# FCC RF Test Report

| | | |
|---|---|---|
| **APPLICANT** | : | **HMD Global Oy** |
| **EQUIPMENT** | : | **Mobile Phone** |
| **BRAND NAME** | : | **Nokia** |
| **MODEL NAME** | : | **TA-1178** |
| **FCC ID** | : | **2AJOTTA-1178** |
| **STANDARD** | : | **FCC Part 15 Subpart C §15.247** |
| **CLASSIFICATION** | : | **(DSS) Spread Spectrum Transmitter** |

**The product was received on May 27, 2019 and testing was completed on Jun. 17, 2019. We, Sporton International (Kunshan) Inc., would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.**

**The test results in this report apply exclusively to the tested model / sample. Without written approval of Sporton International (Kunshan) Inc., the test report shall not be reproduced except in full.**

Jason Jia

**Reviewed by: Jason Jia / Supervisor**

James Huang

**Approved by: James Huang / Manager**

ACCREDITED Cert #5145.02

***Sporton International (Kunshan) Inc.***
***No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300***
***People's Republic of China***

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# REVISION HISTORY

| REPORT NO. | VERSION | DESCRIPTION | ISSUED DATE |
|---|---|---|---|
| FR952704A | Rev. 01 | Initial issue of report | Jul. 25, 2019 |
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# SUMMARY OF TEST RESULT

| Report Section | FCC Rule | Description | Limit | Result | Remark |
|---|---|---|---|---|---|
| 3.1 | 15.247(a)(1) | Number of Channels | ≥ 15Chs | Pass | - |
| 3.2 | 15.247(a)(1) | Hopping Channel Separation | ≥ 2/3 of 20dB BW | Pass | - |
| 3.3 | 15.247(a)(1) | Dwell Time of Each Channel | ≤ 0.4sec in 31.6sec period | Pass | - |
| 3.4 | 15.247(a)(1) | 20dB Bandwidth | NA | Pass | - |
| 3.4 | - | 99% Bandwidth | - | Pass | - |
| 3.5 | 15.247(b)(1) | Peak Output Power | ≤ 125 mW | Pass | - |
| 3.6 | 15.247(d) | Conducted Band Edges | ≤ 20dBc | Pass | - |
| 3.7 | 15.247(d) | Conducted Spurious Emission | ≤ 20dBc | Pass | - |
| 3.8 | 15.247(d) | Radiated Band Edges and Radiated Spurious Emission | 15.209(a) & 15.247(d) | Pass | Under limit 9.05 dB at 44.550 MHz |
| 3.9 | 15.207 | AC Conducted Emission | 15.207(a) | Pass | Under limit 4.77 dB at 0.165 MHz |
| 3.10 | 15.203 & 15.247(b) | Antenna Requirement | N/A | Pass | - |

# 1 General Description

## 1.1 Applicant

**HMD Global Oy**
Bertel Jungin aukio 9,02600 ESPOO. FINLAND

## 1.2 Product Feature of Equipment Under Test

| Product Feature | |
|---|---|
| **Equipment** | Mobile Phone |
| **Brand Name** | Nokia |
| **Model Name** | TA-1178 |
| **FCC ID** | 2AJOTTA-1178 |
| **EUT supports Radios application** | GSM/GPRS/EGPRS/WCDMA/HSPA/<br>DC-HSDPA/HSPA+(16QAM uplink is not supported)<br>LTE/FM Receiver/GNSS/NFC<br>WLAN 2.4GHz 802.11b/g/n HT20<br>WLAN 5GHz 802.11a/n HT20/HT40<br>WLAN 5GHz 802.11ac VHT20/VHT40/VHT80<br>Bluetooth BR/EDR/LE |
| **IMEI Code** | Conducted: N/A<br>Conduction: 352924100008551<br>Radiation: 352924100006340 |
| **HW Version** | LLDM690B |
| **SW Version** | LLDB701 |
| **EUT Stage** | Identical Prototype |

**Remark:** The above EUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.

## 1.3 Product Specification of Equipment Under Test

| Standards-related Product Specification | |
|---|---|
| **Tx/Rx Frequency Range** | 2402 MHz ~ 2480 MHz |
| **Number of Channels** | 79 |
| **Carrier Frequency of Each Channel** | 2402+n*1 MHz; n=0~78 |
| **Maximum Output Power to Antenna** | Bluetooth BR(1Mbps) : 11.65 dBm (0.0146 W)<br>Bluetooth EDR (2Mbps) : 10.92 dBm (0.0124 W)<br>Bluetooth EDR (3Mbps) : 11.23 dBm (0.0133 W) |
| **99% Occupied Bandwidth** | Bluetooth BR(1Mbps) : 0.854MHz<br>Bluetooth EDR (2Mbps) : 1.166MHz<br>Bluetooth EDR (3Mbps) : 1.155MHz |
| **Antenna Type / Gain** | IFA Antenna type with gain -1.0 dBi |
| **Type of Modulation** | Bluetooth BR (1Mbps) : GFSK<br>Bluetooth EDR (2Mbps) : $\pi$ /4-DQPSK<br>Bluetooth EDR (3Mbps) : 8-DPSK |

## 1.4 Modification of EUT

No modifications are made to the EUT during all test items.

## 1.5 Testing Location

Sporton International (Kunshan) Inc. is accredited to ISO/IEC 17025:2017 by American Association for Laboratory Accreditation with Certificate Number 5145.02.

| | | | |
|---|---|---|---|
| **Test Firm** | Sporton International (Kunshan) Inc. | | |
| **Test Site Location** | No. 1098, Pengxi North Road, Kunshan Economic Development Zone<br>Jiangsu Province 215300 People's Republic of China<br>TEL : +86-512-57900158<br>FAX : +86-512-57900958 | | |
| **Test Site No.** | **Sporton Site No.** | **FCC Designation No.** | **FCC Test Firm Registration No.** |
| | CO01-KS<br>03CH06-KS<br>TH01-KS | CN1257 | 314309 |

## 1.6 Applicable Standards

According to the specifications of the manufacturer, the EUT must comply with the requirements of the following standards:

- 47 CFR Part 15 Subpart C §15.247
- FCC KDB 558074 D01 15.247 Meas Guidance v05r01
- ANSI C63.10-2013

**Remark:**

1. All test items were verified and recorded according to the standards and without any deviation during the test.
2. This EUT has also been tested and complied with the requirements of FCC Part 15, Subpart B, recorded in a separate test report.

# 2 Test Configuration of Equipment Under Test

## 2.1 Carrier Frequency Channel

| Frequency Band | Channel | Freq. (MHz) | Channel | Freq. (MHz) | Channel | Freq. (MHz) |
|---|---|---|---|---|---|---|
| 2400-2483.5 MHz | 0 | 2402 | 27 | 2429 | 54 | 2456 |
| | 1 | 2403 | 28 | 2430 | 55 | 2457 |
| | 2 | 2404 | 29 | 2431 | 56 | 2458 |
| | 3 | 2405 | 30 | 2432 | 57 | 2459 |
| | 4 | 2406 | 31 | 2433 | 58 | 2460 |
| | 5 | 2407 | 32 | 2434 | 59 | 2461 |
| | 6 | 2408 | 33 | 2435 | 60 | 2462 |
| | 7 | 2409 | 34 | 2436 | 61 | 2463 |
| | 8 | 2410 | 35 | 2437 | 62 | 2464 |
| | 9 | 2411 | 36 | 2438 | 63 | 2465 |
| | 10 | 2412 | 37 | 2439 | 64 | 2466 |
| | 11 | 2413 | 38 | 2440 | 65 | 2467 |
| | 12 | 2414 | 39 | 2441 | 66 | 2468 |
| | 13 | 2415 | 40 | 2442 | 67 | 2469 |
| | 14 | 2416 | 41 | 2443 | 68 | 2470 |
| | 15 | 2417 | 42 | 2444 | 69 | 2471 |
| | 16 | 2418 | 43 | 2445 | 70 | 2472 |
| | 17 | 2419 | 44 | 2446 | 71 | 2473 |
| | 18 | 2420 | 45 | 2447 | 72 | 2474 |
| | 19 | 2421 | 46 | 2448 | 73 | 2475 |
| | 20 | 2422 | 47 | 2449 | 74 | 2476 |
| | 21 | 2423 | 48 | 2450 | 75 | 2477 |
| | 22 | 2424 | 49 | 2451 | 76 | 2478 |
| | 23 | 2425 | 50 | 2452 | 77 | 2479 |
| | 24 | 2426 | 51 | 2453 | 78 | 2480 |
| | 25 | 2427 | 52 | 2454 | - | - |
| | 26 | 2428 | 53 | 2455 | - | - |

## 2.2 Test Mode

a. The EUT has been associated with peripherals and configuration operated in a manner tended to maximize its emission characteristics in a typical application. Frequency range investigated: conduction emission (150 kHz to 30 MHz), radiation emission (9 kHz to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower). For radiated measurement, pre-scanned in three orthogonal panels, X, Y, Z. The worst cases (X plane) were recorded in this report, and the worst mode of radiated spurious emissions is Bluetooth 1Mbps mode, and recorded in this report.

