# FCC TEST REPORT

| | |
|---|---|
| **Application No.**: | ZR/2020/50042 |
| **Applicant:** | Xiaomi Communications Co., Ltd. |
| **Address of Applicant** | #019, 9th Floor, Building 6, 33 Xi'erqi Middle Road, Haidian District, Beijing, China, 100085 |
| **Manufacturer:** | Xiaomi Communications Co., Ltd. |
| **Address of Manufacturer** | #019, 9th Floor, Building 6, 33 Xi'erqi Middle Road, Haidian District, Beijing, China, 100085 |
| **EUT Description:** | Mobile Phone |
| **Model No.:** | M2006C3LVG |
| **Trade Mark:** | Redmi |
| **FCC ID:** | 2AFZZC3LVG |
| **Standards:** | 47 CFR FCC Part 2, Subpart J<br>47 CFR Part 15, Subpart C |
| **Test Method** | ANSI C63.10 (2013)<br>KDB558074 D01 15.247 Meas Guidance v05r02 |
| **Date of Receipt:** | 2020/6/1 |
| **Date of Test:** | 2020/6/2 to 2020/7/4 |
| **Date of Issue:** | 2020/7/4 |
| **Test Result:** | **PASS *** |

* In the configuration tested, the EUT complied with the standards specified above.

Authorized Signature:

Derek Yang
Wireless Laboratory Manager

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# 1 Version

| Revision Record | | | | |
|---|---|---|---|---|
| **Version** | **Chapter** | **Date** | **Modifier** | **Remark** |
| 01 | | 2020/7/4 | | Original |
| | | | | |
| | | | | |

| | | | | |
|---|---|---|---|---|
| **Authorized for issue by:** | | | | |
| **Tested By** | | Mike Hu<br>**(Mike Hu) /Project Engineer** | | |
| **Checked By** | | David Chen<br>**(David Chen) /Reviewer** | | |

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# 2 Test Summary

| Test Item | Test Requirement | Test method | Test Result | Result |
|---|---|---|---|---|
| AC Power Line Conducted Emission | 15.207 | ANSI C63.10 (2013) | Clause 4.3 | PASS |
| Conducted Peak Output Power | 15.247 (a)(1) | ANSI C63.10 (2013) | Clause 4.4 | PASS |
| 20dB Emission Bandwidth & 99% Occupied Bandwidth | 15.247 (a)(1) | ANSI C63.10 (2013) | Clause 4.5 | PASS |
| Carrier Frequencies Separation | 15.247 (a)(1) | ANSI C63.10 (2013) | Clause 4.6 | PASS |
| Hopping Channel Number | 15.247 (a)(1) | ANSI C63.10 (2013) | Clause 4.7 | PASS |
| Dwell Time | 15.247 (a)(1) | ANSI C63.10 (2013) | Clause 4.8 | PASS |
| Band-edge for RF Conducted Emissions | 15.247(d) | ANSI C63.10 (2013) | Clause 4.9 | PASS |
| RF Conducted Spurious Emissions | 15.247(d) | ANSI C63.10 (2013) | Clause 4.10 | PASS |
| Radiated Spurious emissions | 15.247(d); 15.205/15.209 | ANSI C63.10 (2013) | Clause 4.11 | PASS |
| Restricted bands around fundamental frequency (Radiated Emission) | 15.247(d); 15.205/15.209 | ANSI C63.10 (2013) | Clause 4.12 | PASS |

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# 3 General Information

## 3.1 Client Information

| | |
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| Applicant: | Xiaomi Communications Co., Ltd. |
| Address of Applicant: | #019, 9th Floor, Building 6, 33 Xi'erqi Middle Road, Haidian District, Beijing, China, 100085 |
| Manufacturer: | Xiaomi Communications Co., Ltd. |
| Address of Manufacturer: | #019, 9th Floor, Building 6, 33 Xi'erqi Middle Road, Haidian District, Beijing, China, 100085 |

## 3.2 Test Location

| | |
|---|---|
| Company: | SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch |
| Address: | No. 1 Workshop, M-10, Middle section, Science & Technology Park, Shenzhen, Guangdong, China |
| Post code: | 518057 |
| Telephone: | +86 (0) 755 2601 2053 |
| Fax: | +86 (0) 755 2671 0594 |
| E-mail: | ee.shenzhen@sgs.com |

## 3.3 Test Facility

The test facility is recognized, certified, or accredited by the following organizations:

**• CNAS (No. CNAS L2929)**

CNAS has accredited SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch EMC Lab to ISO/IEC 17025:2005 General Requirements for the Competence of Testing and Calibration Laboratories (CNAS-CL01 Accreditation Criteria for the Competence of Testing and Calibration Laboratories) for the competence in the field of testing.

**• A2LA (Certificate No. 3816.01)**

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen EMC Laboratory is accredited by the American Association for Laboratory Accreditation(A2LA). Certificate No. 3816.01.

**• VCCI**

The 3m Fully-anechoic chamber for above 1GHz, 10m Semi-anechoic chamber for below 1GHz, Shielded Room for Mains Port Conducted Interference Measurement and Telecommunication Port Conducted Interference Measurement of SGS-CSTC Standards Technical Services Co., Ltd. have been registered in accordance with the Regulations for Voluntary Control Measures with Registration No.: G-20026, R-14188, C-12383 and T-11153 respectively.

**• FCC –Designation Number: CN1178**

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen EMC Laboratory has been recognized as an accredited testing laboratory.

Designation Number: CN1178. Test Firm Registration Number: 406779.

**• Industry Canada (IC)**

Two 3m Semi-anechoic chambers and the 10m Semi-anechoic chamber of SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch EMC Lab have been registered by Certification and Engineering Bureau of Industry Canada for radio equipment testing with Registration No.: 4620C-1, 4620C-2, 4620C-3.

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## 3.4 General Description of EUT

| | |
|---|---|
| EUT Description: | Mobile Phone |
| Model No.: | M2006C3LVG |
| Trade Mark: | Redmi |
| Hardware Version: | P2 |
| Software Version: | MIUI 12 |
| Operation Frequency: | 2400MHz~2483.5MHz<br>fc = 2402 MHz + N * 1 MHz, where:<br>-fc = “Operating Frequency” in MHz,<br>-N = “Channel Number” with the range from 0 to 78. |
| Bluetooth Version: | Bluetooth V3.0 +EDR |
| Modulation Technique: | Frequency Hopping Spread Spectrum(FHSS) |
| Modulation Type: | GFSK, π/4DQPSK, 8DPSK |
| Number of Channel: | 79 |
| Hopping Channel Type: | Adaptive Frequency Hopping systems |
| Sample Type: | ☒ Portable Device, ☐ Module |
| Antenna Type: | ☐ External, ☒ Integrated |
| Antenna Gain: | 1.0dBi |
| Power Supply | ☒ AC/DC Adapter; ☒ Battery ☐ PoE:; ☐ Other: |

| Operation Frequency each of channel | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Channel** | **Frequency** | **Channel** | **Frequency** | **Channel** | **Frequency** | **Channel** | **Frequency** |
| 0 | 2402MHz | 20 | 2422MHz | 40 | 2442MHz | 60 | 2462MHz |
| 1 | 2403MHz | 21 | 2423MHz | 41 | 2443MHz | 61 | 2463MHz |
| 2 | 2404MHz | 22 | 2424MHz | 42 | 2444MHz | 62 | 2464MHz |
| 3 | 2405MHz | 23 | 2425MHz | 43 | 2445MHz | 63 | 2465MHz |
| 4 | 2406MHz | 24 | 2426MHz | 44 | 2446MHz | 64 | 2466MHz |
| 5 | 2407MHz | 25 | 2427MHz | 45 | 2447MHz | 65 | 2467MHz |
| 6 | 2408MHz | 26 | 2428MHz | 46 | 2448MHz | 66 | 2468MHz |
| 7 | 2409MHz | 27 | 2429MHz | 47 | 2449MHz | 67 | 2469MHz |
| 8 | 2410MHz | 28 | 2430MHz | 48 | 2450MHz | 68 | 2470MHz |
| 9 | 2411MHz | 29 | 2431MHz | 49 | 2451MHz | 69 | 2471MHz |
| 10 | 2412MHz | 30 | 2432MHz | 50 | 2452MHz | 70 | 2472MHz |
| 11 | 2413MHz | 31 | 2433MHz | 51 | 2453MHz | 71 | 2473MHz |
| 12 | 2414MHz | 32 | 2434MHz | 52 | 2454MHz | 72 | 2474MHz |
| 13 | 2415MHz | 33 | 2435MHz | 53 | 2455MHz | 73 | 2475MHz |
| 14 | 2416MHz | 34 | 2436MHz | 54 | 2456MHz | 74 | 2476MHz |
| 15 | 2417MHz | 35 | 2437MHz | 55 | 2457MHz | 75 | 2477MHz |
| 16 | 2418MHz | 36 | 2438MHz | 56 | 2458MHz | 76 | 2478MHz |
| 17 | 2419MHz | 37 | 2439MHz | 57 | 2459MHz | 77 | 2479MHz |
| 18 | 2420MHz | 38 | 2440MHz | 58 | 2460MHz | 78 | 2480MHz |

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| | | | | | | |
|---|---|---|---|---|---|---|
| 19 | 2421MHz | 39 | 2441MHz | 59 | 2461MHz | |

Remark:

In section 15.31(m), regards to the operating frequency range over 10 MHz, the Lowest frequency, the middle

frequency, and the highest frequency of channel were selected to perform the test, and the selected channel see below:

| Channel | Frequency |
|---|---|
| The Lowest channel | 2402MHz |
| The Middle channel | 2441MHz |
| The Highest channel | 2480MHz |

## 3.5 Test Environment

| Operating Environment | |
|---|---|
| Temperature: | 24.0 °C |
| Humidity: | 55 % RH |
| Atmospheric Pressure: | 101.30 KPa |

## 3.6 Description of Support Units

The EUT has been tested independent unit.

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# 4 Test results and Measurement Data

## 4.1 Antenna Requirement

| **Standard requirement:** | 47 CFR Part 15C Section 15.203 /247(c) |
|---|---|
| 15.203 requirement: 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, 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.<br>15.247(b) (4) requirement: The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi. | |
| The antenna is integrated on the main PCB and no consideration of replacement. The best case gain of the antenna is1.0dBi. | |

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## 4.2 Other requirements Frequency Hopping Spread Spectrum System Hopping Sequence

### 4.2.1 Test Requirement:

47 CFR Part 15, Subpart C 15.247(a)(1),(g),(h)

### 4.2.2 Conclusion

Standard Requirement:

The system shall hop to channel frequencies that are selected at the system hopping rate from a Pseudorandom ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

Compliance for section 15.247(a)(1):

According to Technical Specification, the pseudorandom sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first ONE of 9 consecutive ONEs; i.e. the shift register is initialized with nine ones.

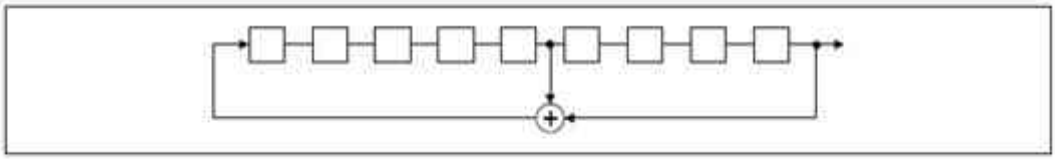
> Number of shift register stages: 9

> Length of pseudo-random sequence: 29 -1 = 511 bits

> Longest sequence of zeros: 8 (non-inverted signal)

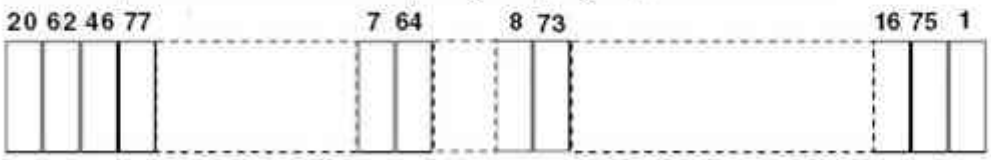
Linear Feedback Shift Register for Generation of the PRBS sequence

An example of Pseudorandom Frequency Hopping Sequence as follow:



*Linear Feedback Shift Register for Generation of the PRBS sequence*

An example of Pseudorandom Frequency Hopping Sequence as follow:




Each frequency used equally on the average by each transmitter.

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According to Technical Specification, the receivers are designed to have input and IF bandwidths that match the hopping channel bandwidths of any transmitters and shift frequencies in synchronization with the transmitted signals.

Compliance for section 15.247(g):

According to Technical Specification, the system transmits the packet with the pseudorandom hopping frequency with a continuous data and the short burst transmission from the RF system is also transmitted under the frequency hopping system with the pseudorandom hopping frequency system.

Compliance for section 15.247(h):

According to Technical specification, the system incorporates with an adaptive system to detect other user within the spectrum band so that it individually and independently to avoid hopping on the occupied channels. The system is designed not have the ability to coordinated with other FHSS System in an effort to avoid the simultaneous occupancy of individual hopping frequencies by multiple transmitter.

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## 4.3 AC Power Line Conducted Emissions

| | | | |
|---|---|---|---|
| Test Requirement: | 47 CFR Part 15C Section 15.207 | | |
| Test Method: | ANSI C63.10: 2013 | | |
| Test Frequency Range: | 150kHz to 30MHz | | |
| Limit: | Frequency range (MHz) | Limit (dBuV) | |
| | | Quasi-peak | Average |
| | 0.15-0.5 | 66 to 56* | 56 to 46* |
| | 0.5-5 | 56 | 46 |
| | 5-30 | 60 | 50 |
| | * Decreases with the logarithm of the frequency. | | |
| Test Procedure: | 1) The mains terminal disturbance voltage test was conducted in a shielded room.<br>2) The EUT was connected to AC power source through a LISN 1 (Line Impedance Stabilization Network) which provides a 50Ω/50μH + 5Ω linear impedance. The power cables of all other units of the EUT were connected to a second LISN 2, which was bonded to the ground reference plane in the same way as the LISN 1 for the unit being measured. A multiple socket outlet strip was used to connect multiple power cables to a single LISN provided the rating of the LISN was not exceeded.<br>3) The tabletop EUT was placed upon a non-metallic table 0.8m above the ground reference plane. And for floor-standing arrangement, the EUT was placed on the horizontal ground reference plane,<br>4) The test was performed with a vertical ground reference plane. The rear of the EUT shall be 0.4 m from the vertical ground reference plane. The vertical ground reference plane was bonded to the horizontal ground reference plane. The LISN 1 was placed 0.8 m from the boundary of the unit under test and bonded to a ground reference plane for LISNs mounted on top of the ground reference plane. This distance was between the closest points of the LISN 1 and the EUT. All other units of the EUT and associated equipment was at least 0.8 m from the LISN 2.<br>5) In order to find the maximum emission, the relative positions of equipment and all of the interface cables must be changed according to ANSI C63.10: 2013 on conducted measurement. | | |

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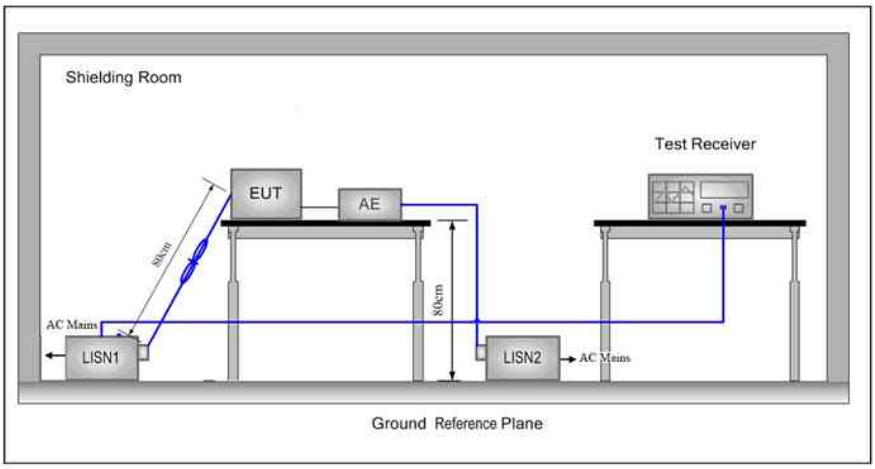
| | |
|---|---|
| Test Setup: |  |
| Exploratory Test Mode: | Non-hopping transmitting mode with all kind of modulation and all kind of data type at the lowest, middle, high channel.<br>Charge + Transmitting mode. |
| Final Test Mode: | Through Pre-scan, find the<br>DH5 of data type and GFSK modulation at the lowest channel is the worst case.<br>Charge + Transmitting mode<br>Only the worst case is recorded in the report. |
| Instruments Used: | Refer to section 5.10 for details |
| Test Results: | Pass |

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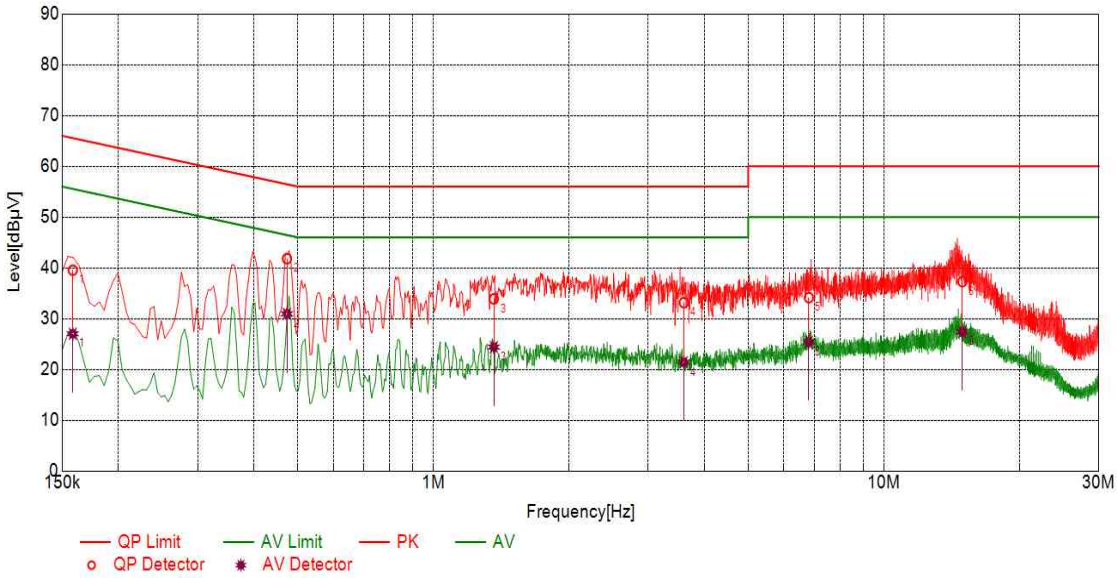
Measurement Data

An initial pre-scan was performed on the live and neutral lines with peak detector.

Quasi-Peak and Average measurement were performed at the frequencies with maximized peak emission were detected.

Live line:




**Test Graph**

| Final Data List | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Factor [dB] | QP Value | QP Limit | QP Margin | AV Value | AV Limit | AV Margin | Type |
| 1 | 0.1584 | 10.10 | 39.54 | 65.55 | 26.01 | 27.02 | 55.55 | 28.53 | L |
| 2 | 0.4732 | 10.10 | 41.82 | 56.46 | 14.64 | 30.95 | 46.46 | 15.51 | L |
| 3 | 1.3626 | 10.10 | 33.89 | 56.00 | 22.11 | 24.41 | 46.00 | 21.59 | L |
| 4 | 3.5977 | 10.10 | 33.15 | 56.00 | 22.85 | 21.41 | 46.00 | 24.59 | L |
| 5 | 6.8160 | 10.10 | 34.14 | 60.00 | 25.86 | 25.42 | 50.00 | 24.58 | L |
| 6 | 14.9348 | 10.11 | 37.28 | 60.00 | 22.72 | 27.39 | 50.00 | 22.61 | L |

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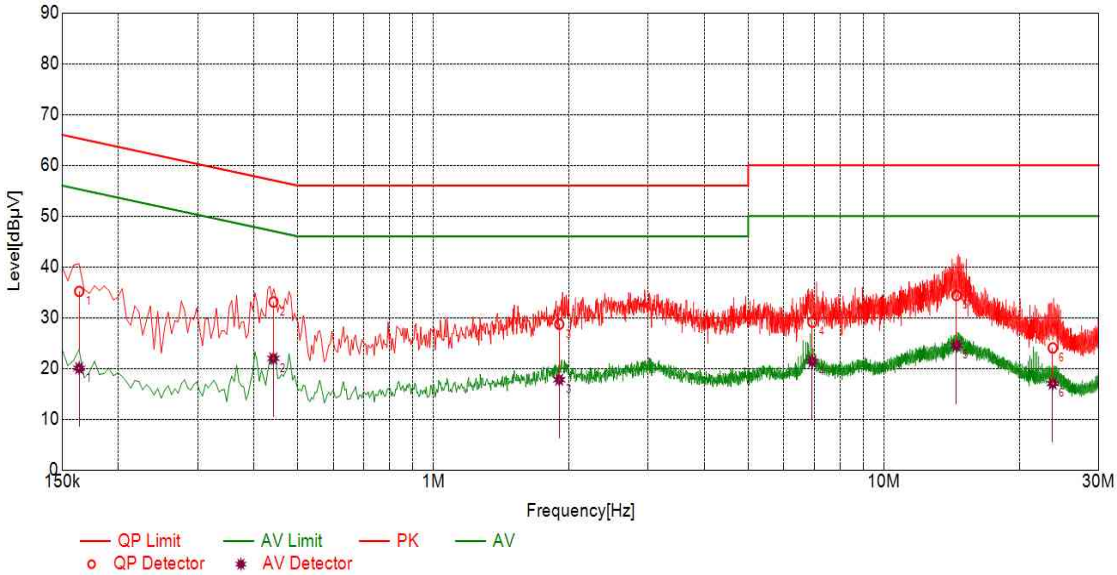
Neutral line:




**Test Graph**

| Final Data List | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Factor [dB] | QP Value | QP Limit | QP Margin | AV Value | AV Limit | AV Margin | Type |
| 1 | 0.1637 | 10.10 | 35.17 | 65.28 | 30.11 | 20.05 | 55.28 | 35.23 | N |
| 2 | 0.4417 | 10.10 | 33.09 | 57.03 | 23.94 | 21.98 | 47.03 | 25.05 | N |
| 3 | 1.9034 | 10.10 | 28.70 | 56.00 | 27.30 | 17.78 | 46.00 | 28.22 | N |
| 4 | 6.9386 | 10.10 | 29.14 | 60.00 | 30.86 | 21.37 | 50.00 | 28.63 | N |
| 5 | 14.4924 | 10.11 | 34.38 | 60.00 | 25.62 | 24.50 | 50.00 | 25.50 | N |
| 6 | 23.7020 | 10.11 | 24.04 | 60.00 | 35.96 | 17.03 | 50.00 | 32.97 | N |

Remarks:

1. The following Quasi-Peak and Average measurements were performed on the EUT:
2. Final Test Level =Receiver Reading + LISN Factor + Cable Loss.

