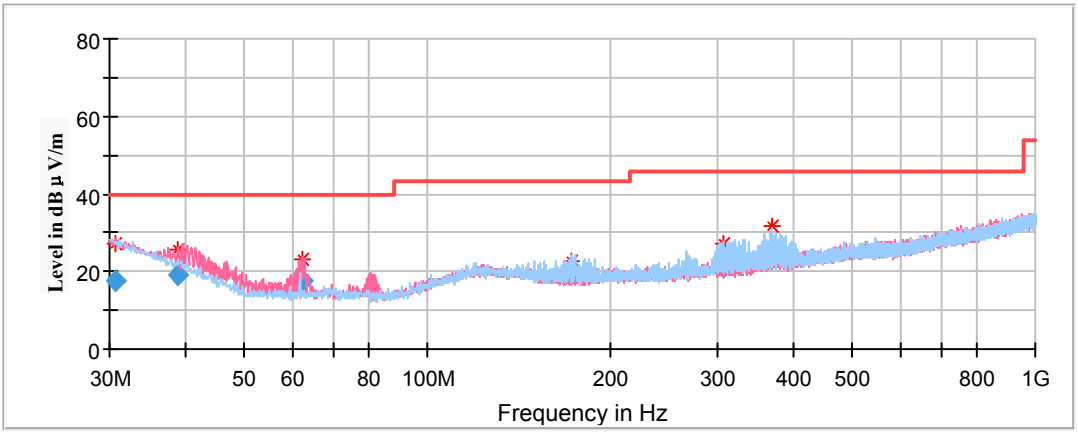
*The testing was performed by HopeDD Zhang from 2018-05-29 to 2018-06-06.*

*EUT operation mode: Transmitting*

### Spurious Emission Test:

### 30MHz-1GHz:

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



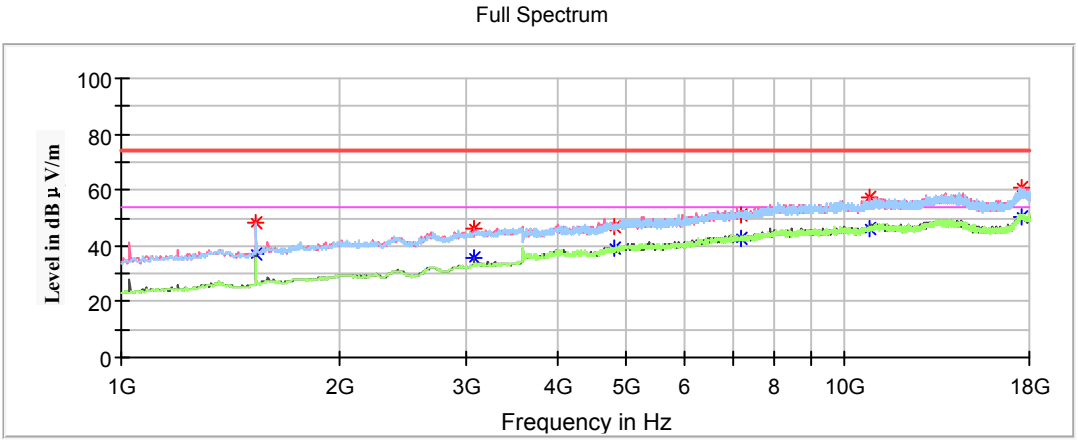

| Frequency (MHz) | Corrected Amplitude | Rx Antenna | | Turntable Degree | Corrected Factor (dB/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|
| | Quasi-peak (dBµV/m) | Height (cm) | Polar (H/V) | | | | |
| 30.631962 | 17.73 | 199.0 | V | 327.0 | -4.8 | 40.00 | 22.27 |
| 38.875550 | 19.04 | 101.0 | V | 309.0 | -10.4 | 40.00 | 20.96 |
| 62.184150 | 17.49 | 101.0 | V | 142.0 | -18.2 | 40.00 | 22.51 |
| 172.485250 | 20.48 | 199.0 | H | 269.0 | -13.8 | 43.50 | 23.02 |
| 306.782650 | 21.09 | 101.0 | H | 140.0 | -10.9 | 46.00 | 24.91 |
| 369.047250 | 24.17 | 101.0 | H | 248.0 | -9.4 | 46.00 | 21.83 |

**1GHz-18GHz:**

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

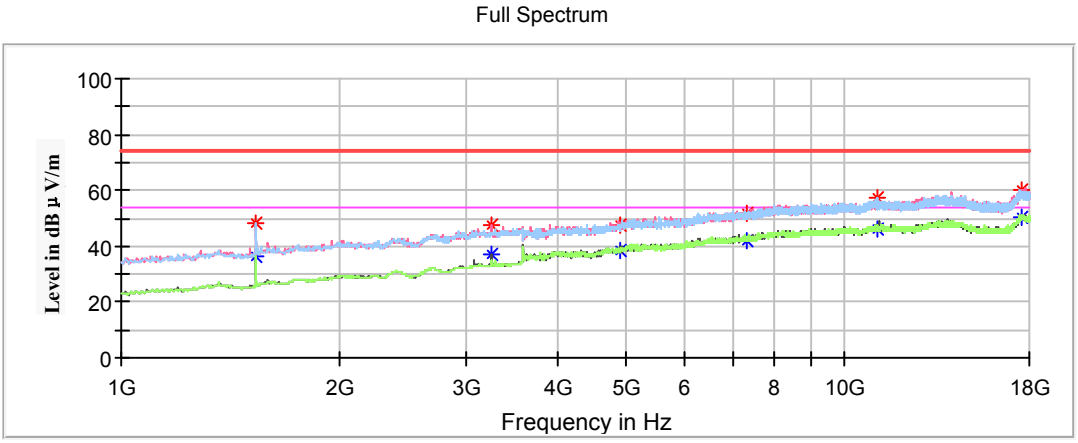
Note:
1. This test was performed with the 2.4-2.5GHz notch filter.
2. Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor
   Corrected Amplitude = Corrected Factor + Reading
   Margin = Limit - Corrected. Amplitude

**Low Channel: 2402MHz**



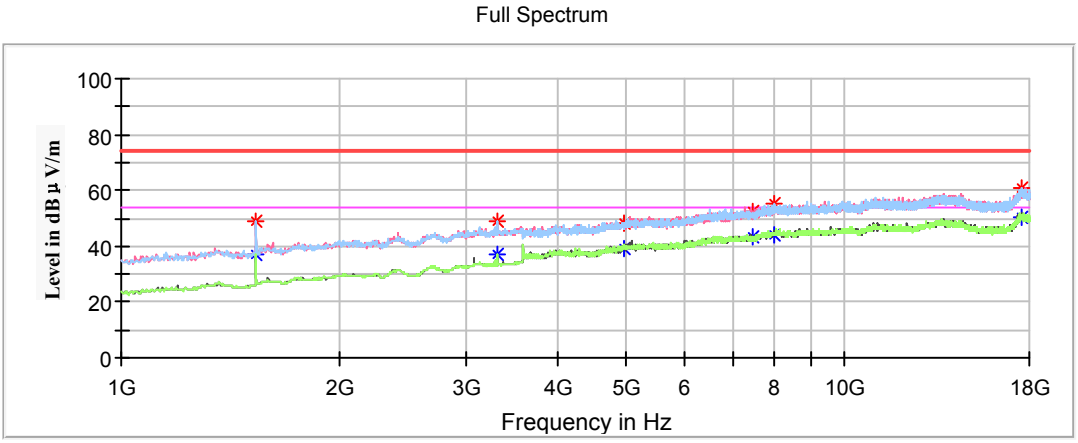

| Frequency (MHz) | Corrected Amplitude | | Rx Antenna | | Turntable Degree | Corrected Factor (dB/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| | MaxPeak (dBµV /m) | Average (dBµV /m) | Height (cm) | Polar (H/V) | | | | |
| 1533.800000 | --- | 36.89 | 150.0 | V | 209.0 | -1.0 | 54.00 | 17.11 |
| 1533.800000 | 48.59 | --- | 150.0 | V | 209.0 | -1.0 | 74.00 | 25.41 |
| 3070.600000 | --- | 35.80 | 200.0 | V | 88.0 | 6.2 | 54.00 | 18.20 |
| 3070.600000 | 46.42 | --- | 200.0 | V | 88.0 | 6.2 | 74.00 | 27.58 |
| 4804.000000 | --- | 39.00 | 200.0 | H | 81.0 | 10.7 | 54.00 | 15.00 |
| 4804.000000 | 47.13 | --- | 200.0 | H | 81.0 | 10.7 | 74.00 | 26.87 |
| 7206.000000 | --- | 42.44 | 150.0 | H | 288.0 | 15.2 | 54.00 | 11.56 |
| 7206.000000 | 50.82 | --- | 150.0 | H | 288.0 | 15.2 | 74.00 | 23.18 |
| 10802.200000 | --- | 45.85 | 200.0 | V | 320.0 | 19.0 | 54.00 | 8.15 |
| 10802.200000 | 57.28 | --- | 200.0 | V | 320.0 | 19.0 | 74.00 | 16.72 |
| 17592.000000 | --- | 50.53 | 150.0 | V | 347.0 | 23.0 | 54.00 | 3.47 |
| 17592.000000 | 60.82 | --- | 150.0 | V | 347.0 | 23.0 | 74.00 | 13.18 |

**Middle Channel: 2441MHz**




| 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) | | | | |
| 1533.800000 | --- | 36.25 | 200.0 | H | 194.0 | -1.0 | 54.00 | 17.75 |
| 1533.800000 | 48.23 | --- | 200.0 | H | 194.0 | -1.0 | 74.00 | 25.77 |
| 3254.200000 | --- | 37.33 | 200.0 | V | 182.0 | 6.7 | 54.00 | 16.67 |
| 3254.200000 | 47.69 | --- | 200.0 | V | 182.0 | 6.7 | 74.00 | 26.31 |
| 4882.000000 | --- | 38.33 | 200.0 | H | 118.0 | 11.1 | 54.00 | 15.67 |
| 4882.000000 | 47.35 | --- | 150.0 | H | 118.0 | 11.1 | 74.00 | 26.65 |
| 7323.000000 | --- | 42.24 | 150.0 | H | 63.0 | 15.4 | 54.00 | 11.76 |
| 7323.000000 | 51.92 | --- | 150.0 | H | 63.0 | 15.4 | 74.00 | 22.08 |
| 11074.200000 | --- | 46.13 | 150.0 | H | 178.0 | 19.6 | 54.00 | 7.87 |
| 11074.200000 | 57.22 | --- | 200.0 | H | 178.0 | 19.6 | 74.00 | 16.78 |
| 17527.400000 | --- | 50.05 | 200.0 | V | 0.0 | 23.1 | 54.00 | 3.95 |
| 17527.400000 | 60.00 | --- | 200.0 | V | 0.0 | 23.1 | 74.00 | 14.00 |

**High Channel: 2480MHz**

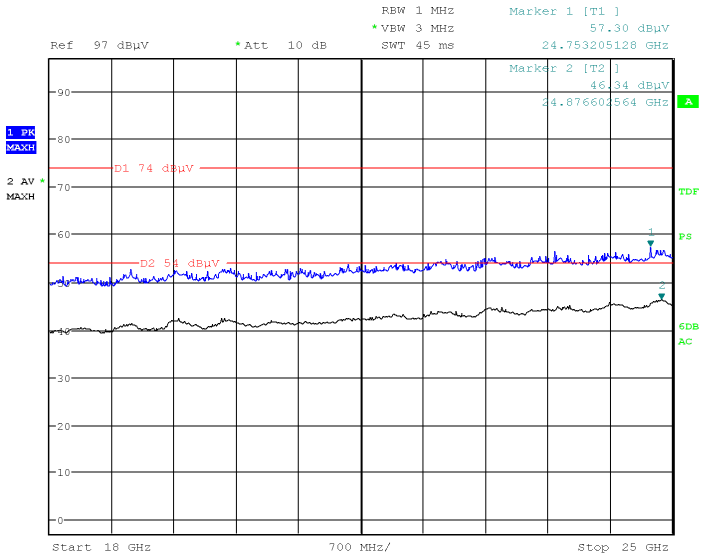



| Frequency (MHz) | Corrected Amplitude | | Rx Antenna | | Turntable Degree | Corrected Factor (dB/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| | MaxPeak (dBµV /m) | Average (dBµV /m) | Height (cm) | Polar (H/V) | | | | |
| 1533.800000 | --- | 37.28 | 200.0 | H | 177.0 | -1.0 | 54.00 | 16.72 |
| 1533.800000 | 49.17 | --- | 200.0 | H | 177.0 | -1.0 | 74.00 | 24.83 |
| 3305.200000 | --- | 36.95 | 100.0 | H | 129.0 | 6.8 | 54.00 | 17.05 |
| 3305.200000 | 48.63 | --- | 100.0 | H | 129.0 | 6.8 | 74.00 | 25.37 |
| 4960.000000 | --- | 39.03 | 200.0 | H | 131.0 | 11.5 | 54.00 | 14.97 |
| 4960.000000 | 48.46 | --- | 200.0 | H | 131.0 | 11.5 | 74.00 | 25.54 |
| 7440.000000 | --- | 43.01 | 150.0 | H | 102.0 | 15.6 | 54.00 | 10.99 |
| 7440.000000 | 52.26 | --- | 150.0 | H | 102.0 | 15.6 | 74.00 | 21.74 |
| 8010.800000 | --- | 44.25 | 200.0 | V | 177.0 | 17.1 | 54.00 | 9.75 |
| 8010.800000 | 55.25 | --- | 200.0 | V | 177.0 | 17.1 | 74.00 | 18.75 |
| 17609.000000 | --- | 50.53 | 150.0 | H | 2.0 | 23.0 | 54.00 | 3.47 |
| 17609.000000 | 60.61 | --- | 150.0 | H | 2.0 | 23.0 | 74.00 | 13.39 |

**18GHz-25GHz:**

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

**Horizontal**

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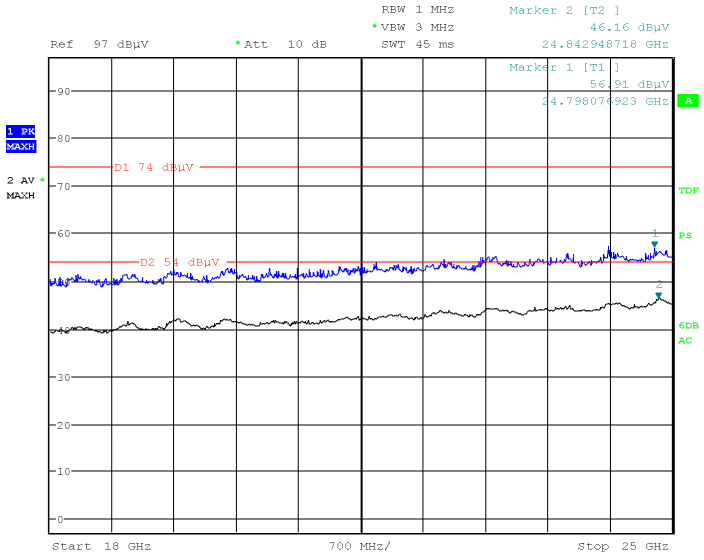
**Vertical**

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**Fundamental Test & Restricted Bands Emissions:**

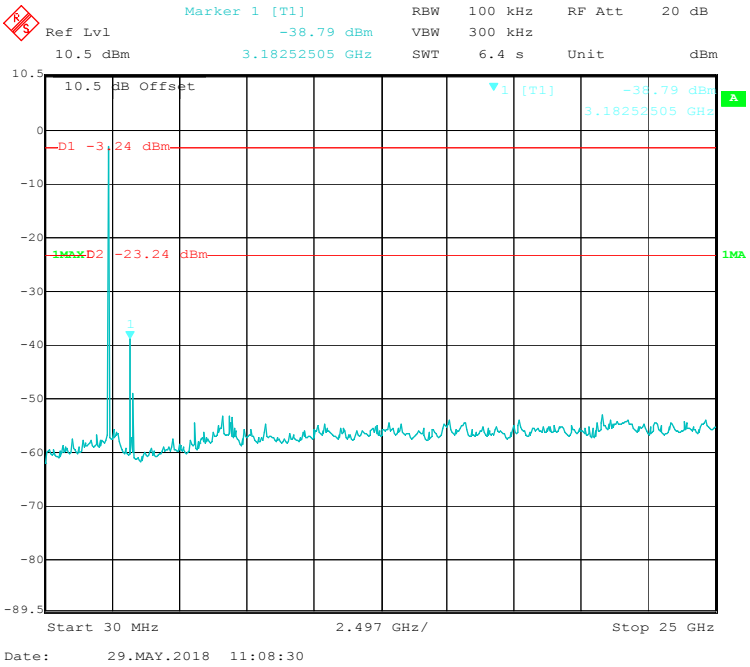
*Pre-Scan with GFSK, π/4-DQPSK, 8DPSK modes of operation in the X,Y and Z axes of orientation, the worst case* ***π/4-DQPSK Mode in X-axis of orientation*** *was recorded*

Note:
1. Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor
   Corrected Amplitude = Corrected Factor + Reading
   Margin = Limit - Corrected. Amplitude

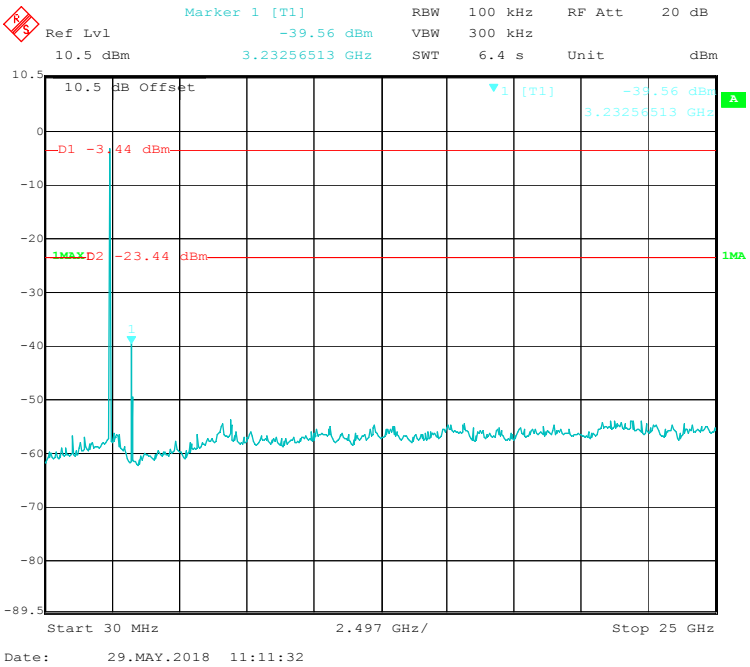
| Frequency (MHz) | Corrected Amplitude | | Rx Antenna | | Turntable Degree | Corrected Factor (dB/m) | Limit (dBμV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| | MaxPeak (dBμV /m) | Average (dBμV /m) | Height (cm) | Polar (H/V) | | | | |
| Low Channel: 2402MHz | | | | | | | | |
| 2402.000000 | --- | 90.35 | 100.0 | H | 206.0 | 5.1 | / | / |
| 2402.000000 | 91.40 | --- | 100.0 | H | 206.0 | 5.1 | / | / |
| 2402.000000 | --- | 88.49 | 250.0 | V | 211.0 | 5.1 | / | / |
| 2402.000000 | 89.52 | --- | 250.0 | V | 211.0 | 5.1 | / | / |
| 2390.000000 | 52.16 | --- | 200.0 | H | 165.0 | 5.1 | 74.00 | 21.84 |
| 2390.000000 | --- | 43.28 | 200.0 | H | 165.0 | 5.1 | 54.00 | 10.72 |
| Middle Channel: 2441MHz | | | | | | | | |
| 2441.000000 | 92.22 | --- | 200.0 | H | 248.0 | 5.2 | / | / |
| 2441.000000 | --- | 91.18 | 200.0 | H | 248.0 | 5.2 | / | / |
| 2441.000000 | 90.32 | --- | 100.0 | V | 112.0 | 5.2 | / | / |
| 2441.000000 | --- | 89.33 | 100.0 | V | 112.0 | 5.2 | / | / |
| High Channel: 2480MHz | | | | | | | | |
| 2480.000000 | 92.59 | --- | 200.0 | H | 69.0 | 5.3 | / | / |
| 2480.000000 | --- | 91.46 | 200.0 | H | 69.0 | 5.3 | / | / |
| 2480.000000 | 90.70 | --- | 250.0 | V | 158.0 | 5.3 | / | / |
| 2480.000000 | --- | 89.55 | 250.0 | V | 158.0 | 5.3 | / | / |
| 2483.500000 | --- | 45.37 | 100.0 | H | 178.0 | 5.3 | 54.00 | 8.63 |
| 2483.500000 | 54.22 | --- | 100.0 | H | 178.0 | 5.3 | 74.00 | 19.78 |