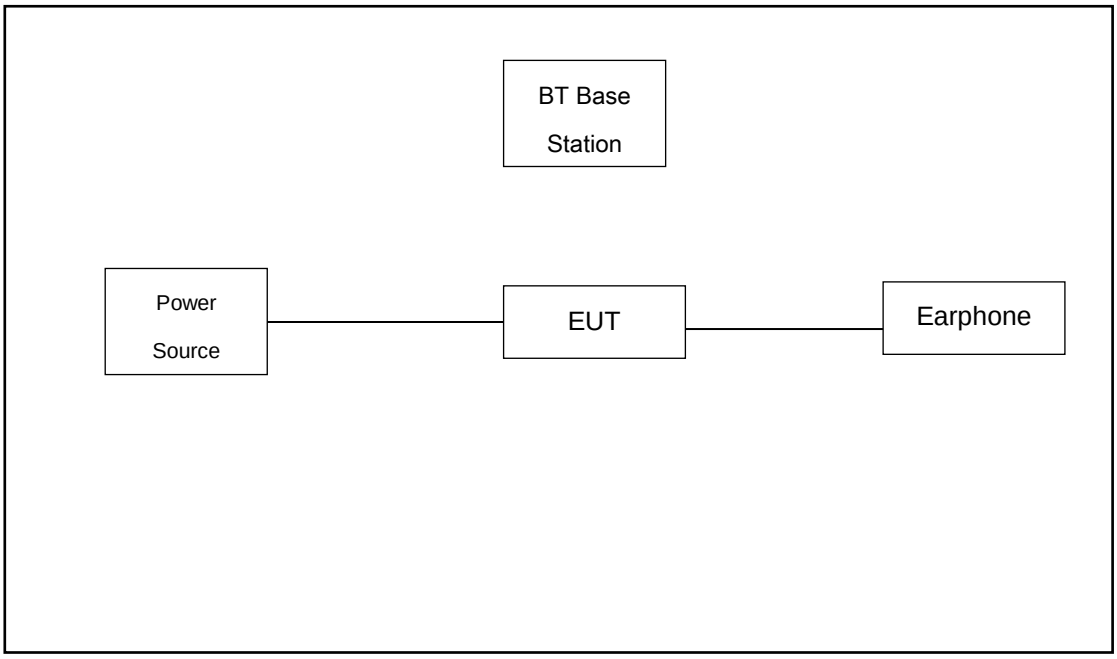
b. AC power line Conducted Emission was tested under maximum output power.

The following summary table is showing all test modes to demonstrate in compliance with the standard.

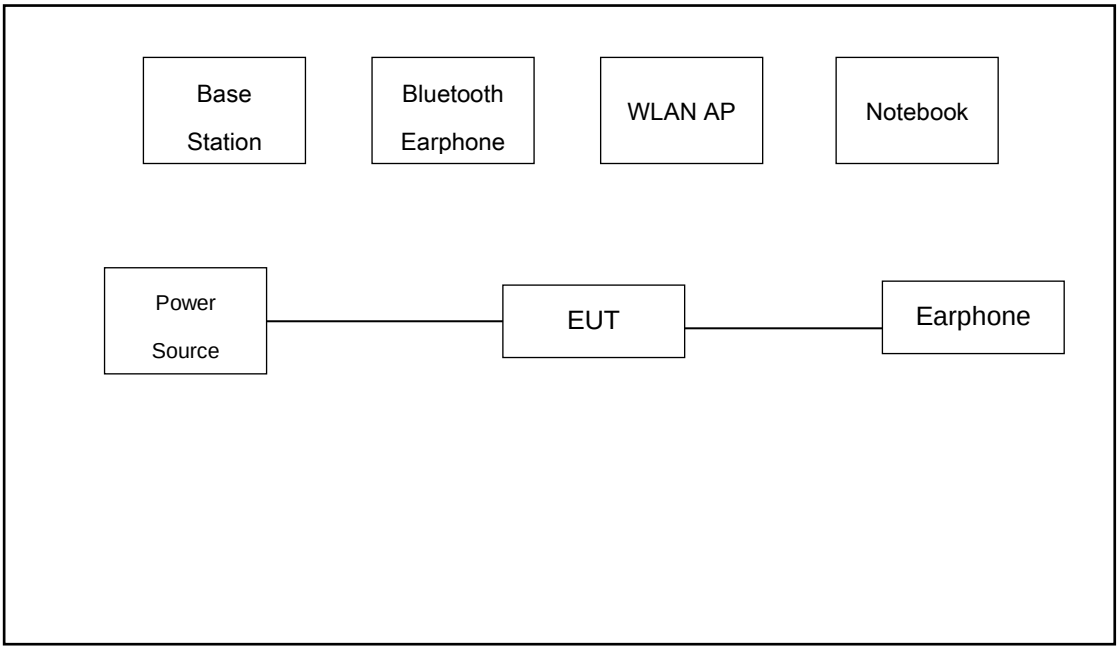
| Summary table of Test Cases | | | |
|---|---|---|---|
| **Test Item** | **Data Rate / Modulation** | | |
| | **Bluetooth BR 1Mbps GFSK** | **Bluetooth EDR 2Mbps π/4-DQPSK** | **Bluetooth EDR 3Mbps 8-DPSK** |
| **Conducted Test Cases** | Mode 1: CH00_2402 MHz<br>Mode 2: CH39_2441 MHz<br>Mode 3: CH78_2480 MHz | Mode 4: CH00_2402 MHz<br>Mode 5: CH39_2441 MHz<br>Mode 6: CH78_2480 MHz | Mode 7: CH00_2402 MHz<br>Mode 8: CH39_2441 MHz<br>Mode 9: CH78_2480 MHz |
| **Radiated Test Cases** | **Bluetooth BR 1Mbps GFSK** | | |
| | Mode 1: CH00_2402 MHz<br>Mode 2: CH39_2441 MHz<br>Mode 3: CH78_2480 MHz | | |
| **AC Conducted Emission** | Mode 1 : GSM 850 Idle + Bluetooth Link + WLAN Link(2.4G) + USB Cable1(Charging from Adapter1) + Earphone1 + Battery 1 | | |
| **Remark:**<br>1. For radiated test cases, the worst mode data rate 1Mbps was reported only, because this data rate has the highest RF output power at preliminary tests, and no other significantly frequencies found in conducted spurious emission.<br>2. For Radiated Test Cases, The tests were performed with Adapter4, USB cable 1, Battery 1 and Earphone1 . | | | |

## 2.3 Connection Diagram of Test System

For Radiation




For Conducted Emission



## 2.4 Support Unit used in test configuration and system

| Item | Equipment | Trade Name | Model Name | FCC ID | Data Cable | Power Cord |
|---|---|---|---|---|---|---|
| 1. | Base Station | Anritsu | MT8820C | N/A | N/A | Unshielded,1.8m |
| 2. | BT Base Station | R&S | CBT | N/A | N/A | Unshielded,1.8m |
| 3. | Bluetooth Earphone | Lenovo | LBH308 | N/A | N/A | N/A |
| 4. | Notebook | Lenovo | G480 | N/A | N/A | shielded cable DC O/P 1.8m , Unshielded AC I/P cable 1.8m |
| 5. | WLAN AP | D-link | DIR-855 | KA2DIR855A2 | N/A | Unshielded,1.8m |

## 2.5 EUT Operation Test Setup

For Bluetooth function, the engineering test program was provided and enabled to make EUT connect with Bluetooth base station to continuous transmit/receive.

For AC power line conducted emissions, the EUT was set to connect with the WLAN AP under large package sizes transmission.

## 2.6 Measurement Results Explanation Example

**For all conducted test items:**

The offset level is set in the spectrum analyzer to compensate the RF cable loss between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

Example:

The spectrum analyzer offset is derived from RF cable loss.

*Offset = RF cable loss.*

Following shows an offset computation example with cable loss 6.00 dB.

*Offset(dB) = RF cable loss(dB) .*

= 6.00 (dB)

# 3 Test Result

## 3.1 Number of Channel Measurement

### 3.1.1 Limits of Number of Hopping Frequency

Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

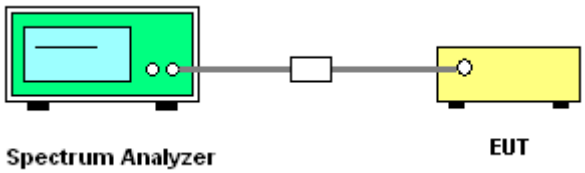
### 3.1.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

### 3.1.3 Test Procedure

1. The testing follows ANSI C63.10-2013 clause 7.8.3.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings: Span = the frequency band of operation; RBW = 300kHz; VBW ≥ RBW; Sweep = auto; Detector function = peak; Trace = max hold.
6. The number of hopping frequency used is defined as the number of total channel.
7. Record the measurement data derived from spectrum analyzer.

### 3.1.4 Test Setup

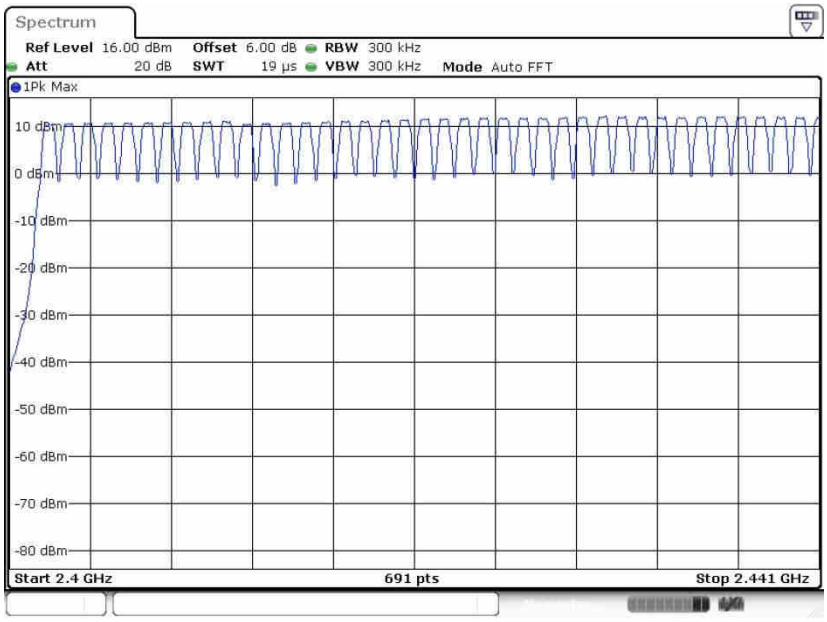


## 3.1.5 Test Result of Number of Hopping Frequency

| Test Mode : | 1Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

| Number of Hopping (Channel) | Adaptive Frequency Hopping (Channel) | Limits (Channel) | Pass/Fail |
|---|---|---|---|
| 79 | 20 | > 15 | Pass |

**Number of Hopping Channel Plot on Channel 00 - 78**

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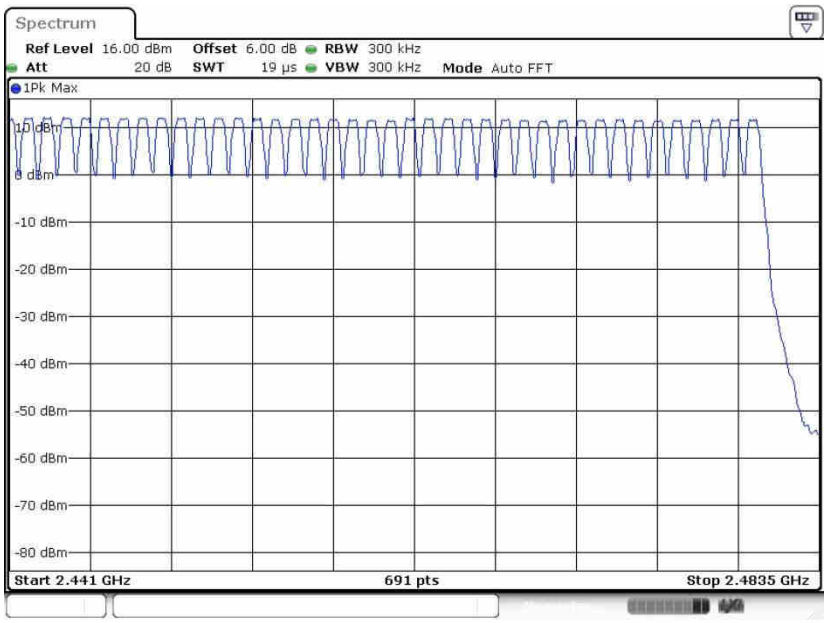


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## 3.2 Hopping Channel Separation Measurement

### 3.2.1 Limit of Hopping Channel Separation

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.