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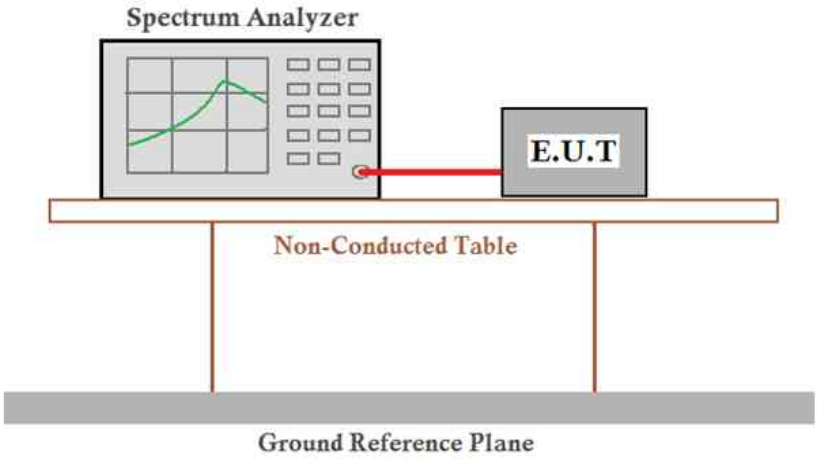
## 4.4 Conducted Peak Output Power

| | |
|---|---|
| Test Requirement: | 47 CFR Part 15C Section 15.247 (a)(1) |
| Test Method: | ANSI C63.10:2013 Section 7.8.5 |
| Test Setup: |  |
| Limit: | (20.97dBm) 125mW |
| Exploratory Test Mode: | Non-hopping transmitting with all kind of modulation and all kind of data type. |
| Final Test Mode: | Through Pre-scan, find the<br>DH5 of data type is the worst case of GFSK modulation type,<br>2-DH5 of data type is the worst case of π/4DQPSK modulation type,<br>3-DH5 of data type is the worst case of 8DPSK modulation type. |
| Instruments Used: | Refer to section 5.10 for details |
| Test Results: | Pass |

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### 4.4.1 Test Results

**Measurement Data of Peak power:**

| GFSK mode | | | |
|---|---|---|---|
| **Test channel** | **Peak Output Power (dBm)** | **Limit (dBm)** | **Result** |
| Lowest | 8.61 | 20.97 | Pass |
| Middle | 9.09 | 20.97 | Pass |
| Highest | 8.10 | 20.97 | Pass |
| **π/4DQPSK mode** | | | |
| **Test channel** | **Peak Output Power (dBm)** | **Limit (dBm)** | **Result** |
| Lowest | 8.24 | 20.97 | Pass |
| Middle | 8.32 | 20.97 | Pass |
| Highest | 7.37 | 20.97 | Pass |
| **8DPSK mode** | | | |
| **Test channel** | **Peak Output Power (dBm)** | **Limit (dBm)** | **Result** |
| Lowest | 8.30 | 20.97 | Pass |
| Middle | 8.38 | 20.97 | Pass |
| Highest | 7.38 | 20.97 | Pass |

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### 4.4.2 Test plots

| Test mode: | GFSK | Test channel: | Lowest |
|---|---|---|---|

Date: 19.JUN.2020 09:28:40

| Test mode: | GFSK | Test channel: | Middle |
|---|---|---|---|

Date: 19.JUN.2020 09:28:58

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| Test mode: | GFSK | Test channel: | Highest |
|---|---|---|---|

Date: 19.JUN.2020 09:29:10

| Test mode: | π/4DQPSK | Test channel: | Lowest |
|---|---|---|---|

Date: 19.JUN.2020 09:27:30

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| Test mode: | π/4DQPSK | Test channel: | Middle |
|---|---|---|---|

Date: 19.JUN.2020 09:27:16

| Test mode: | π/4DQPSK | Test channel: | Highest |
|---|---|---|---|

Date: 19.JUN.2020 09:27:01

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| Test mode: | 8DPSK | Test channel: | Lowest |
|---|---|---|---|

Date: 19.JUN.2020 09:25:37

| Test mode: | 8DPSK | Test channel: | Middle |
|---|---|---|---|

Date: 19.JUN.2020 09:26:32

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| Test mode: | 8DPSK | Test channel: | Highest |
|---|---|---|---|

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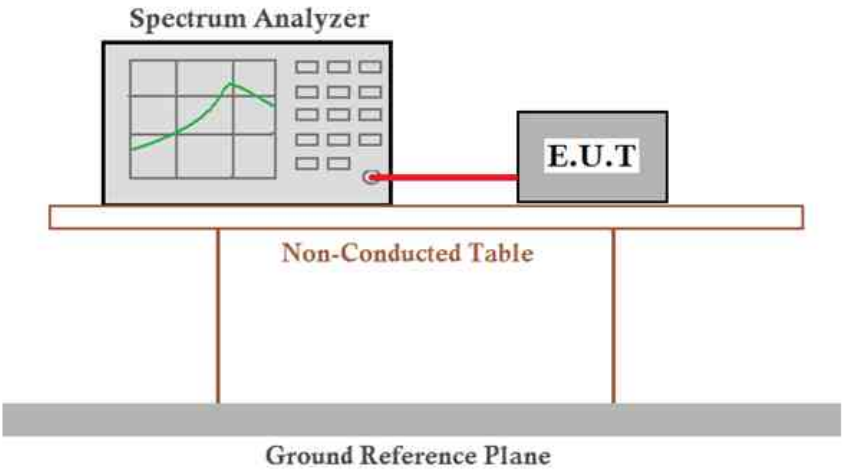
## 4.5 20dB Emission Bandwidth & 99% Occupied Bandwidth

| | |
|---|---|
| Test Requirement: | 47 CFR Part 15C Section 15.247 (a)(1) |
| Test Method: | ANSI C63.10:2013 Section 7.8.7 |
| Test Setup: |  |
| Limit: | NA |
| Exploratory Test Mode: | Non-hopping transmitting with all kind of modulation and all kind of data type. |
| Final Test Mode: | Through Pre-scan, find the<br>DH5 of data type is the worst case of GFSK modulation type,<br>2-DH5 of data type is the worst case of π/4DQPSK modulation type,<br>3-DH5 of data type is the worst case of 8DPSK modulation type. |
| Instruments Used: | Refer to section 5.10 for details |
| Test Results: | Pass |

### 4.5.1 Test Results

| Mode | Test Channel | 99% Occupied Bandwidth (KHz) | 20dB Emission Bandwidth (KHz) | Result |
|---|---|---|---|---|
| GFSK | Lowest | 759.8 | 816.2 | Pass |
| | Middle | 759.8 | 816.2 | Pass |
| | Highest | 759.8 | 820.5 | Pass |
| π/4DQPSK | Lowest | 1141.8 | 1254.7 | Pass |
| | Middle | 1141.8 | 1254.7 | Pass |
| | Highest | 1141.8 | 1250.4 | Pass |
| 8DPSK | Lowest | 1146.2 | 1263.4 | Pass |
| | Middle | 1146.2 | 1263.4 | Pass |
| | Highest | 1146.2 | 1259.0 | Pass |

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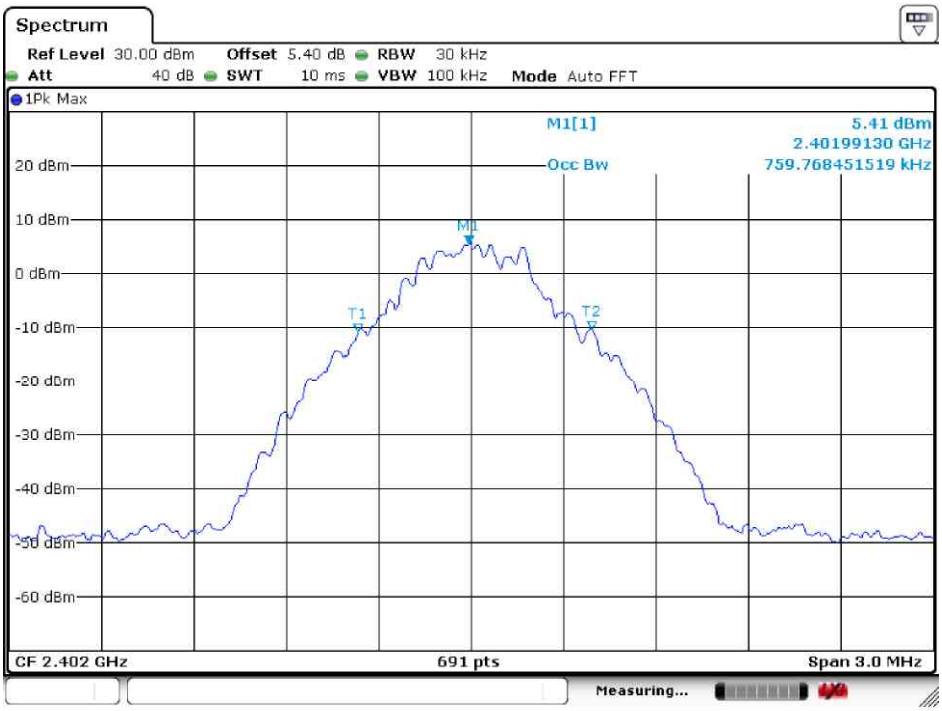
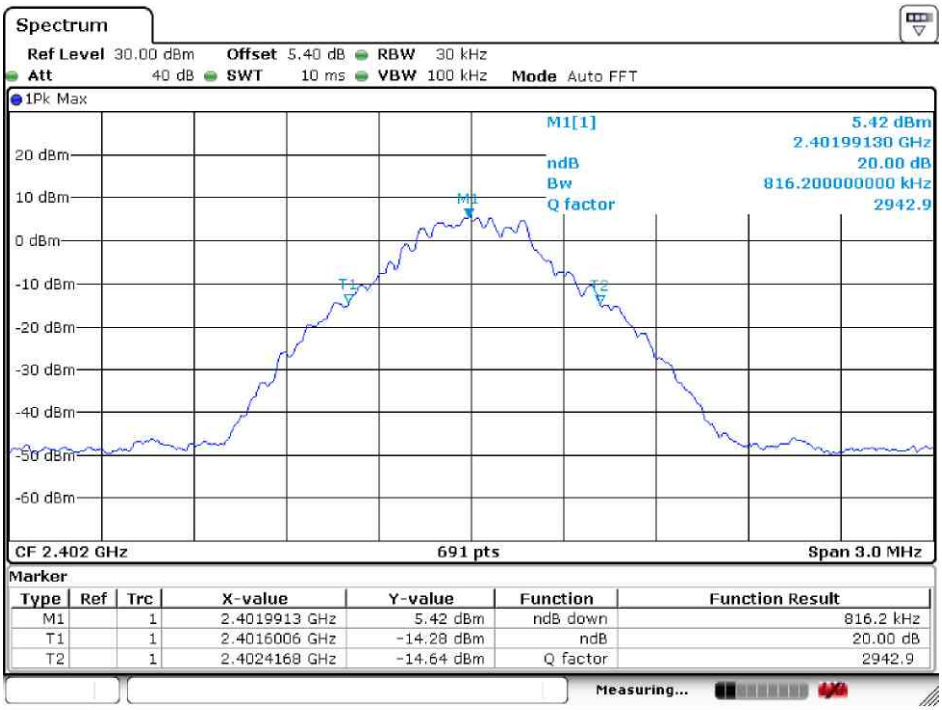
### 4.5.2 Test plots

#### 4.5.2.1 GFSK _Lowest Channel




Date: 19.JUN.2020 09:34:10




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.4019913 GHz | 5.42 dBm | ndB down | 816.2 kHz |
| T1 | | 1 | 2.4016006 GHz | -14.28 dBm | ndB | 20.00 dB |
| T2 | | 1 | 2.4024168 GHz | -14.64 dBm | Q factor | 2942.9 |

Date: 19.JUN.2020 09:34:23

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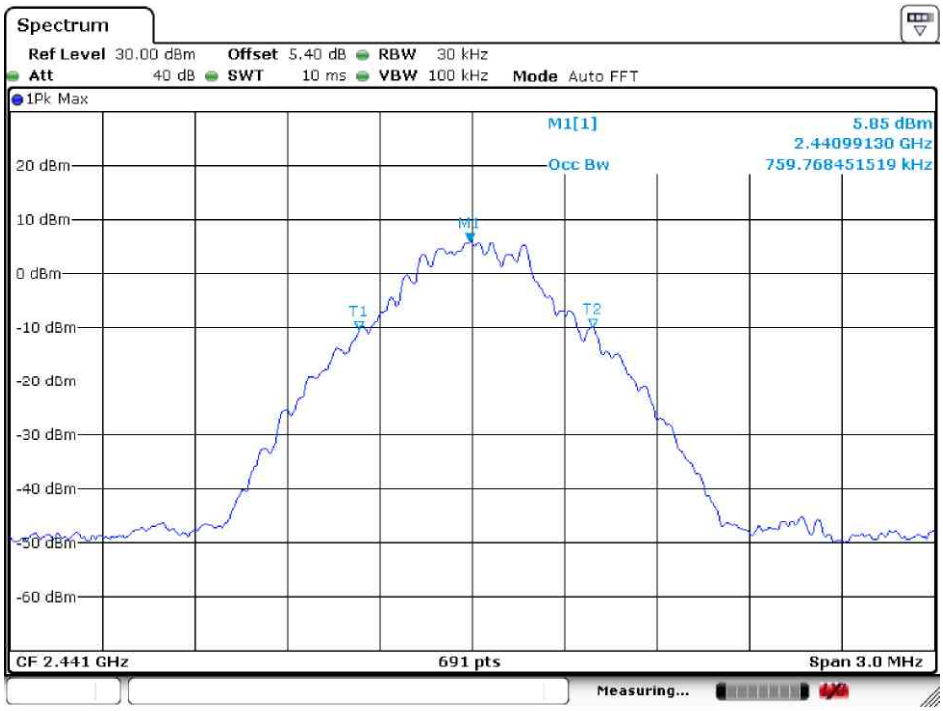
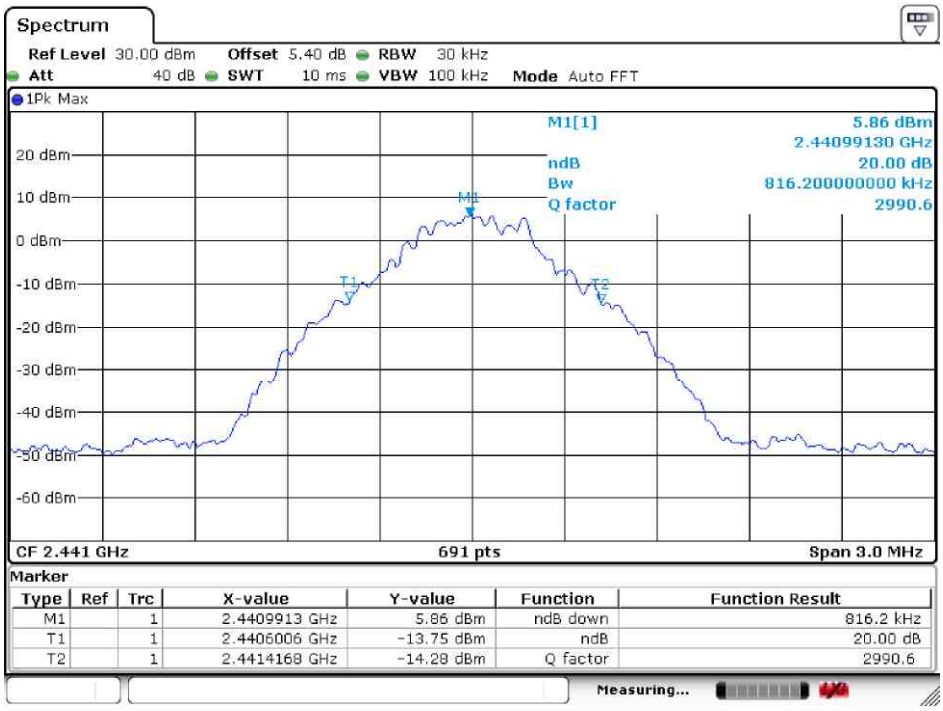
### 4.5.2.2 GFSK _Middle Channel




Date: 19.JUN.2020 09:33:56




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.4409913 GHz | 5.86 dBm | ndB down | 816.2 kHz |
| T1 | | 1 | 2.4406006 GHz | -13.75 dBm | ndB | 20.00 dB |
| T2 | | 1 | 2.4414168 GHz | -14.28 dBm | Q factor | 2990.6 |

Date: 19.JUN.2020 09:33:47

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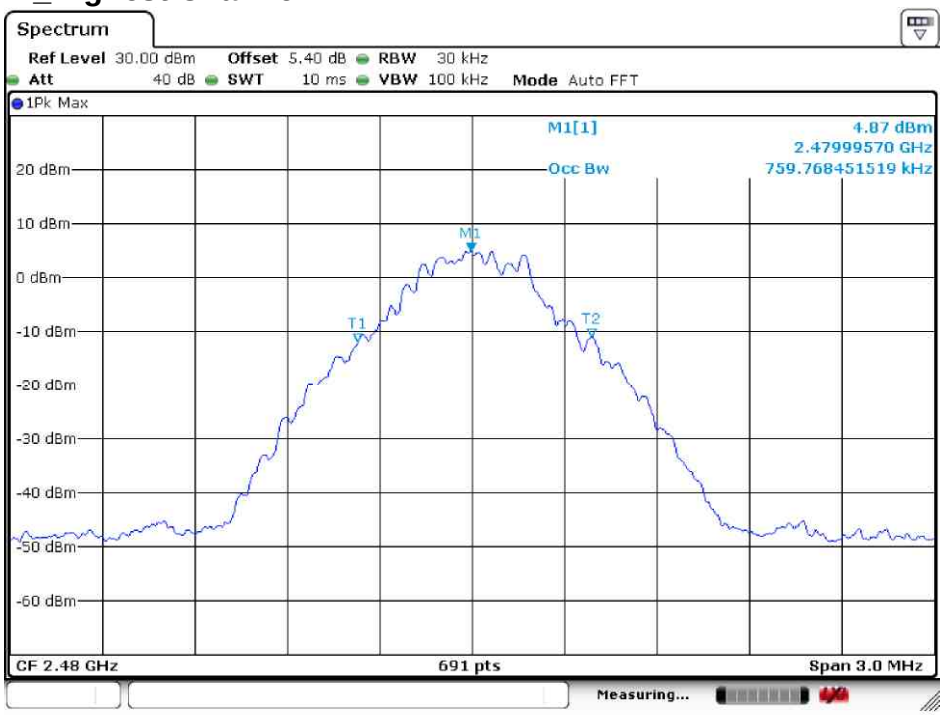
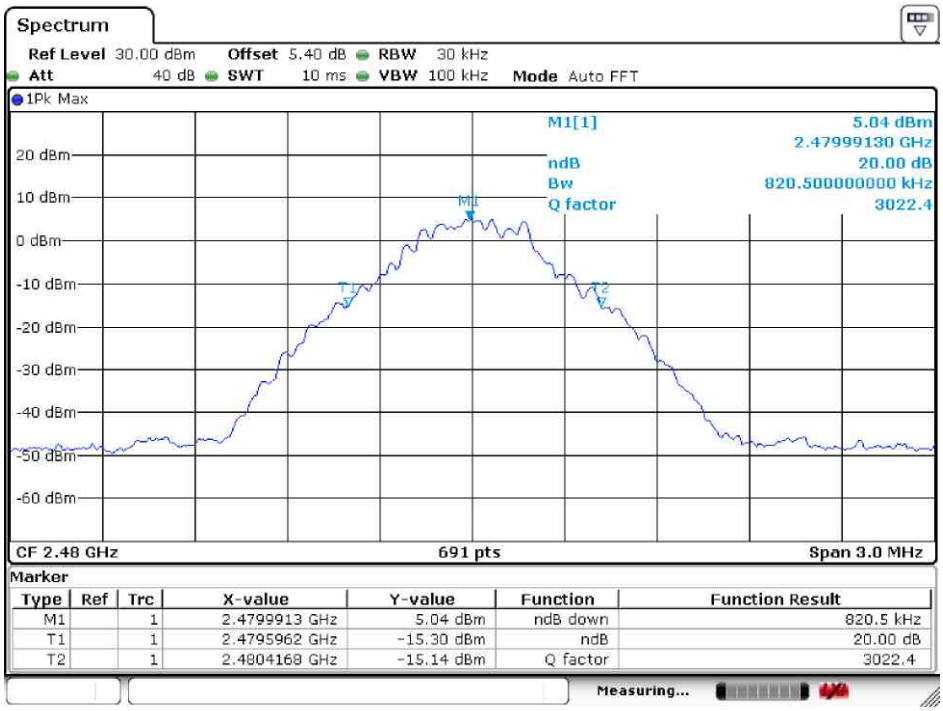
### 4.5.2.3 GFSK _Highest Channel




Date: 19.JUN.2020 09:33:08




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.4799913 GHz | 5.04 dBm | ndB down | 820.5 kHz |
| T1 | | 1 | 2.4795962 GHz | -15.30 dBm | ndB | 20.00 dB |
| T2 | | 1 | 2.4804168 GHz | -15.14 dBm | Q factor | 3022.4 |

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### 4.5.2.4 π/4DQPSK _Lowest Channel

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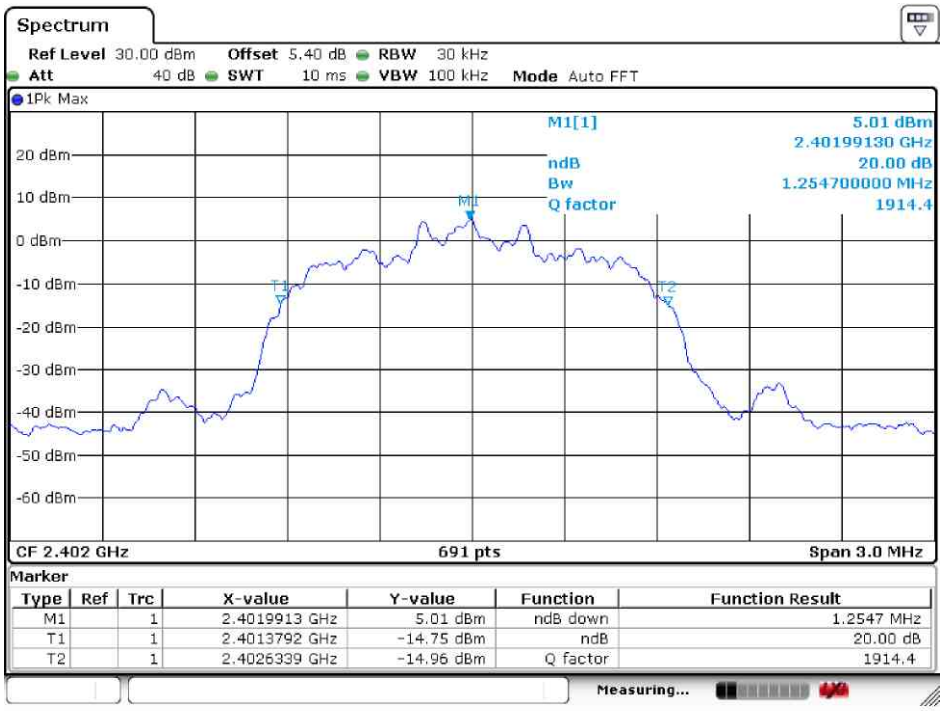


Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.4019913 GHz | 5.01 dBm | ndB down | 1.2547 MHz |
| T1 | | 1 | 2.4013792 GHz | -14.75 dBm | ndB | 20.00 dB |
| T2 | | 1 | 2.4026339 GHz | -14.96 dBm | Q factor | 1914.4 |

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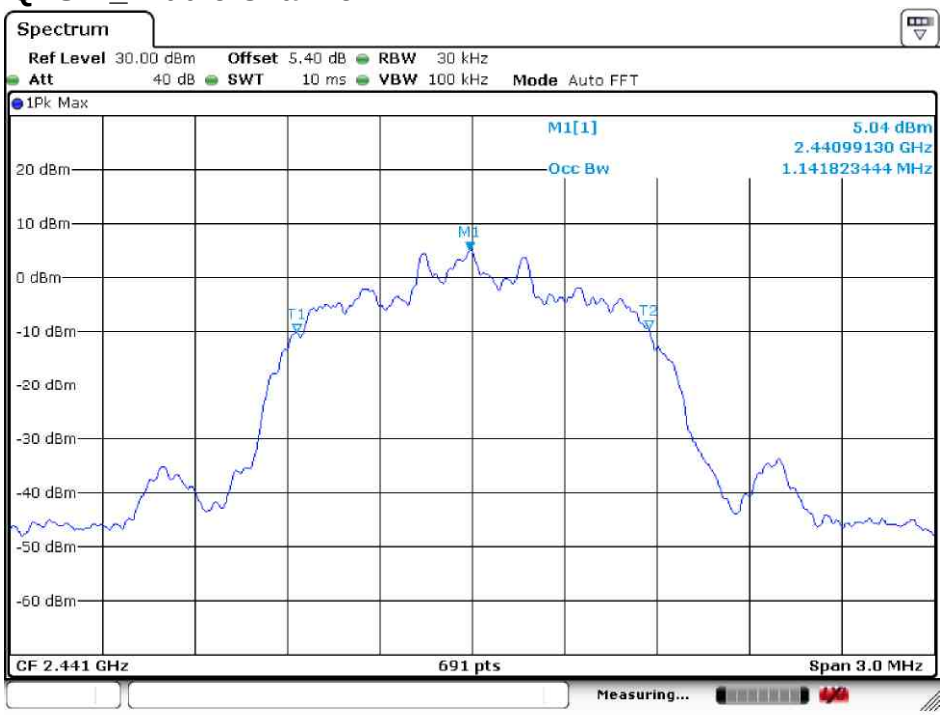
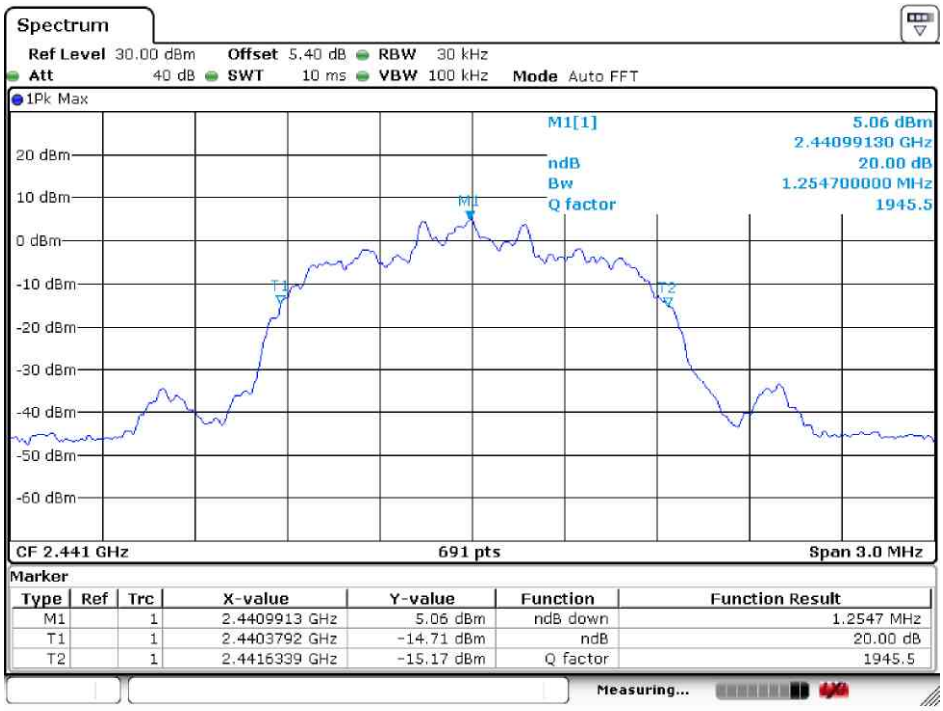
### 4.5.2.5 π/4DQPSK _Middle Channel