## Conducted Spurious Emissions at Antenna Port

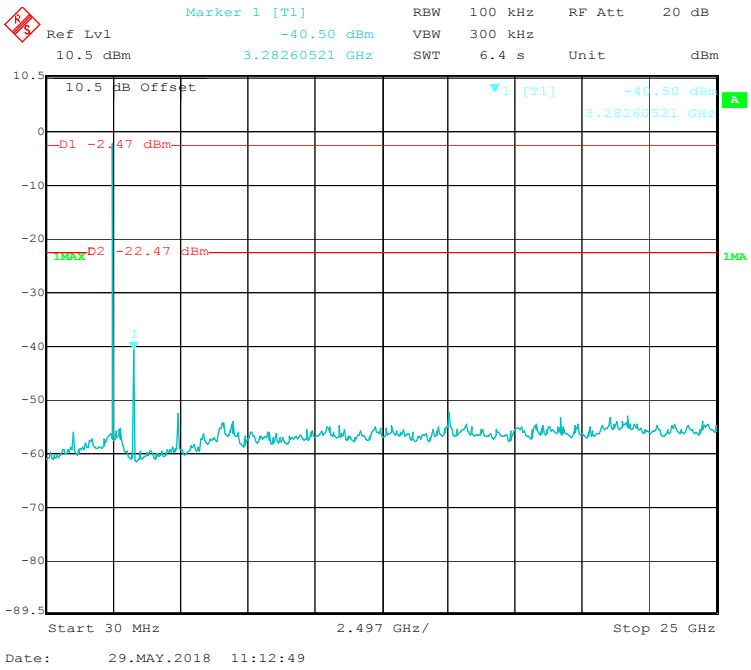
### BDR (GFSK): Low Channel



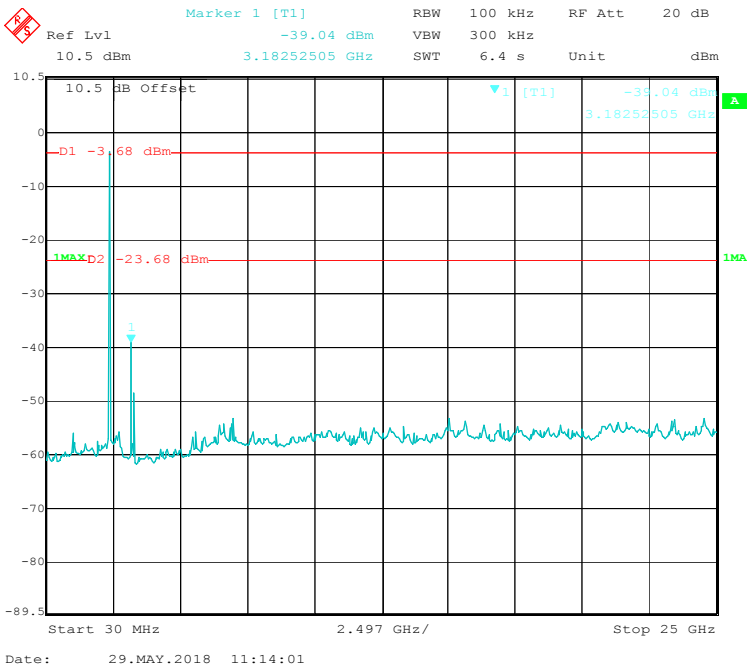

### BDR (GFSK): Middle Channel



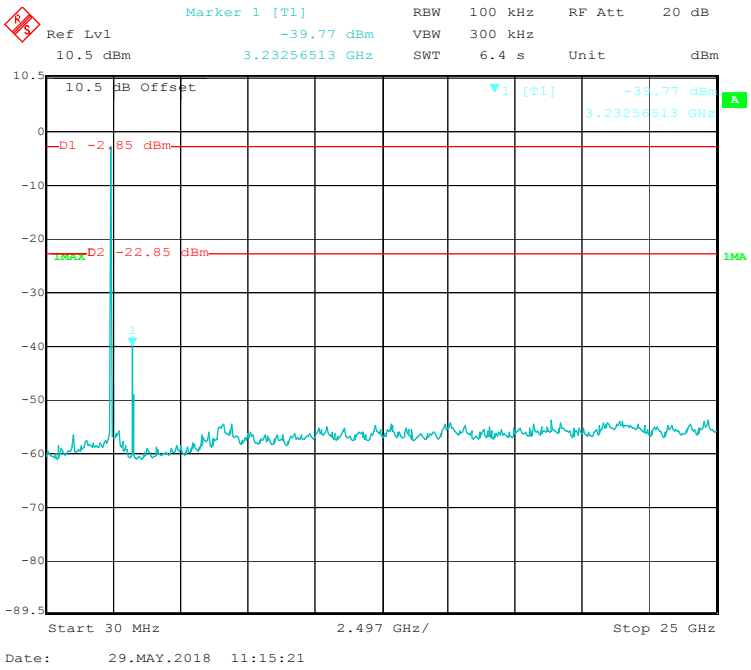
**BDR (GFSK): High Channel**



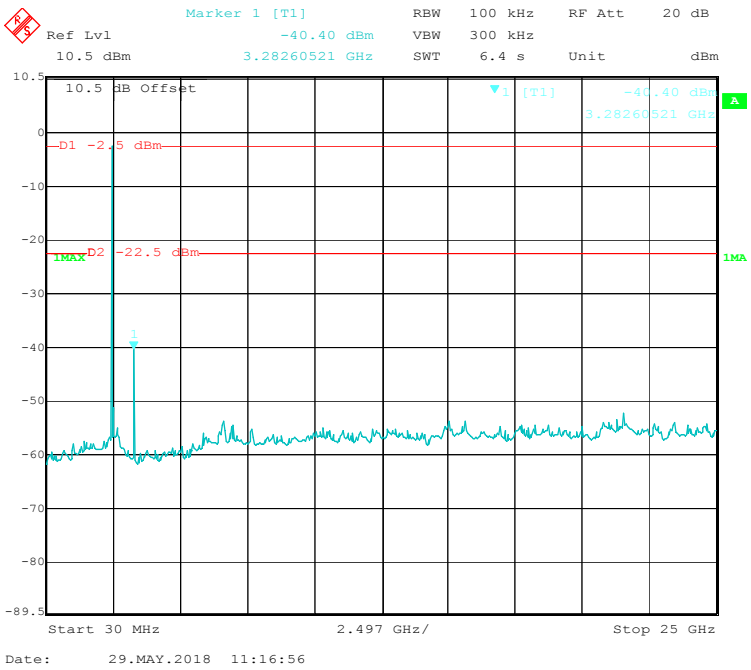

**EDR (π/4-DQPSK): Low Channel**



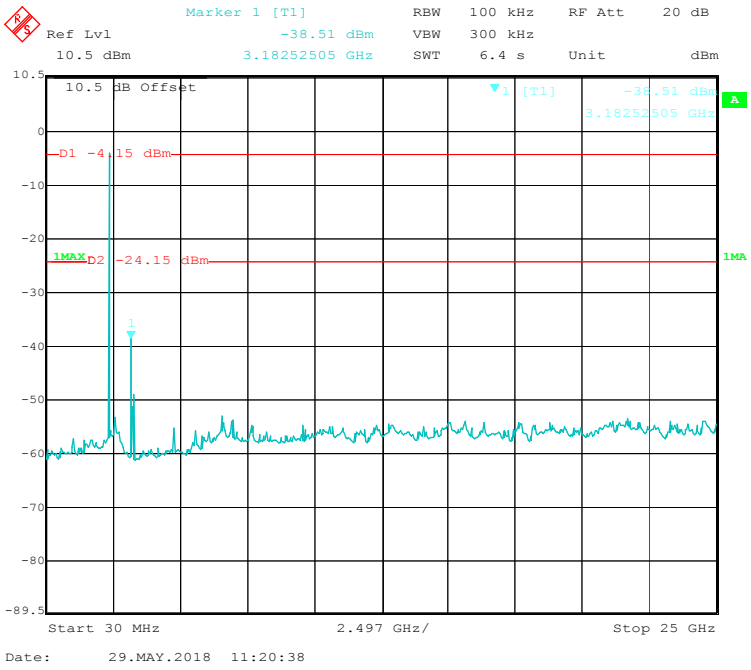
**EDR (π/4-DQPSK): Middle Channel**



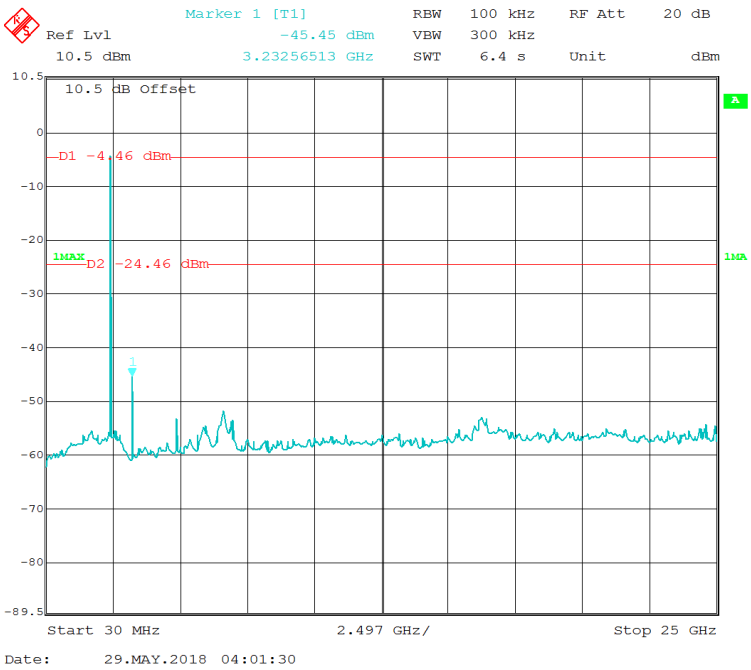

**EDR (π/4-DQPSK): High Channel**



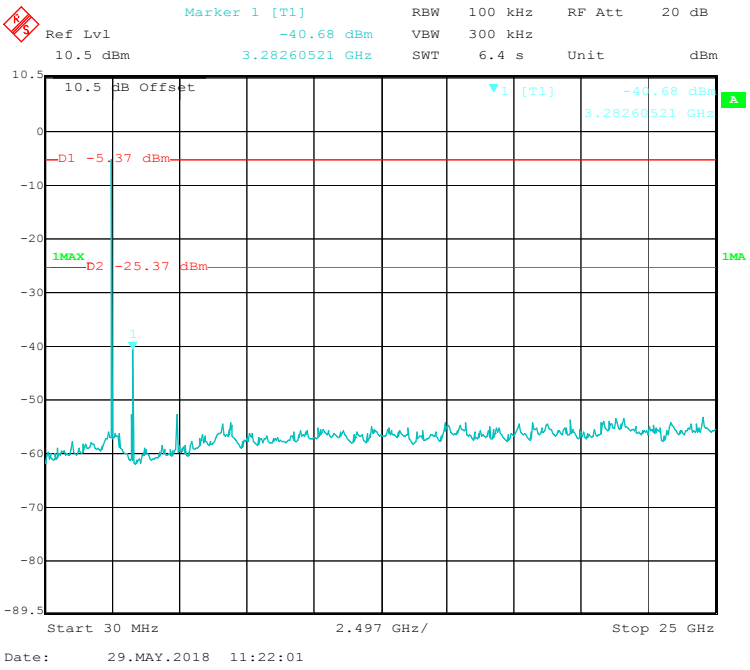
## EDR (8DPSK): Low Channel




## EDR (8DPSK): Middle Channel



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



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

## Applicable Standard

Frequency hopping systems shall have hoping 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

1. Set the EUT in transmitting mode, maxhold the channel.
2. Set the adjacent channel of the EUT and maxhold another trace.
3. Measure the channel separation.

## Test Data

### Environmental Conditions

| | |
|---|---|
| **Temperature:** | 23.4 ℃ |
| **Relative Humidity:** | 49 % |
| **ATM Pressure:** | 101.1 kPa |

*The testing was performed by HopeDD Zhang on 2018-05-29.*

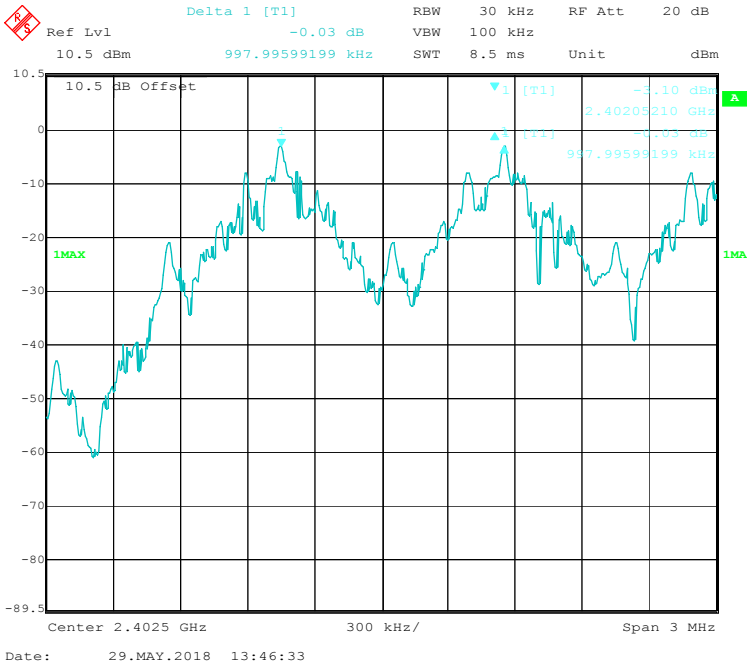
*EUT operation mode: Transmitting*

*Test Result: Compliance.*

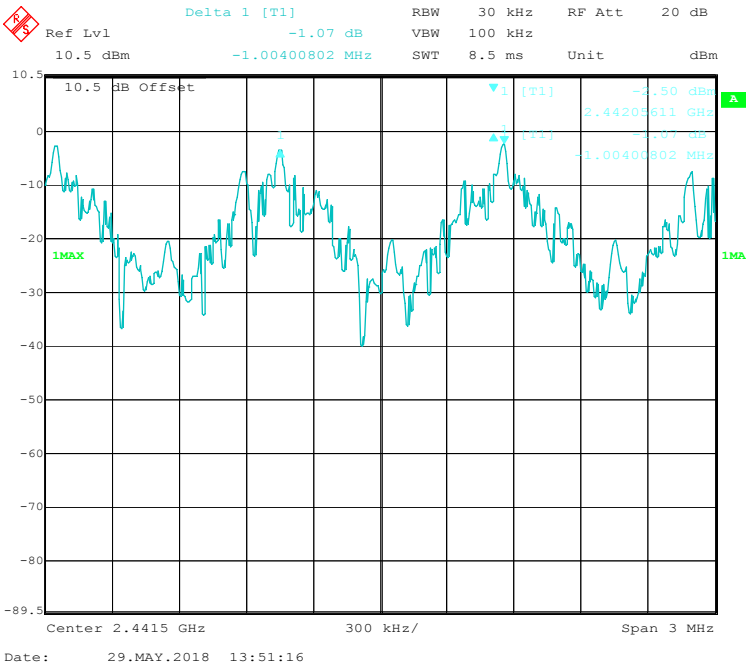
| Mode | Channel | Frequency (MHz) | Channel Separation (MHz) | Limit (MHz) | Result |
|---|---|---|---|---|---|
| BDR (GFSK) | Low | 2402 | 0.998 | ≥0.689 | Pass |
| | Adjacent | 2403 | | | |
| | Middle | 2441 | 1.004 | ≥0.693 | Pass |
| | Adjacent | 2442 | | | |
| | High | 2480 | 1.010 | ≥0.693 | Pass |
| | Adjacent | 2479 | | | |
| EDR (π/4-DQPSK) | Low | 2402 | 1.004 | ≥0.753 | Pass |
| | Adjacent | 2403 | | | |
| | Middle | 2441 | 1.004 | ≥0.757 | Pass |
| | Adjacent | 2442 | | | |
| | High | 2480 | 1.004 | ≥0.753 | Pass |
| | Adjacent | 2479 | | | |
| EDR (8DPSK) | Low | 2402 | 1.016 | ≥0.829 | Pass |
| | Adjacent | 2403 | | | |
| | Middle | 2441 | 1.010 | ≥0.809 | Pass |
| | Adjacent | 2442 | | | |
| | High | 2480 | 1.004 | ≥0.825 | Pass |
| | Adjacent | 2479 | | | |