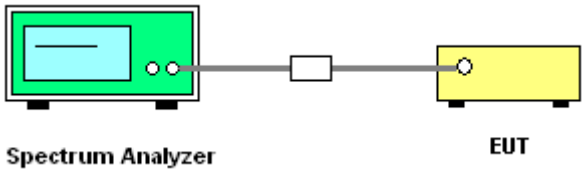
### 3.2.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

### 3.2.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.2.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings:
   Span = wide enough to capture the peaks of two adjacent channels;
   RBW = 300kHz; VBW ≥ RBW; Sweep = auto; Detector function = peak; Trace = max hold.
6. Measure and record the results in the test report.

### 3.2.4 Test Setup

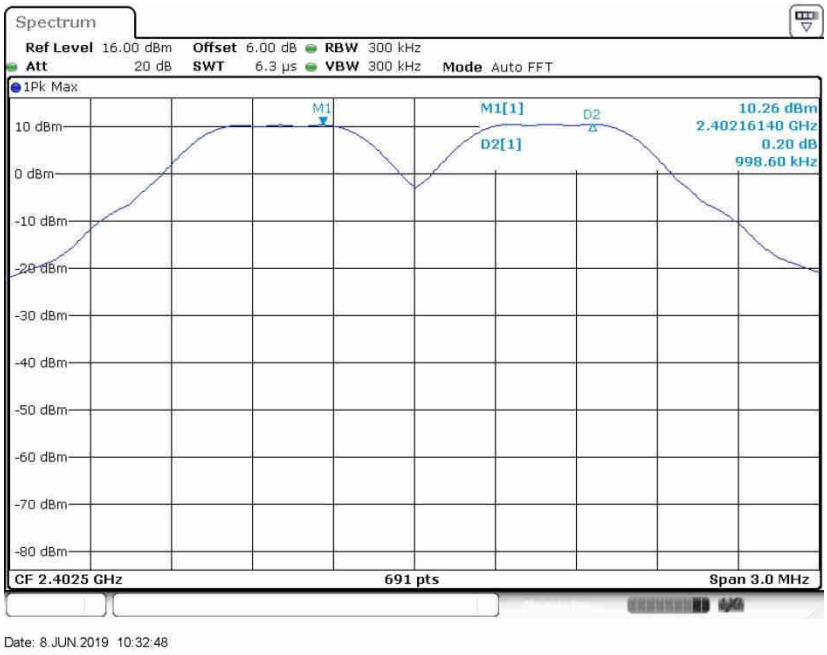


## 3.2.5 Test Result of Hopping Channel Separation

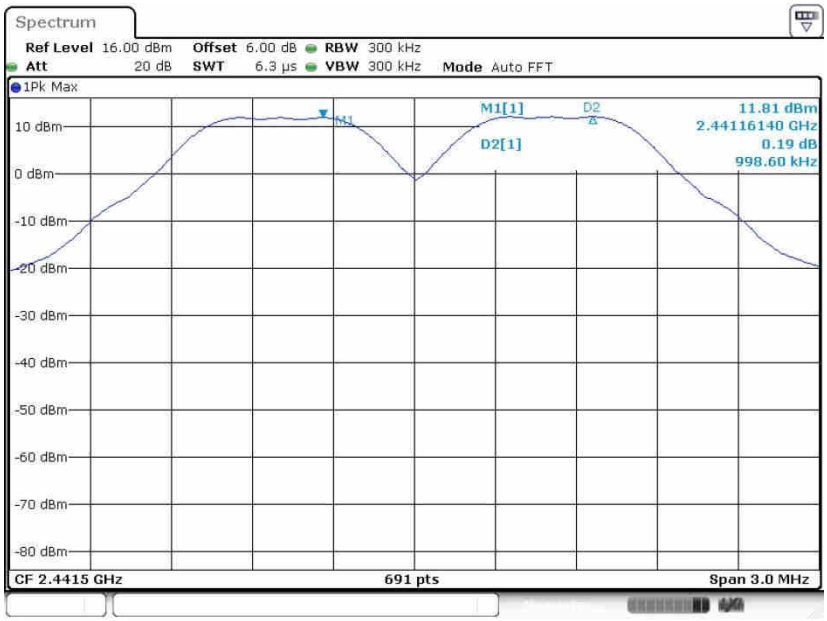
| Test Mode : | 1Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

| Channel | Frequency (MHz) | Frequency Separation (MHz) | (2/3 of 20dB BW) Limits (MHz) | Pass/Fail |
|---|---|---|---|---|
| 00 | 2402 | 0.9986 | 0.6291 | Pass |
| 39 | 2441 | 0.9986 | 0.6291 | Pass |
| 78 | 2480 | 0.9986 | 0.6310 | Pass |

**Channel Separation Plot on Channel 00 - 01**



### Channel Separation Plot on Channel 39 - 40

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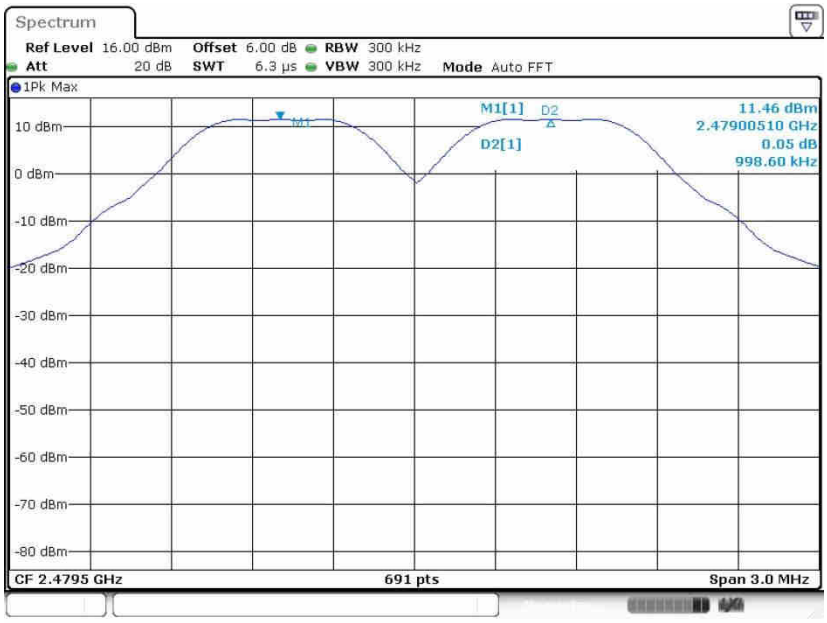
### Channel Separation Plot on Channel 77 - 78

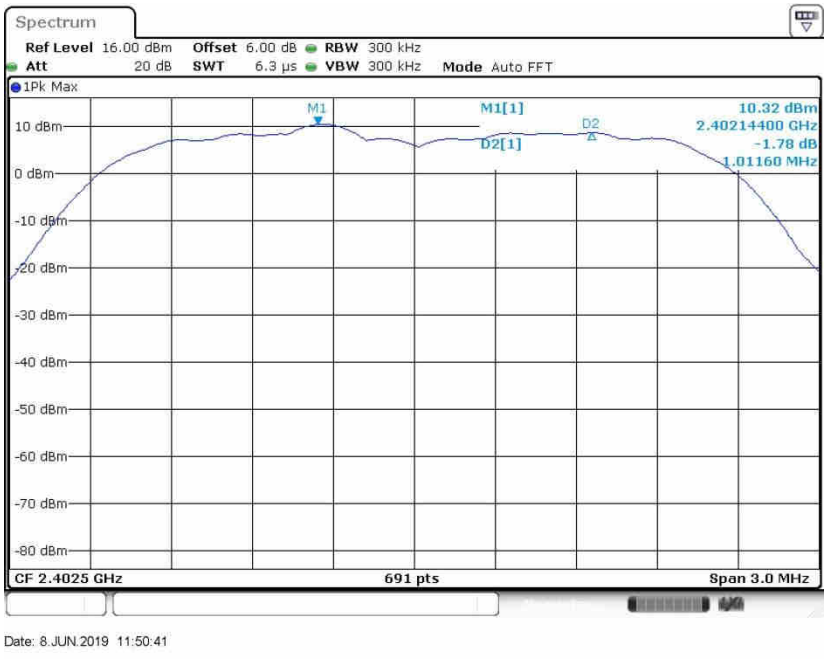



Date: 8.JUN.2019 10:39:37

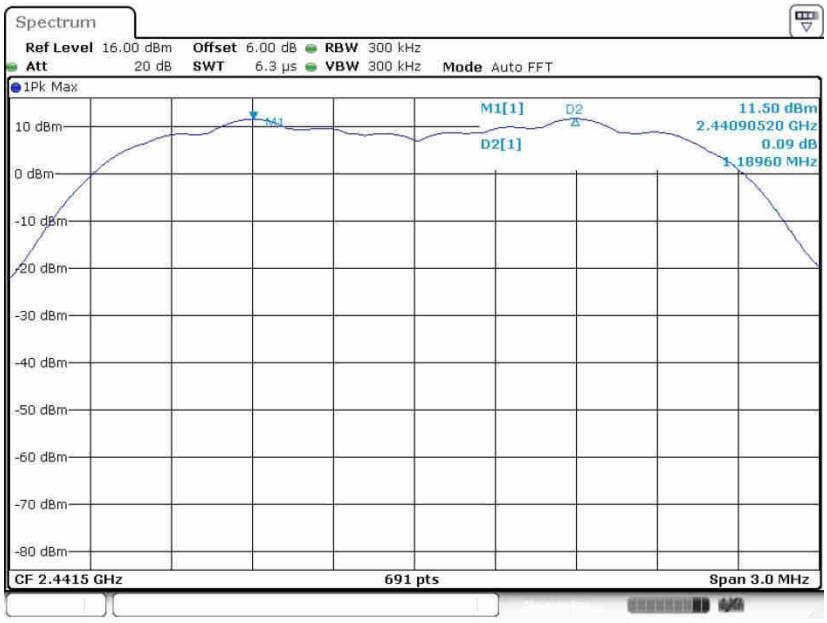
| Test Mode : | 2Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

| Channel | Frequency (MHz) | Frequency Separation (MHz) | (2/3 of 20dB BW) Limits (MHz) | Pass/Fail |
|---|---|---|---|---|
| 00 | 2402 | 1.0116 | 0.8365 | Pass |
| 39 | 2441 | 1.1896 | 0.8365 | Pass |
| 78 | 2480 | 1.0941 | 0.8481 | Pass |