Date: 19.JUN.2020 09:36:00




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.4409913 GHz | 5.06 dBm | ndB down | 1.2547 MHz |
| T1 | | 1 | 2.4403792 GHz | -14.71 dBm | ndB | 20.00 dB |
| T2 | | 1 | 2.4416339 GHz | -15.17 dBm | Q factor | 1945.5 |

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### 4.5.2.6 π/4DQPSK _Highest Channel

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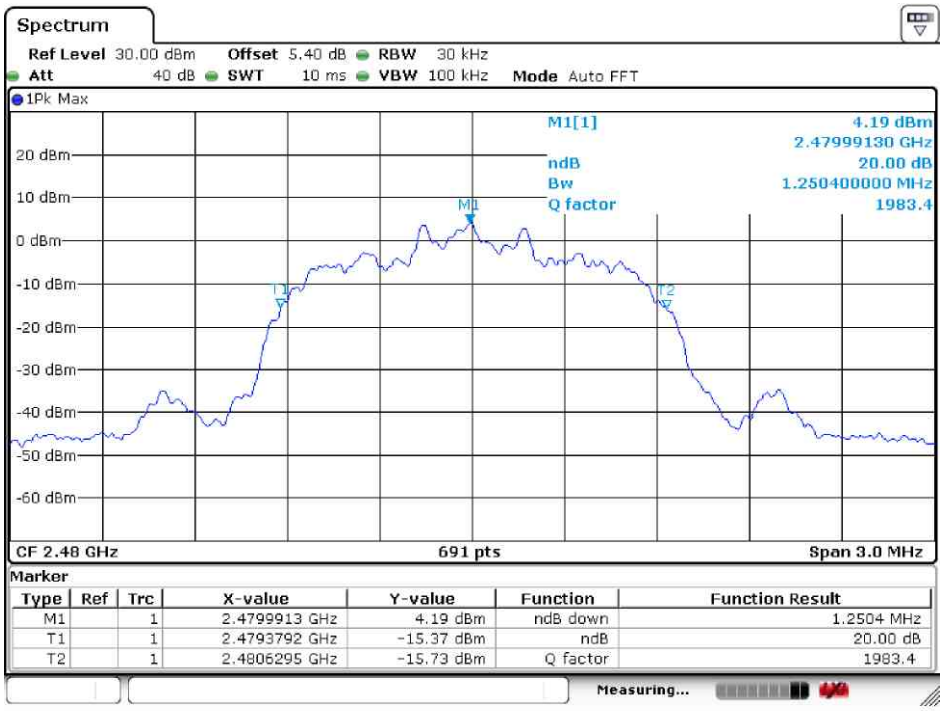


Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.4799913 GHz | 4.19 dBm | ndB down | 1.2504 MHz |
| T1 | | 1 | 2.4793792 GHz | -15.37 dBm | ndB | 20.00 dB |
| T2 | | 1 | 2.4806295 GHz | -15.73 dBm | Q factor | 1983.4 |

Date: 19.JUN.2020 09:36:29

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### 4.5.2.7 8DPSK_Lowest Channel

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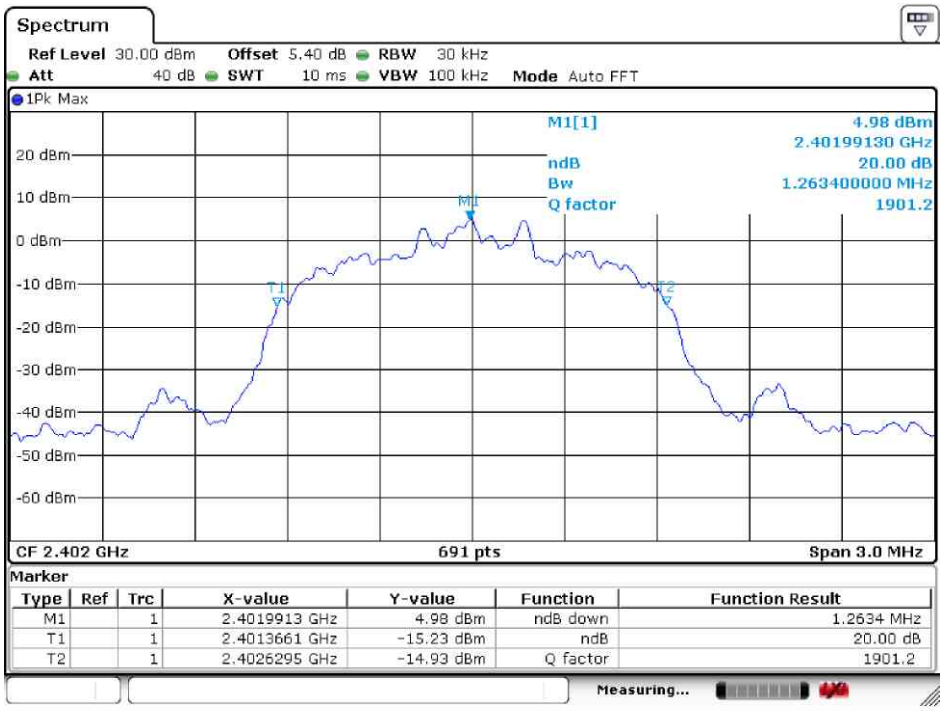


Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.4019913 GHz | 4.98 dBm | ndB down | 1.2634 MHz |
| T1 | | 1 | 2.4013661 GHz | -15.23 dBm | ndB | 20.00 dB |
| T2 | | 1 | 2.4026295 GHz | -14.93 dBm | Q factor | 1901.2 |

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### 4.5.2.8 8DPSK _Middle Channel

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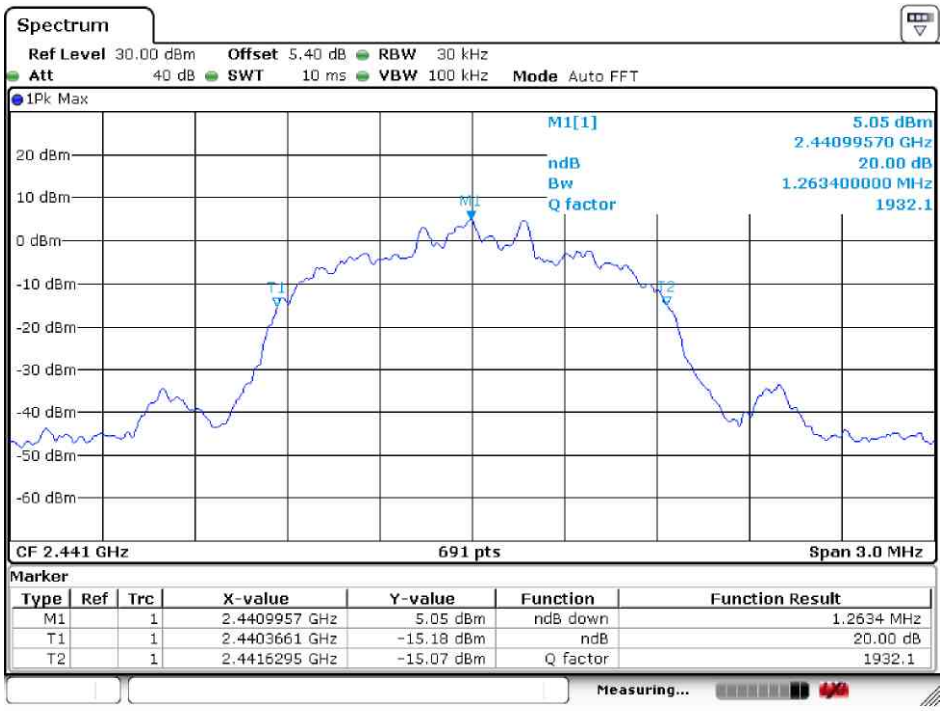


Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.4409957 GHz | 5.05 dBm | ndB down | 1.2634 MHz |
| T1 | | 1 | 2.4403661 GHz | -15.18 dBm | ndB | 20.00 dB |
| T2 | | 1 | 2.4416295 GHz | -15.07 dBm | Q factor | 1932.1 |

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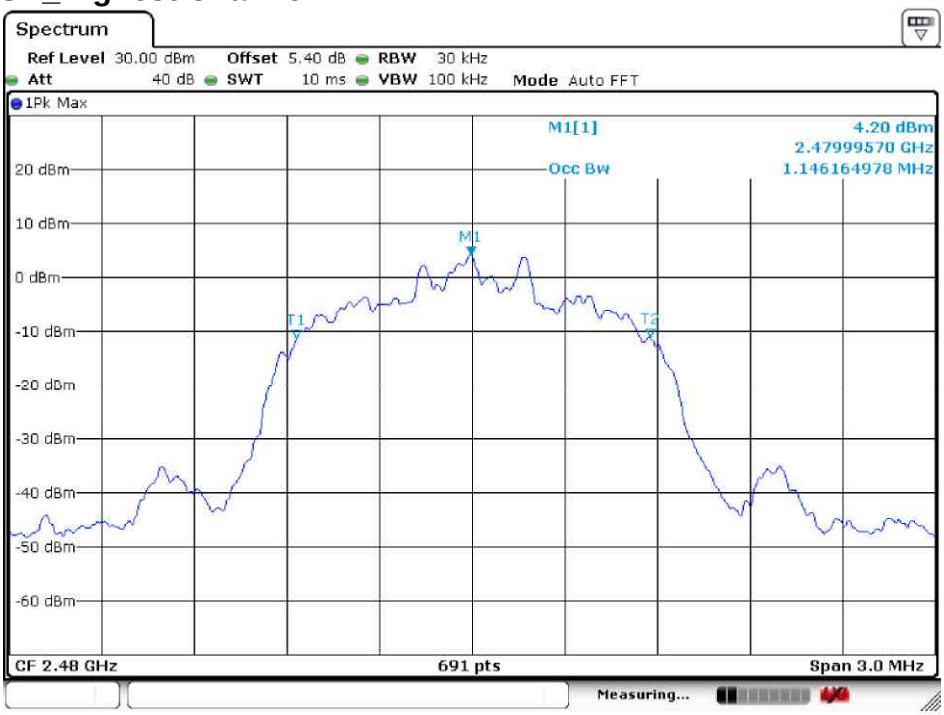
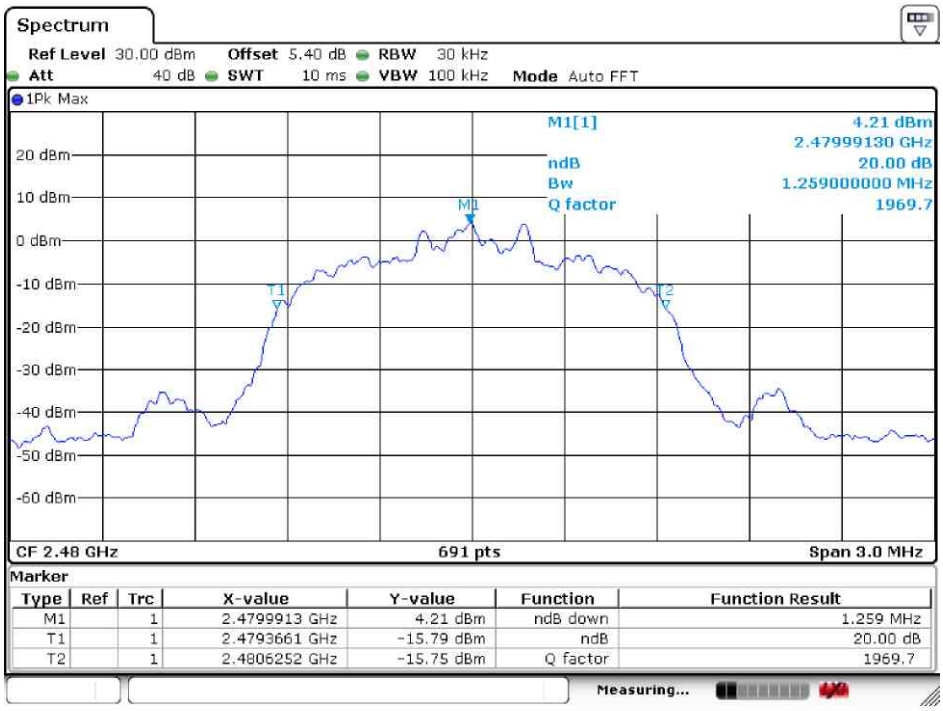
### 4.5.2.9 8DPSK_Highest Channel




Date: 19.JUN.2020 09:36:59




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.4799913 GHz | 4.21 dBm | ndB down | 1.259 MHz |
| T1 | | 1 | 2.4793661 GHz | -15.79 dBm | ndB | 20.00 dB |
| T2 | | 1 | 2.4806252 GHz | -15.75 dBm | Q factor | 1969.7 |

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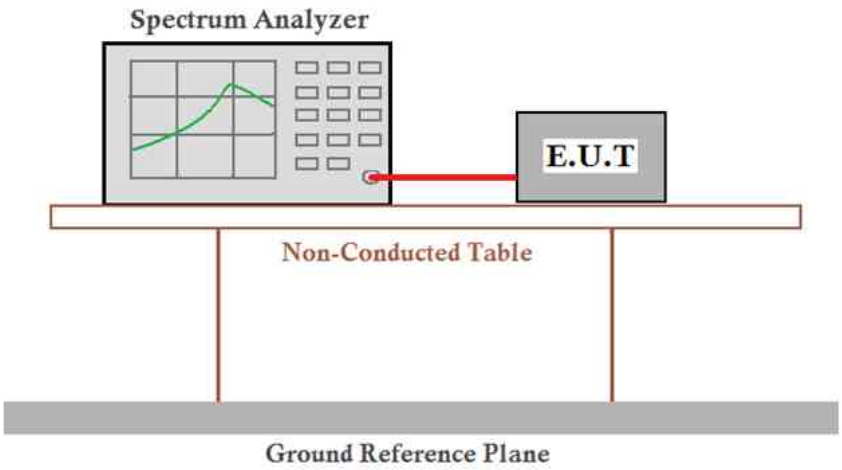
## 4.6 Carrier Frequencies Separation

| | |
|---|---|
| Test Requirement: | 47 CFR Part 15C Section 15.247 (a)(1) |
| Test Method: | ANSI C63.10:2013 Section 7.8.2 |
| Test Setup: |  |
| Limit: | 2/3 of the 20dB bandwidth |
| | Remark: the transmission power is less than 0.125W. |
| Exploratory Test Mode: | Hopping transmitting with all kind of modulation and all kind of data type. |
| Final Test Mode: | Through Pre-scan, find the<br>DH5 of data type is the worst case of GFSK modulation type,<br>2-DH5 of data type is the worst case of π/4DQPSK modulation type,<br>3-DH5 of data type is the worst case of 8DPSK modulation type. |
| Instruments Used: | Refer to section 5.10 for details |
| Test Results: | Pass |

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### 4.6.1 Test Results

| GFSK mode | | | |
|---|---|---|---|
| **Test channel** | **Carrier Frequencies Separation (kHz)** | **Limit (kHz)** | **Result** |
| Middle | 1003 | 547.0 | Pass |
| **π/4DQPSK mode** | | | |
| **Test channel** | **Carrier Frequencies Separation (kHz)** | **Limit (kHz)** | **Result** |
| Middle | 1003 | 836.5 | Pass |
| **8DPSK mode** | | | |
| **Test channel** | **Carrier Frequencies Separation (kHz)** | **Limit (kHz)** | **Result** |
| Middle | 1003 | 842.3 | Pass |

*Remark: According to section 6.4,*

| Mode | 20dB bandwidth (kHz) (worse case) | Limit (kHz) (Carrier Frequencies Separation) |
|---|---|---|
| GFSK | 820.5 | 547.0 |
| π/4DQPSK | 1254.7 | 836.5 |
| 8DPSK | 1263.4 | 842.3 |

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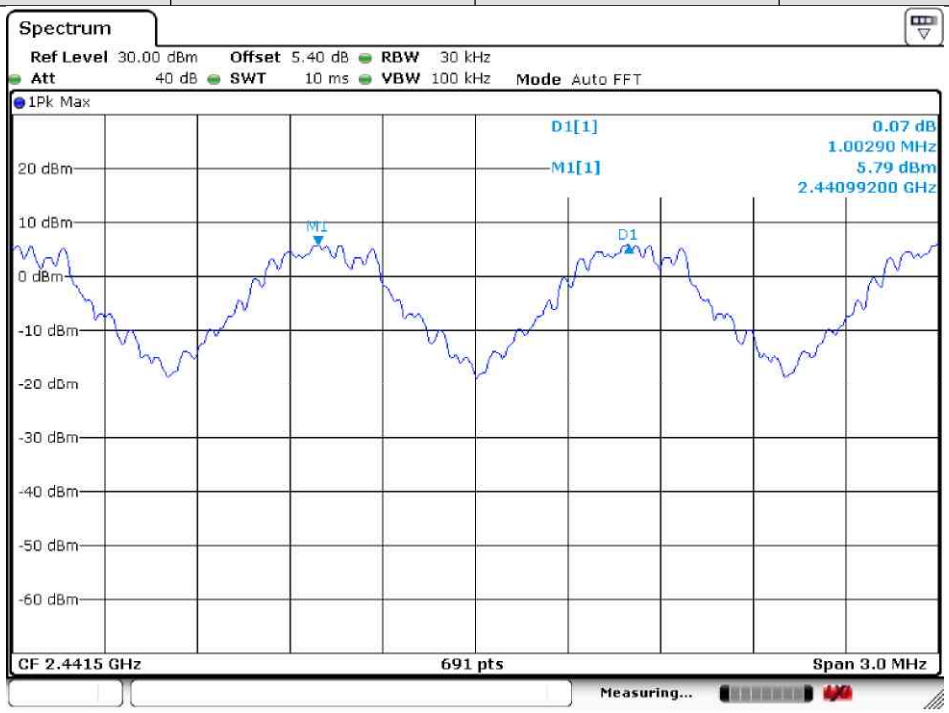
### 4.6.2 Test plots:

| Test mode: | GFSK | Test channel: | Middle |
|---|---|---|---|

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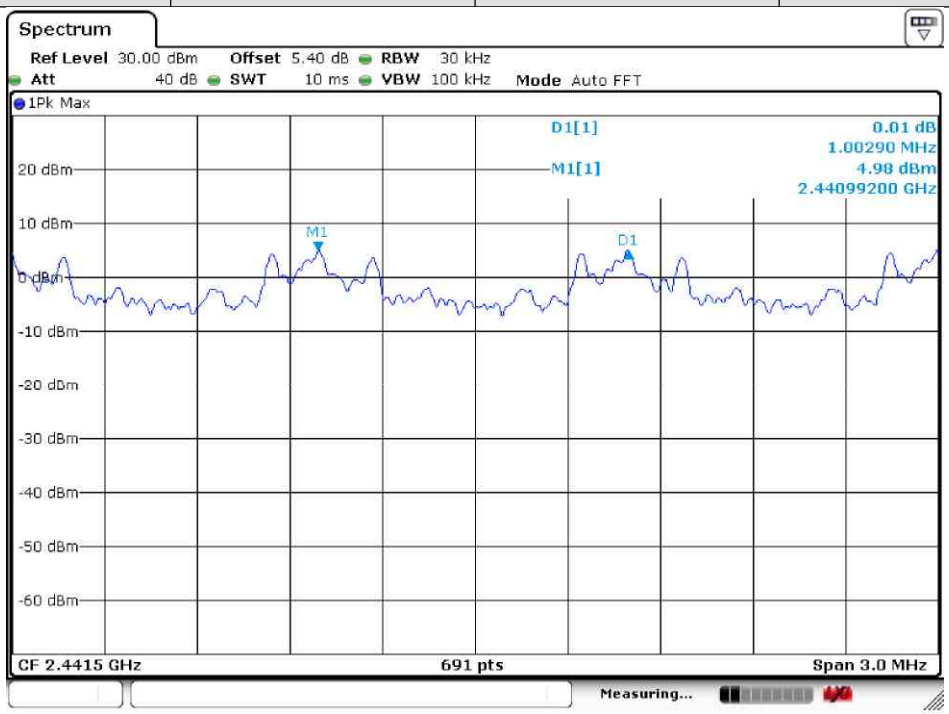
| Test mode: | π/4DQPSK | Test channel: | Middle |
|---|---|---|---|

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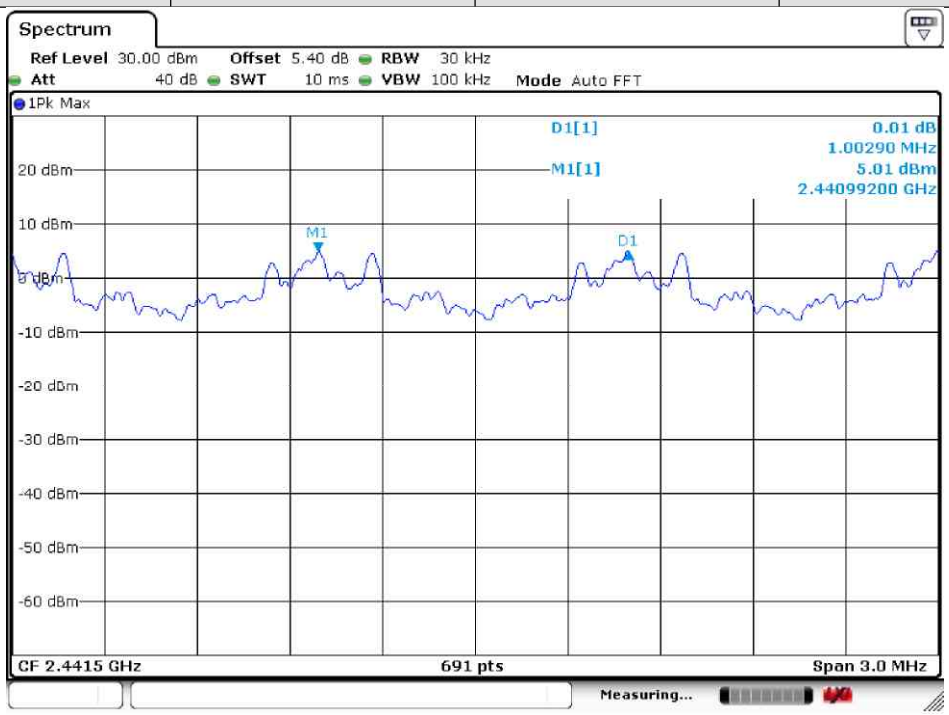
| Test mode: | 8DPSK | Test channel: | Middle |
|---|---|---|---|

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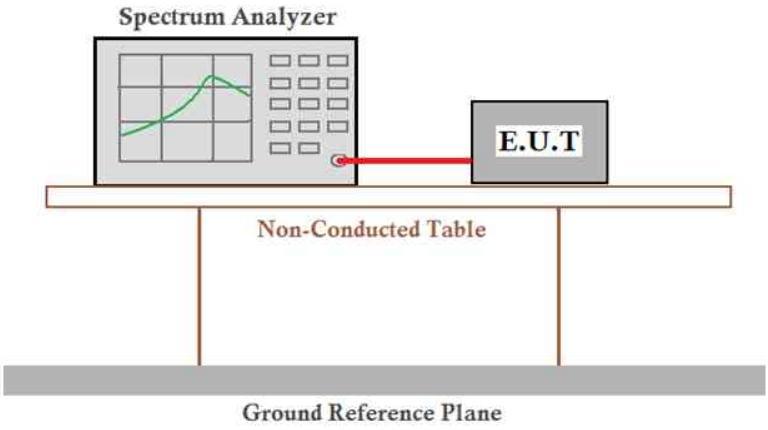
## 4.7 Hopping Channel Number

| | |
|---|---|
| Test Requirement: | 47 CFR Part 15C Section 15.247 (a)(1) |
| Test Method: | ANSI C63.10:2013 Section 7.8.3 |
| Test Setup: |  |
| Limit: | At least 15 channels |
| Test Mode: | Hopping transmitting with all kind of modulation |
| Instruments Used: | Refer to section 5.10 for details |
| Test Results: | Pass |

### 4.7.1 Test Results

| Mode | Hopping channel numbers | Limit |
|---|---|---|
| GFSK | 79 | ≥15 |
| π/4DQPSK | 79 | ≥15 |
| 8DPSK | 79 | ≥15 |