Note: Limit = 20 dB bandwidth*2/3

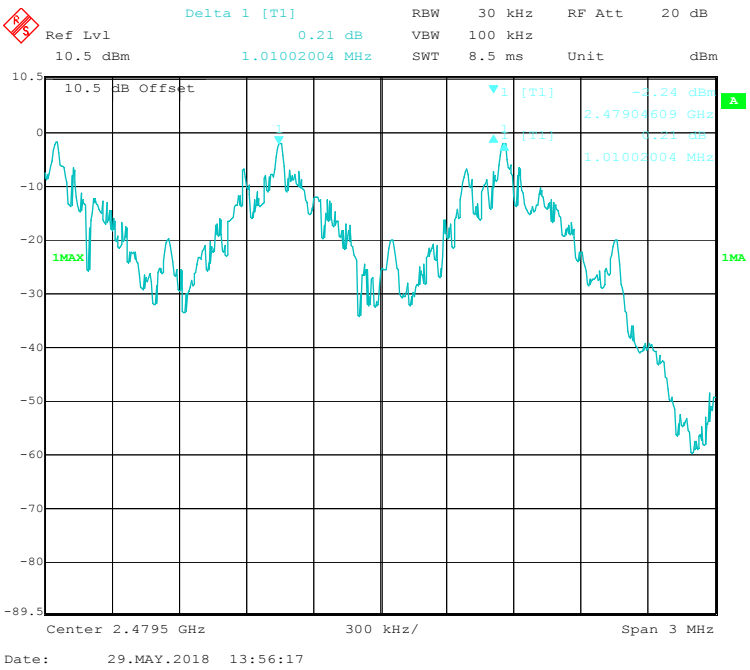
**BDR (GFSK): Low Channel**



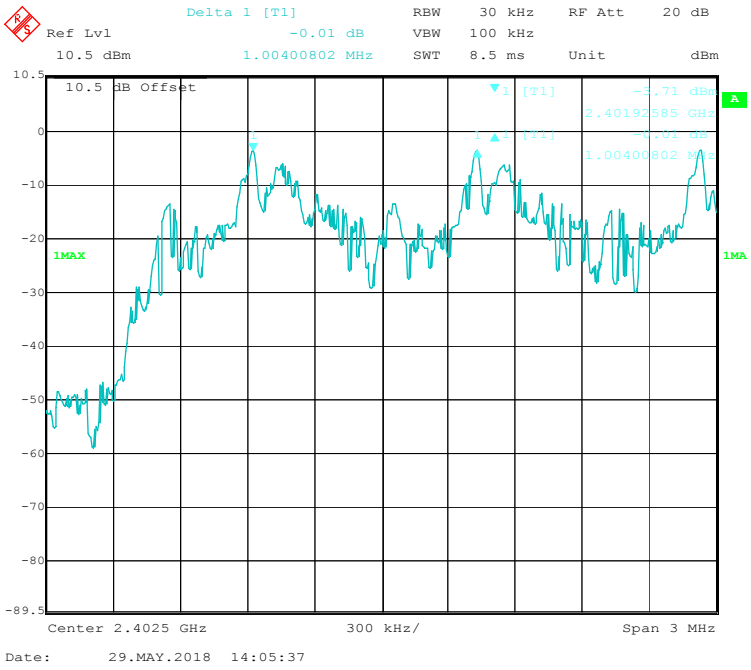
## BDR (GFSK): Middle Channel



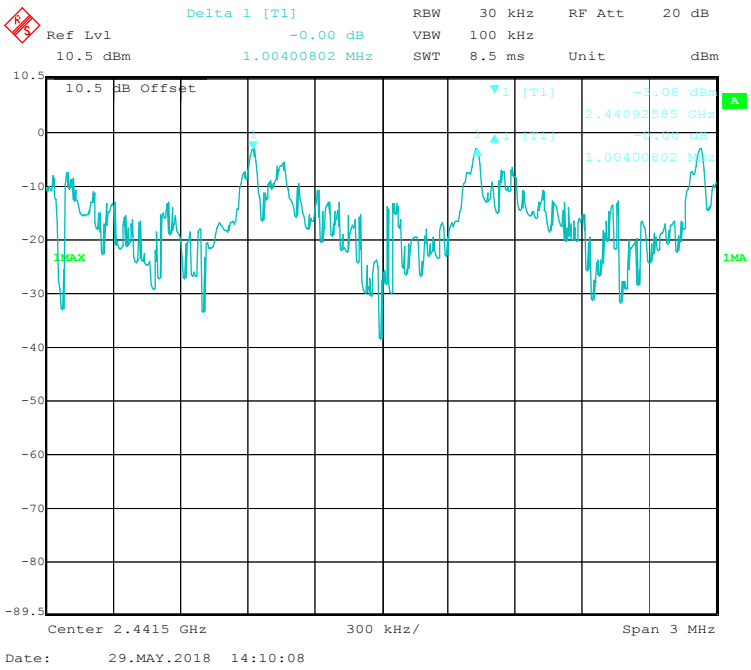

## BDR (GFSK): High Channel



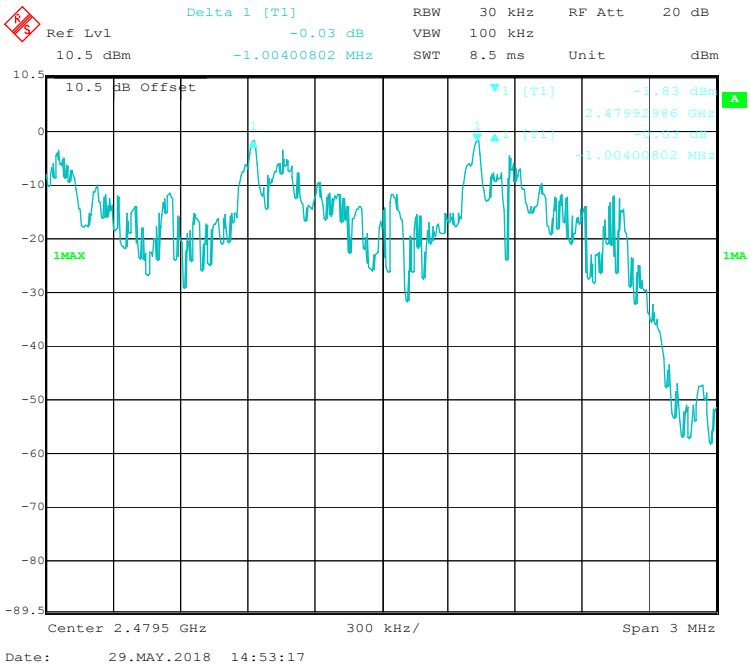
**EDR (π/4-DQPSK): Low Channel**



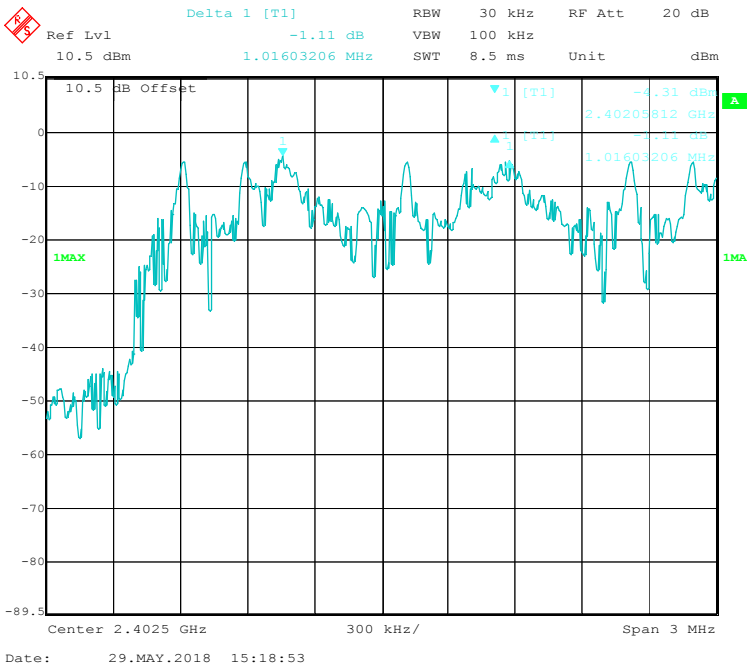

**EDR (π/4-DQPSK): Middle Channel**



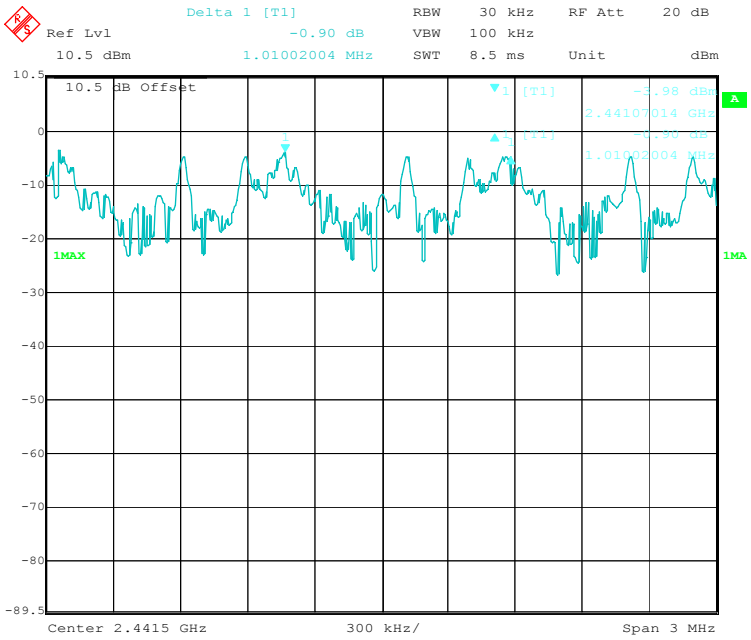
**EDR (π/4-DQPSK): High Channel**



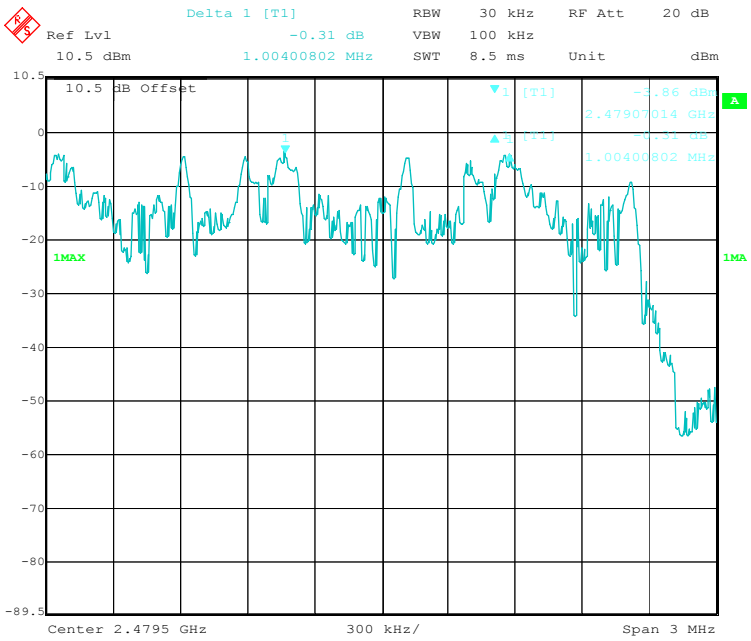

**EDR (8DPSK): Low Channel**



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




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



# FCC §15.247(a) (1) – 20 dB EMISSION BANDWIDTH

## Applicable Standard

Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

## Test Procedure

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

## Test Data

### Environmental Conditions

| | |
|---|---|
| **Temperature:** | 23.2 ℃ |
| **Relative Humidity:** | 50 % |
| **ATM Pressure:** | 101.3 kPa |

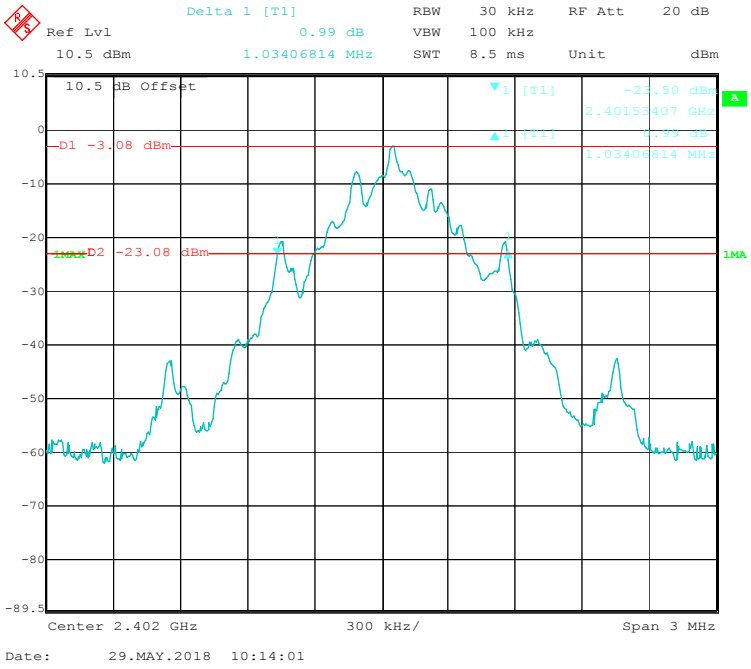
*The testing was performed by HopeDD Zhang on 2018-05-29.*

*EUT operation mode: Transmitting*

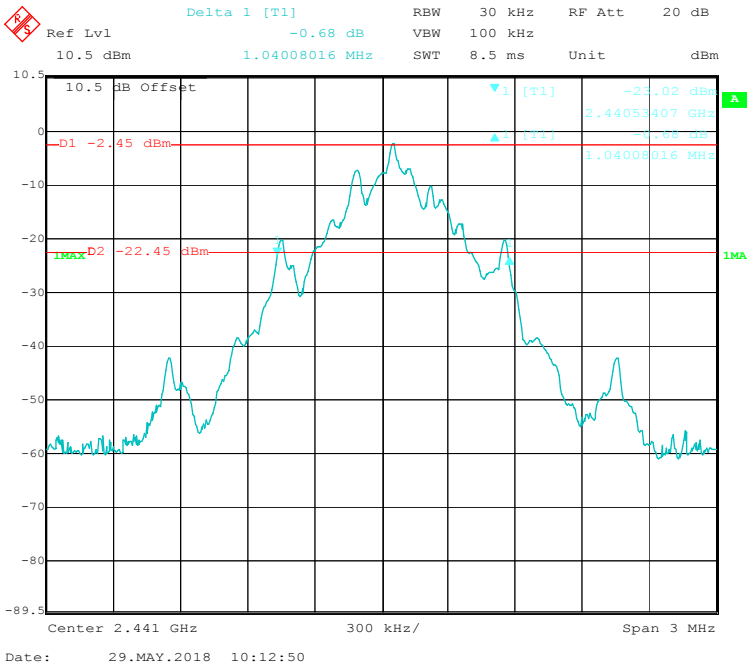
*Test Result: Compliance.*

| Mode | Channel | Frequency (MHz) | 20 dB Emission Bandwidth (MHz) |
|---|---|---|---|
| BDR (GFSK) | Low | 2402 | 1.034 |
| | Middle | 2441 | 1.040 |
| | High | 2480 | 1.040 |
| EDR (π/4-DQPSK) | Low | 2402 | 1.130 |
| | Middle | 2441 | 1.136 |
| | High | 2480 | 1.130 |
| EDR (8DPSK) | Low | 2402 | 1.244 |
| | Middle | 2441 | 1.214 |
| | High | 2480 | 1.238 |