**Channel Separation Plot on Channel 00 - 01**

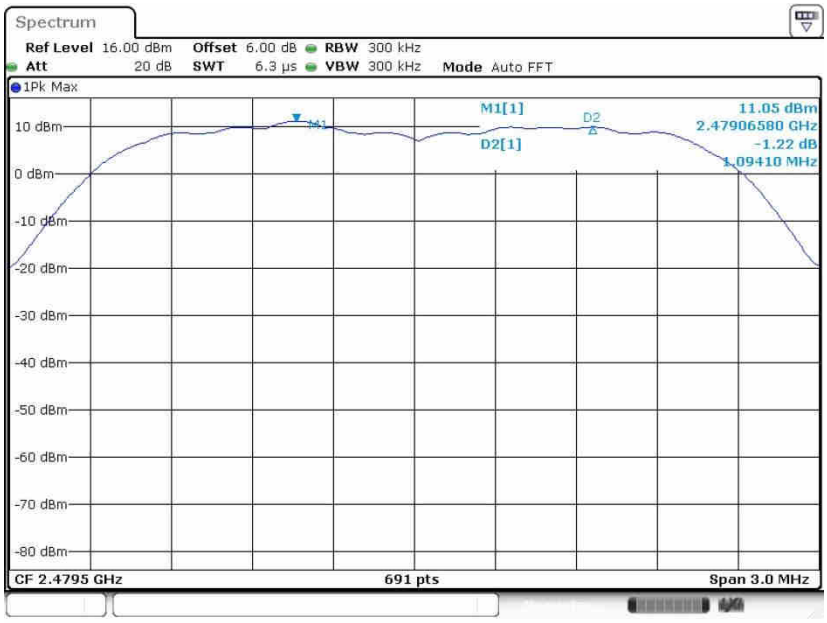


### Channel Separation Plot on Channel 39 - 40




Date: 8.JUN.2019 10:49:41

### Channel Separation Plot on Channel 77 - 78

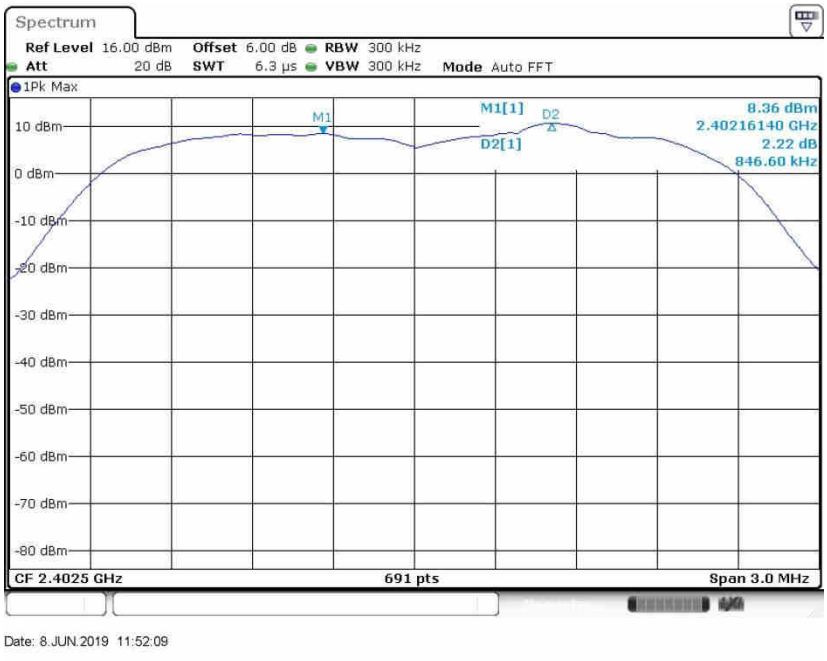



Date: 8.JUN.2019 10:54:40

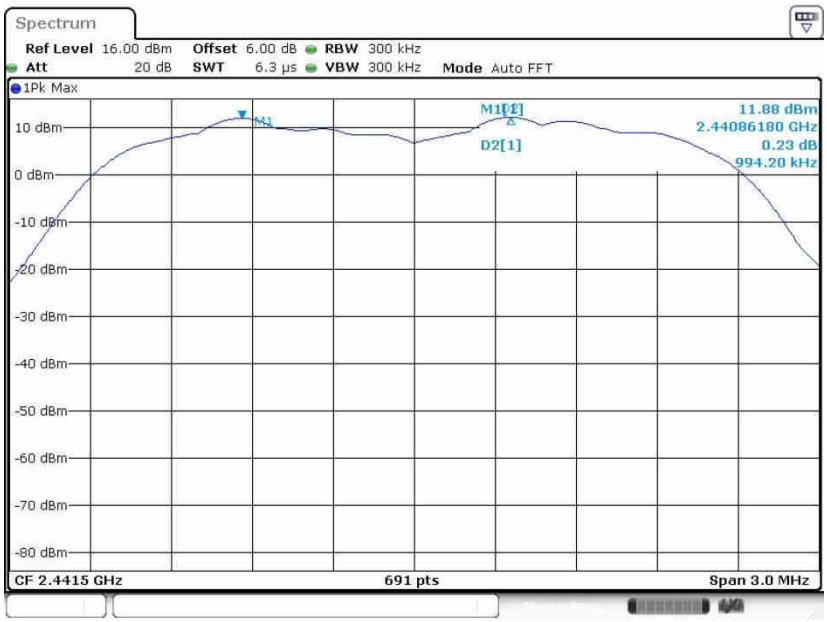
| Test Mode : | 3Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

| Channel | Frequency (MHz) | Frequency Separation (MHz) | (2/3 of 20dB BW) Limits (MHz) | Pass/Fail |
|---|---|---|---|---|
| 00 | 2402 | 0.8466 | 0.8162 | Pass |
| 39 | 2441 | 0.9942 | 0.8220 | Pass |
| 78 | 2480 | 0.9986 | 0.8191 | Pass |

**Channel Separation Plot on Channel 00 - 01**

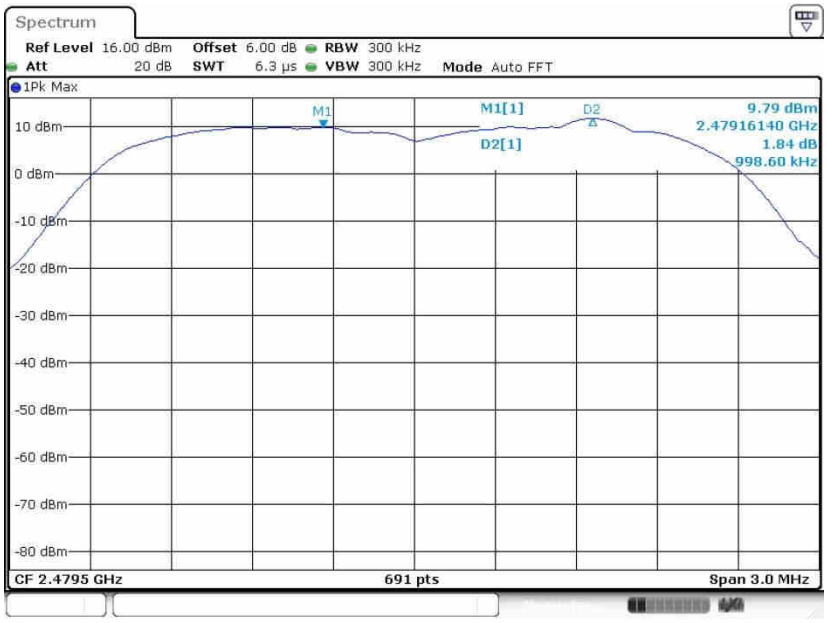


### Channel Separation Plot on Channel 39 - 40




Date: 8.JUN.2019 11:08:49

### Channel Separation Plot on Channel 77 - 78

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## 3.3 Dwell Time Measurement

### 3.3.1 Limit of Dwell Time

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.

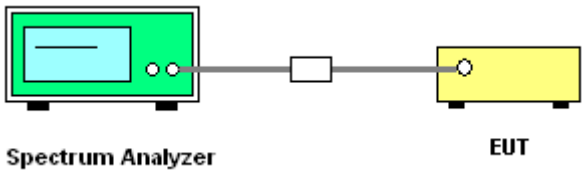
### 3.3.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

### 3.3.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.4.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings: Span = zero span, centered on a hopping channel; RBW = 1 MHz; VBW ≥ RBW; Sweep = as necessary to capture the entire dwell time per hopping channel; Detector function = peak; Trace = max hold.
6. Measure and record the results in the test report.