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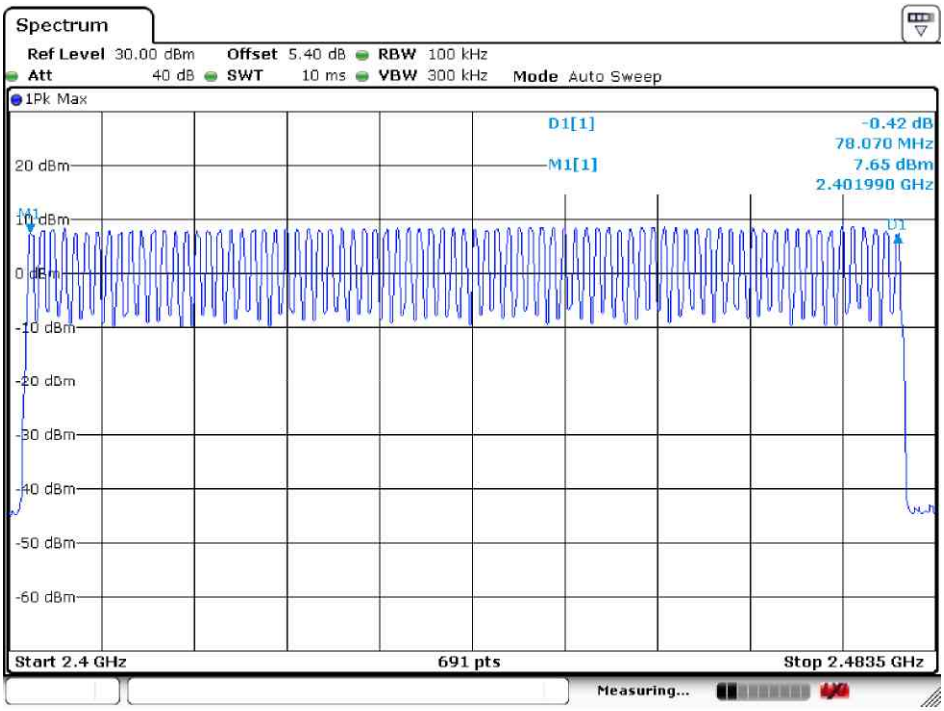
### 4.7.2 Test plots

#### 4.7.2.1 GFSK

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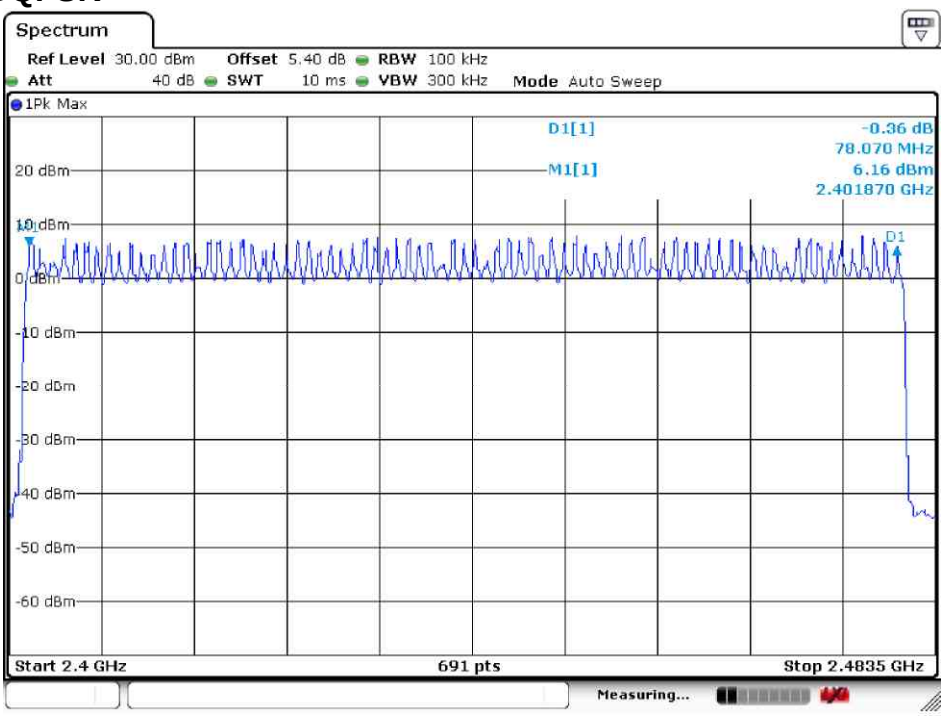
#### 4.7.2.2 π/4DQPSK

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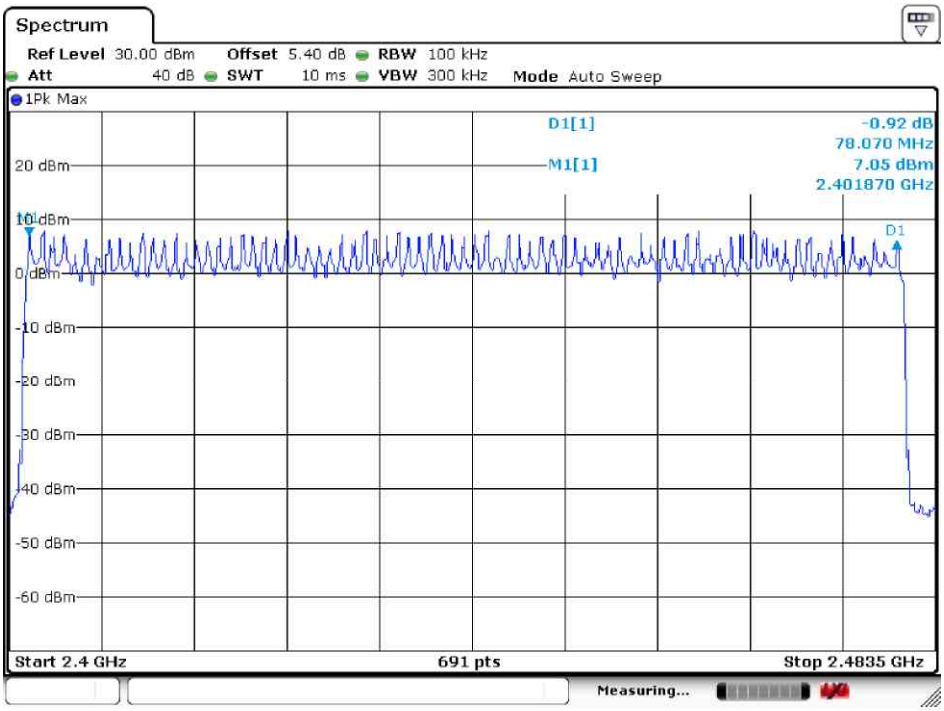
### 4.7.2.3 8DPSK

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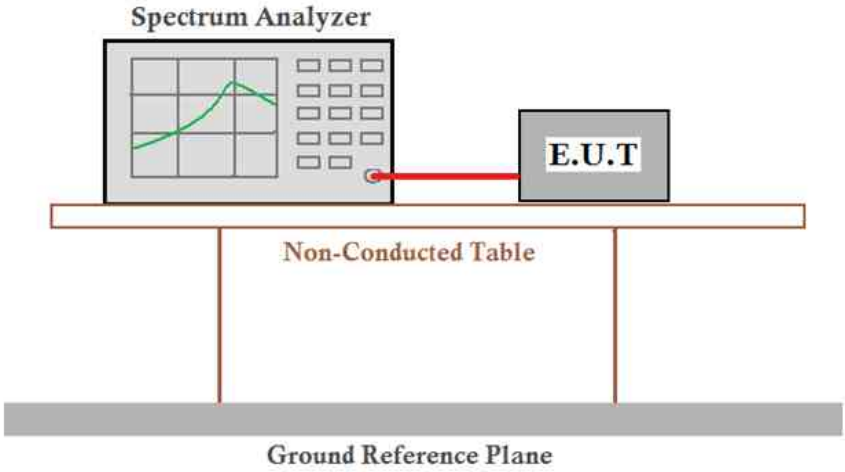
## 4.8 Dwell Time

| | |
|---|---|
| Test Requirement: | 47 CFR Part 15C Section 15.247 (a)(1) |
| Test Method: | ANSI C63.10:2013 Section 7.8.4 |
| Test Setup: |  |
| Instruments Used: | Refer to section 5.10 for details |
| Test Mode: | Hopping transmitting with all kind of modulation and all kind of data type. |
| Limit: | 0.4 Second |
| Test Results: | Pass |

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### 4.8.1 Test Results

| Operation Modes | On time（ms）on one channel |
|---|---|
| DH1 | 0.390 |
| DH3 | 1.670 |
| DH5 | 2.906 |
| 2-DH1 | 0.399 |
| 2-DH3 | 1.670 |
| 2-DH5 | 2.906 |
| 3-DH1 | 0.399 |
| 3-DH3 | 1.662 |
| 3-DH5 | 2.913 |

**Bluetooth Time of Occupancy Calculation**

Typically, Bluetooth 1x/EDR mode has a channel hopping rate of 1600 hops/s, since 1x/EDR modes use 5 transmit and 1 receive slot, for a total of 6 slots, the Bluetooth transmitter is actually hopping at a rate of 1600/6=266.67 hops/slot

400ms x 79 Channel = 31.6 s (Time of Occupancy Limit)

Worst case BT has 266.67 hops/second（for 1x/EDR modes with 3-DH5 operation）

266.67 hops/second/79 channels=3.38 hops/second (# of hops/second on one channel)

3.38 hops/second/channel*31.6seconds=106.67 hops (#hops over a 31.6 second period)

106.67 hops *2.913 ms/channel =310.73 ms(worst case dwell time for one channel in 1x/EDR modes)

With AFH, the number of channels is reduced to a minimum of 20 channels and the channel hopping rate is reduced by 50% to 800hops/s, AFH mode also uses 6 slots so the Bluetooth transmitter hops at a rate of 800/6=133.3 hops/s/slot

400ms x 20 Channel = 8 s (Time of Occupancy Limit)

Worst case BT has 133.3 hops/second/slot (for AFH mode with 3-DH5 operation)

133.3 hops/second/20 channels=6.67 hops/second (#hops/second on one channel)

6.67 hops/second *8seconds=53.34 hops (#hops over a 8 seconds period)

53.34 hops x2.913 ms/channel=155.38 ms(worst case dwell time for one channel in AFH mode)

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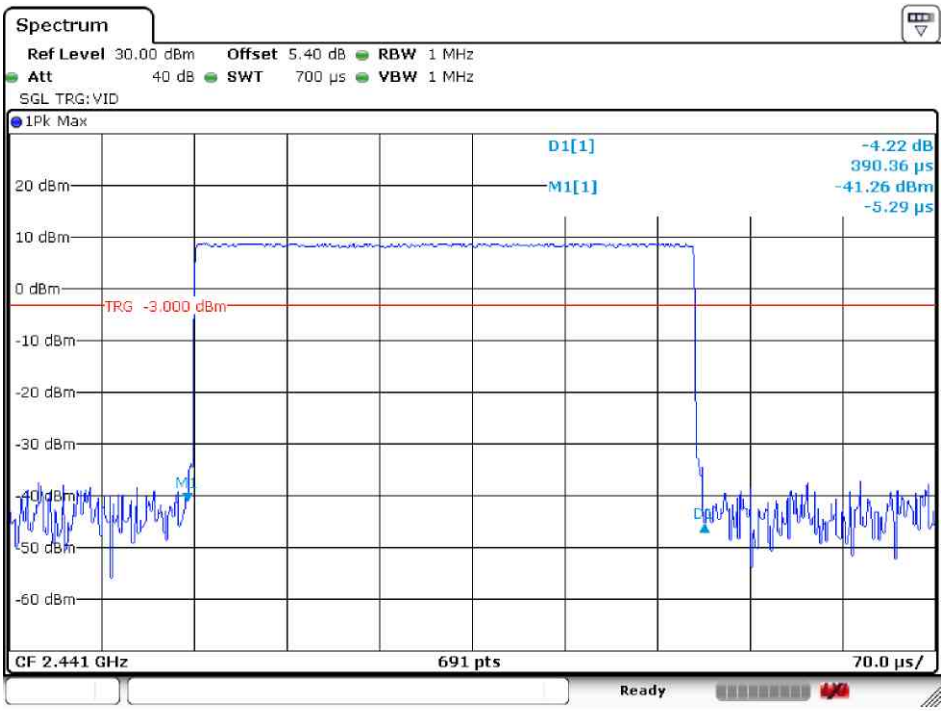
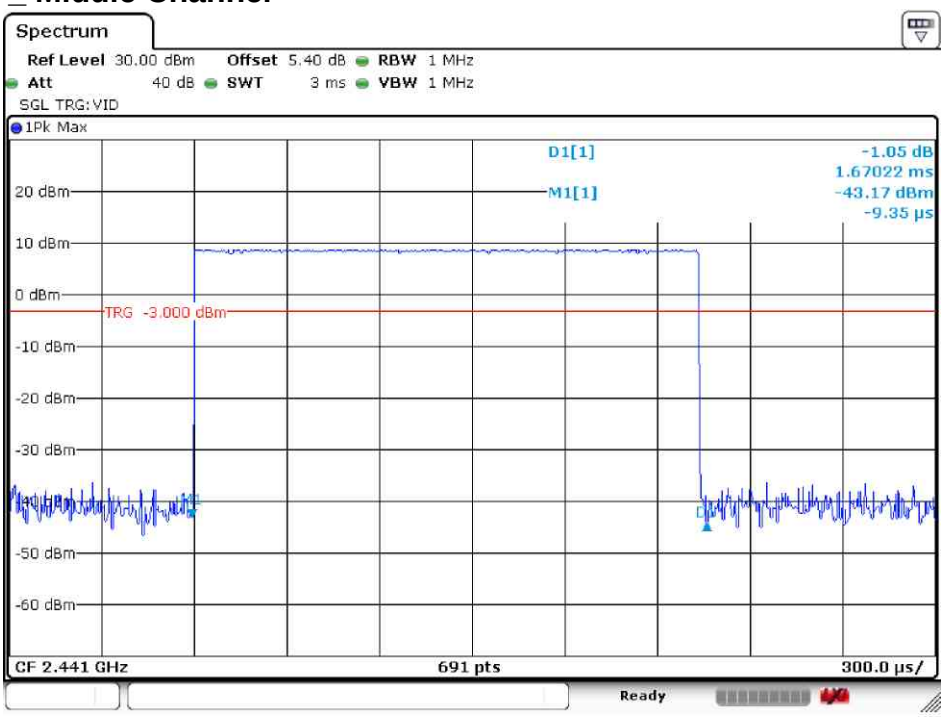
### 4.8.2 Test plots

#### 4.8.2.1 DH1 _Middle Channel




Date: 19.JUN.2020 10:20:22

#### 4.8.2.2 DH3 _ Middle Channel

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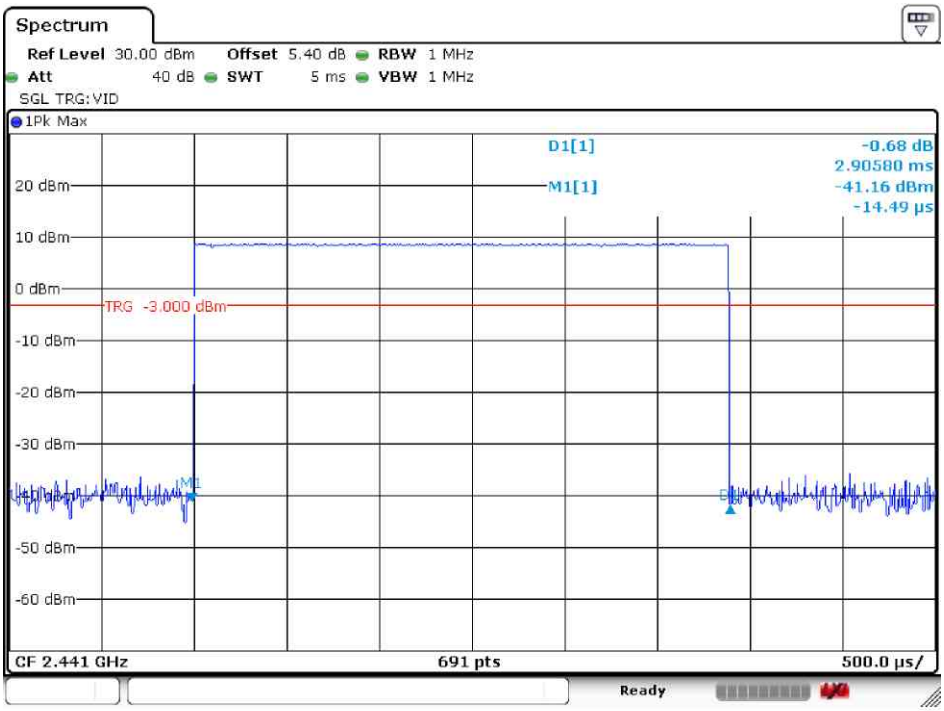
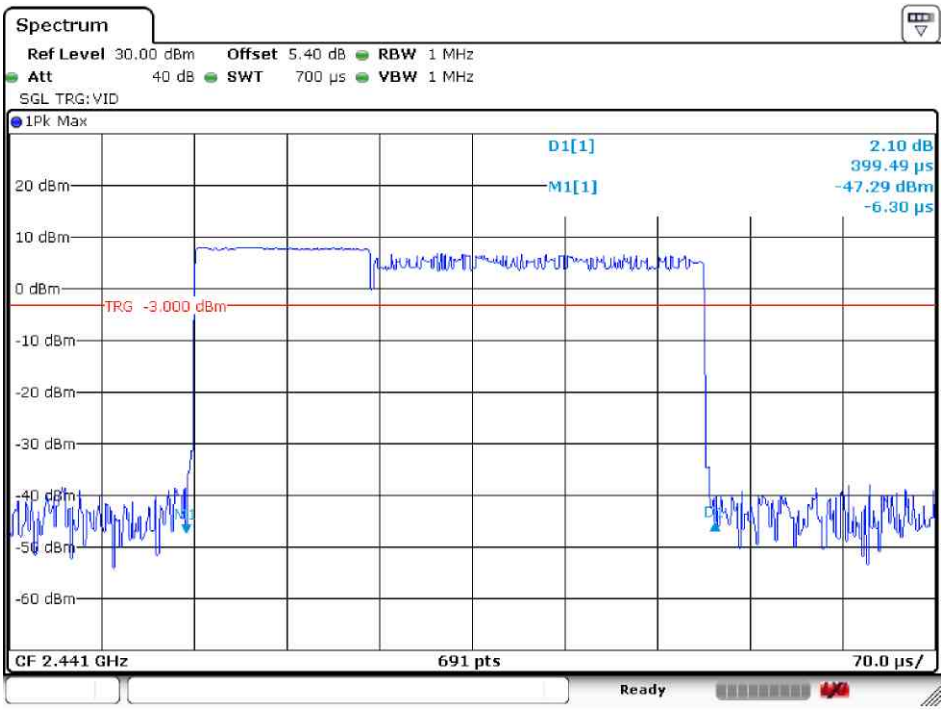
### 4.8.2.3 DH5 _ Middle Channel




Date: 19.JUN.2020 10:17:12

### 4.8.2.4 2DH1 _Middle Channel

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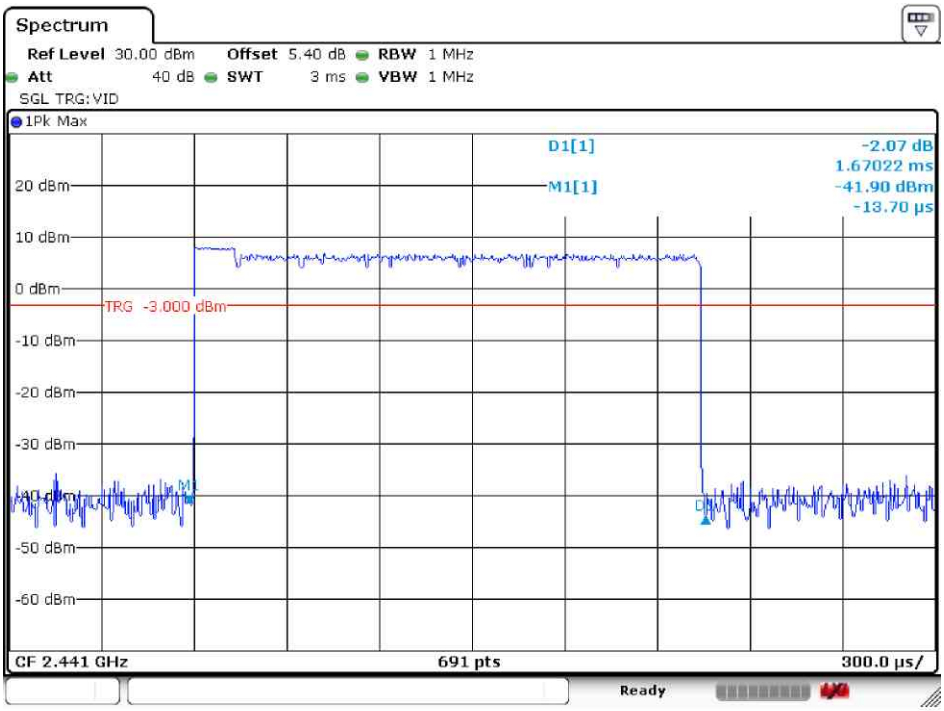
### 4.8.2.5 2DH3 _ Middle Channel

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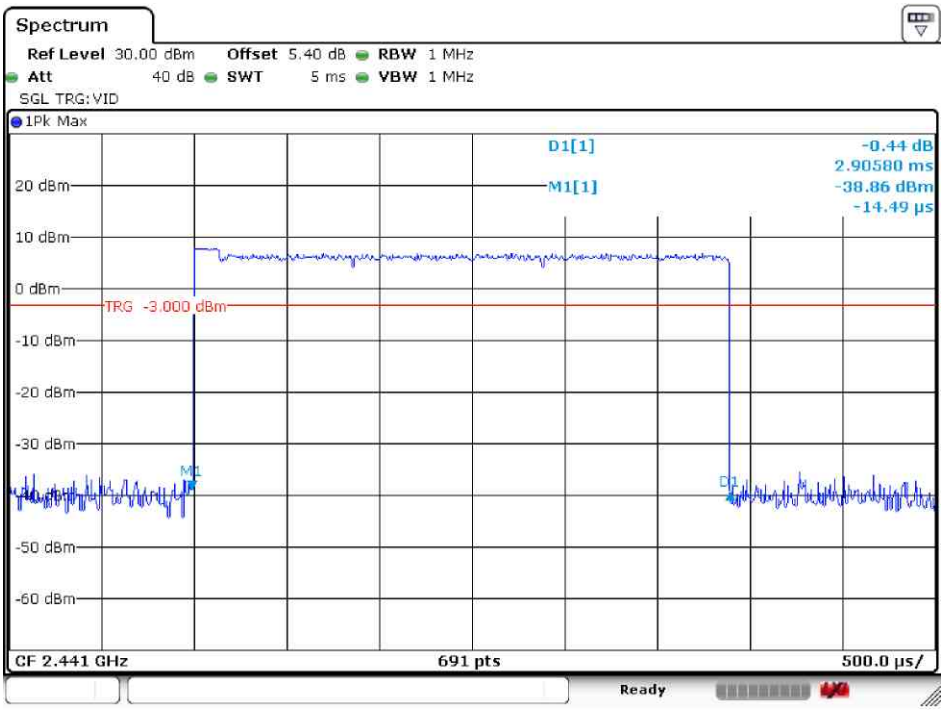
### 4.8.2.6 2DH5 _ Middle Channel

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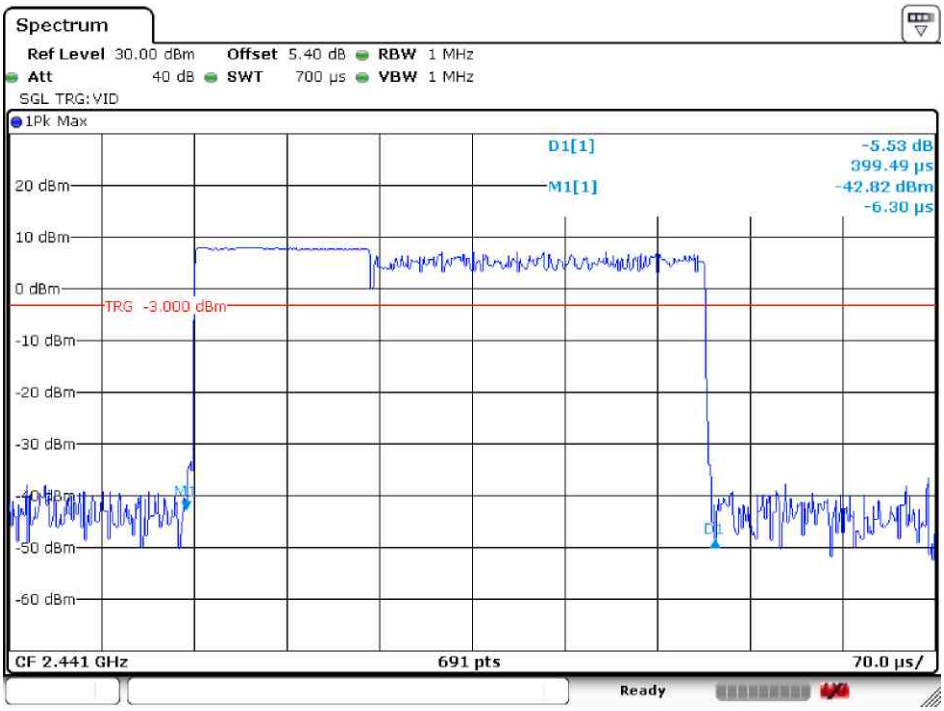
### 4.8.2.7 3DH1 _Middle Channel