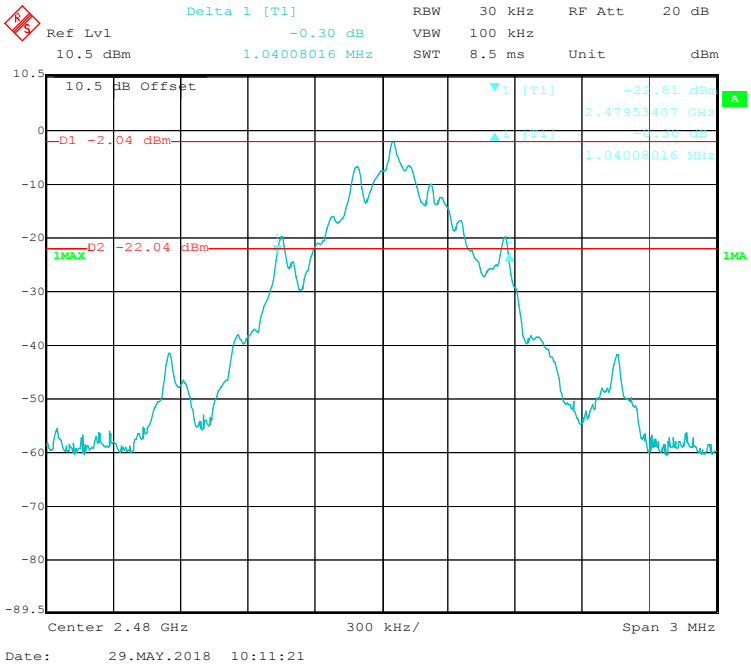
**BDR (GFSK): Low Channel**



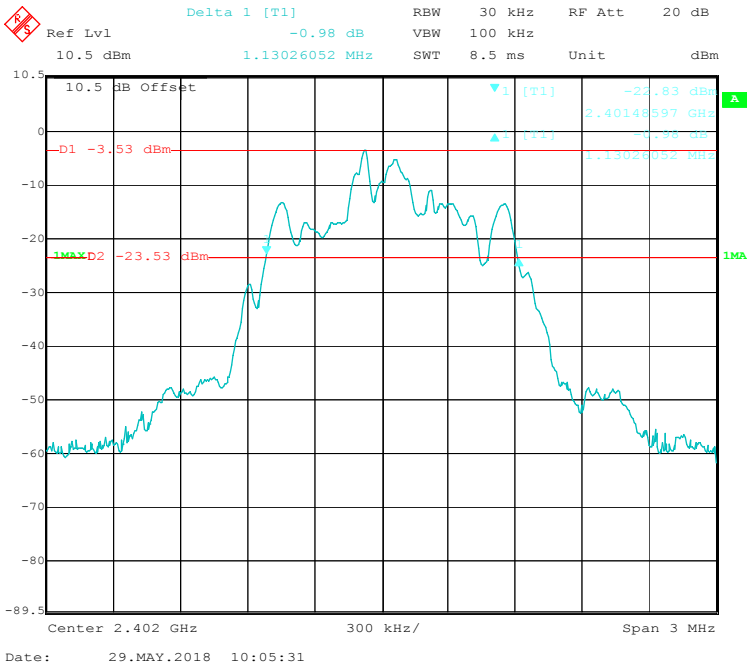
**BDR (GFSK): Middle Channel**



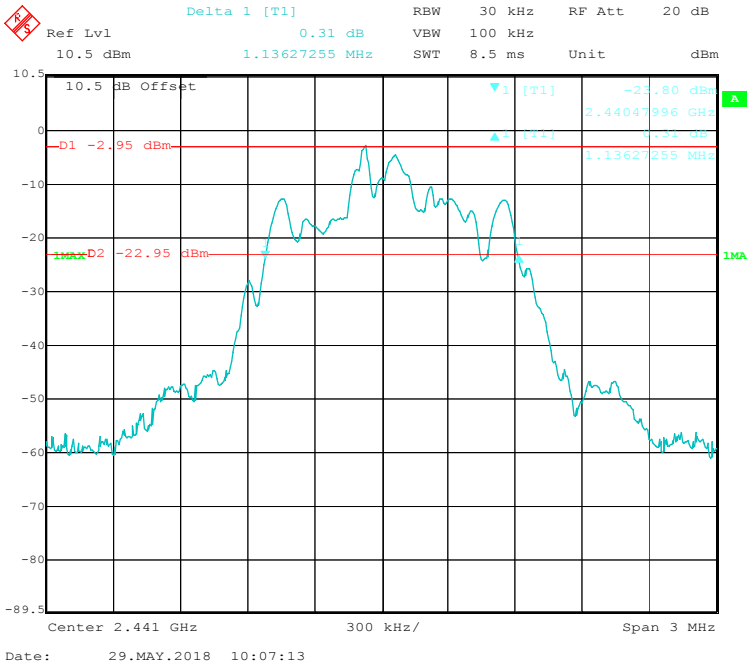

**BDR (GFSK): High Channel**



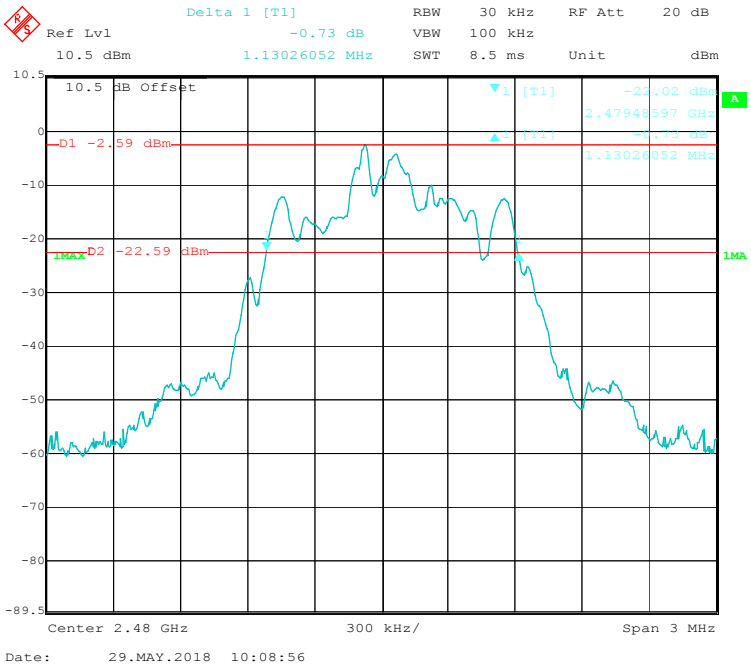
**EDR (π/4-DQPSK): Low Channel**



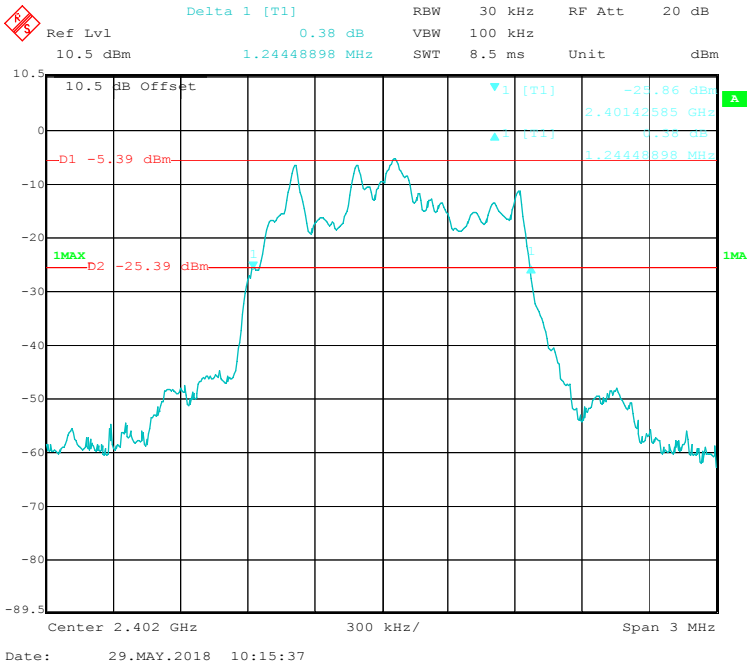

**EDR(π/4-DQPSK): Middle Channel**



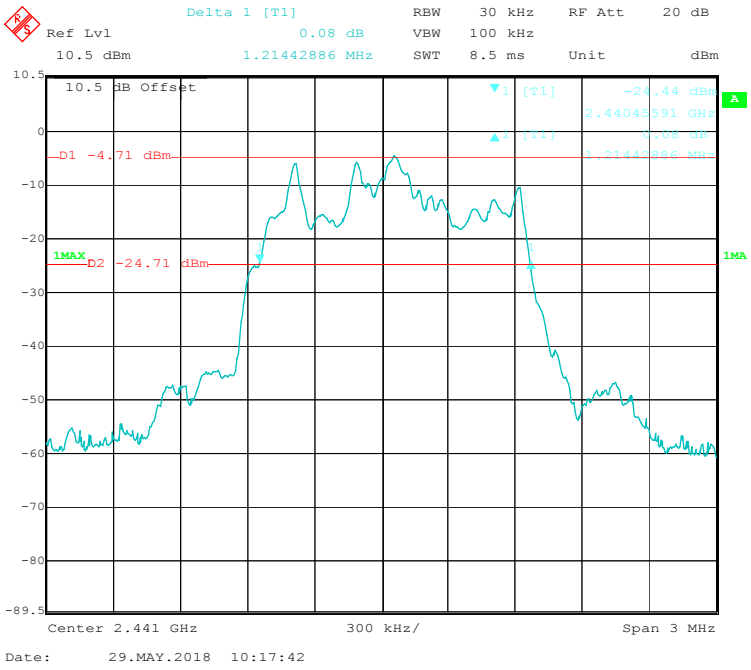
**EDR (π/4-DQPSK): High Channel**



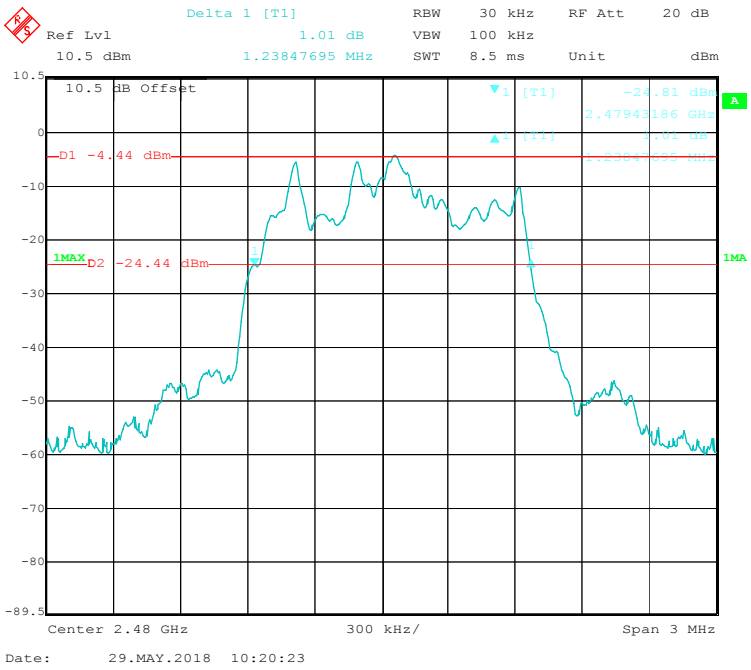

**EDR (8DPSK): Low Channel**



## EDR (8DPSK): Middle Channel




## EDR (8DPSK): High Channel



# 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

1. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.

2. Set the EUT in hopping mode from first channel to last.

3. By using the max-hold function record the quantity of the channel.

## Test Data

### Environmental Conditions

| | |
|---|---|
| **Temperature:** | 23.2 ℃ |
| **Relative Humidity:** | 50 % |
| **ATM Pressure:** | 101.3 kPa |

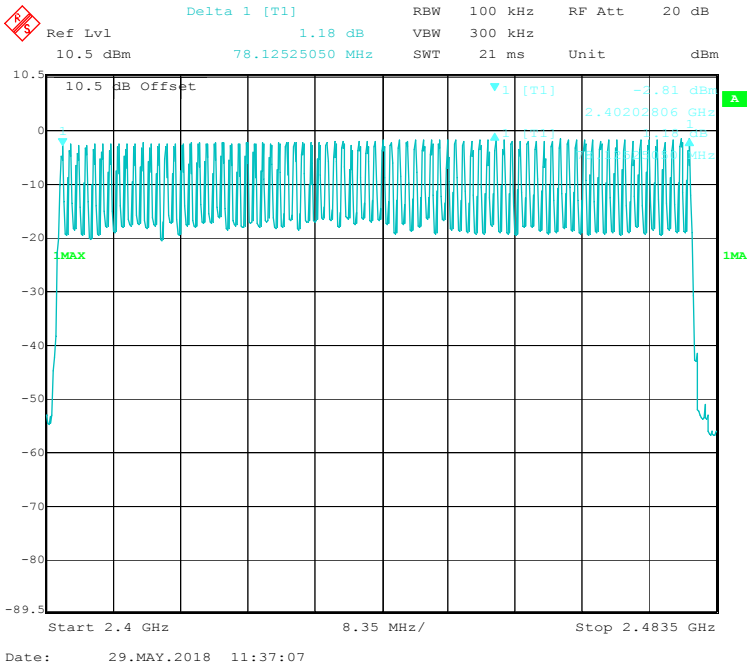
*The testing was performed by HopeDD Zhang on 2018-05-29.*

*EUT operation mode: Hopping*

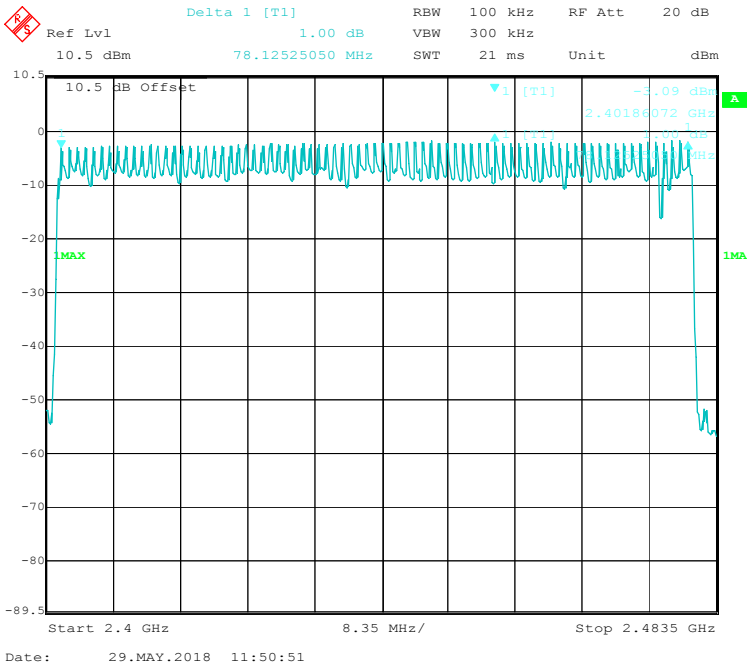
*Test Result: Compliance.*

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

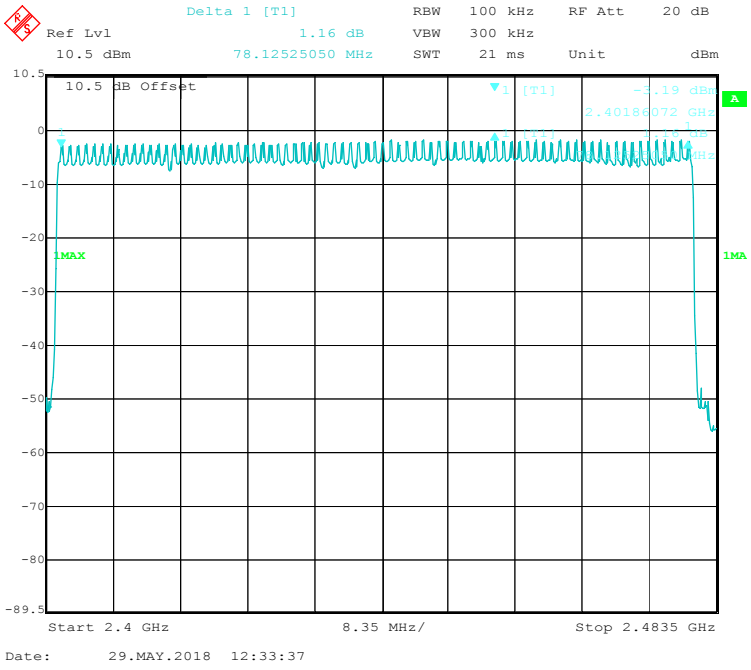
**BDR (GFSK): Number of Hopping Channels**



## EDR (π/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

1 Span: Zero span, centered on a hopping channel.
2 RBW shall be ⩽ channel spacing and where possible RBW should be set ⩾ 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

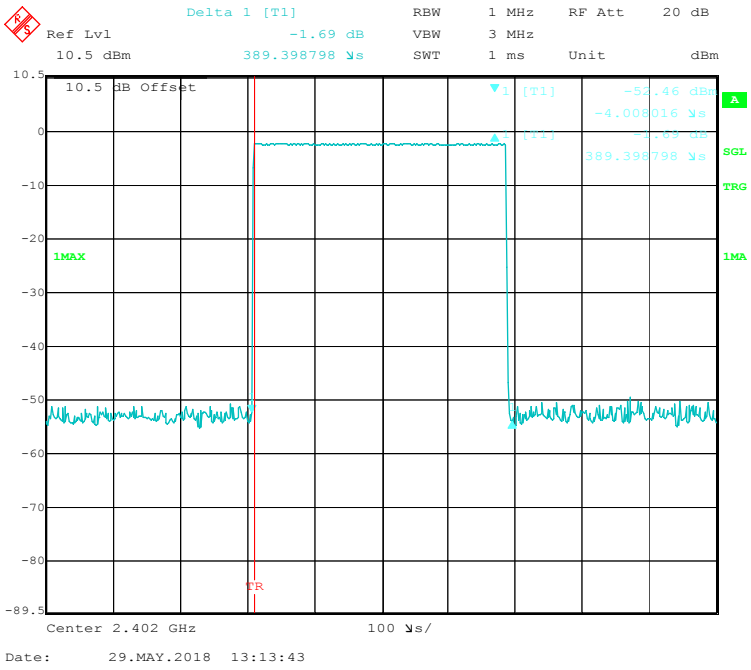
| | |
|---|---|
| **Temperature:** | 23.4 ℃ |
| **Relative Humidity:** | 51 % |
| **ATM Pressure:** | 101.2 kPa |

*The testing was performed by HopeDD Zhang on 2018-05-29.*

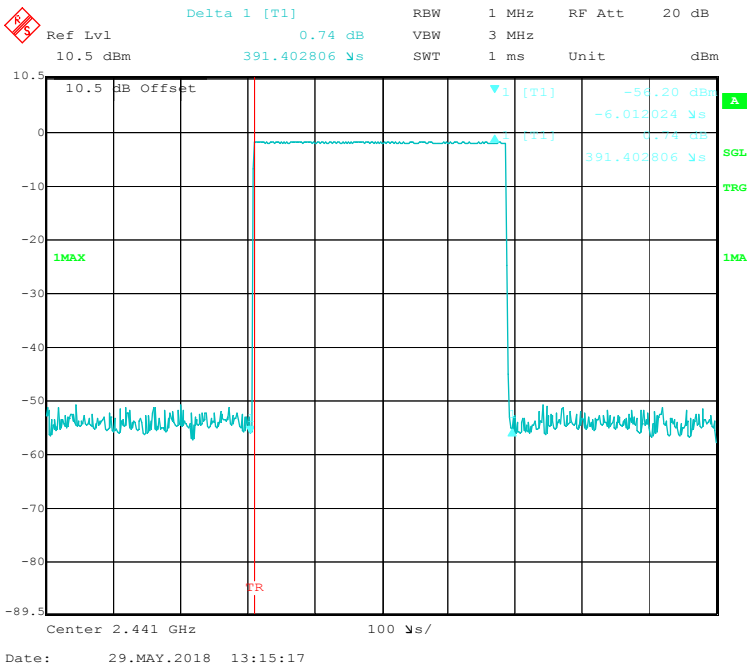
*EUT operation mode: Hopping*

| Mode | | Channel | Pulse Width (ms) | Dwell Time (s) | Limit (s) | Result |
|---|---|---|---|---|---|---|
| BDR (GFSK) | DH1 | Low | 0.389 | 0.124 | 0.4 | Pass |
| | | Middle | 0.391 | 0.125 | 0.4 | Pass |
| | | High | 0.389 | 0.124 | 0.4 | Pass |
| | | Note: DH1:Dwell time = Pulse time*(1600/2/79)*31.6S | | | | |
| | DH3 | Low | 1.662 | 0.266 | 0.4 | Pass |
| | | Middle | 1.667 | 0.267 | 0.4 | Pass |
| | | High | 1.662 | 0.266 | 0.4 | Pass |
| | | Note: DH3:Dwell time = Pulse time*(1600/4/79)*31.6S | | | | |
| | DH5 | Low | 2.915 | 0.311 | 0.4 | Pass |
| | | Middle | 2.915 | 0.311 | 0.4 | Pass |
| | | High | 2.922 | 0.312 | 0.4 | Pass |
| | | Note: DH5:Dwell time = Pulse time*(1600/6/79)*31.6S | | | | |
| EDR (π/4-DQPSK) | 2DH1 | Low | 0.402 | 0.129 | 0.4 | Pass |
| | | Middle | 0.402 | 0.129 | 0.4 | Pass |
| | | High | 0.408 | 0.131 | 0.4 | Pass |
| | | Note: 2DH1:Dwell time = Pulse time*(1600/2/79)*31.6S | | | | |
| | 2DH3 | Low | 1.660 | 0.266 | 0.4 | Pass |
| | | Middle | 1.675 | 0.268 | 0.4 | Pass |
| | | High | 1.665 | 0.266 | 0.4 | Pass |
| | | Note: 2DH3:Dwell time = Pulse time*(1600/4/79)*31.6S | | | | |
| | 2DH5 | Low | 2.922 | 0.312 | 0.4 | Pass |
| | | Middle | 2.940 | 0.314 | 0.4 | Pass |
| | | High | 2.922 | 0.312 | 0.4 | Pass |
| | | Note: 2DH5:Dwell time = Pulse time*(1600/6/79)*31.6S | | | | |
| EDR (8DPSK) | 3DH1 | Low | 0.402 | 0.129 | 0.4 | Pass |
| | | Middle | 0.398 | 0.127 | 0.4 | Pass |
| | | High | 0.400 | 0.128 | 0.4 | Pass |
| | | Note:3 DH1:Dwell time = Pulse time*(1600/2/79)*31.6S | | | | |
| | 3DH3 | Low | 1.685 | 0.270 | 0.4 | Pass |
| | | Middle | 1.660 | 0.266 | 0.4 | Pass |
| | | High | 1.660 | 0.266 | 0.4 | Pass |
| | | Note: 3DH3:Dwell time = Pulse time*(1600/4/79)*31.6S | | | | |
| | 3DH5 | Low | 2.967 | 0.316 | 0.4 | Pass |
| | | Middle | 2.967 | 0.316 | 0.4 | Pass |
| | | High | 2.940 | 0.314 | 0.4 | Pass |
| | | Note: 3DH5:Dwell time = Pulse time*(1600/6/79)*31.6S | | | | |