### 3.3.4 Test Setup

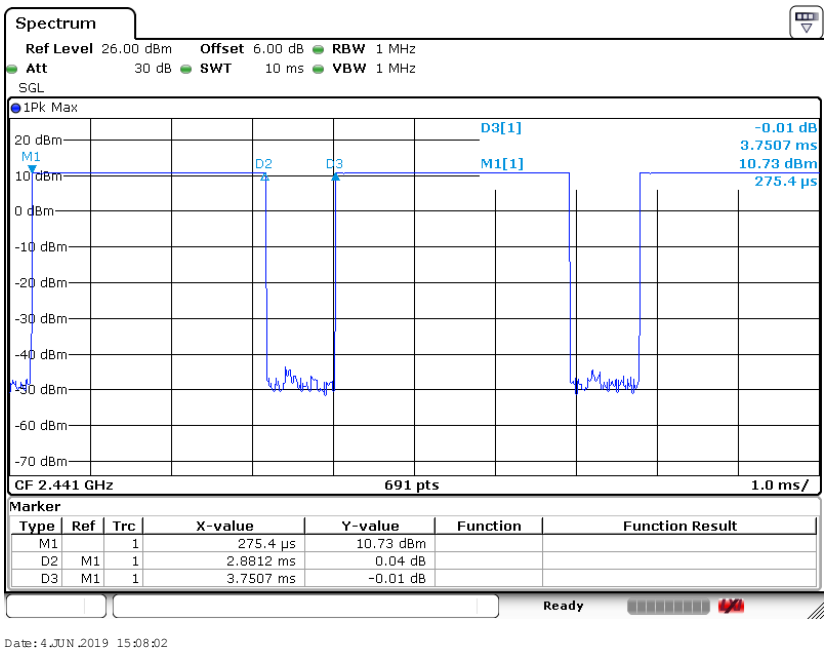


### 3.3.5 Test Result of Dwell Time

| Test Mode : | DH5 | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

| Mode | Hopping Channel Number | Hops Over Occupancy Time(hops) | Package Transfer Time (msec) | Dwell Time (sec) | Limits (sec) | Pass/Fail |
|---|---|---|---|---|---|---|
| Normal | 79 | 106.67 | 2.8812 | 0.31 | 0.4 | Pass |
| AFH | 20 | 53.34 | 2.8812 | 0.15 | 0.4 | Pass |

**Package Transfer Time Plot**




**Remark:**

1. In normal mode, hopping rate is 1600 hops/s with 6 slots in 79 hopping channels. With channel hopping rate (1600 / 6 / 79) in Occupancy Time Limit (0.4 x 79) (s), Hops Over Occupancy Time comes to (1600 / 6 / 79) x (0.4 x 79) = 106.67 hops.
2. In AFH mode, hopping rate is 800 hops/s with 6 slots in 20 hopping channels. With channel hopping rate (800 / 6 / 20) in Occupancy Time Limit (0.4 x 20) (s), Hops Over Occupancy Time comes to (800 / 6 / 20) x (0.4 x 20) = 53.33 hops.
3. Dwell Time(s) = Hops Over Occupancy Time (hops) x Package Transfer Time

# 3.4 20dB and 99% Bandwidth Measurement

## 3.4.1 Limit of 20dB and 99% Bandwidth

Reporting only

## 3.4.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

## 3.4.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 6.9.2 and 6.9.3.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Use the following spectrum analyzer settings for 20dB Bandwidth measurement.
   Span = approximately 2 to 5 times the 20 dB bandwidth, centered on a hopping channel;
   RBW ≥ 1% of the 20 dB bandwidth; VBW ≥ RBW; Sweep = auto; Detector function = peak;
   Trace = max hold.
5. Use the following spectrum analyzer settings for 99 % Bandwidth measurement.
   Span = approximately 1.5 to 5 times the 99% bandwidth, centered on a hopping channel;
   RBW ≥ 1% of the 99% bandwidth; VBW ≥ RBW; Sweep = auto; Detector function = sample;
   Trace = max hold.
6. Measure and record the results in the test report.

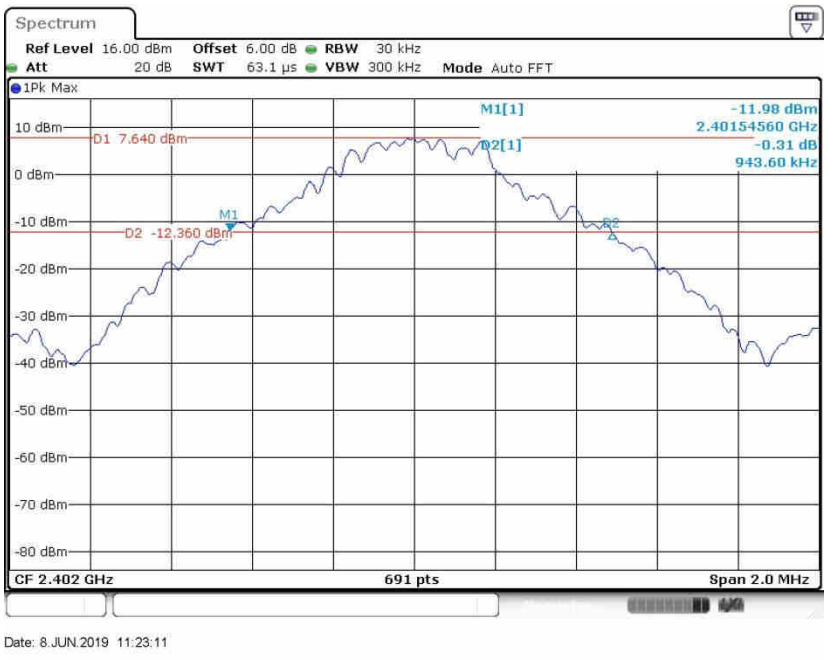
## 3.4.4 Test Setup

### 3.4.5 Test Result of 20dB Bandwidth

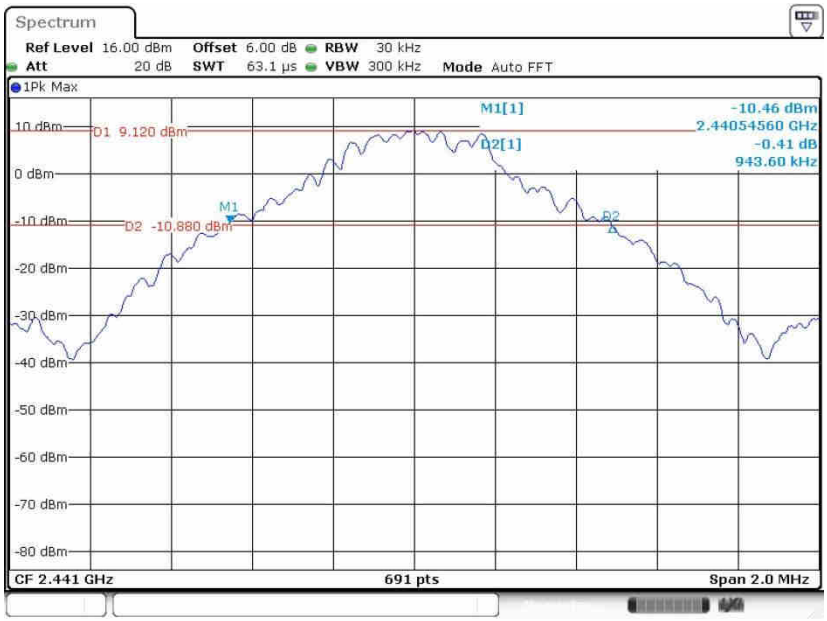
| Test Mode : | 1Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

| Channel | Frequency (MHz) | 20dB Bandwidth (MHz) |
|---|---|---|
| 00 | 2402 | 0.944 |
| 39 | 2441 | 0.944 |
| 78 | 2480 | 0.947 |