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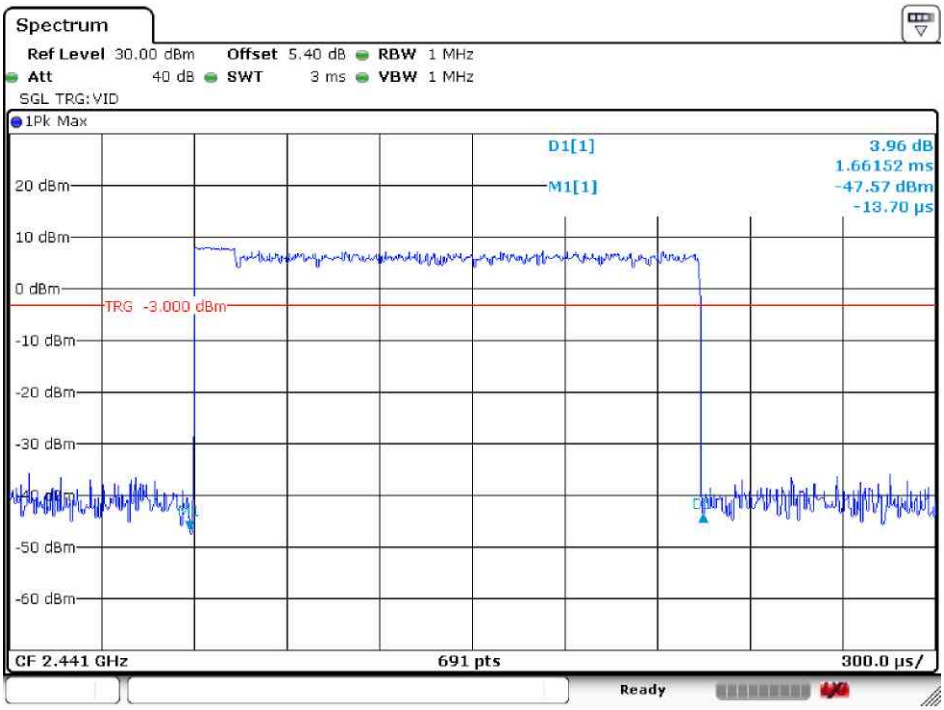
### 4.8.2.8 3DH3 _ Middle Channel

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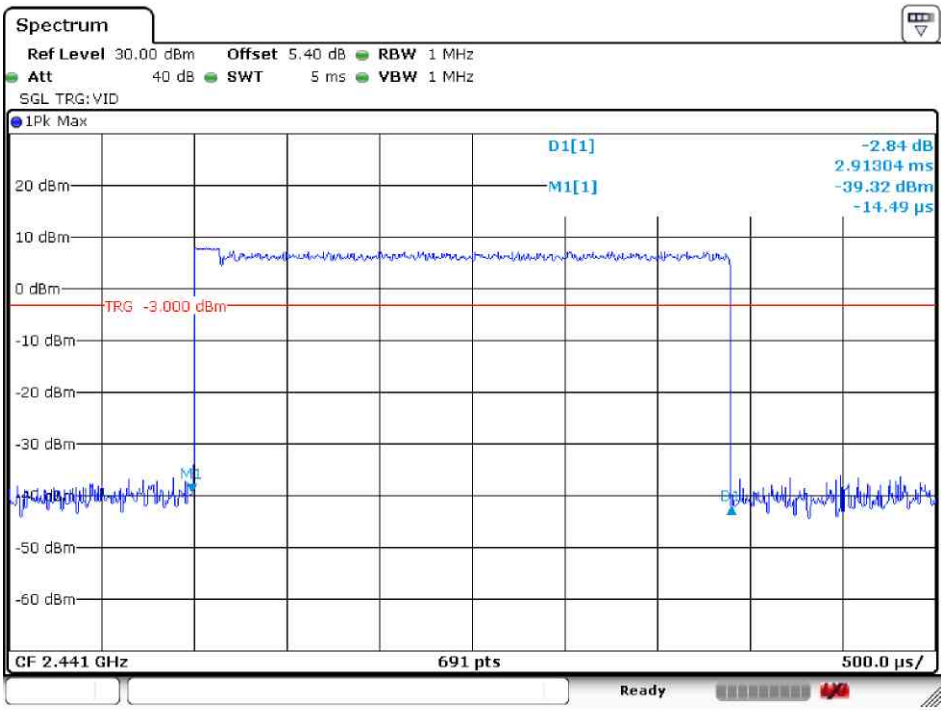
### 4.8.2.9 3DH5 _ Middle Channel

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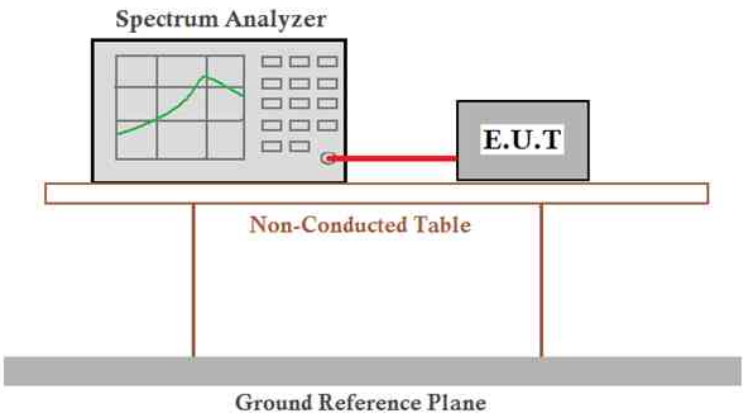
## 4.9 Band-edge for RF Conducted Emissions

| | |
|---|---|
| Test Requirement: | 47 CFR Part 15C Section 15.247 (d) |
| Test Method: | ANSI C63.10:2013 Section 7.8.6 |
| Test Setup: |  |
| Limit: | In any 100 kHz bandwidth outside the frequency band in which the spread spectrum 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. |
| Exploratory Test Mode: | Hopping and Non-hopping transmitting with all kind of modulation and all kind of data type |
| Final Test Mode: | Through Pre-scan, find the<br>DH5 of data type is the worst case of GFSK modulation type,<br>2-DH5 of data type is the worst case of π/4DQPSK modulation type,<br>3-DH5 of data type is the worst case of 8DPSK modulation type. |
| Instruments Used: | Refer to section 5.10 for details |
| Test Results: | Pass |

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## 4.9.1 Test plots

### 4.9.1.1 GFSK _Lowest Channel_ Hopping ON

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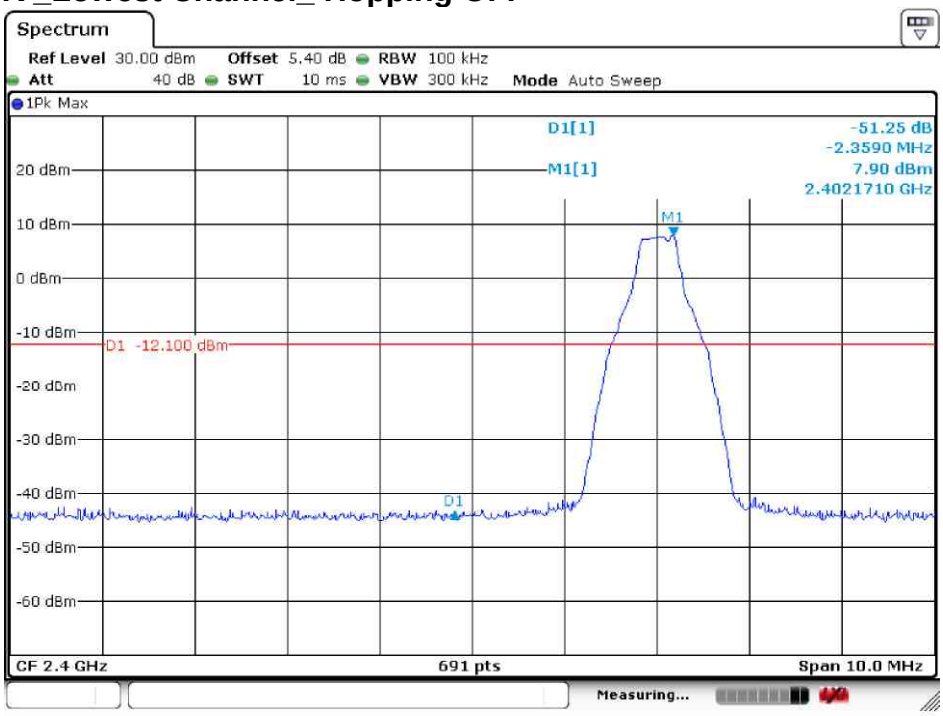
### 4.9.1.2 GFSK _Lowest Channel_ Hopping OFF

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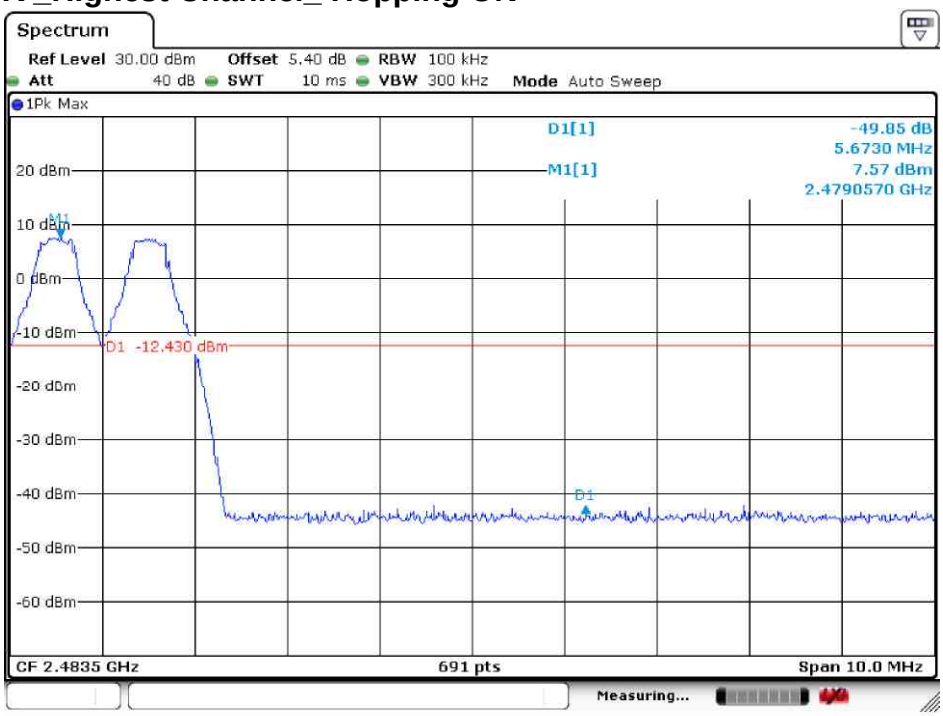
### 4.9.1.3 GFSK _Highest Channel_ Hopping ON

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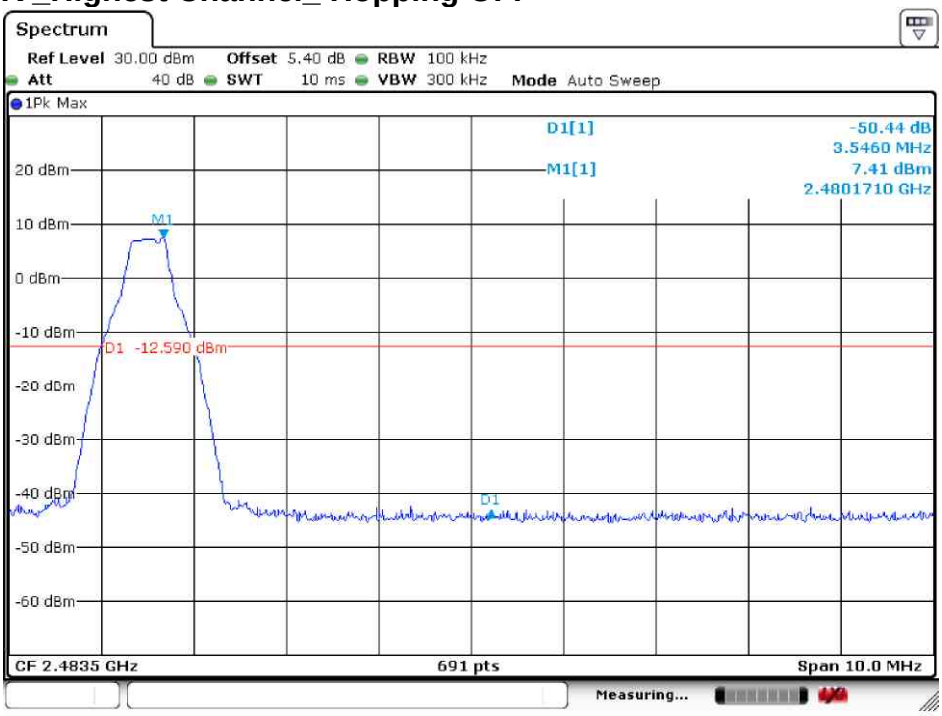
### 4.9.1.4 GFSK _Highest Channel_ Hopping OFF

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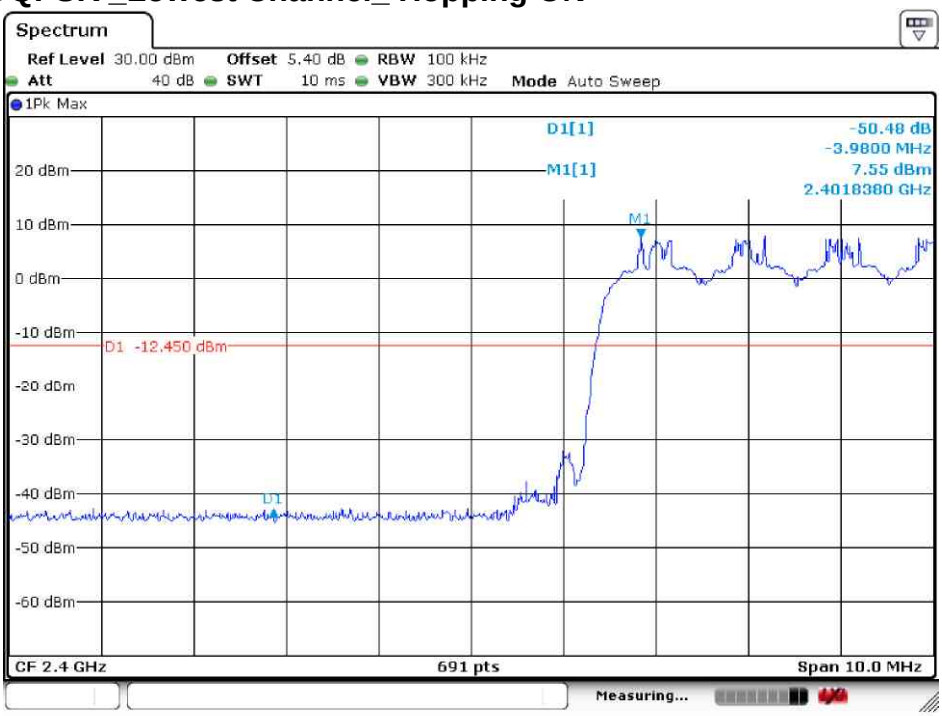
### 4.9.1.5 π/4DQPSK _Lowest Channel_ Hopping ON

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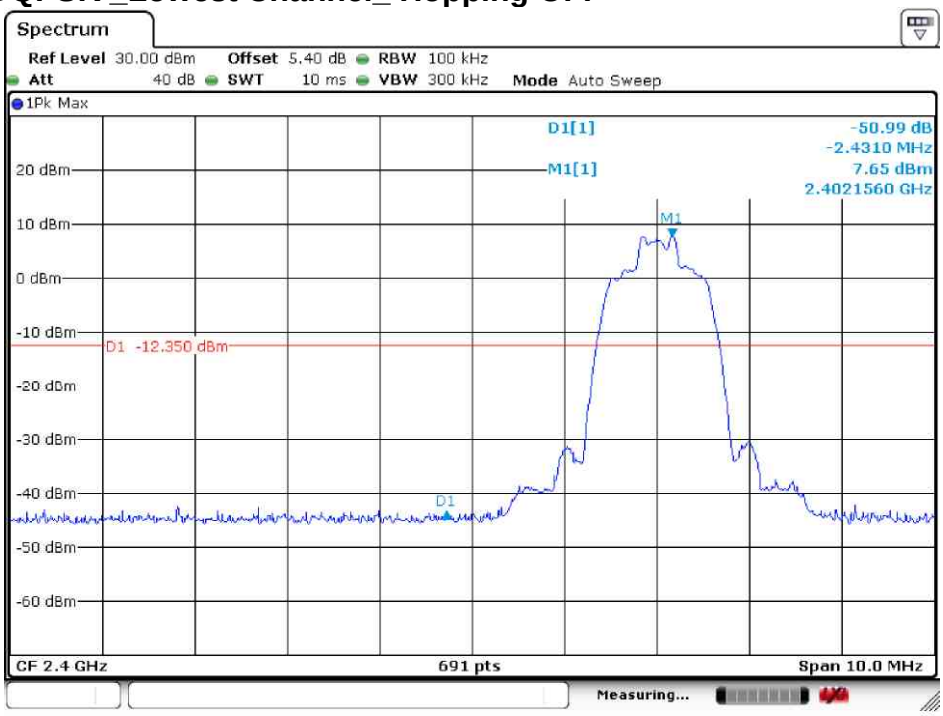
### 4.9.1.6 π/4DQPSK _Lowest Channel_ Hopping OFF

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### 4.9.1.7 π/4DQPSK _Highest Channel_ Hopping ON

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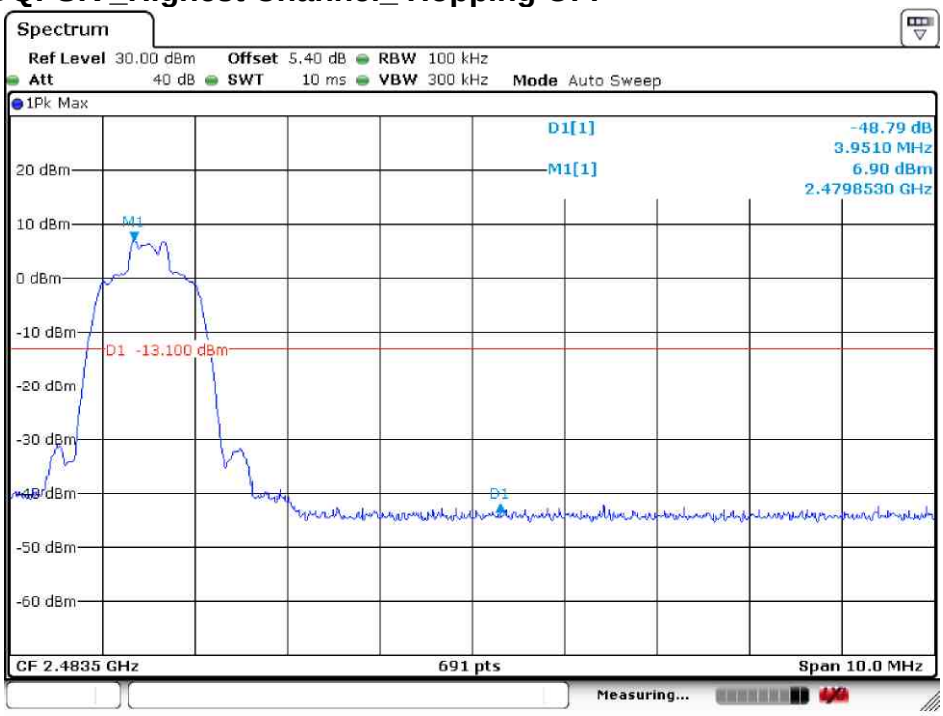
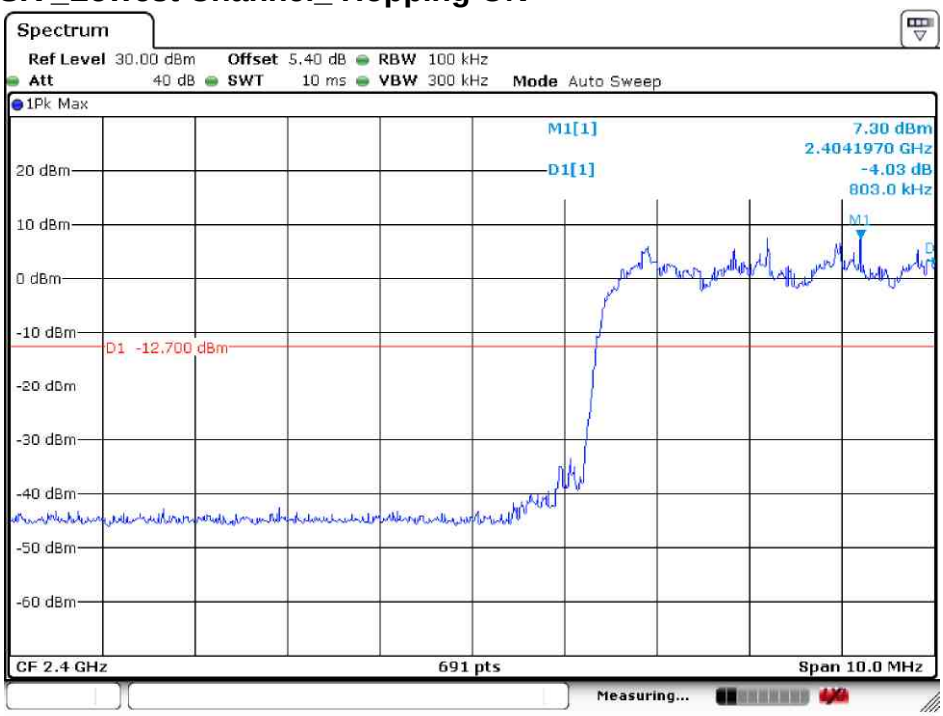
### 4.9.1.8 π/4DQPSK _Highest Channel_ Hopping OFF




Date: 19.JUN.2020 09:41:27

### 4.9.1.9 8DPSK _Lowest Channel_ Hopping ON




Date: 19.JUN.2020 09:51:51

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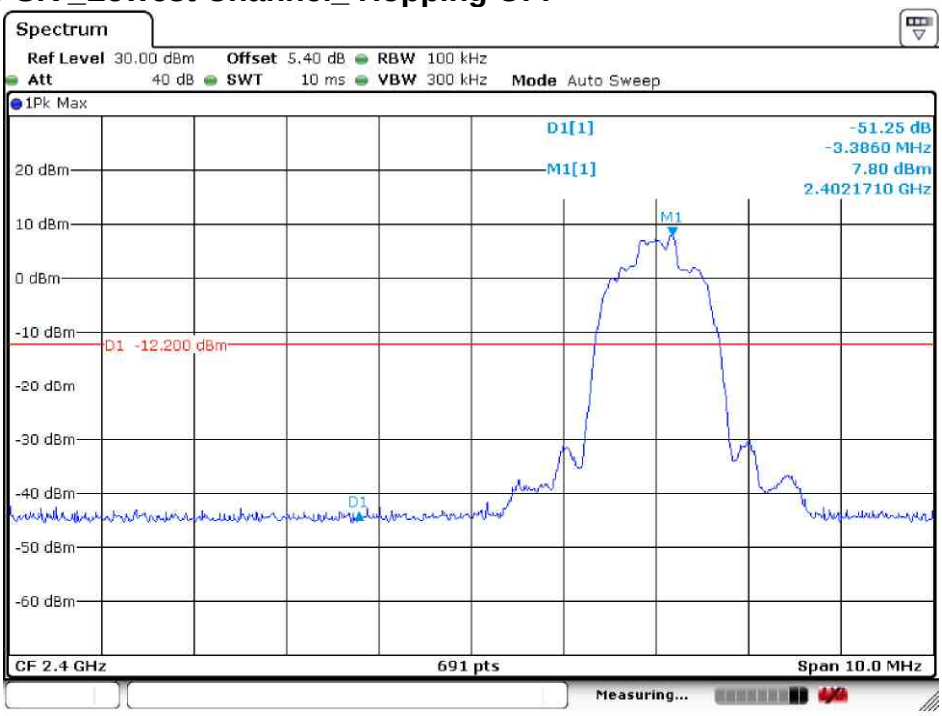
### 4.9.1.10 8DPSK _Lowest Channel_ Hopping OFF

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### 4.9.1.11 8DPSK _Highest Channel_ Hopping ON

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### 4.9.1.12 8DPSK _Highest Channel_ Hopping OFF