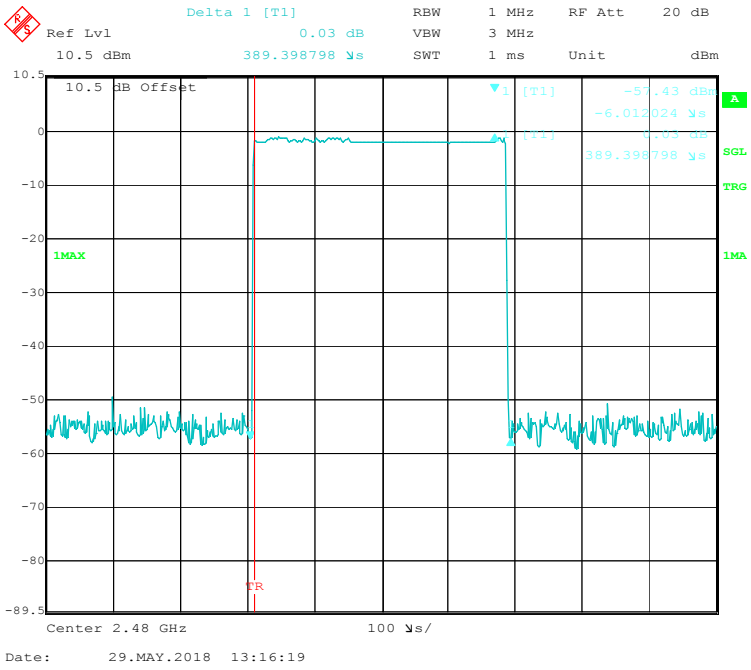
**BDR (GFSK): Pulse time, Low Channel, DH1**



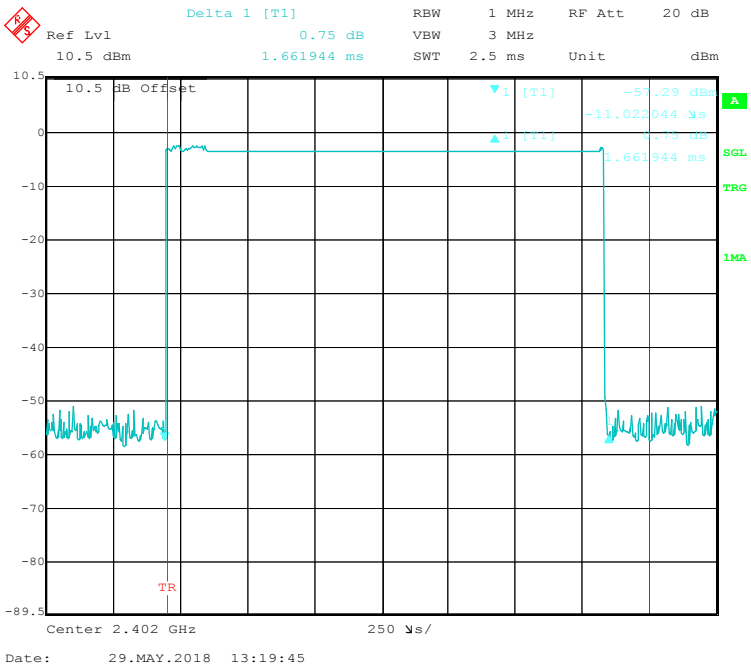

**BDR (GFSK): Pulse time, Middle Channel, DH1**



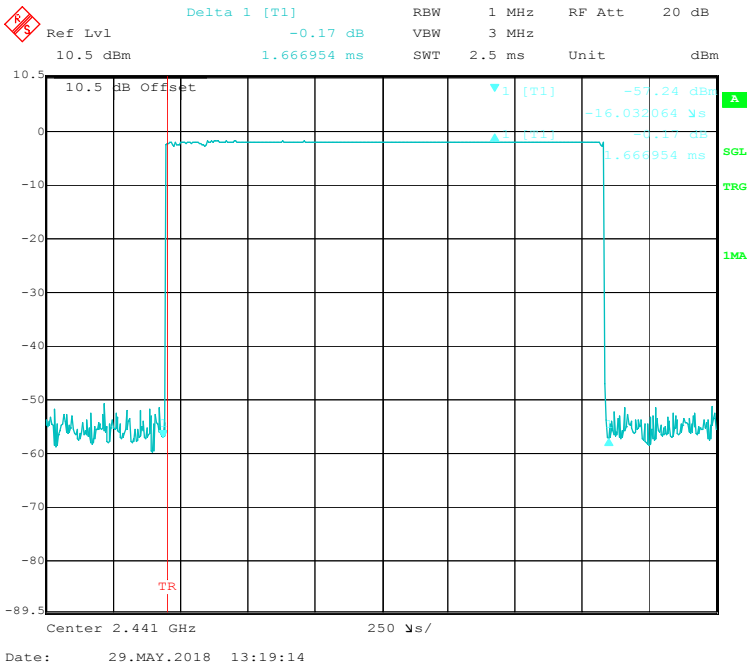
**BDR (GFSK): Pulse time, High Channel, DH1**



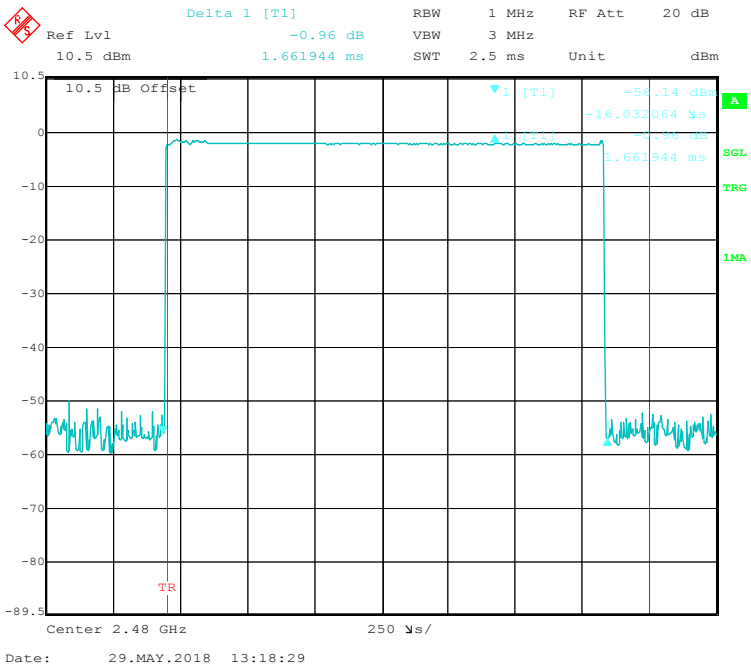

**BDR (GFSK): Pulse time, Low Channel, DH3**



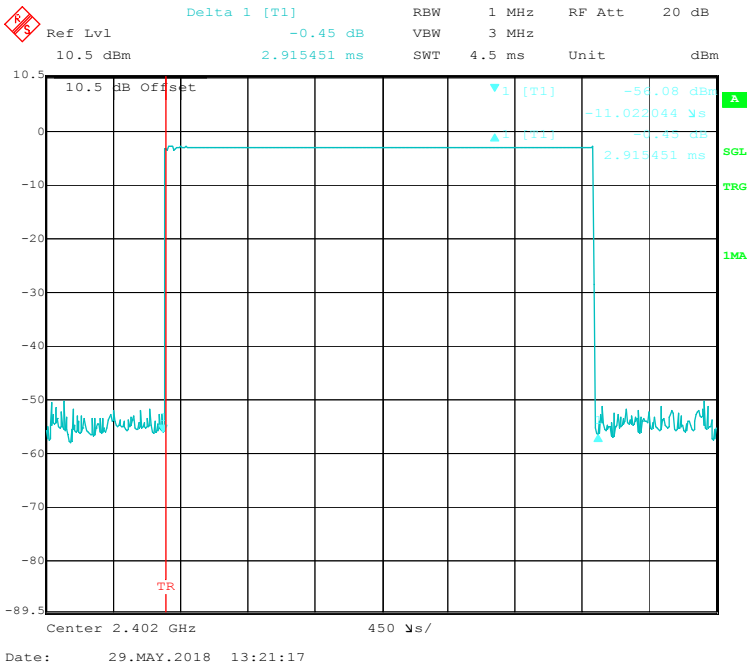
**BDR (GFSK): Pulse time, Middle Channel, DH3**



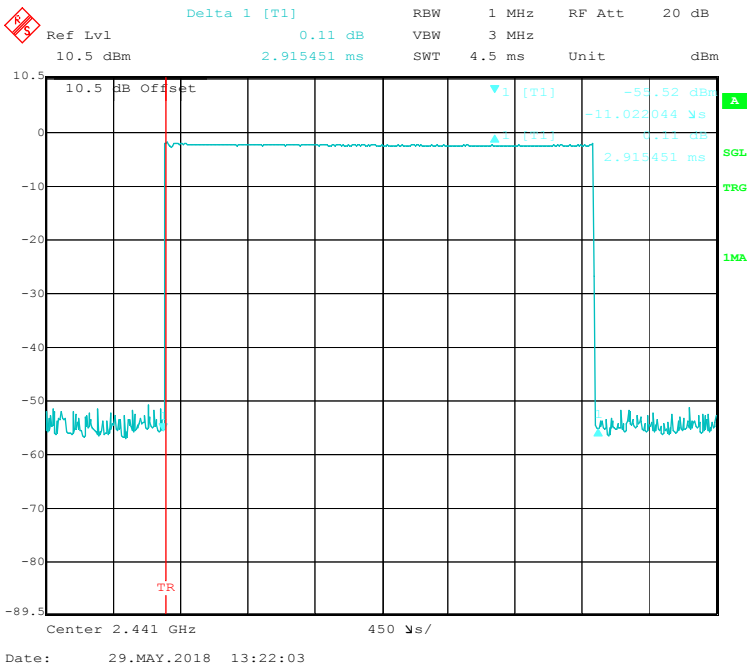

**BDR (GFSK): Pulse time, High Channel, DH3**



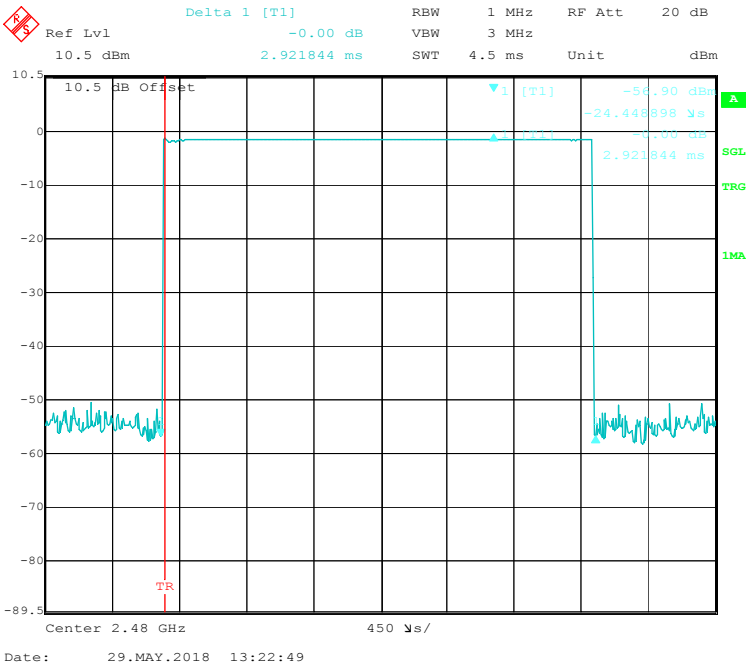
**BDR (GFSK): Pulse time, Low Channel, DH5**



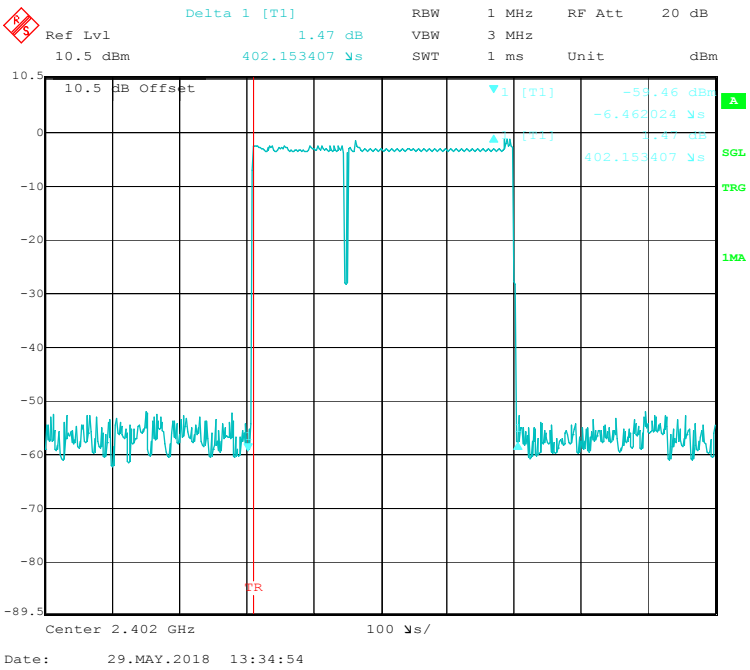

**BDR (GFSK): Pulse time, Middle Channel, DH5**



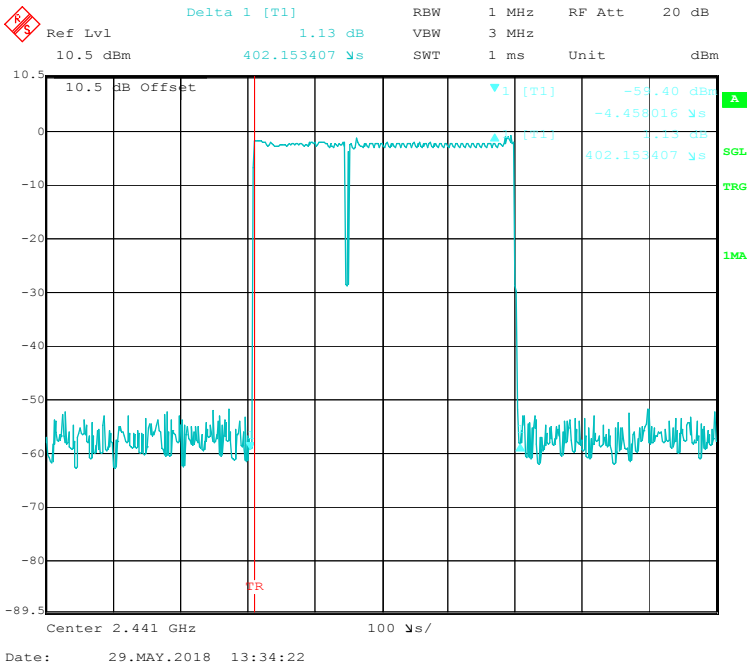
**BDR (GFSK): Pulse time, High Channel, DH5**



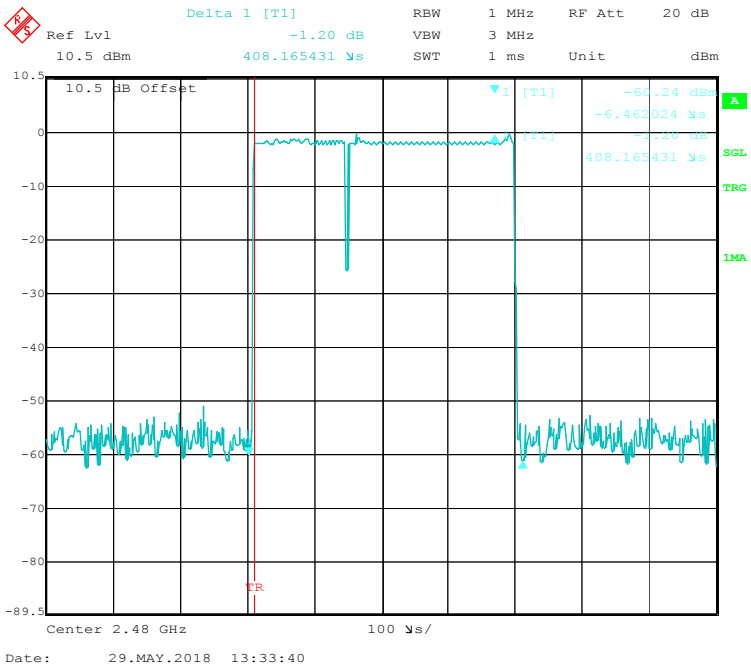

**EDR (π/4-DQPSK): Pulse time, Low Channel, 2DH1**



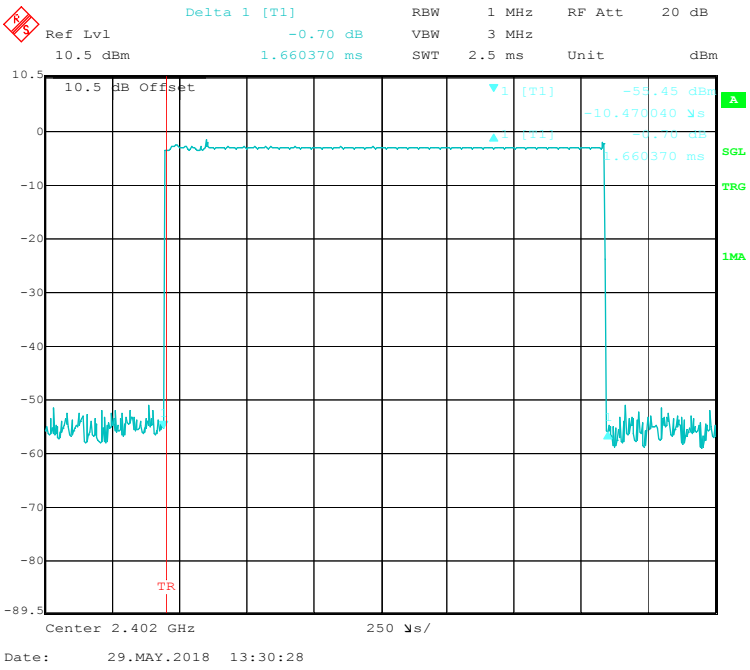
**EDR (π/4-DQPSK):Pulse time, Middle Channel, 2DH1**