**20 dB Bandwidth Plot on Channel 00**

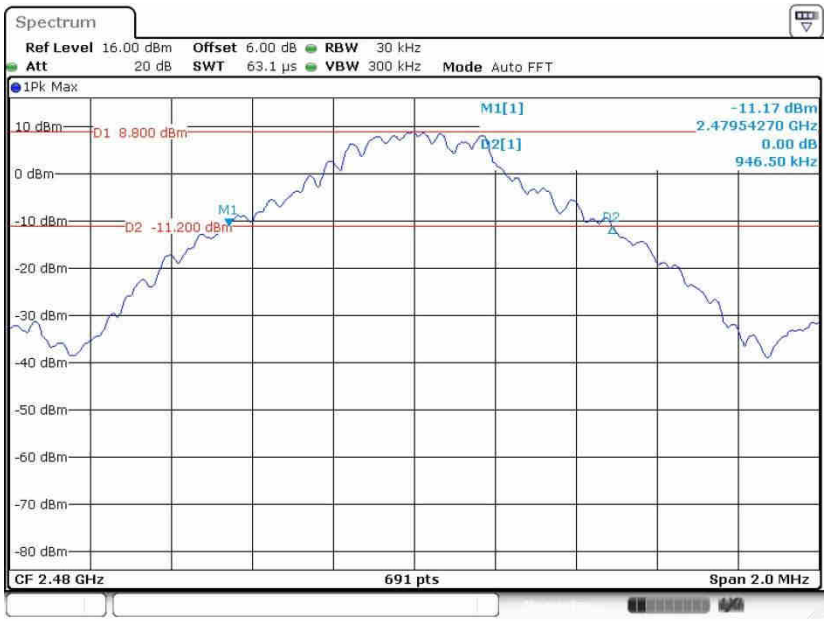


### 20 dB Bandwidth Plot on Channel 39




Date: 8.JUN.2019 11:24:16

### 20 dB Bandwidth Plot on Channel 78

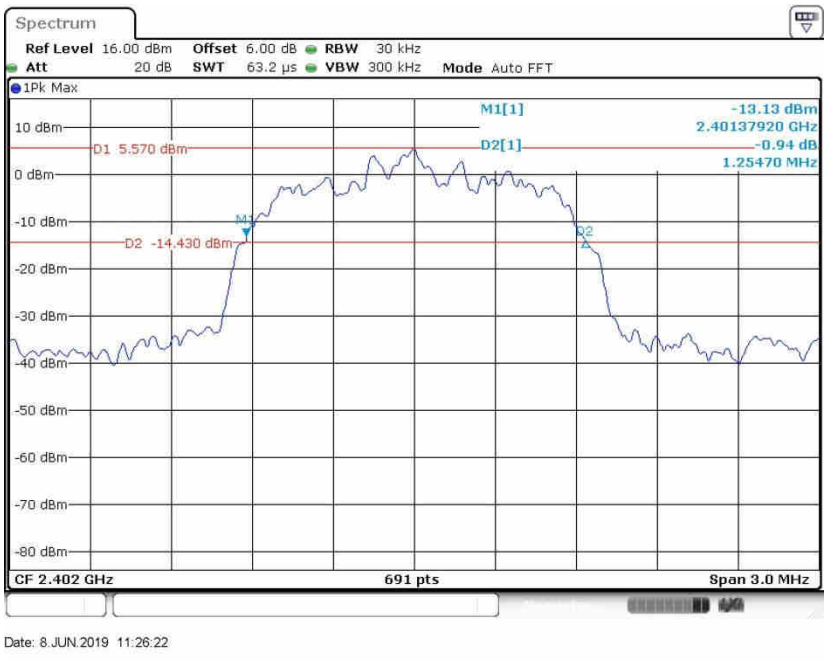



Date: 8.JUN.2019 11:25:15

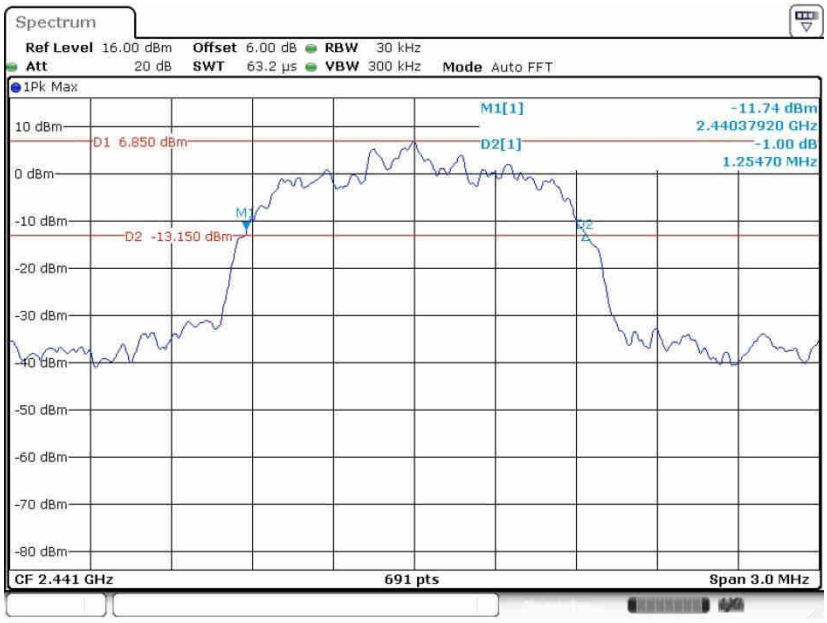
| Test Mode : | 2Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

| Channel | Frequency (MHz) | 20dB Bandwidth (MHz) |
|---|---|---|
| 00 | 2402 | 1.255 |
| 39 | 2441 | 1.255 |
| 78 | 2480 | 1.272 |

**20 dB Bandwidth Plot on Channel 00**

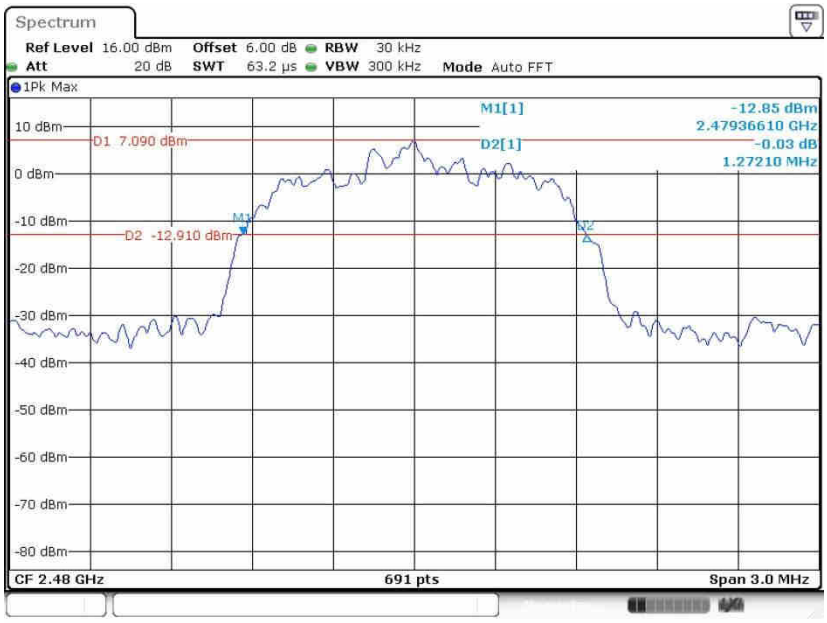


### 20 dB Bandwidth Plot on Channel 39




Date: 8.JUN.2019 11:27:14

### 20 dB Bandwidth Plot on Channel 78

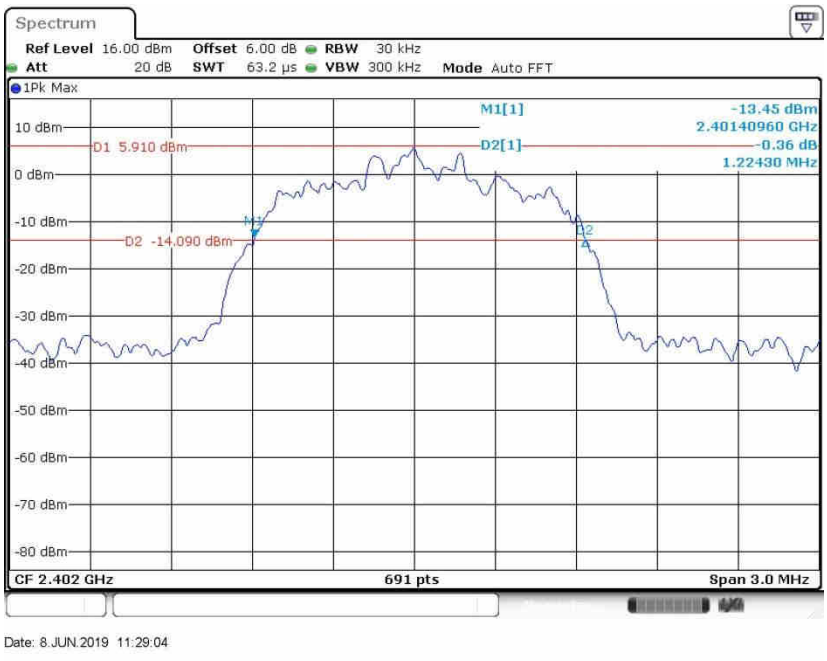



Date: 8.JUN.2019 11:28:04

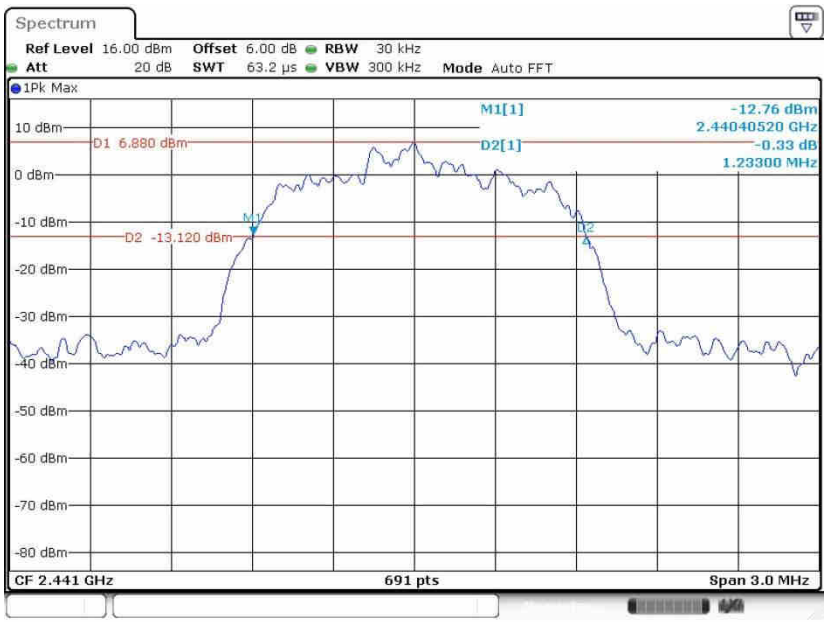
| Test Mode : | 3Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

| Channel | Frequency (MHz) | 20dB Bandwidth (MHz) |
|---|---|---|
| 00 | 2402 | 1.224 |
| 39 | 2441 | 1.233 |
| 78 | 2480 | 1.229 |