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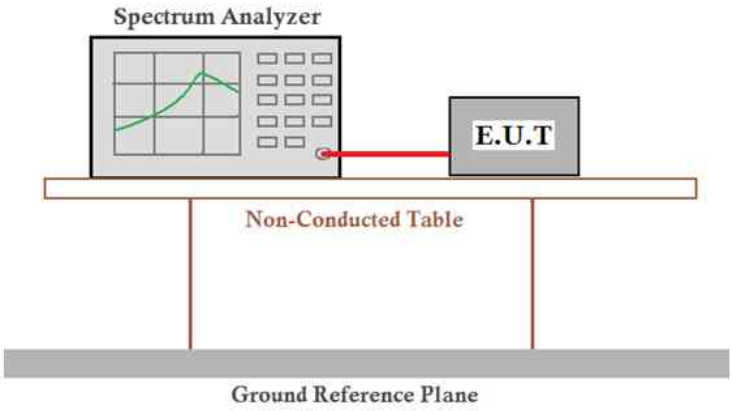
## 4.10 Spurious RF Conducted Emissions

| | |
|---|---|
| Test Requirement: | 47 CFR Part 15C Section 15.247 (d) |
| Test Method: | ANSI C63.10:2013 Section 7.8.8 |
| Test Setup: |  |
| Limit: | In any 100 kHz bandwidth outside the frequency band in which the spread spectrum 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. |
| Exploratory Test Mode: | Non-hopping transmitting with all kind of modulation and all kind of data type |
| Final Test Mode: | Through Pre-scan, find the<br>DH5 of data type is the worst case of GFSK modulation type,<br>2-DH5 of data type is the worst case of π/4DQPSK modulation type,<br>3-DH5 of data type is the worst case of 8DPSK modulation type. |
| Instruments Used: | Refer to section 5.10 for details |
| Test Results: | Pass |

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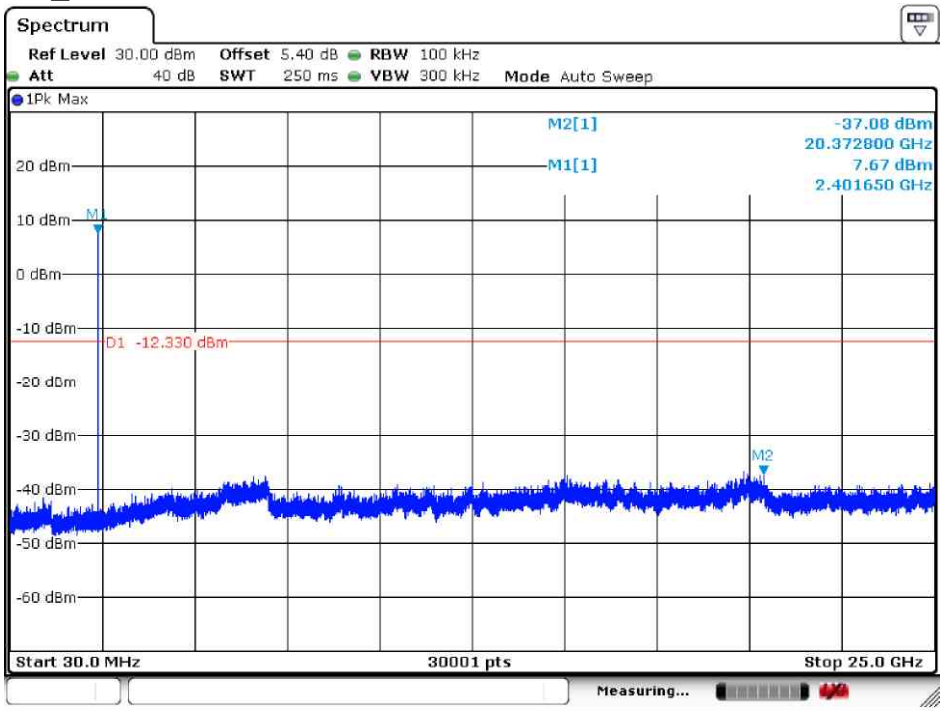
## 4.10.1 Test plots

### 4.10.1.1 GFSK _Lowest Channel

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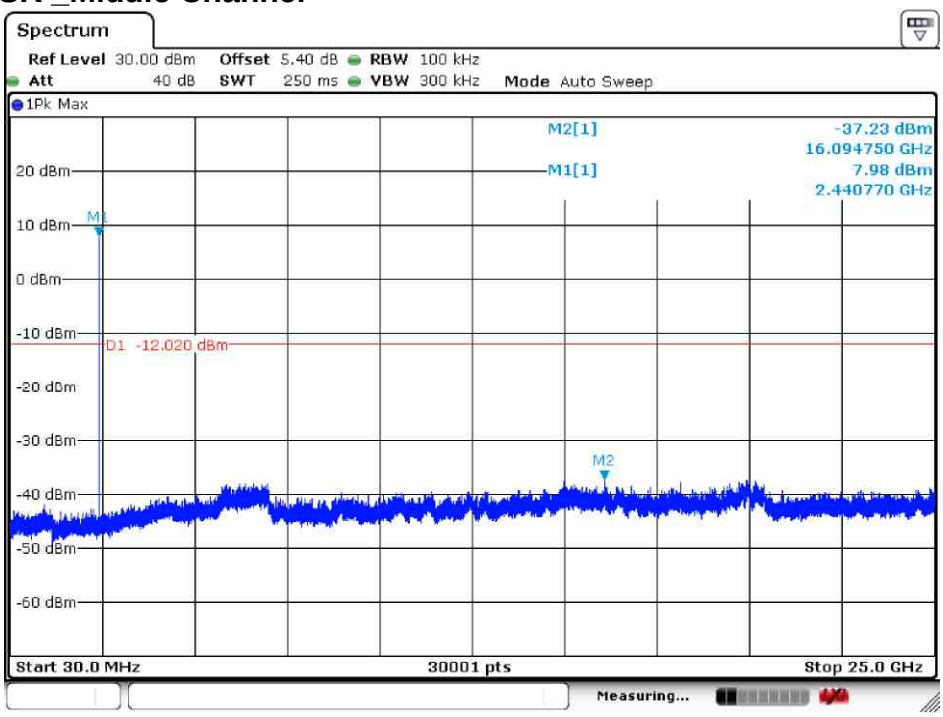
### 4.10.1.2 GFSK _Middle Channel

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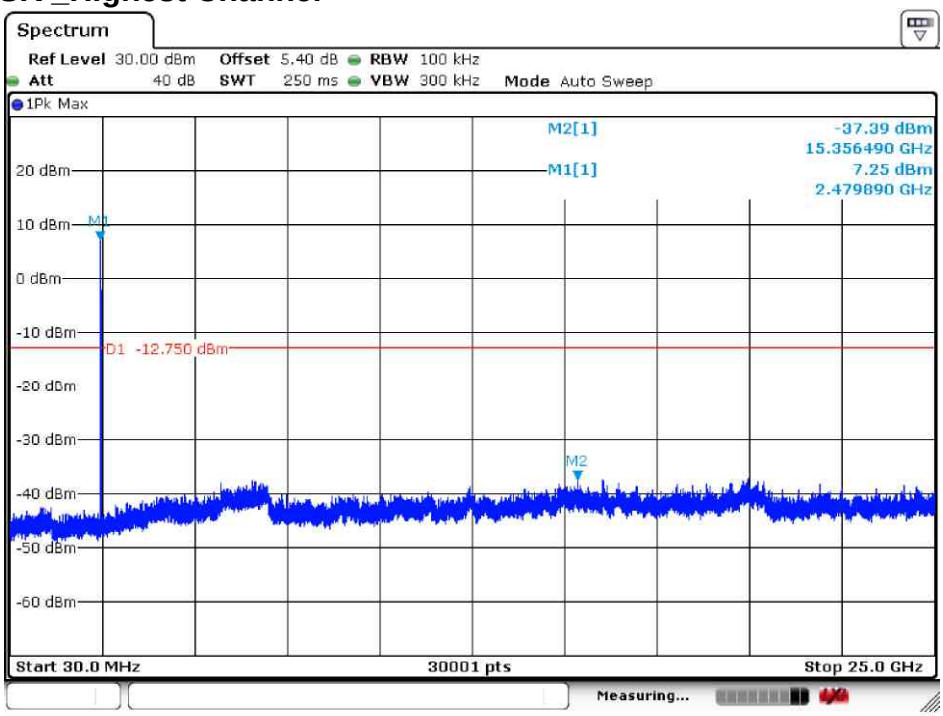
### 4.10.1.3 GFSK _Highest Channel

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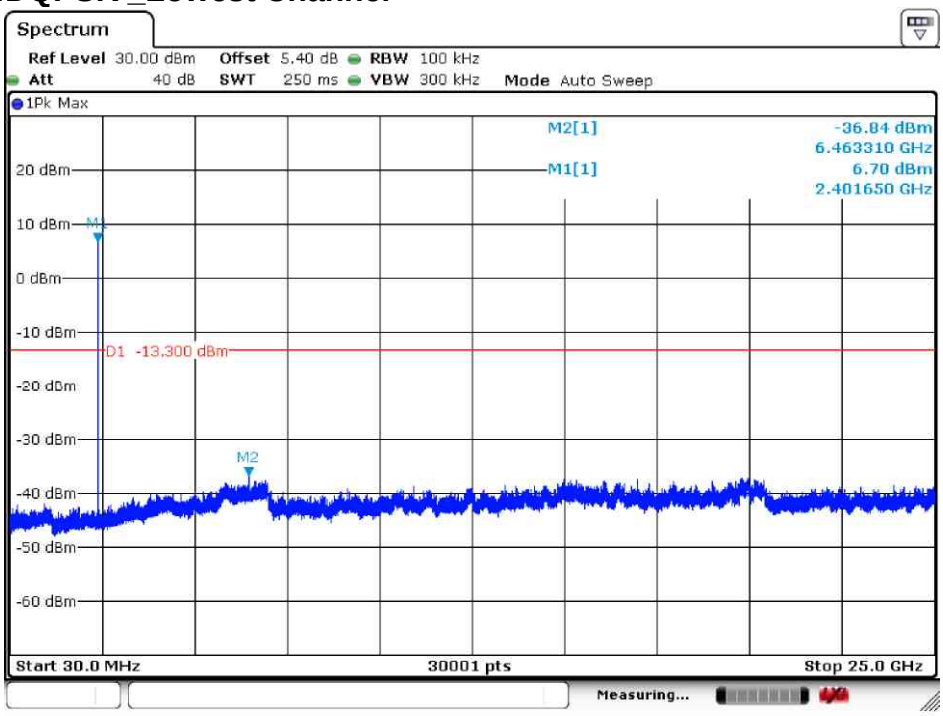
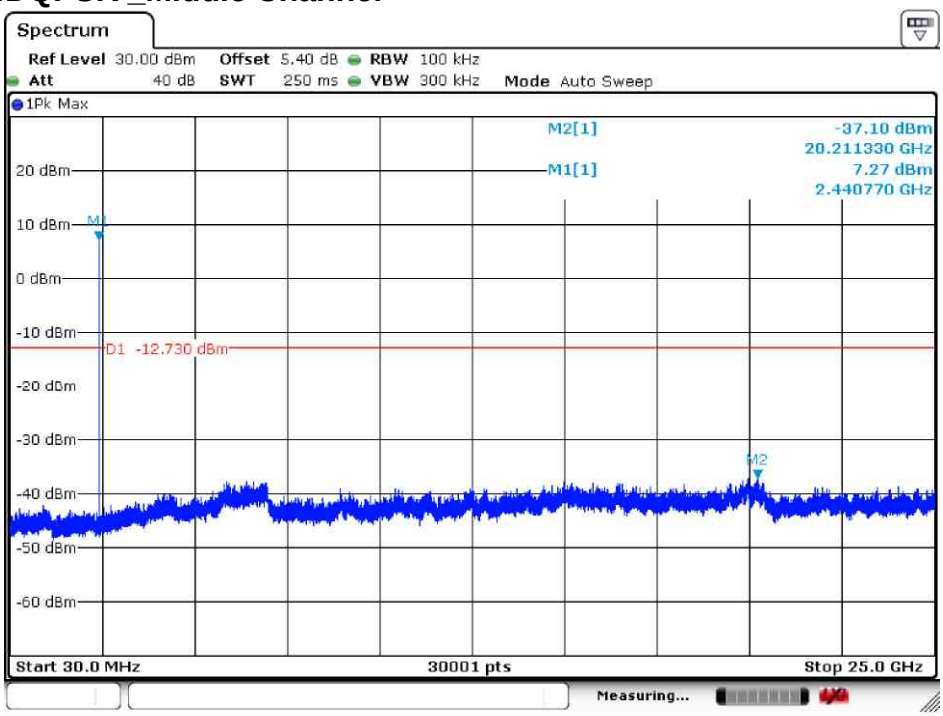
### 4.10.1.4 π/4DQPSK _Lowest Channel




Date: 19.JUN.2020 10:06:07

### 4.10.1.5 π/4DQPSK _Middle Channel

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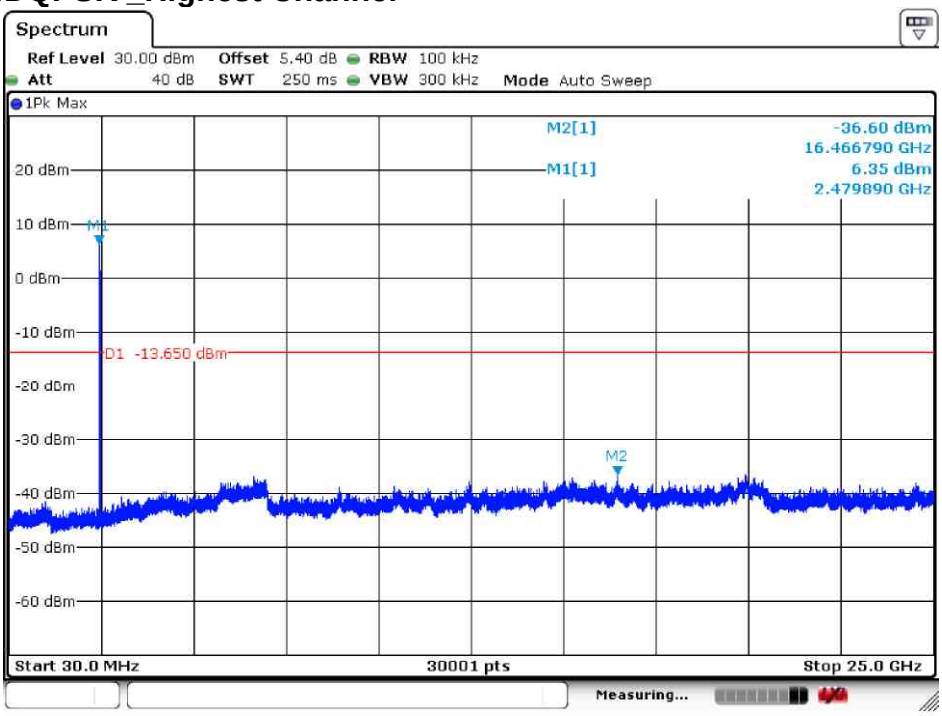
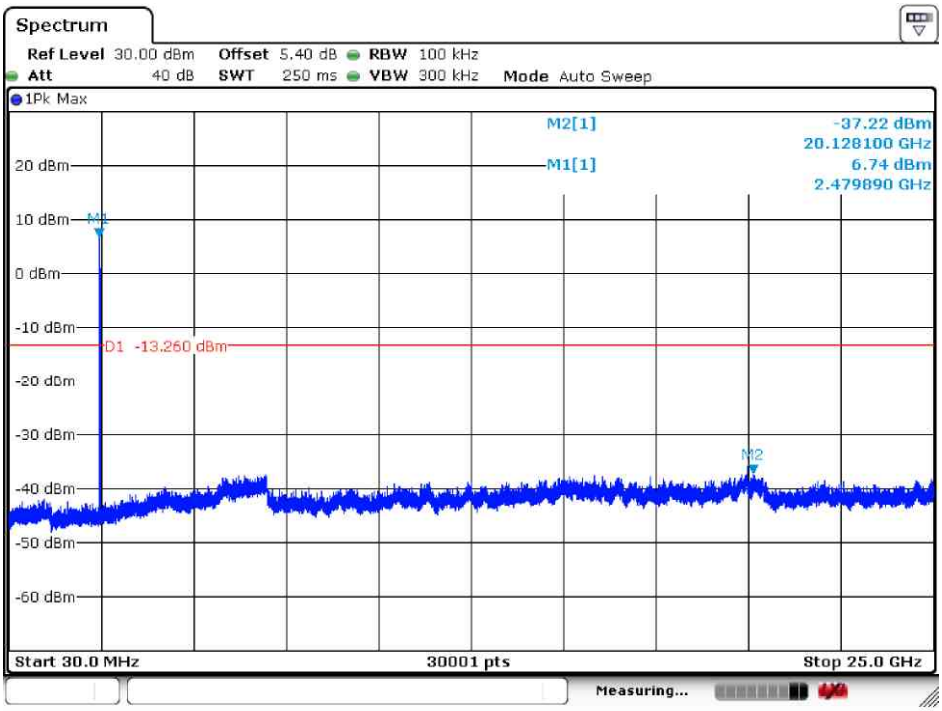
### 4.10.1.6 π/4DQPSK _Highest Channel




Date: 19.JUN.2020 10:03:02

### 4.10.1.7 8DPSK_Lowest Channel

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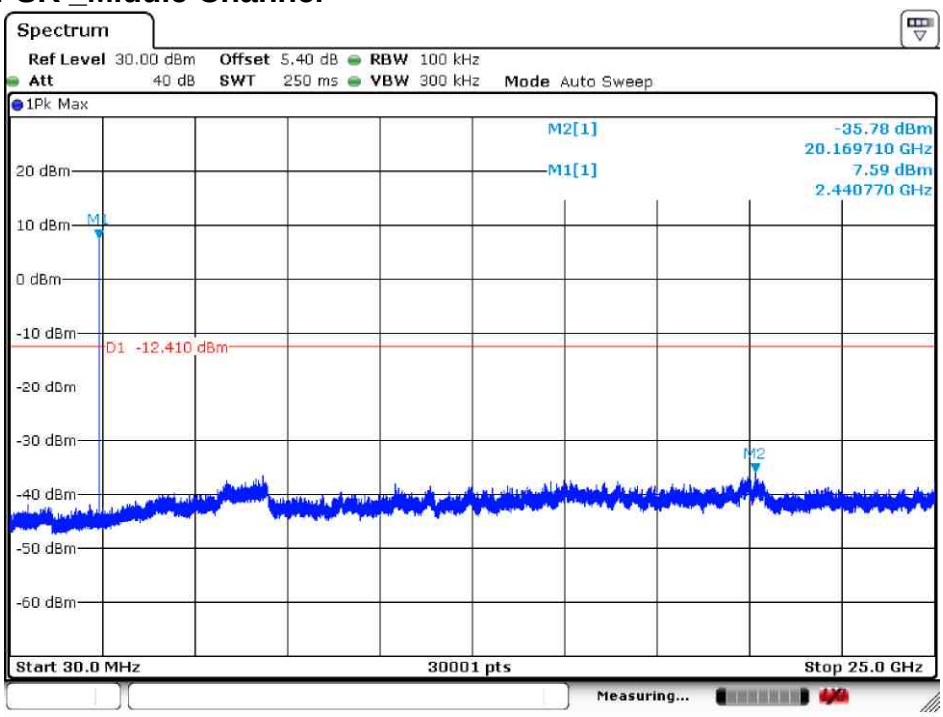
### 4.10.1.8 8DPSK _Middle Channel

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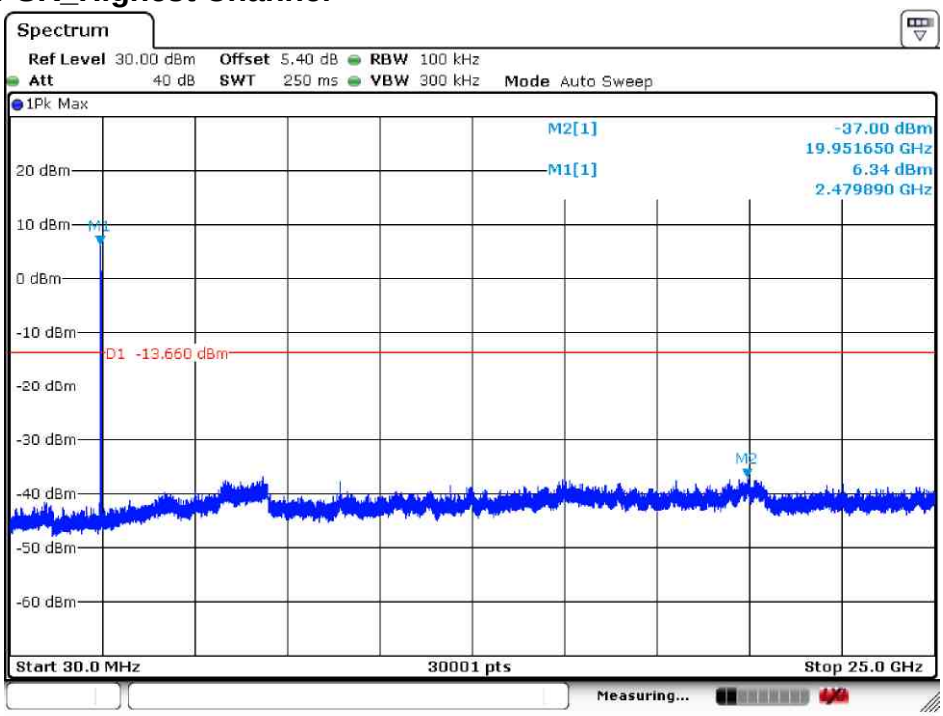
### 4.10.1.9 8DPSK_Highest Channel

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Remark:

Scan from 9kHz to 25GHz, the disturbance between 9KHz to 30MHz was very low, and the above harmonics were the highest point could be found when testing, The amplitude of spurious emissions from the radiator which are attenuated more than 20dB below the limit need not be reported.