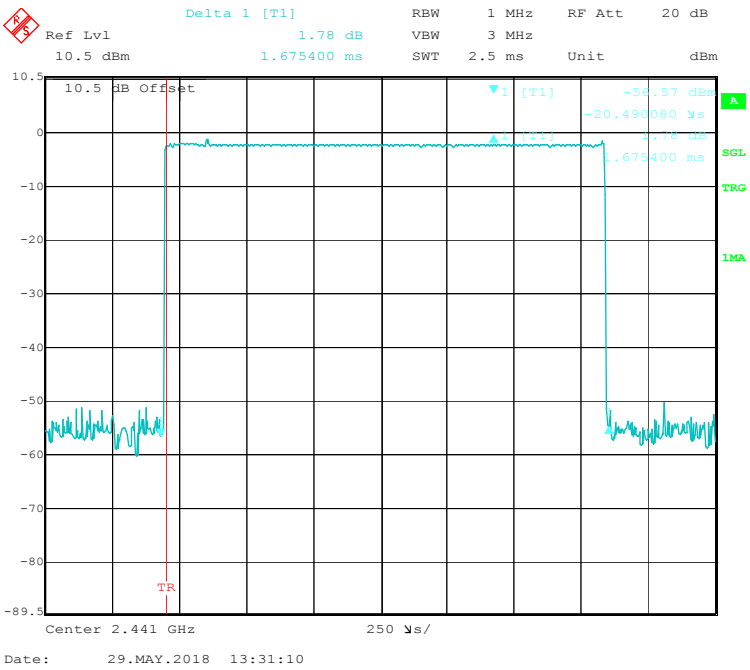

**EDR (π/4-DQPSK):Pulse time, High Channel, 2DH1**



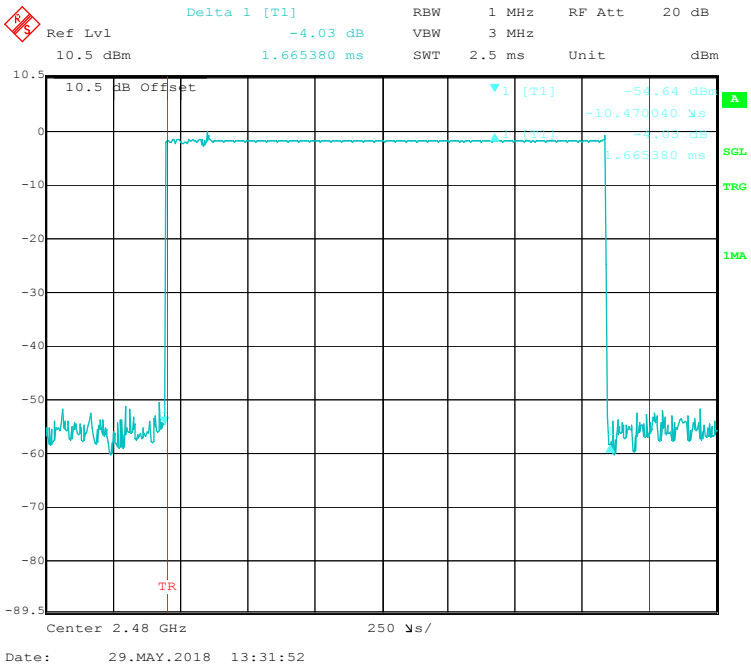
**EDR (π/4-DQPSK):Pulse time, Low Channel, 2DH3**



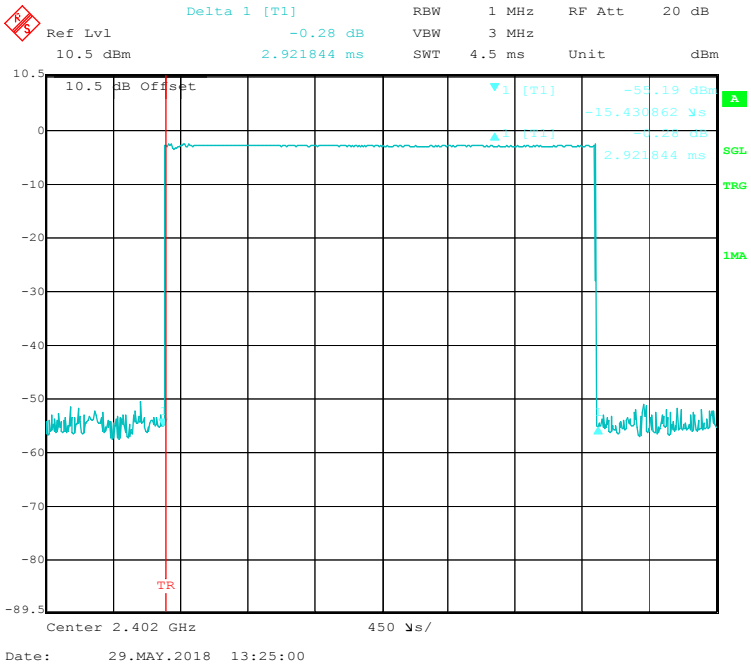

**EDR (π/4-DQPSK):Pulse time, Middle Channel, 2DH3**



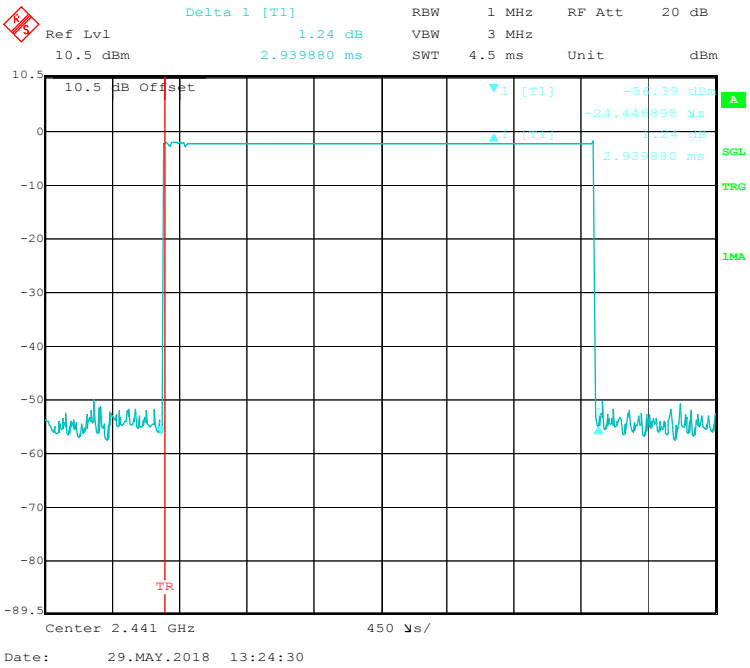
**EDR (π/4-DQPSK):Pulse time, High Channel, 2DH3**



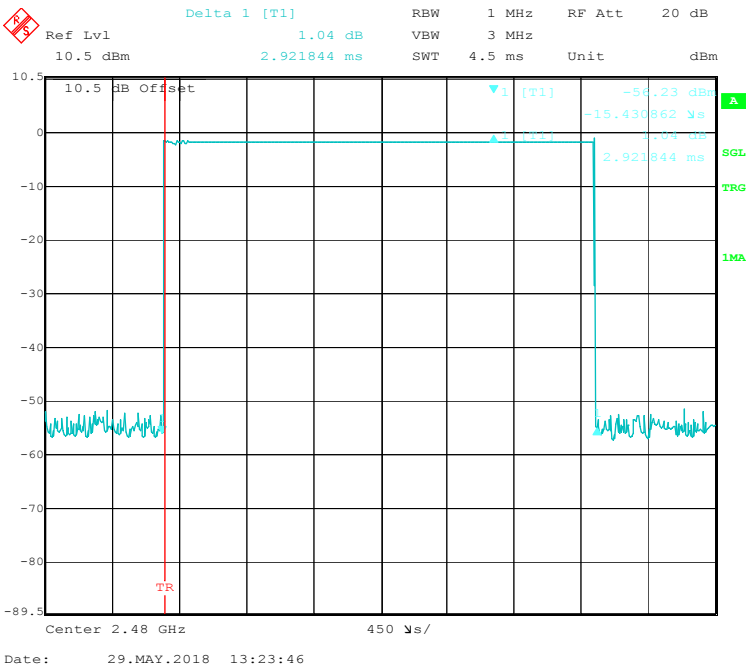

**EDR (π/4-DQPSK):Pulse time, Low Channel, 2DH5**



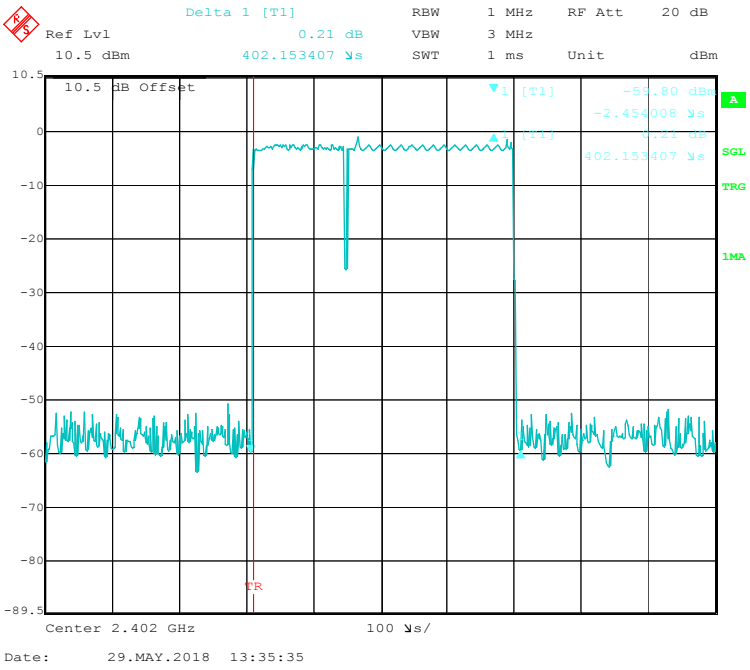
**EDR (π/4-DQPSK):Pulse time, Middle Channel, 2DH5**



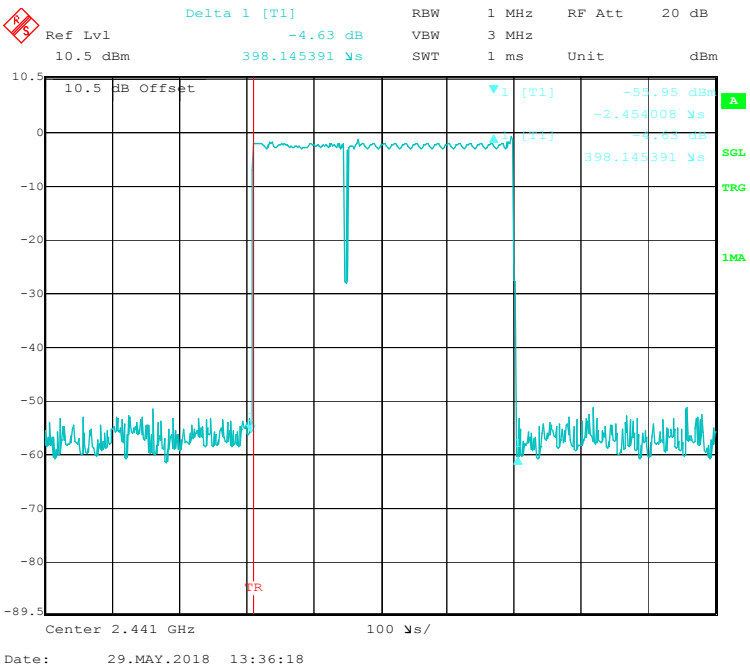

**EDR (π/4-DQPSK):Pulse time, High Channel, 2DH5**



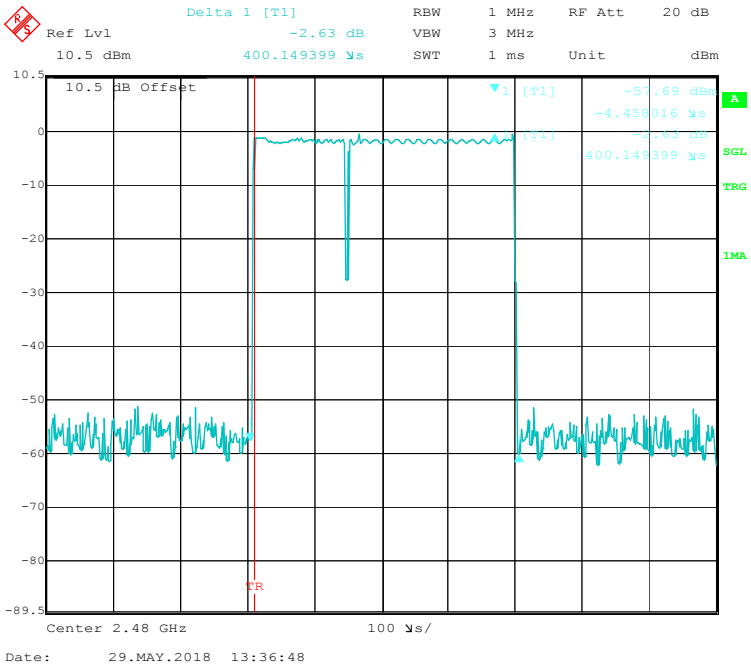
**EDR (8DPSK): Pulse time, Low Channel, 3DH1**



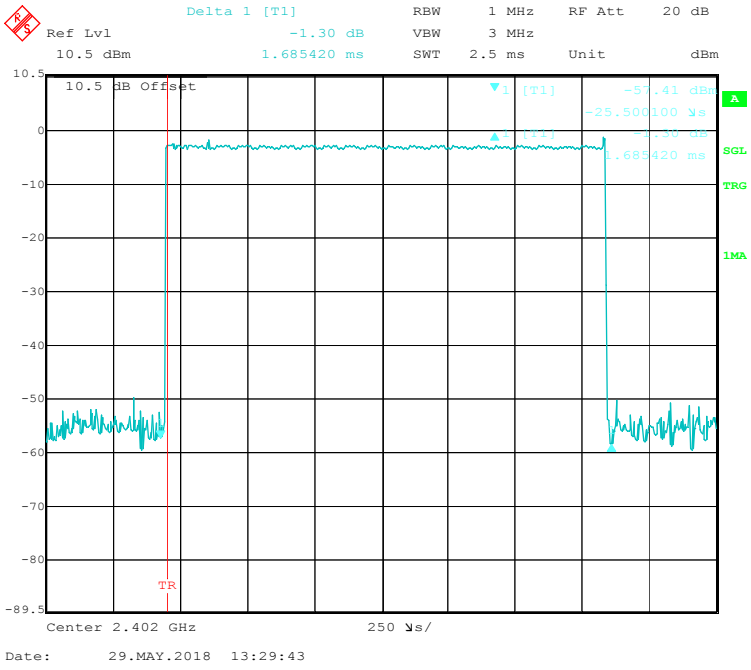

**EDR (8DPSK): Pulse time, Middle Channel, 3DH1**



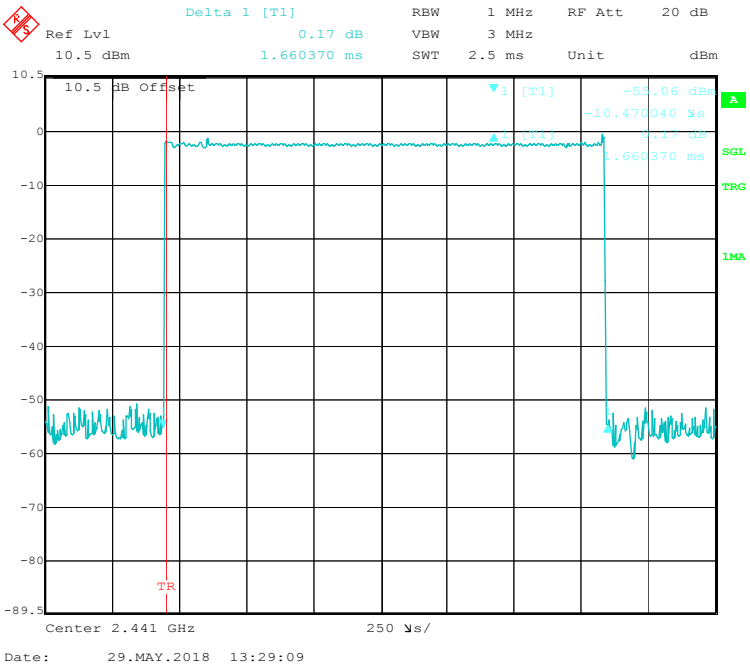
**EDR (8DPSK): Pulse time, High Channel, 3DH1**



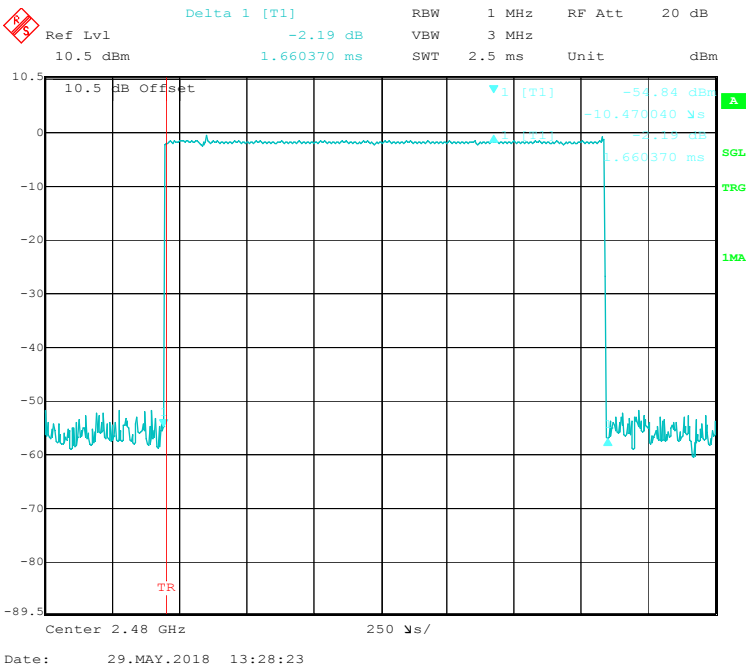

**EDR (8DPSK): Pulse time, Low Channel, 3DH3**



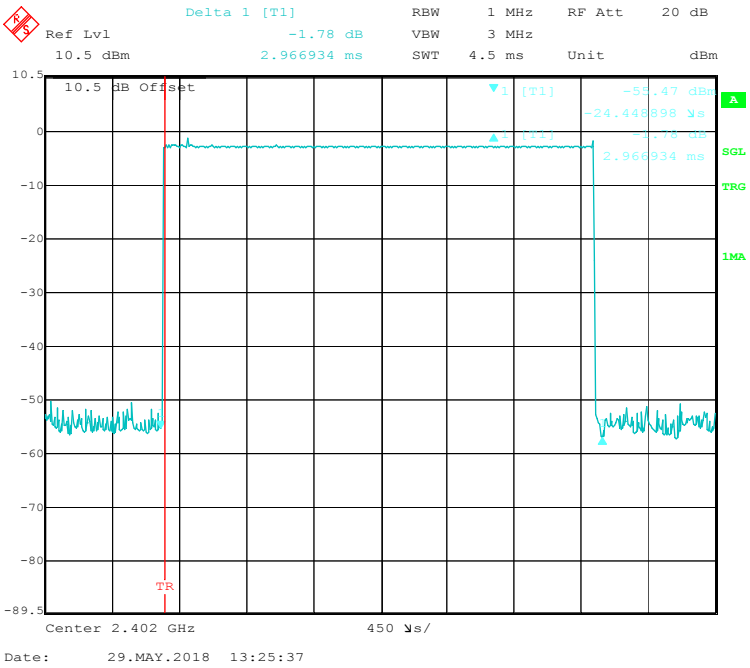
**EDR (8DPSK): Pulse time, Middle Channel, 3DH3**