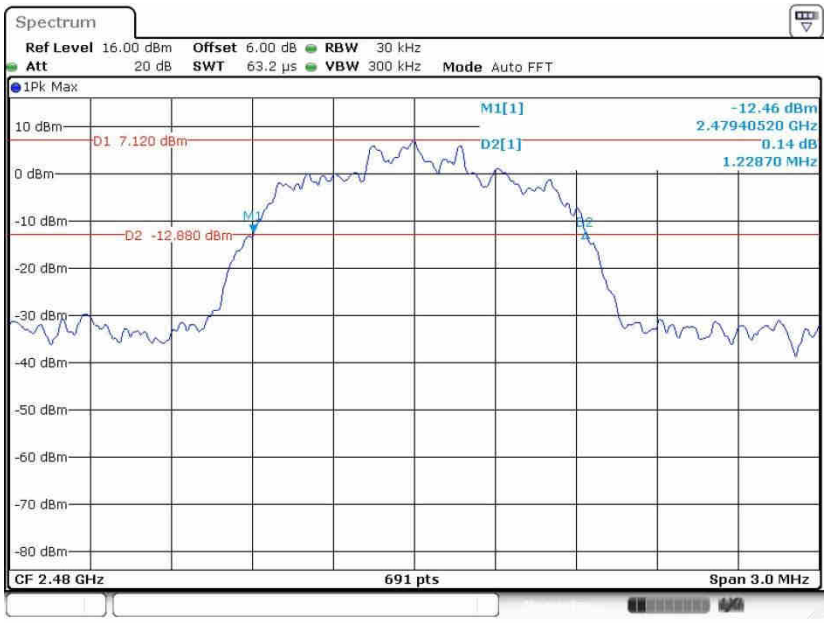
**20 dB Bandwidth Plot on Channel 00**



### 20 dB Bandwidth Plot on Channel 39




### 20 dB Bandwidth Plot on Channel 78

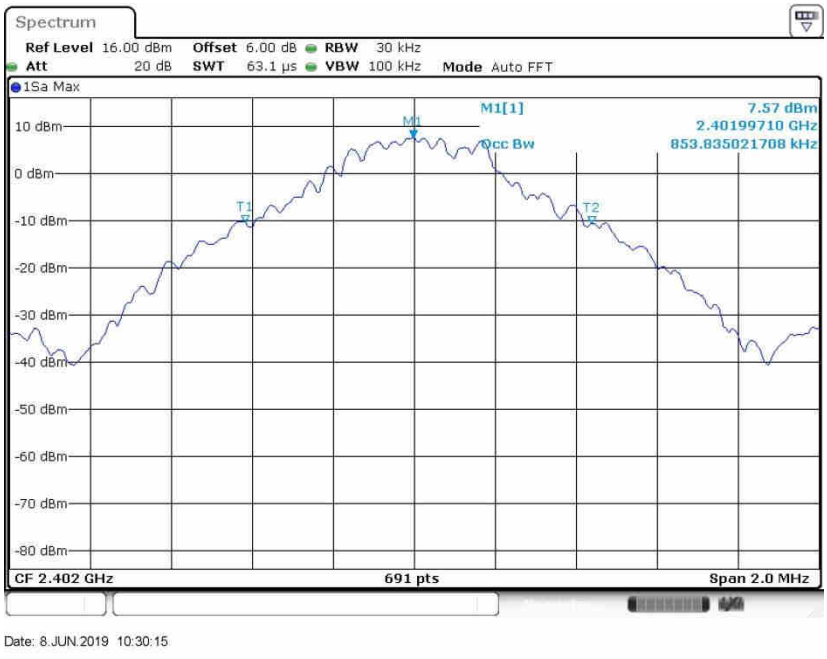


## 3.4.6 Test Result of 99% Occupied Bandwidth

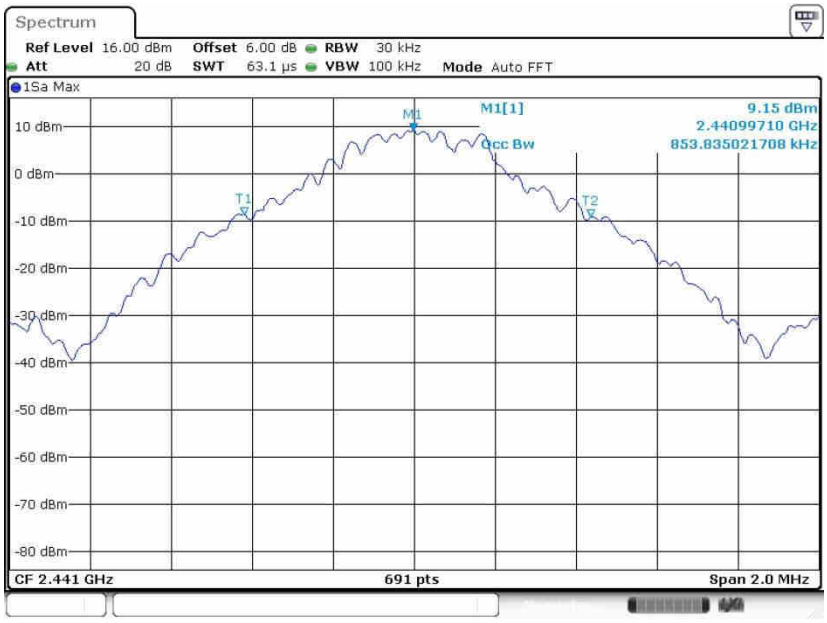
| Test Mode : | 1Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

| Channel | Frequency (MHz) | 99% Occupied Bandwidth (MHz) |
|---|---|---|
| 00 | 2402 | 0.854 |
| 39 | 2441 | 0.854 |
| 78 | 2480 | 0.854 |

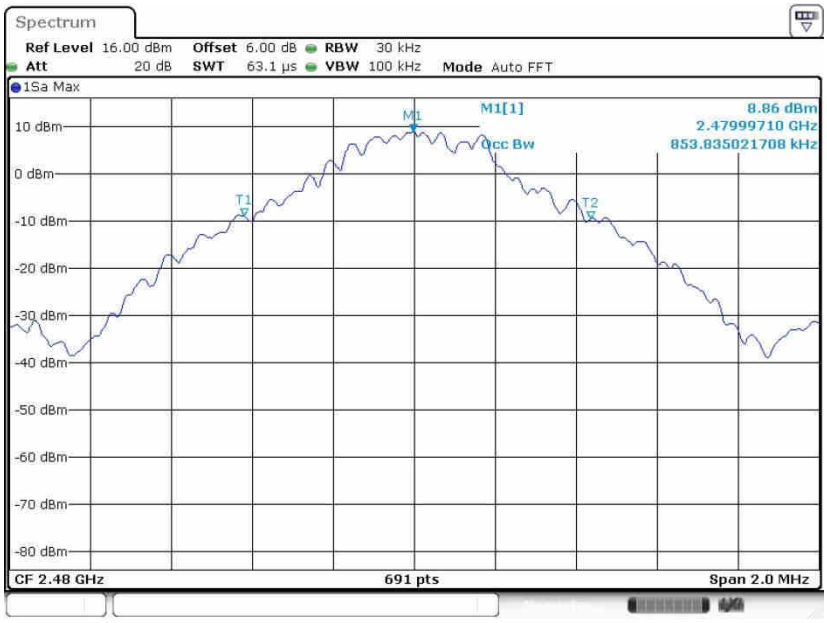
**99% Occupied Bandwidth Plot on Channel 00**



### 99% Occupied Bandwidth Plot on Channel 39



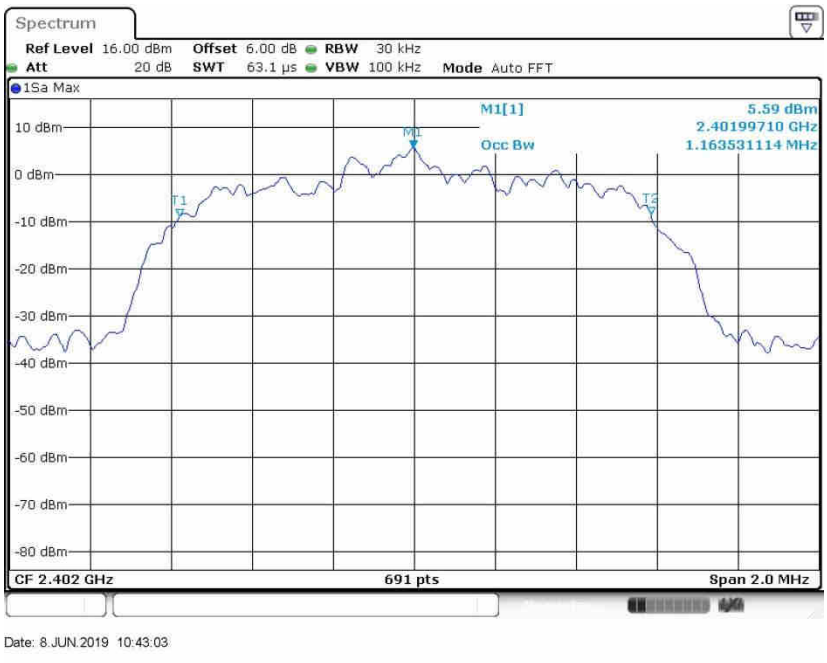

### 99% Occupied Bandwidth Plot on Channel 78



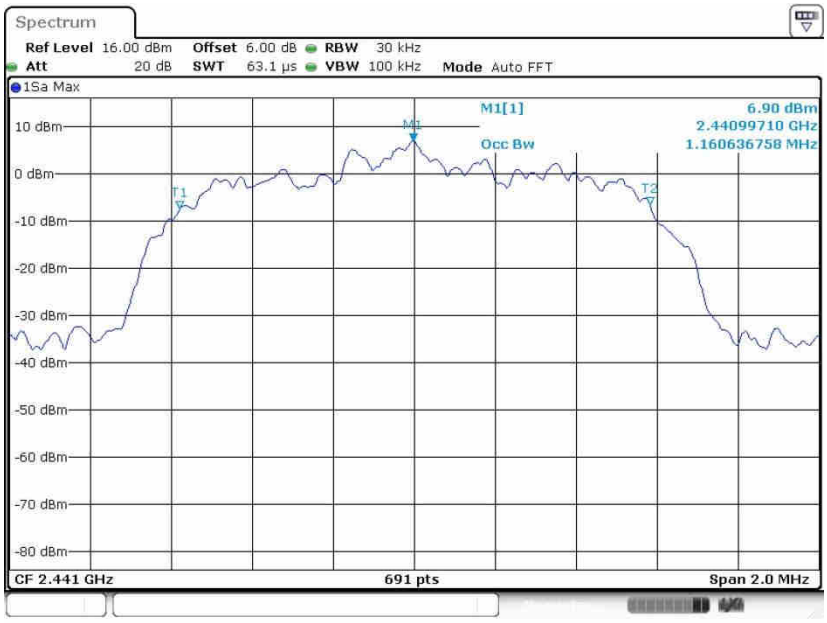
| Test Mode : | 2Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

| Channel | Frequency (MHz) | 99% Occupied Bandwidth (MHz) |
|---|---|---|
| 00 | 2402 | 1.164 |
| 39 | 2441 | 1.161 |
| 78 | 2480 | 1.166 |