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## 4.11 Radiated Spurious Emission

| | | | | | |
|---|---|---|---|---|---|
| Test Requirement: | 47 CFR Part 15C Section 15.209 and 15.205 | | | | |
| Test Method: | ANSI C63.10: 2013 | | | | |
| Test Site: | Measurement Distance: 3m or 10m (Semi-Anechoic Chamber) | | | | |
| Receiver Setup: | Frequency | Detector | RBW | VBW | Remark |
| | 0.009MHz-0.090MHz | Peak | 10kHz | 30kHz | Peak |
| | 0.009MHz-0.090MHz | Average | 10kHz | 30kHz | Average |
| | 0.090MHz-0.110MHz | Quasi-peak | 10kHz | 30kHz | Quasi-peak |
| | 0.110MHz-0.490MHz | Peak | 10kHz | 30kHz | Peak |
| | 0.110MHz-0.490MHz | Average | 10kHz | 30kHz | Average |
| | 0.490MHz -30MHz | Quasi-peak | 10kHz | 30kHz | Quasi-peak |
| | 30MHz-1GHz | Quasi-peak | 100 kHz | 300kHz | Quasi-peak |
| | Above 1GHz | Peak | 1MHz | 3MHz | Peak |
| | | Peak | 1MHz | 10Hz | Average |
| Limit: | Frequency | Field strength (microvolt/meter) | Limit (dBuV/m) | Remark | Measurement distance (m) |
| | 0.009MHz-0.490MHz | 2400/F(kHz) | - | - | 300 |
| | 0.490MHz-1.705MHz | 24000/F(kHz) | - | - | 30 |
| | 1.705MHz-30MHz | 30 | - | - | 30 |
| | 30MHz-88MHz | 100 | 40.0 | Quasi-peak | 3 |
| | 88MHz-216MHz | 150 | 43.5 | Quasi-peak | 3 |
| | 216MHz-960MHz | 200 | 46.0 | Quasi-peak | 3 |
| | 960MHz-1GHz | 500 | 54.0 | Quasi-peak | 3 |
| | Above 1GHz | 500 | 54.0 | Average | 3 |
| | Remark: 15.35(b), Unless otherwise specified, the limit on peak radio frequency emissions is 20dB above the maximum permitted average emission limit applicable to the equipment under test. This peak limit applies to the total peak emission level radiated by the device. | | | | |

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Test Setup:

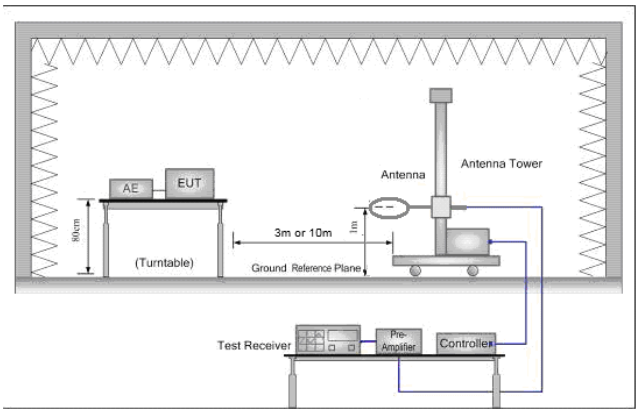


Figure 1. Below 30MHz

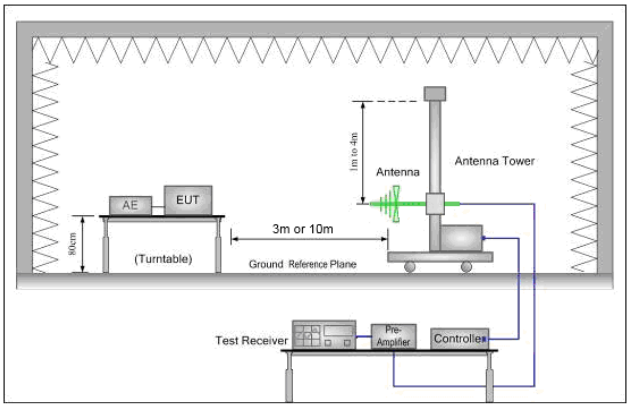


Figure 2. 30MHz to 1GHz

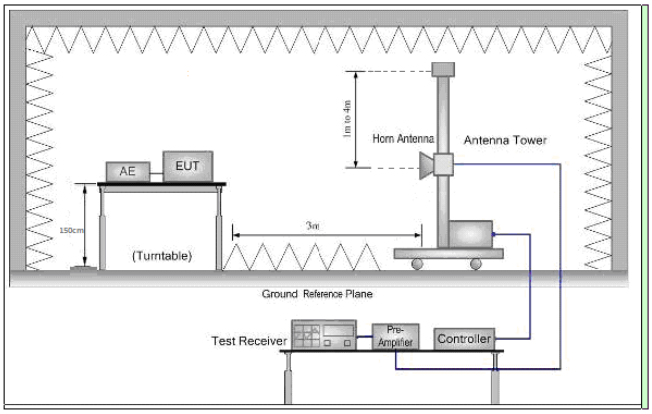


Figure 3. Above 1 GHz

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| | |
|---|---|
| Test Procedure: | a. For below 1GHz, the EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 or 10 meter semi-anechoic camber. The table was rotated 360 degrees to determine the position of the highest radiation.<br>b. For above 1GHz, the EUT was placed on the top of a rotating table 1.5 meters above the ground at a 3 meter semi-anechoic camber. The table was rotated 360 degrees to determine the position of the highest radiation.<br>c. The EUT was set 3 or 10 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.<br>d. The antenna height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.<br>e. Use the following spectrum analyzer settings:<br>(1) Span shall wide enough to fully capture the emission being measured;<br>(2) Set RBW=100 kHz for f < 1 GHz, RBW=1MHz for f>1GHz ; VBW ≥ RBW; Sweep = auto;<br>Detector function = peak; Trace = max hold for peak<br>(3) For average measurement: use duty cycle correction factor method per 15.35(c).<br>Duty cycle = On time/100 milliseconds<br>On time = N 1 *L 1 +N 2 *L 2 +...+N n-1 *LN n-1 +N n *L n<br>Where N 1 is number of type 1 pulses, L 1 is length of type 1 pulses, etc.<br>Average Emission Level = Peak Emission Level + 20*log(Duty cycle)<br>f. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters (for the test frequency of below 30MHz, the antenna was tuned to heights 1 meter) and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.<br>g. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.<br>h. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.<br>i. Test the EUT in the lowest channel (2402MHz),the middle channel (2441MHz),the Highest channel (2480MHz)<br>j. The radiation measurements are performed in X, Y, Z axis positioning for Transmitting mode, and found the X axis positioning which it is the worst case.<br>k. Repeat above procedures until all frequencies measured was complete. |
| Exploratory Test Mode: | Non-hopping transmitting mode with all kind of modulation and all kind of data type |

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| | |
|---|---|
| | Charge + Transmitting mode. |
| Final Test Mode: | Through Pre-scan, find the<br>DH5 of data type and GFSK modulation is the worst case.<br>Pretest the EUT at Charge + Transmitting mode<br>For below 1GHz part, through pre-scan, the worst case is the lowest channel.<br>Only the worst case is recorded in the report. |
| Instruments Used: | Refer to section 5.10 for details |
| Test Results: | Pass |

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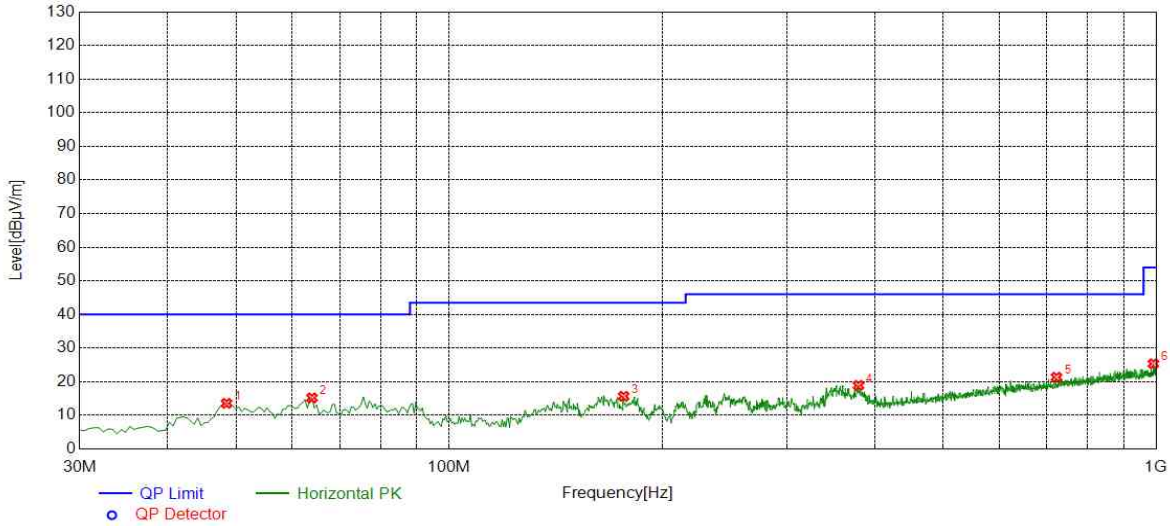
### 4.11.1 Radiated Emission below 1GHz

#### 4.11.1.1 Charge + Transmitting, Vertical




| Suspected List | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Level [dBµV/m] | Factor [dB] | Limit [dBµV/m] | Margin [dB] | Height [cm] | Angle [°] | Polarity |
| 1 | 48.4392 | 13.58 | -30.19 | 40.00 | 26.42 | 150 | 170 | Horizontal |
| 2 | 63.9670 | 15.20 | -32.66 | 40.00 | 24.80 | 150 | 319 | Horizontal |
| 3 | 176.543 | 15.68 | -33.15 | 43.50 | 27.82 | 150 | 63 | Horizontal |
| 4 | 379.374 | 18.91 | -25.53 | 46.00 | 27.09 | 150 | 218 | Horizontal |
| 5 | 722.926 | 21.35 | -18.17 | 46.00 | 24.65 | 150 | 291 | Horizontal |
| 6 | 991.265 | 25.38 | -13.97 | 54.00 | 28.62 | 150 | 338 | Horizontal |

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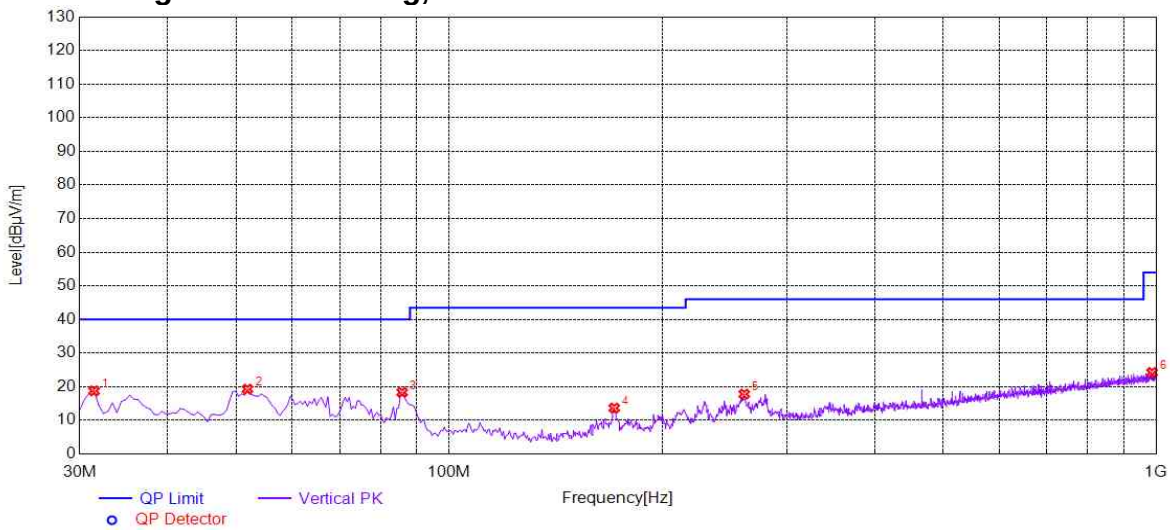
### 4.11.1.2 Charge + Transmitting, Horizontal




| Suspected List | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Level [dBµV/m] | Factor [dB] | Limit [dBµV/m] | Margin [dB] | Height [cm] | Angle [°] | Polarity |
| 1 | 31.4557 | 18.77 | -32.82 | 40.00 | 21.23 | 150 | 256 | Vertical |
| 2 | 51.8359 | 19.28 | -30.46 | 40.00 | 20.72 | 150 | 24 | Vertical |
| 3 | 85.8029 | 18.33 | -34.44 | 40.00 | 21.67 | 150 | 88 | Vertical |
| 4 | 171.205 | 13.68 | -33.53 | 43.50 | 29.82 | 150 | 194 | Vertical |
| 5 | 261.460 | 17.82 | -28.91 | 46.00 | 28.18 | 150 | 1 | Vertical |
| 6 | 986.898 | 24.26 | -14.03 | 54.00 | 29.74 | 150 | 12 | Vertical |

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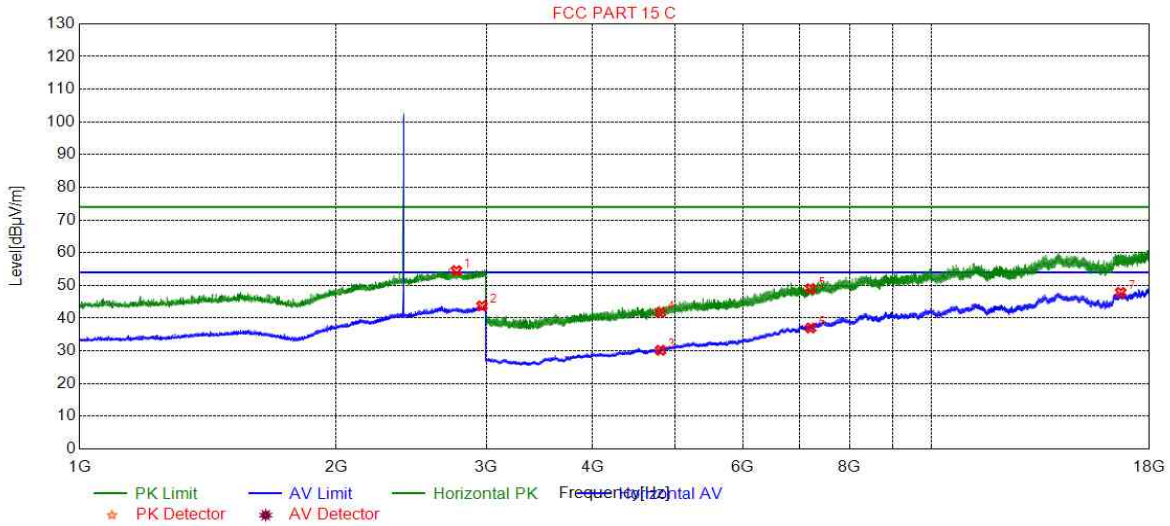
### 4.11.2 Transmitter Emission above 1GHz

#### 4.11.2.1 GFSK(DH5) _Lowest Channel _Horizontal




| Suspected List | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Level [dBµV/m] | Factor [dB] | Limit [dBµV/m] | Margin [dB] | Height [cm] | Angle [°] | Polarity |
| 1 | 2767.94 | 54.55 | 9.06 | 74.00 | 19.45 | 150 | 113 | Horizontal |
| 2 | 2964.99 | 43.76 | 9.61 | 54.00 | 10.24 | 150 | 73 | Horizontal |
| 3 | 4804.00 | 30.18 | -18.30 | 54.00 | 23.82 | 150 | 346 | Horizontal |
| 4 | 4804.00 | 41.75 | -18.30 | 74.00 | 32.25 | 150 | 263 | Horizontal |
| 5 | 7206.00 | 49.04 | -10.09 | 74.00 | 24.96 | 150 | 342 | Horizontal |
| 6 | 7206.00 | 37.01 | -10.09 | 54.00 | 16.99 | 150 | 45 | Horizontal |
| 7 | 16651.3 | 47.88 | 0.40 | 54.00 | 6.12 | 150 | 144 | Horizontal |

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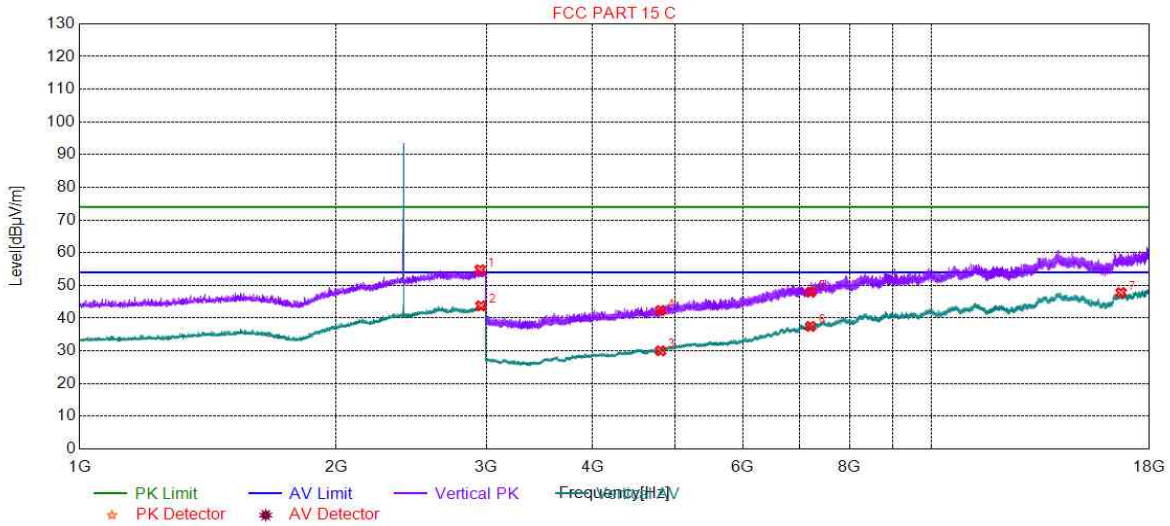
### 4.11.2.2 GFSK(DH5) _Lowest Channel _Vertical




| Suspected List | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Level [dBµV/m] | Factor [dB] | Limit [dBµV/m] | Margin [dB] | Height [cm] | Angle [°] | Polarity |
| 1 | 2950.98 | 54.84 | 9.68 | 74.00 | 19.16 | 150 | 97 | Vertical |
| 2 | 2957.48 | 43.77 | 9.65 | 54.00 | 10.23 | 150 | 152 | Vertical |
| 3 | 4804.00 | 30.02 | -18.30 | 54.00 | 23.98 | 150 | 360 | Vertical |
| 4 | 4804.00 | 42.37 | -18.30 | 74.00 | 31.63 | 150 | 45 | Vertical |
| 5 | 7206.00 | 47.94 | -10.09 | 74.00 | 26.06 | 150 | 343 | Vertical |
| 6 | 7206.00 | 37.49 | -10.09 | 54.00 | 16.51 | 150 | 116 | Vertical |
| 7 | 16668.3 | 47.83 | 0.47 | 54.00 | 6.17 | 150 | 205 | Vertical |

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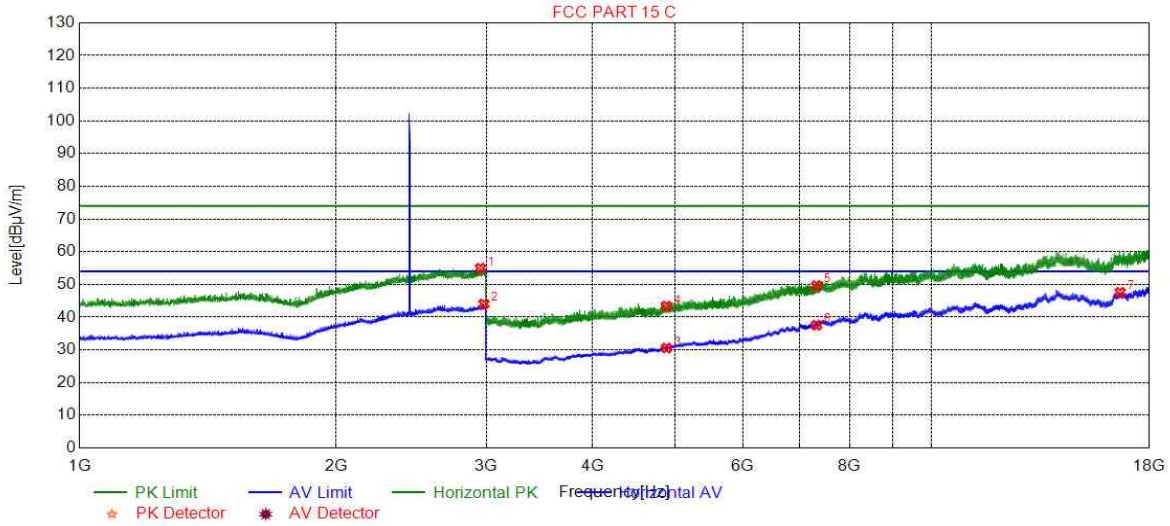
### 4.11.2.3 GFSK(DH5) _Middle Channel _ Horizontal




| Suspected List | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Level [dBµV/m] | Factor [dB] | Limit [dBµV/m] | Margin [dB] | Height [cm] | Angle [°] | Polarity |
| 1 | 2952.98 | 54.97 | 9.67 | 74.00 | 19.03 | 150 | 333 | Horizontal |
| 2 | 2980.99 | 44.06 | 9.54 | 54.00 | 9.94 | 150 | 237 | Horizontal |
| 3 | 4882.00 | 30.56 | -17.96 | 54.00 | 23.44 | 150 | 235 | Horizontal |
| 4 | 4882.00 | 43.38 | -17.96 | 74.00 | 30.62 | 150 | 72 | Horizontal |
| 5 | 7323.00 | 49.68 | -9.71 | 74.00 | 24.32 | 150 | 242 | Horizontal |
| 6 | 7323.00 | 37.56 | -9.71 | 54.00 | 16.44 | 150 | 242 | Horizontal |
| 7 | 16631.5 | 47.58 | 0.32 | 54.00 | 6.42 | 150 | 42 | Horizontal |

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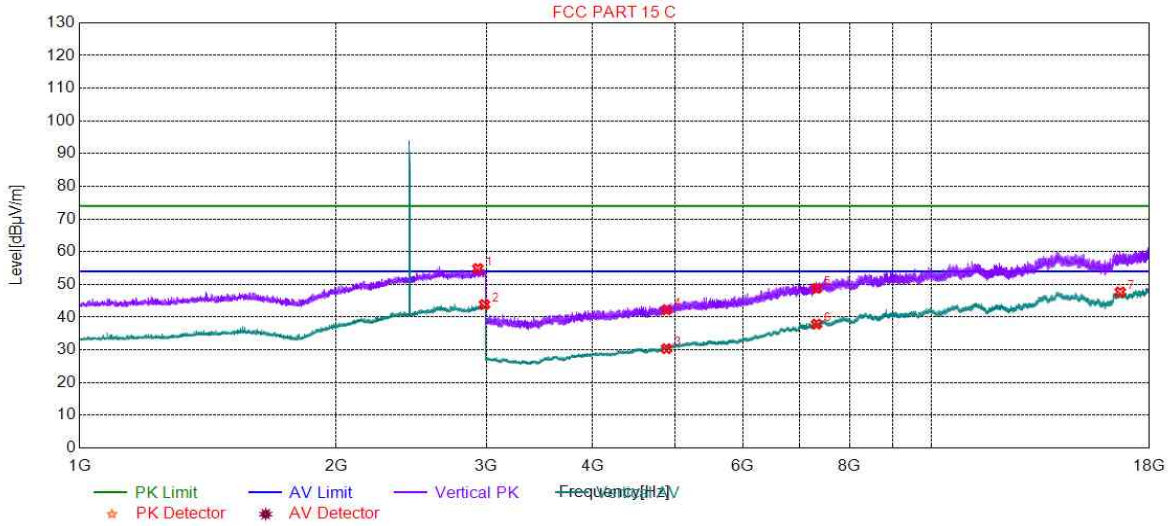
### 4.11.2.4 GFSK(DH5) _Middle Channel _Vertical




| Suspected List | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Level [dBµV/m] | Factor [dB] | Limit [dBµV/m] | Margin [dB] | Height [cm] | Angle [°] | Polarity |
| 1 | 2932.98 | 54.89 | 9.50 | 74.00 | 19.11 | 150 | 288 | Vertical |
| 2 | 2985.49 | 43.88 | 9.52 | 54.00 | 10.12 | 150 | 342 | Vertical |
| 3 | 4882.00 | 30.40 | -17.96 | 54.00 | 23.60 | 150 | 289 | Vertical |
| 4 | 4882.00 | 42.22 | -17.96 | 74.00 | 31.78 | 150 | 180 | Vertical |
| 5 | 7323.00 | 48.83 | -9.71 | 74.00 | 25.17 | 150 | 0 | Vertical |
| 6 | 7323.00 | 37.88 | -9.71 | 54.00 | 16.12 | 150 | 342 | Vertical |
| 7 | 16632.6 | 47.70 | 0.32 | 54.00 | 6.30 | 150 | 144 | Vertical |

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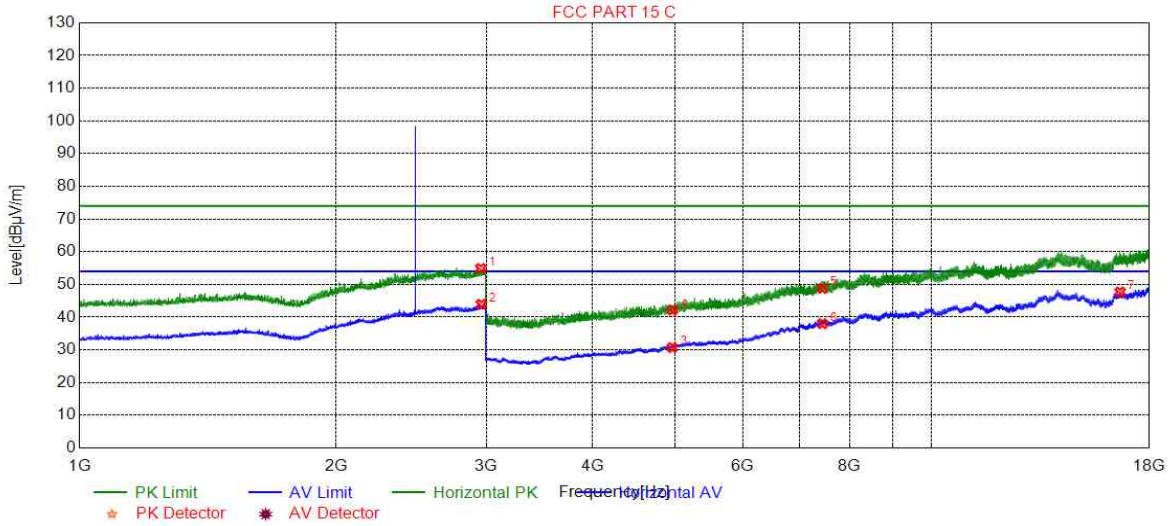
### 4.11.2.5 GFSK(DH5) _Highest Channel _ Horizontal




| Suspected List | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Level [dBµV/m] | Factor [dB] | Limit [dBµV/m] | Margin [dB] | Height [cm] | Angle [°] | Polarity |
| 1 | 2956.48 | 54.89 | 9.65 | 74.00 | 19.11 | 150 | 220 | Horizontal |
| 2 | 2960.49 | 43.96 | 9.63 | 54.00 | 10.04 | 150 | 248 | Horizontal |
| 3 | 4960.00 | 30.71 | -17.47 | 54.00 | 23.29 | 150 | 271 | Horizontal |
| 4 | 4960.00 | 42.16 | -17.47 | 74.00 | 31.84 | 150 | 325 | Horizontal |
| 5 | 7440.00 | 48.81 | -9.35 | 74.00 | 25.19 | 150 | 292 | Horizontal |
| 6 | 7440.00 | 38.03 | -9.35 | 54.00 | 15.97 | 150 | 0 | Horizontal |
| 7 | 16624.3 | 47.70 | 0.29 | 54.00 | 6.30 | 150 | 44 | Horizontal |

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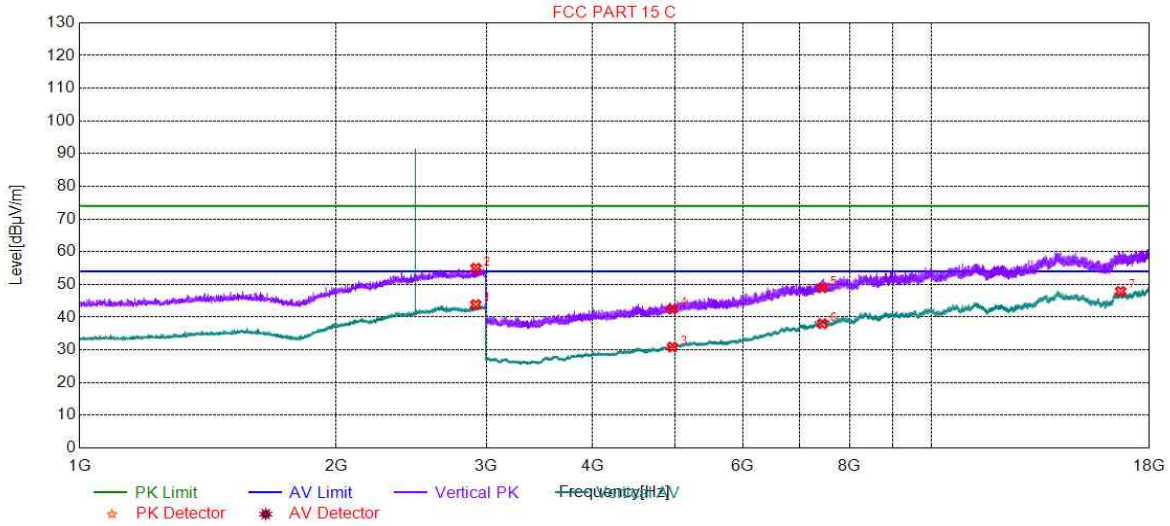
### 4.11.2.6 GFSK(DH5) _Highest Channel _Vertical




| Suspected List | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Level [dBµV/m] | Factor [dB] | Limit [dBµV/m] | Margin [dB] | Height [cm] | Angle [°] | Polarity |
| 1 | 2915.97 | 43.85 | 9.31 | 54.00 | 10.15 | 150 | 234 | Vertical |
| 2 | 2917.47 | 54.99 | 9.33 | 74.00 | 19.01 | 150 | 275 | Vertical |
| 3 | 4960.00 | 30.86 | -17.47 | 54.00 | 23.14 | 150 | 344 | Vertical |
| 4 | 4960.00 | 42.51 | -17.47 | 74.00 | 31.49 | 150 | 73 | Vertical |
| 5 | 7440.00 | 48.98 | -9.35 | 74.00 | 25.02 | 150 | 93 | Vertical |
| 6 | 7440.00 | 38.02 | -9.35 | 54.00 | 15.98 | 150 | 143 | Vertical |
| 7 | 16651.3 | 47.89 | 0.40 | 54.00 | 6.11 | 150 | 1 | Vertical |

Remark:

1) The field strength is calculated by adding the Antenna Factor, Cable Factor & Preamplifier. The basic equation with a sample calculation is as follows:

Final Test Level =Receiver Reading + Antenna Factor + Cable Factor – Preamplifier Factor

2) Scan from 9kHz to 25GHz, the disturbance between 9KHz to 30MHz and 18GHz to 25GHz was very low, and the above harmonics were the highest point could be found when testing, The amplitude of spurious emissions from the radiator which are attenuated more than 20dB below the limit need not be reported.