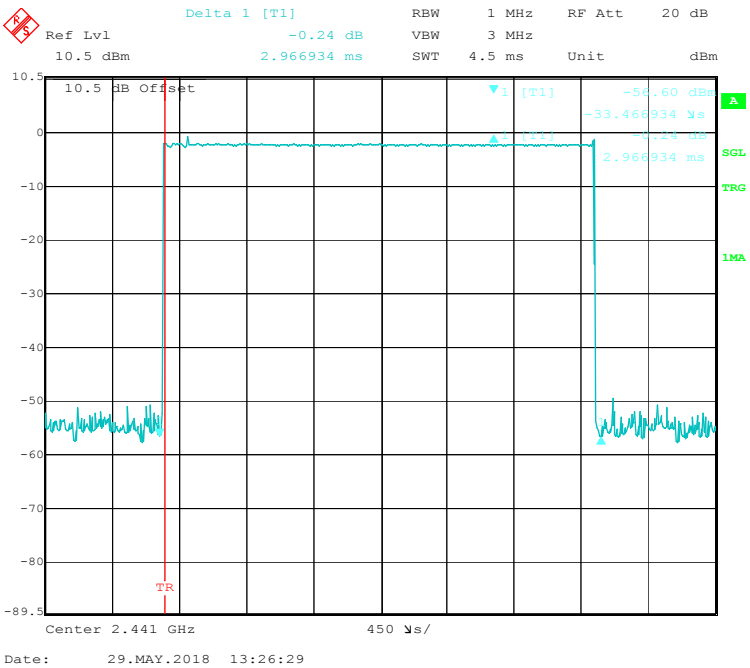

**EDR (8DPSK): Pulse time, High Channel, 3DH3**



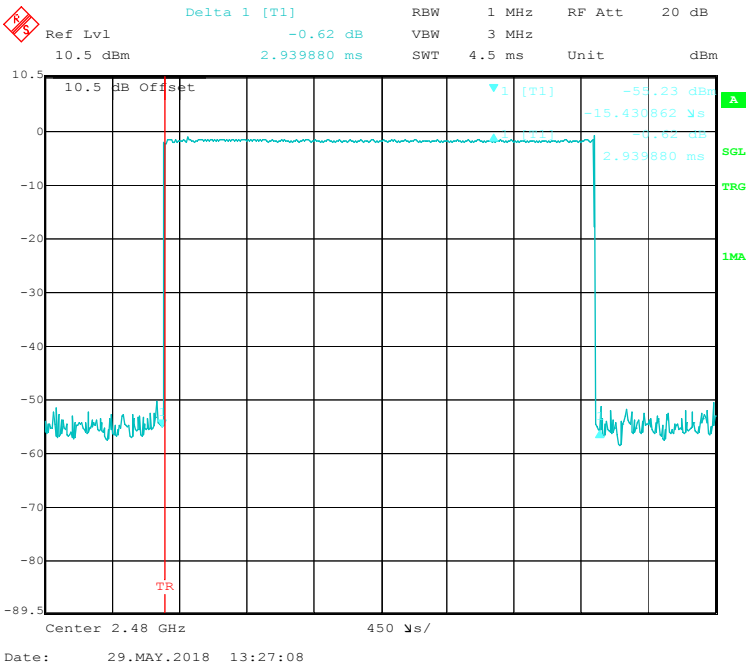
**EDR (8DPSK): Pulse time, Low Channel, 3DH5**




**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

1. Place the EUT on a bench and set in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to one test equipment.
3. Add a correction factor to the display.

## Test Data

### Environmental Conditions

| | |
|---|---|
| **Temperature:** | 23.2 ℃ |
| **Relative Humidity:** | 50 % |
| **ATM Pressure:** | 101.2 kPa |

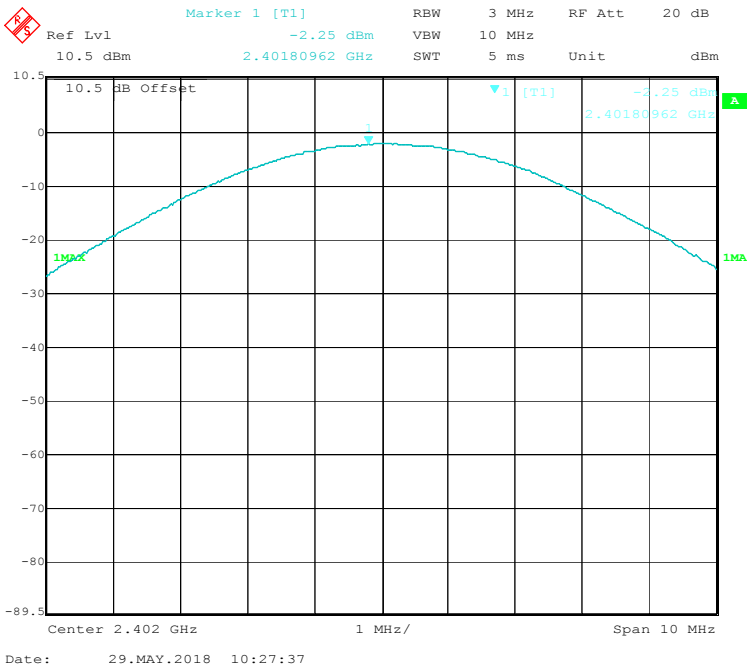
*The testing was performed by HopeDD Zhang on 2018-05-29.*

*EUT operation mode: Transmitting*

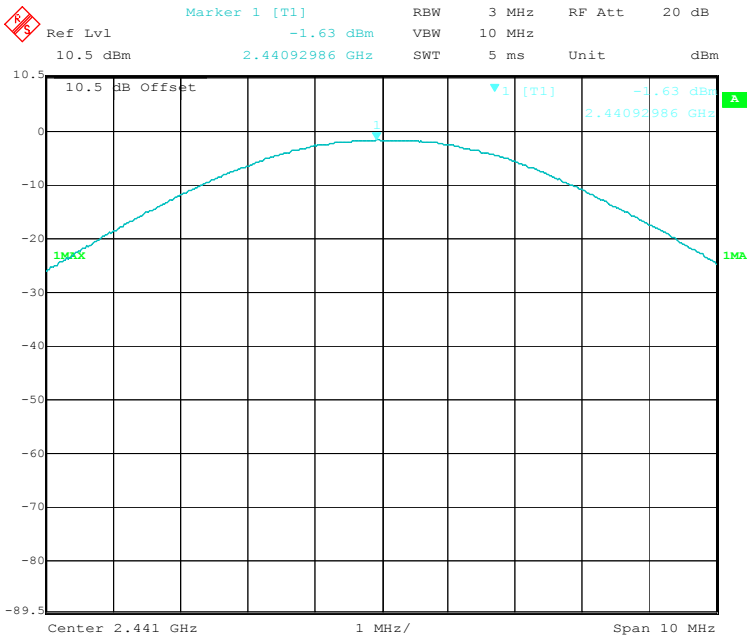
*Test Result: Compliance.*

| Mode | Frequency (MHz) | Output Power | | Limit (mW) |
|---|---|---|---|---|
| | | (dBm) | (mW) | |
| BDR (GFSK) | 2402 | -2.25 | 0.60 | 125 |
| | 2441 | -1.63 | 0.69 | 125 |
| | 2480 | -1.26 | 0.75 | 125 |
| EDR (π/4-DQPSK) | 2402 | -0.29 | 0.94 | 125 |
| | 2441 | 0.26 | 1.06 | 125 |
| | 2480 | 0.65 | 1.16 | 125 |
| EDR (8DPSK) | 2402 | -0.41 | 0.91 | 125 |
| | 2441 | 0.36 | 1.09 | 125 |
| | 2480 | 0.45 | 1.11 | 125 |

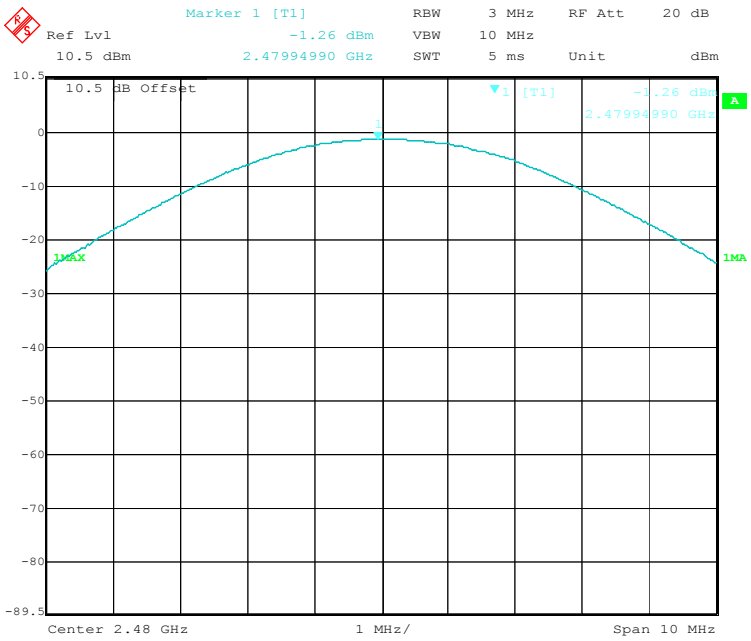
**BDR (GFSK): 2402MHz**



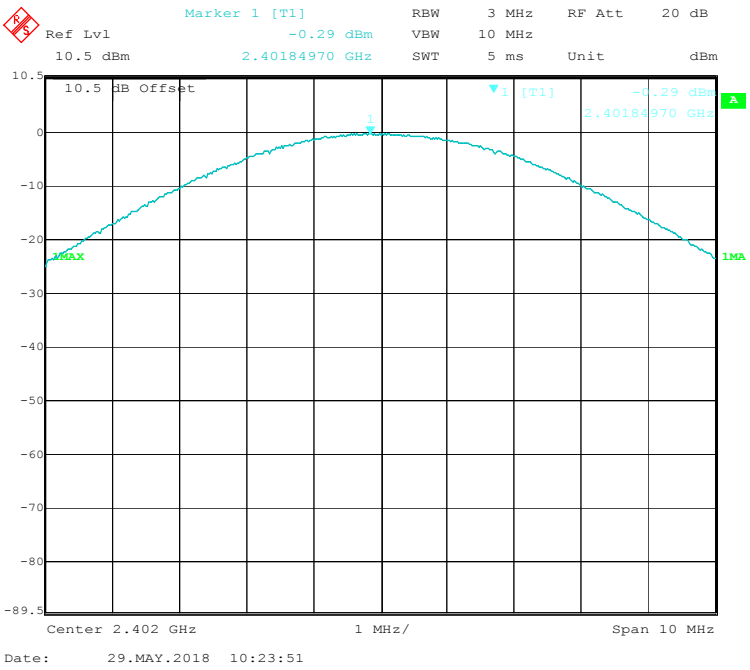
**BDR (GFSK): 2441MHz**



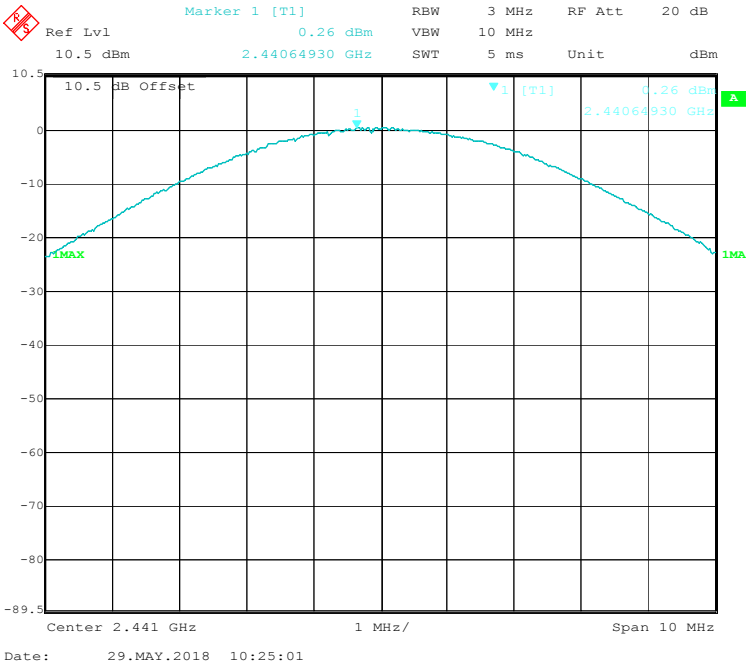

**BDR (GFSK): 2480MHz**



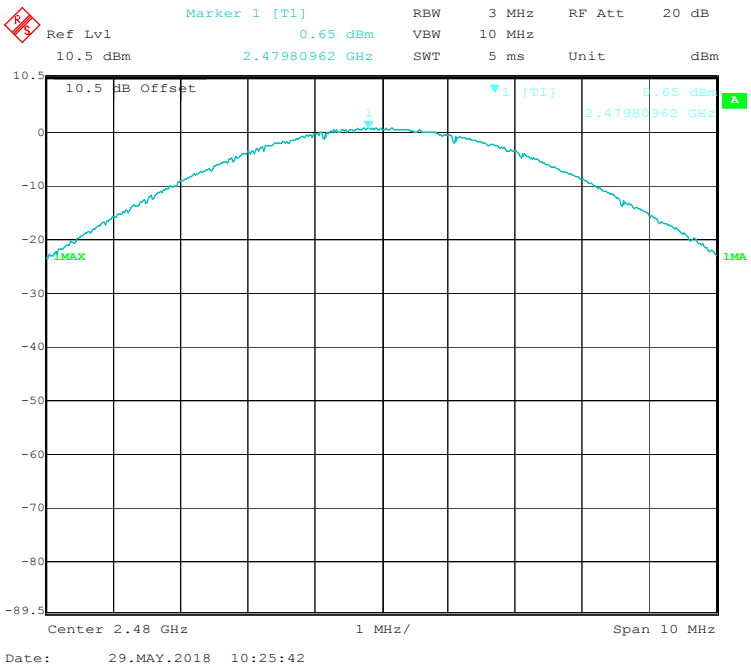
**EDR(π/4-DQPSK): 2402MHz**



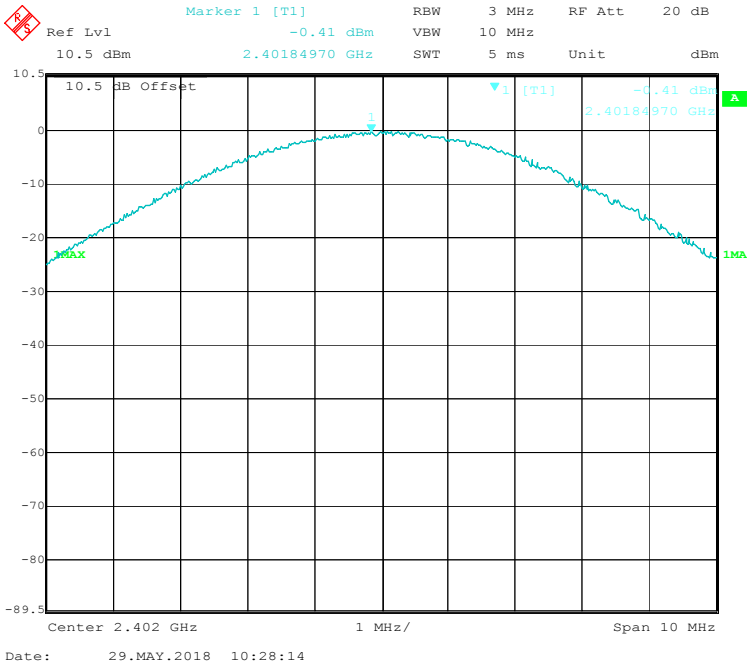

**EDR(π/4-DQPSK): 2441MHz**



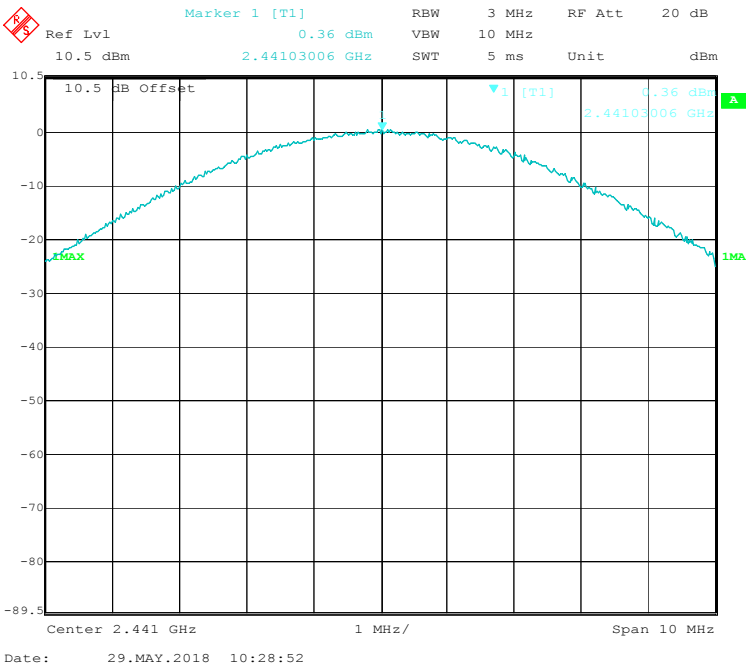
**EDR(π/4-DQPSK): 2480MHz**



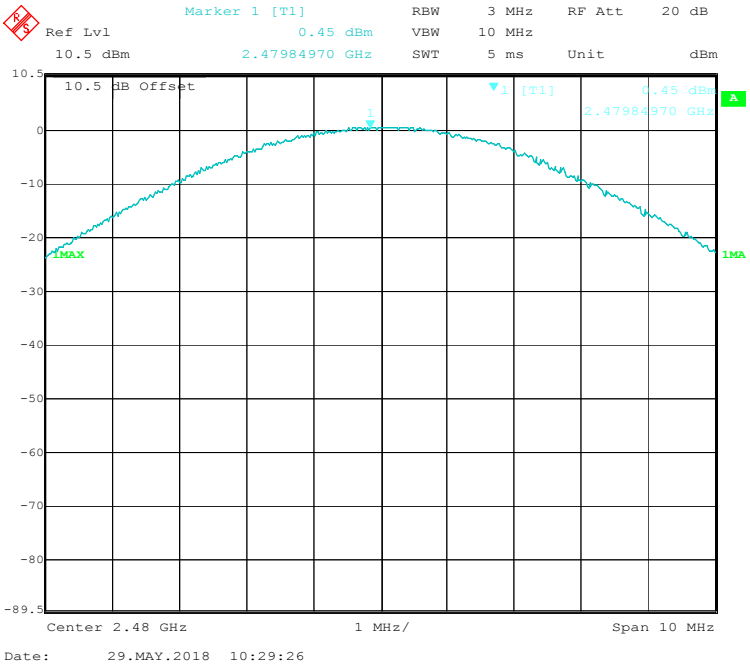

**EDR(8DPSK): 2402MHz**



**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

| | |
|---|---|
| **Temperature:** | 23.2 ℃ |
| **Relative Humidity:** | 50 % |
| **ATM Pressure:** | 101.3 kPa |