3) As shown in this section, for frequencies above 1GHz, the field strength limits are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation. So, only the peak measurements were shown in the report.

4）All Modes have been tested, but only the worst case data displayed in this report.

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## 4.12 Restricted bands around fundamental frequency

| | | | |
|---|---|---|---|
| Test Requirement: | 47 CFR Part 15C Section 15.209 and 15.205 | | |
| Test Method: | ANSI C63.10: 2013 | | |
| Test Site: | Measurement Distance: 3m or 10m (Semi-Anechoic Chamber) | | |
| Limit: | Frequency | Limit (dBuV/m @3m) | Remark |
| | 30MHz-88MHz | 40.0 | Quasi-peak Value |
| | 88MHz-216MHz | 43.5 | Quasi-peak Value |
| | 216MHz-960MHz | 46.0 | Quasi-peak Value |
| | 960MHz-1GHz | 54.0 | Quasi-peak Value |
| | Above 1GHz | 54.0 | Average Value |
| | | 74.0 | Peak Value |
| Test Setup: | | | |

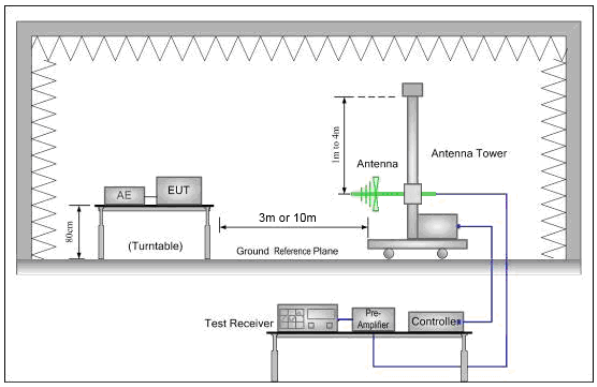


Figure 1. 30MHz to 1GHz

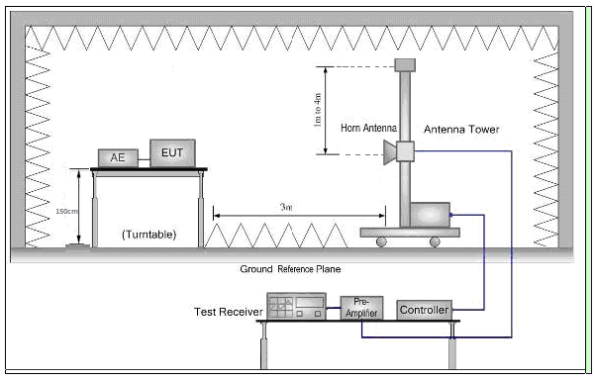


Figure 2. Above 1 GHz

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| | |
|---|---|
| Test Procedure: | a. For below 1GHz, the EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 or 10 meter semi-anechoic camber. The table was rotated 360 degrees to determine the position of the highest radiation.<br>b. For above 1GHz, the EUT was placed on the top of a rotating table 1.5 meters above the ground at a 3 meter semi-anechoic camber. The table was rotated 360 degrees to determine the position of the highest radiation.<br>c. The EUT was set 3 or 10 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.<br>d. The antenna height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.<br>e. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.<br>f. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.<br>g. Place a marker at the end of the restricted band closest to the transmit frequency to show compliance. Also measure any emissions in the restricted bands. Save the spectrum analyzer plot. Repeat for each power and modulation for lowest and highest channel<br>h. Test the EUT in the lowest channel , the Highest channel<br>i. The radiation measurements are performed in X, Y, Z axis positioning for Transmitting mode, and found the X axis positioning which it is the worst case.<br>j. Repeat above procedures until all frequencies measured was complete. |
| Exploratory Test Mode: | Non-hopping transmitting mode with all kind of modulation and all kind of data type<br>Charge + Transmitting mode. |
| Final Test Mode: | Through Pre-scan, find the DH5 of data type and GFSK modulation is the worst case.<br>Pretest the EUT at Charge + Transmitting mode,<br>Only the worst case is recorded in the report. |
| Instruments Used: | Refer to section 5.10 for details |
| Test Results: | Pass |

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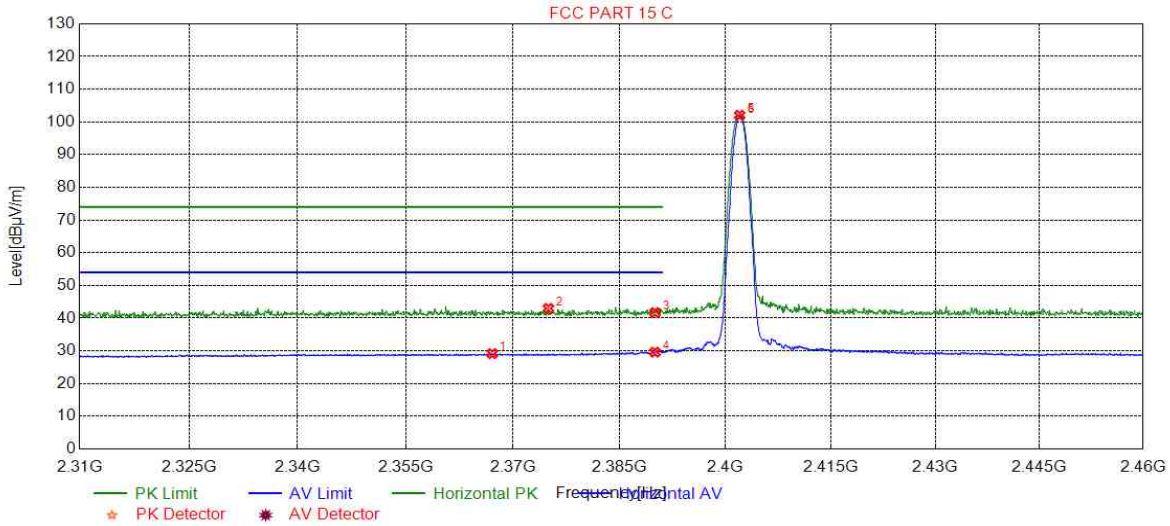
### 4.12.1 Test plots

#### 4.12.1.1 Worst Case Mode (GFSK(DH5)) _Lowest Channel _Horizontal




| Suspected List | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Level [dBµV/m] | Factor [dB] | Limit [dBµV/m] | Margin [dB] | Height [cm] | Angle [°] | Polarity |
| 1 | 2367.10 | 29.18 | 7.79 | 54.00 | 24.82 | 150 | 277 | Horizontal |
| 2 | 2374.98 | 43.01 | 7.79 | 74.00 | 30.99 | 150 | 52 | Horizontal |
| 3 | 2390.00 | 41.72 | 7.77 | 74.00 | 32.28 | 150 | 200 | Horizontal |
| 4 | 2390.00 | 29.62 | 7.77 | 54.00 | 24.38 | 150 | 222 | Horizontal |
| 5 | 2402.00 | 102.04 | 7.77 | 0.00 | -102.04 | 150 | 216 | Horizontal |
| 6 | 2402.00 | 101.91 | 7.77 | 0.00 | -101.91 | 150 | 216 | Horizontal |

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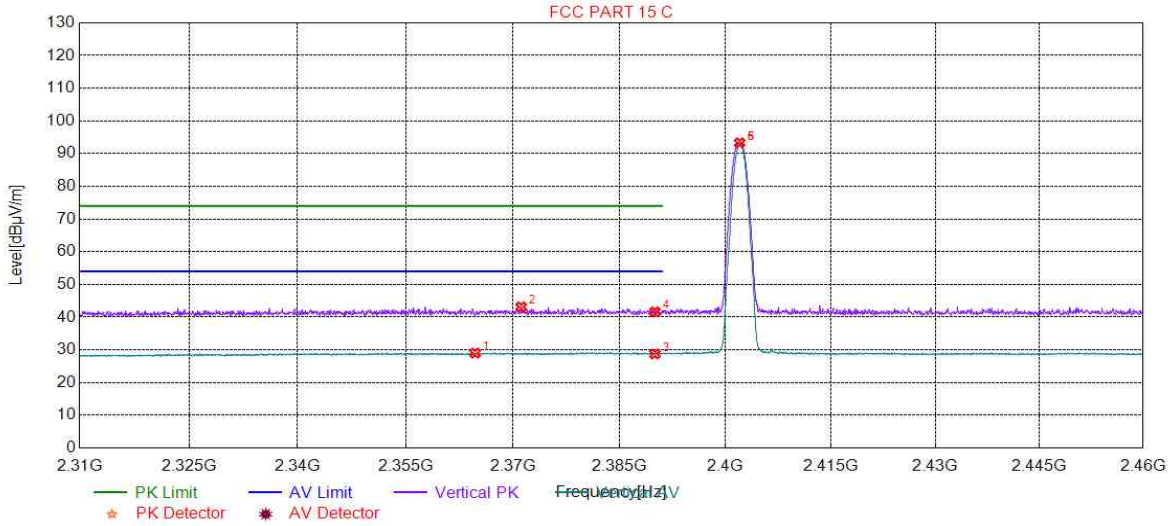
### 4.12.1.2 Worst Case Mode (GFSK(DH5)) _Lowest Channel _Vertical




| Suspected List | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Level [dBµV/m] | Factor [dB] | Limit [dBµV/m] | Margin [dB] | Height [cm] | Angle [°] | Polarity |
| 1 | 2364.70 | 29.01 | 7.80 | 54.00 | 24.99 | 150 | 237 | Vertical |
| 2 | 2371.15 | 43.16 | 7.79 | 74.00 | 30.84 | 150 | 116 | Vertical |
| 3 | 2390.00 | 28.76 | 7.77 | 54.00 | 25.24 | 150 | 226 | Vertical |
| 4 | 2390.00 | 41.65 | 7.77 | 74.00 | 32.35 | 150 | 62 | Vertical |
| 5 | 2402.00 | 93.32 | 7.77 | 0.00 | -93.32 | 150 | 265 | Vertical |
| 6 | 2402.00 | 93.19 | 7.77 | 0.00 | -93.19 | 150 | 265 | Vertical |

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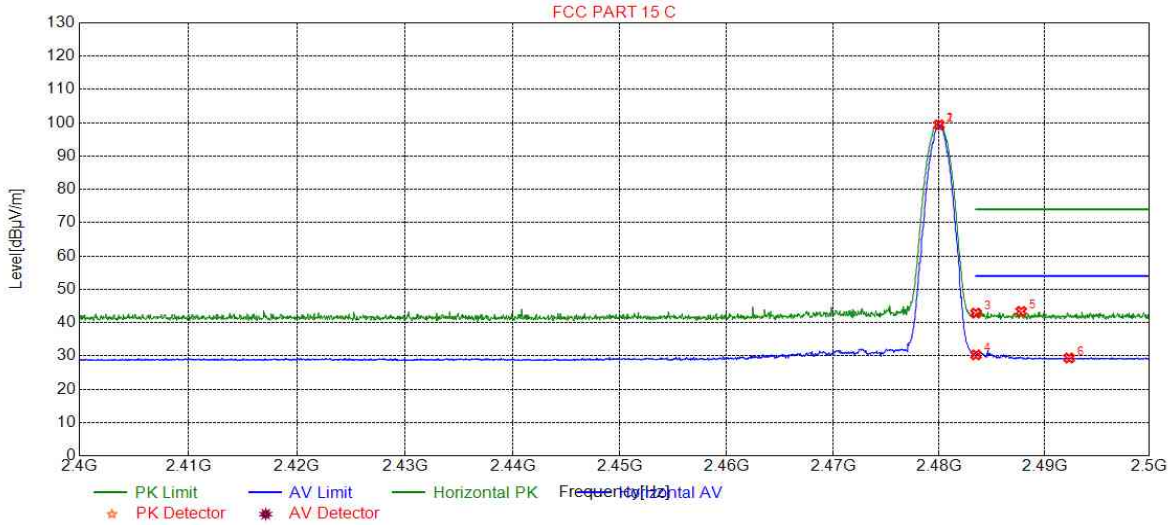
### 4.12.1.3 Worst Case Mode (GFSK(DH5)) _Highest Channel _ Horizontal




| Suspected List | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Level [dBµV/m] | Factor [dB] | Limit [dBµV/m] | Margin [dB] | Height [cm] | Angle [°] | Polarity |
| 1 | 2480.00 | 99.36 | 8.01 | 0.00 | -99.36 | 150 | 220 | Horizontal |
| 2 | 2480.00 | 99.20 | 8.01 | 0.00 | -99.20 | 150 | 215 | Horizontal |
| 3 | 2483.50 | 42.87 | 8.01 | 74.00 | 31.13 | 150 | 116 | Horizontal |
| 4 | 2483.50 | 30.34 | 8.01 | 54.00 | 23.66 | 150 | 215 | Horizontal |
| 5 | 2487.79 | 43.40 | 8.02 | 74.00 | 30.60 | 150 | 84 | Horizontal |
| 6 | 2492.34 | 29.41 | 8.02 | 54.00 | 24.59 | 150 | 14 | Horizontal |

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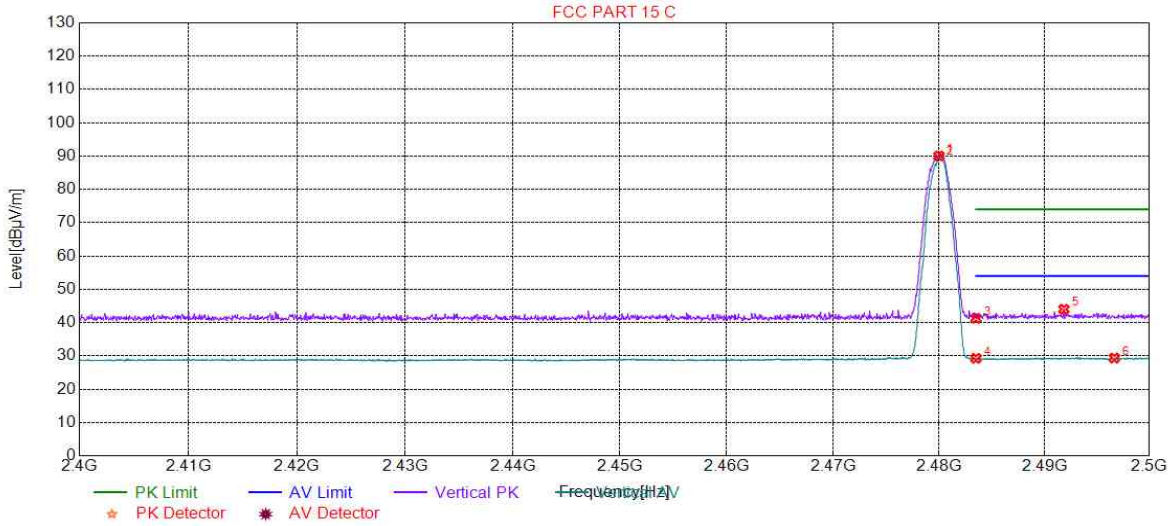
### 4.12.1.4 Worst Case Mode (GFSK(DH5)) _Highest Channel _Vertical




| Suspected List | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Level [dBµV/m] | Factor [dB] | Limit [dBµV/m] | Margin [dB] | Height [cm] | Angle [°] | Polarity |
| 1 | 2480.00 | 90.04 | 8.01 | 0.00 | -90.04 | 150 | 288 | Vertical |
| 2 | 2480.00 | 89.42 | 8.01 | 0.00 | -89.42 | 150 | 346 | Vertical |
| 3 | 2483.50 | 41.30 | 8.01 | 74.00 | 32.70 | 150 | 112 | Vertical |
| 4 | 2483.50 | 29.31 | 8.01 | 54.00 | 24.69 | 150 | 282 | Vertical |
| 5 | 2491.84 | 44.03 | 8.02 | 74.00 | 29.97 | 150 | 205 | Vertical |
| 6 | 2496.64 | 29.40 | 8.03 | 54.00 | 24.60 | 150 | 41 | Vertical |

*Remark:*
*The field strength is calculated by adding the Antenna Factor, Cable Factor & Preamplifier. The basic equation with a sample calculation is as follows:*
*Final Test Level =Receiver Reading + Antenna Factor + Cable Factor – Preamplifier Factor*
*All Modes have been tested, but only the worst case data displayed in this report.*

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# 5 Measurement Uncertainty (95% confidence levels, k=2)

| No. | Item | Measurement Uncertainty |
|---|---|---|
| 1 | Total RF power, conducted | ±0.75dB |
| 2 | RF power density, conducted | ±2.84dB |
| 3 | Spurious emissions, conducted | ±0.75dB |
| 4 | Radiated Spurious emission test | ±4.5dB (30MHz-1GHz) |
| | | ±4.8dB (1GHz-25GHz) |
| 5 | Conduct emission test | ±3.12 dB(9KHz- 30MHz) |
| 6 | Temperature test | ±1°C |
| 7 | Humidity test | ±3% |
| 8 | DC and low frequency voltages | ±0.5% |

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# 6 Equipment List

| Conducted Emission | | | | | |
|---|---|---|---|---|---|
| Test Equipment | Manufacturer | Model No. | Inventory No. | Cal. date (yyyy-mm-dd) | Cal.Duedate (yyyy-mm-dd) |
| Shielding Room | ZhongYu Electron | GB-88 | SEM001-06 | 2020/5/10 | 2023/5/9 |
| LISN | Rohde & Schwarz | ENV216 | SEM007-01 | 2019/7/14 | 2020/7/14 |
| LISN | ETS-LINDGREN | Feb-16 | SEM007-02 | 20120/4/1 | 2021/3/31 |
| Measurement Software | AUDIX | e3 V5.4.1221d | N/A | N/A | N/A |
| Coaxial Cable | SGS | N/A | SEM024-01 | 2020/6/12 | 2021/6/11 |
| 2 Line ISN | Fischer Custom Communications Inc. | FCC-TLISN-T2-02 | EMC0122 | 2020/2/11 | 2021/2/10 |
| EMI Test Receiver | Rohde & Schwarz | ESCI | SEM004-02 | 2020/3/2 | 2021/3/1 |

| RF conducted test | | | | | |
|---|---|---|---|---|---|
| Test Equipment | Manufacturer | Model No. | Inventory No. | Cal. date (yyyy-mm-dd) | Cal.Duedate (yyyy-mm-dd) |
| DC Power Supply | Agilent Technologies Inc | 66311B | W009-09 | 2019/7/15 | 2020/7/15 |
| Signal Analyzer | Rohde & Schwarz | FSV | W025-05 | 2020/1/3 | 2021/1/2 |
| Coaxial Cable | SGS | N/A | SEM031-01 | 2020/6/12 | 2021/6/11 |
| Attenuator | Weinschel Associates | WA41 | SEM021-09 | N/A | N/A |
| Signal Generator | KEYSIGHT | N5173B | SEM006-05 | 2019/7/14 | 2020/7/14 |
| Temperature Chamber | GIANT FORCE | ICT-150-40-CP-AR | W027-03 | 2019/10/27 | 2020/10/27 |
| Power Meter | Rohde & Schwarz | NRVS | SEM014-02 | 2019/7/14 | 2020/7/14 |

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| RE in Chamber | | | | | |
|---|---|---|---|---|---|
| Test Equipment | Manufacturer | Model No. | Inventory No. | Cal. date (yyyy-mm-dd) | Cal.Due date (yyyy-mm-dd) |
| 3m Semi-Anechoic Chamber | AUDIX | N/A | SEM001-02 | 2018/3/13 | 2021/3/12 |
| Measurement Software | AUDIX | e3V8.2014-6-27 | N/A | N/A | N/A |
| Coaxial Cable | SGS | N/A | SEM026-01 | 2020/6/12 | 2021/6/11 |
| EXA Signal Analyzer (10Hz-26.5GHz) | Agilent Technologies Inc | N9010A | SEM004-09 | 2020/3/12 | 2021/3/11 |
| BiConiLog Antenna (26-3000MHz) | ETS-Lindgren | 3142C | SEM003-01 | 2020/6/12 | 2023/6/11 |
| Horn Antenna (0.8-18GHz) | Rohde & Schwarz | HF907 | SEM003-07 | 2018/4/13 | 2021/4/12 |
| Pre-amplifier(0.1-1.3GHz) | HP | 8447D | SEM005-02 | 2019/7/14 | 2020/7/14 |
| Low Noise Amplifier(100MHz-18GHz) | Black Diamond Series | BDLNA-0118-352810 | SEM005-05 | 2019/9/3 | 2020/9/2 |
| Horn Antenna (15-40GHz) | Schwarzbeck | BBHA 9170 | SEM003-15 | 2017/10/17 | 2020/10/16 |
| Pre-amplifier(18-26GHz) | Rohde & Schwarz | CH14-H052 | SEM005-17 | 2020/3/2 | 2021/3/1 |
| Band filter | N/A | N/A | SEM023-01 | N/A | N/A |

| RE in Chamber | | | | | |
|---|---|---|---|---|---|
| Test Equipment | Manufacturer | Model No. | Inventory No. | Cal. date (yyyy-mm-dd) | Cal.Due date (yyyy-mm-dd) |
| 3m Semi-Anechoic Chamber | ETS-LINDGREN | N/A | SEM001-01 | 2017/8/5 | 2020/8/4 |
| Measurement Software | AUDIX | e3 V8.2014-6-27 | N/A | N/A | N/A |
| Coaxial Cable | SGS | N/A | SEM025-01 | 2020/6/12 | 2021/6/11 |
| MXE EMI Receiver (20Hz-8.4GHz) | Agilent Technologies | N9038A | SEM004-05 | 2019/7/14 | 2020/7/14 |
| BiConiLog Antenna (26-3000MHz) | ETS-LINDGREN | 3142C | SEM003-01 | 2020/6/12 | 2023/6/11 |
| Pre-amplifier (0.1-1.3GHz) | Agilent Technologies | 8447D | SEM005-01 | 2020/3/2 | 2021/3/1 |

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# 7 Photographs - EUT Constructional Details

Refer to Appendix A - Photographs of Set-Up for ZR/2020/50042.

The End

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