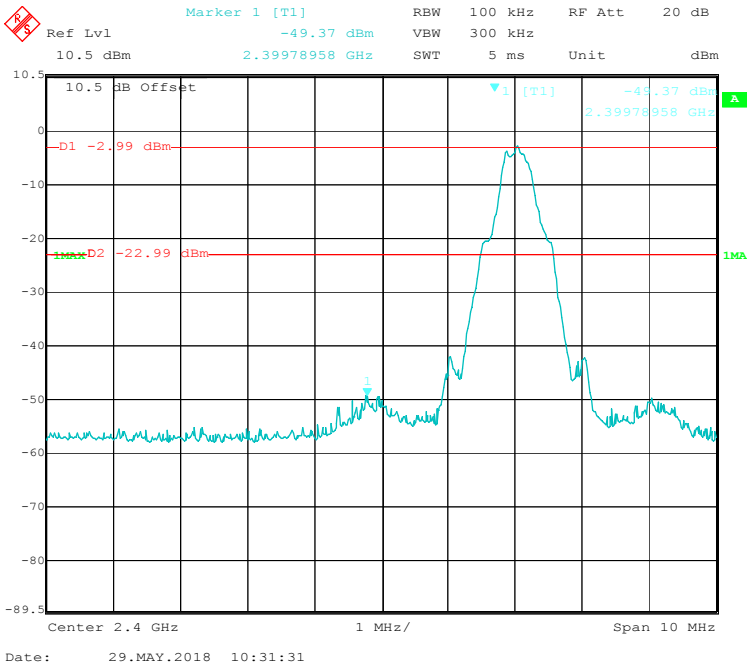
*The testing was performed by HopeDD Zhang on 2018-05-29.*

*EUT operation mode: Transmitting & Hopping*

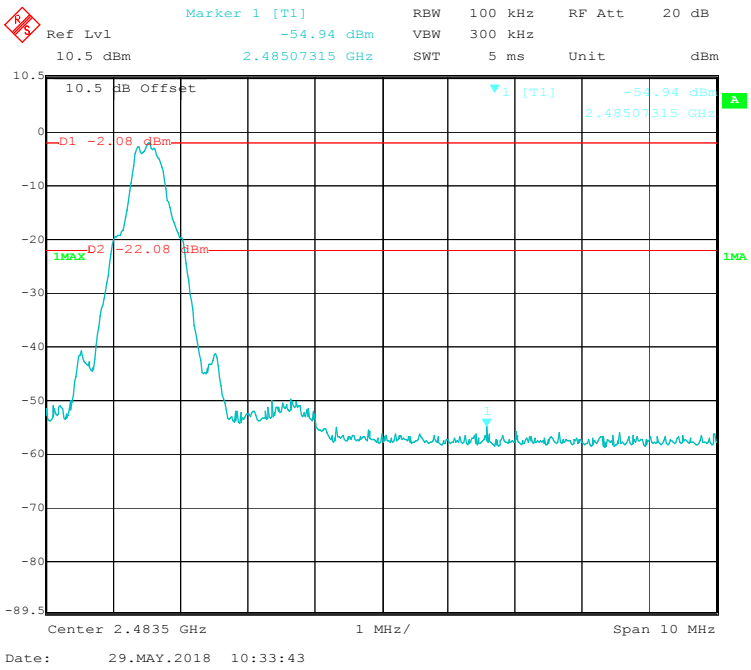
*Test Result: Compliance.*

## Band Edge

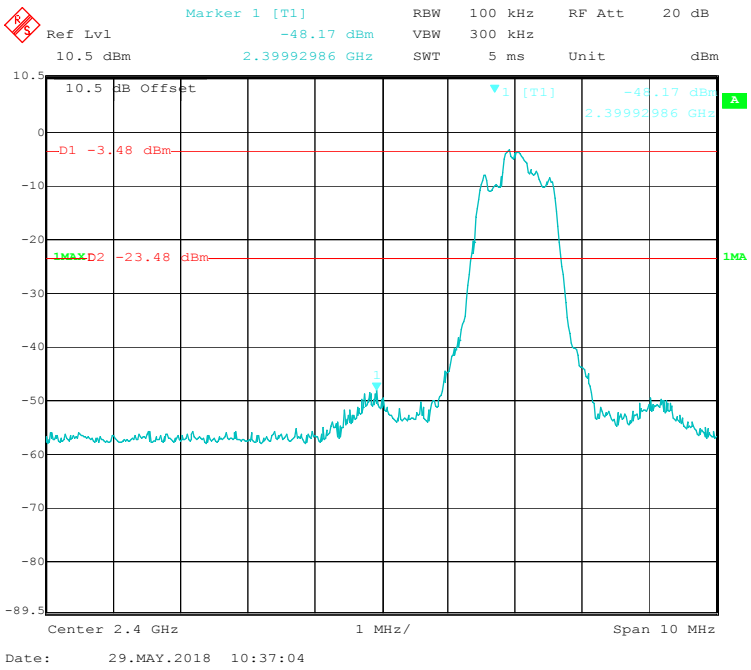
### BDR (GFSK): Left Side



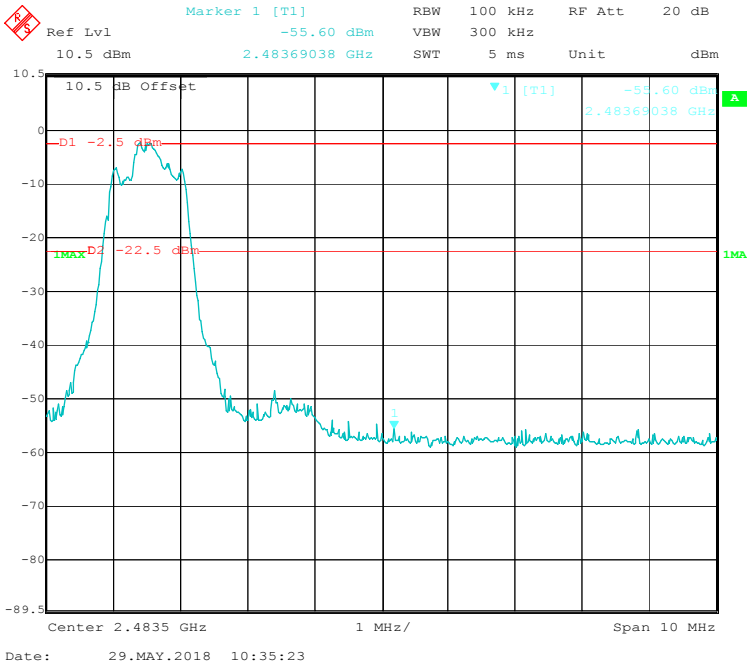

### BDR (GFSK): Right Side



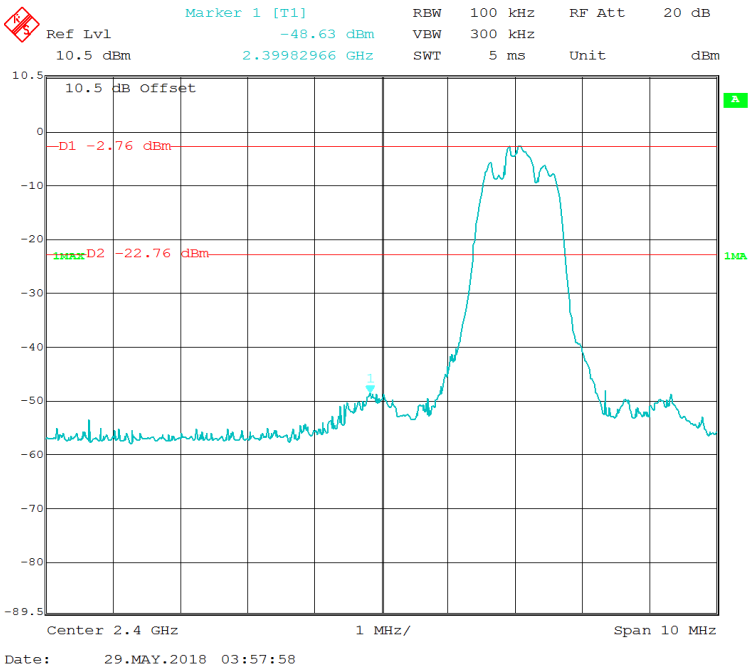
## EDR (π/4-DQPSK): Left Side



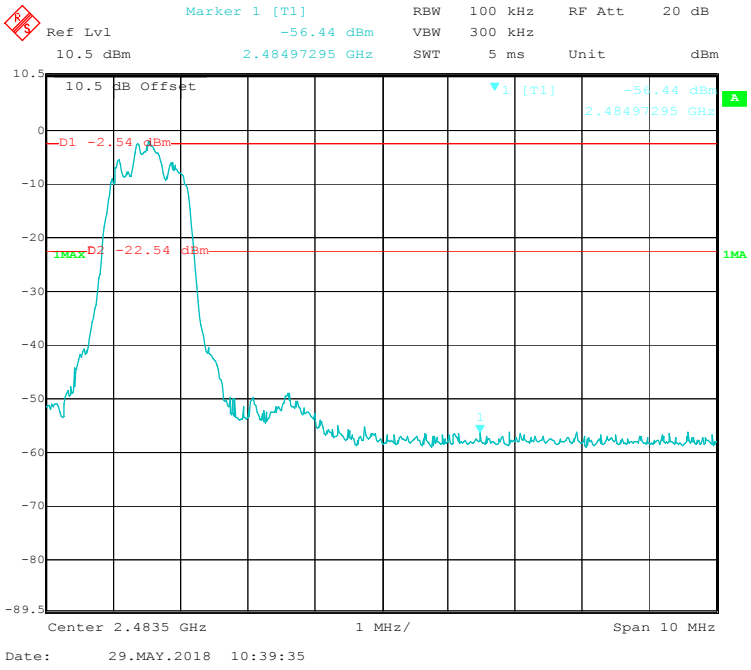

## EDR (π/4-DQPSK): Right Side



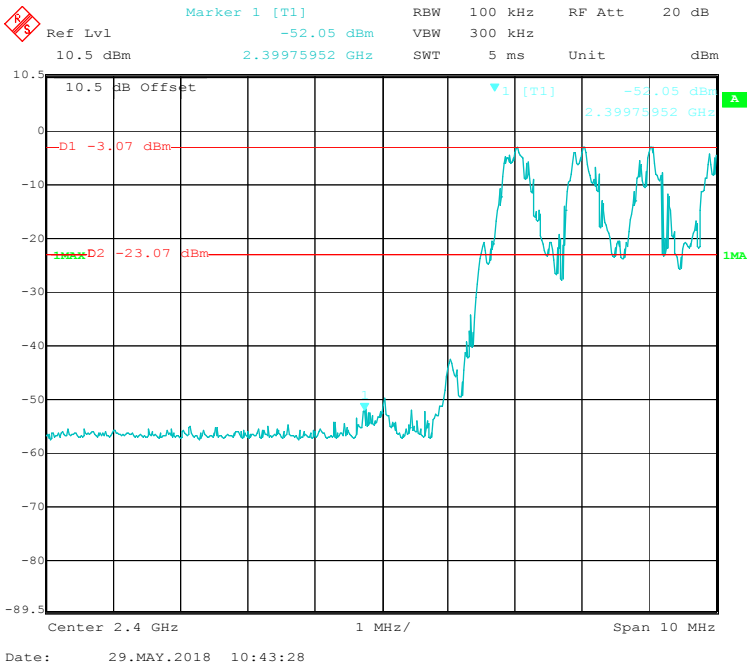
## EDR (8DPSK): Left Side



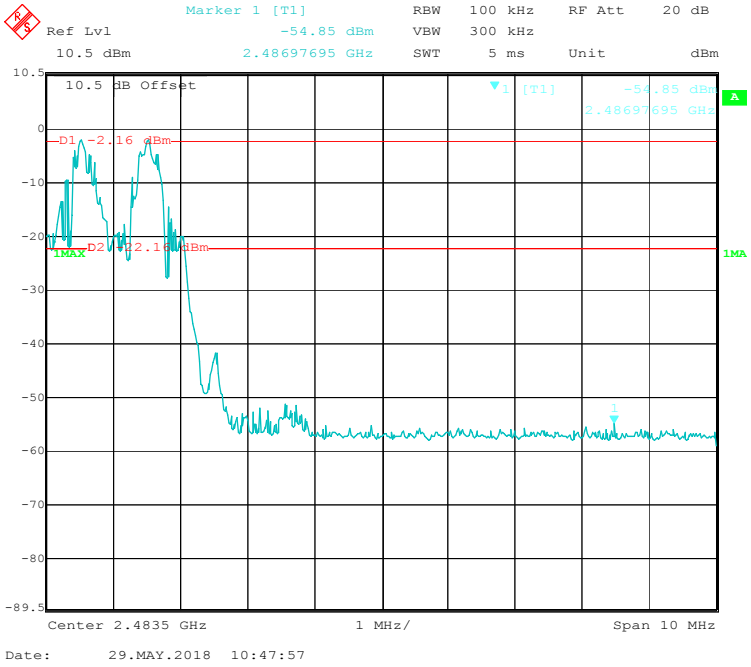

## EDR (8DPSK): Right Side



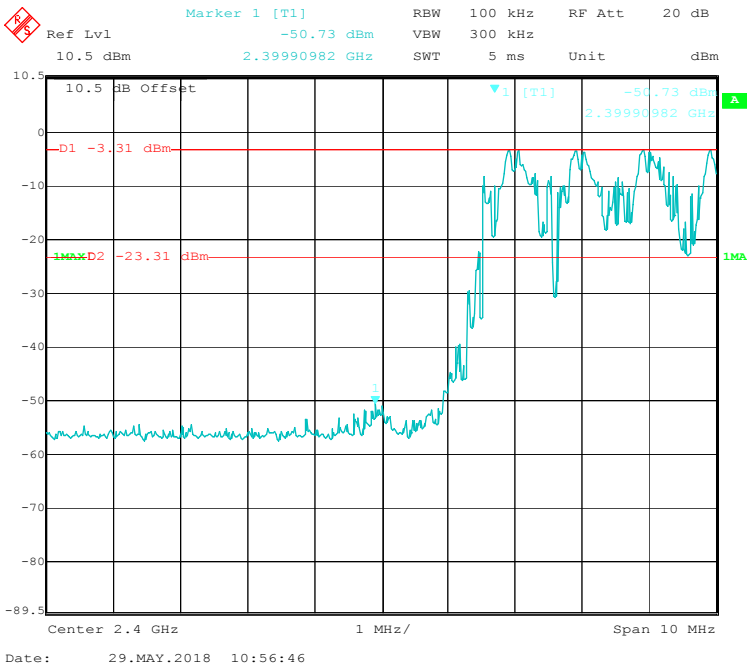
## BDR (GFSK): Left Side - Hopping



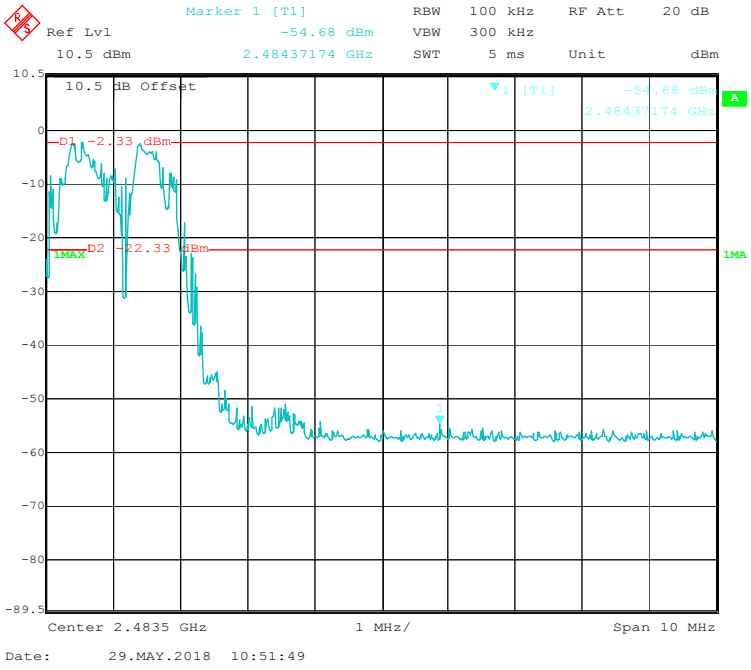

## BDR (GFSK): Right Side- Hopping



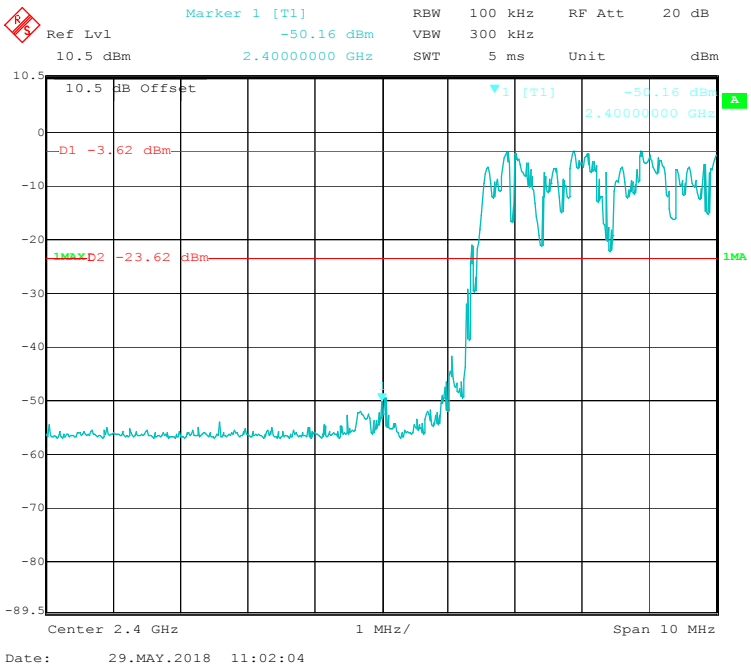
## EDR (π/4-DQPSK): Left Side- Hopping



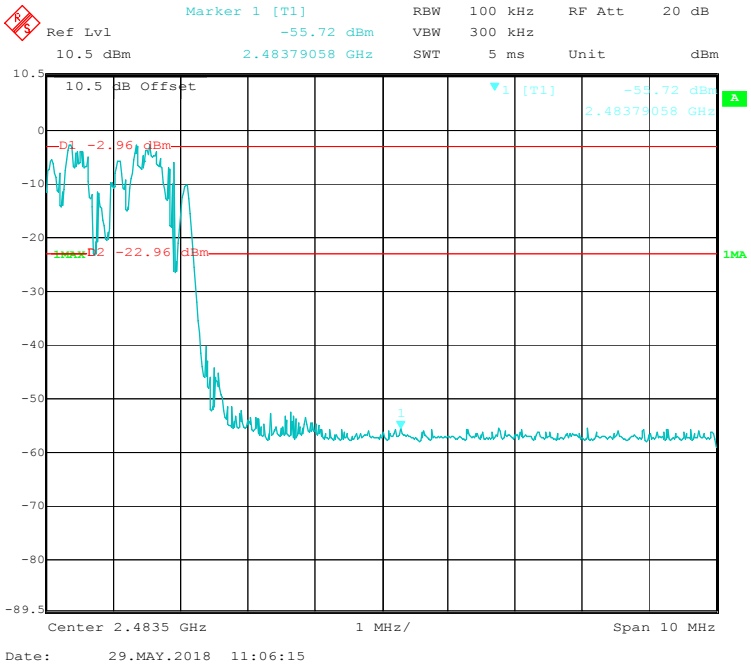

## EDR (π/4-DQPSK): Right Side- Hopping



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




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




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