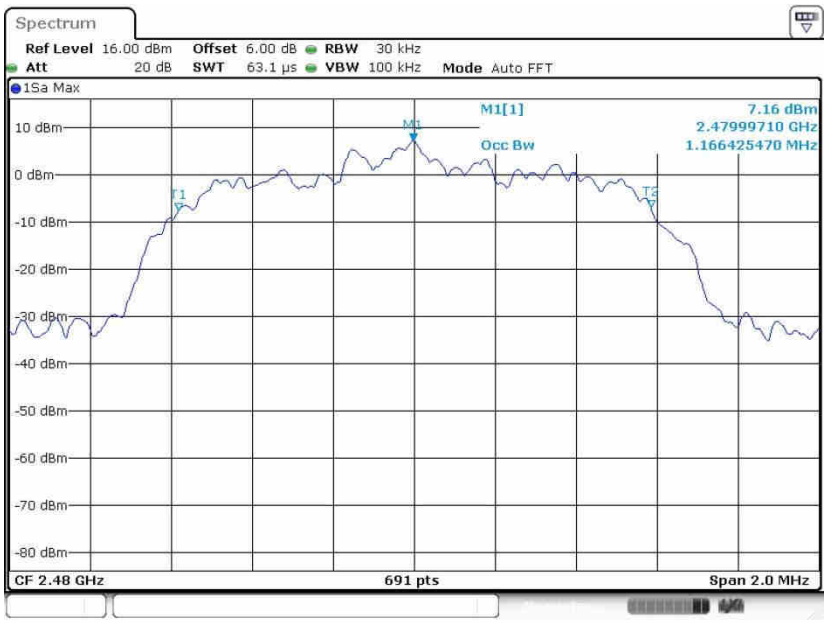
**99% Occupied Bandwidth Plot on Channel 00**



**99% Occupied Bandwidth Plot on Channel 39**



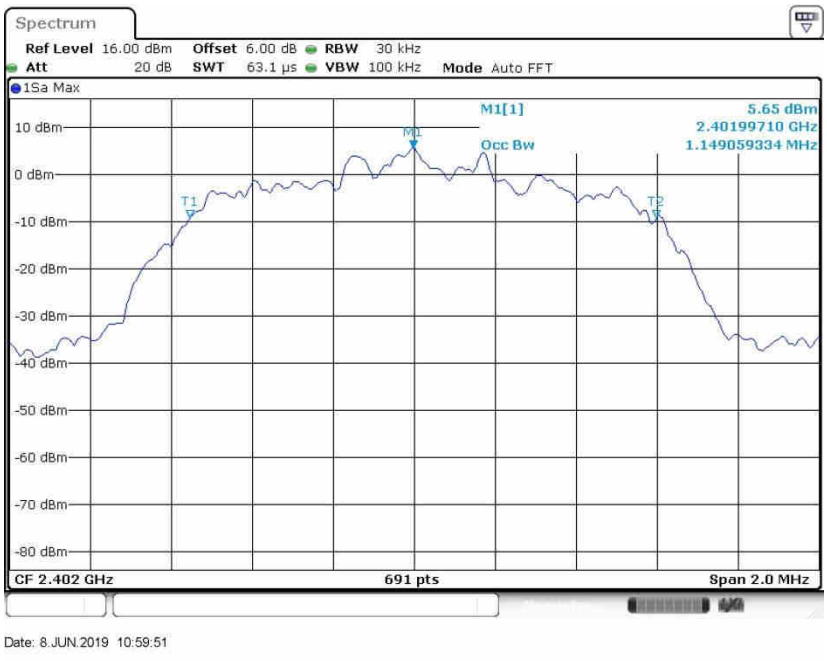

**99% Occupied Bandwidth Plot on Channel 78**



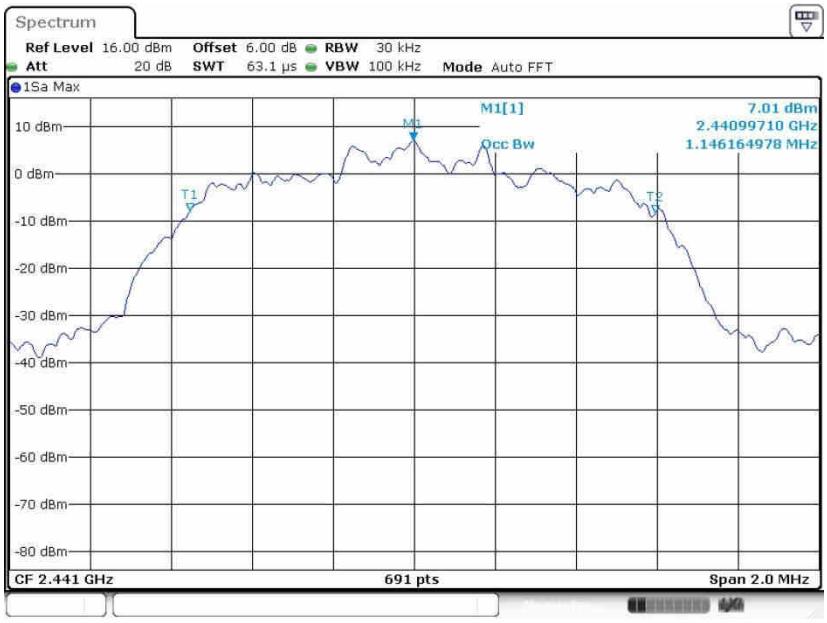
| Test Mode : | 3Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

| Channel | Frequency (MHz) | 99% Occupied Bandwidth (MHz) |
|---|---|---|
| 00 | 2402 | 1.149 |
| 39 | 2441 | 1.146 |
| 78 | 2480 | 1.155 |

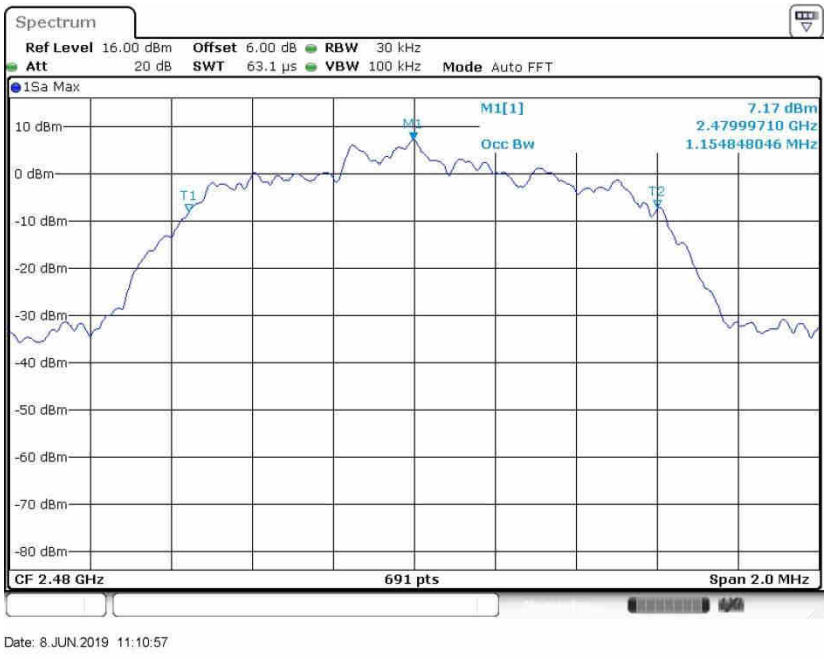
**99% Occupied Bandwidth Plot on Channel 00**



**99% Occupied Bandwidth Plot on Channel 39**




**99% Occupied Bandwidth Plot on Channel 78**




Note : The occupied channel bandwidth is maintained within the band of operation for all of the modulations.

# 3.5 Output Power Measurement

## 3.5.1 Limit of Output Power

The maximum peak conducted output power of the intentional radiator shall not exceed the following: (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. For all other frequency hopping systems in the 2400-2483.5 MHz band 0.125 watts.

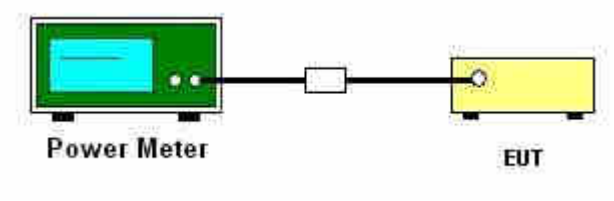
## 3.5.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

## 3.5.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.5.
2. The RF output of EUT was connected to the power meter by RF cable. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Measure the conducted output power with cable loss and record the results in the test report.
5. Measure and record the results in the test report.

## 3.5.4 Test Setup



### 3.5.5 Test Result of Peak Output Power

| Test Mode : | 1Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

| Channel | Frequency (MHz) | RF Power (dBm) | | |
|---|---|---|---|---|
| | | GFSK | Max. Limits (dBm) | Pass/Fail |
| | | 1 Mbps | | |
| 00 | 2402 | 10.07 | 20.97 | Pass |
| 39 | 2441 | 11.65 | 20.97 | Pass |
| 78 | 2480 | 10.81 | 20.97 | Pass |

| Test Mode : | 2Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

| Channel | Frequency (MHz) | RF Power (dBm) | | |
|---|---|---|---|---|
| | | $\pi$ /4-DQPSK | Max. Limits (dBm) | Pass/Fail |
| | | 2 Mbps | | |
| 00 | 2402 | 9.61 | 20.97 | Pass |
| 39 | 2441 | 10.92 | 20.97 | Pass |
| 78 | 2480 | 10.35 | 20.97 | Pass |

| Test Mode : | 3Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

| Channel | Frequency (MHz) | RF Power (dBm) | | |
|---|---|---|---|---|
| | | 8-DPSK | Max. Limits (dBm) | Pass/Fail |
| | | 3 Mbps | | |
| 00 | 2402 | 9.83 | 20.97 | Pass |
| 39 | 2441 | 11.23 | 20.97 | Pass |
| 78 | 2480 | 10.61 | 20.97 | Pass |

# 3.6 Conducted Band Edges Measurement

## 3.6.1 Limit of Band Edges

In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.

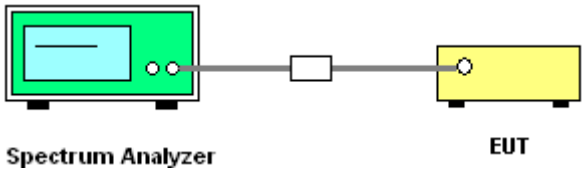
## 3.6.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

## 3.6.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.6.
2. Set to the maximum power setting and enable the EUT transmit continuously.
3. Set RBW = 100kHz, VBW = 300kHz. Band edge emissions must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100kHz RBW. The attenuation shall be 30 dB instead of 20 dB when RMS conducted output power procedure is used.
4. Enable hopping function of the EUT and then repeat step 2. and 3.
5. Measure and record the results in the test report.

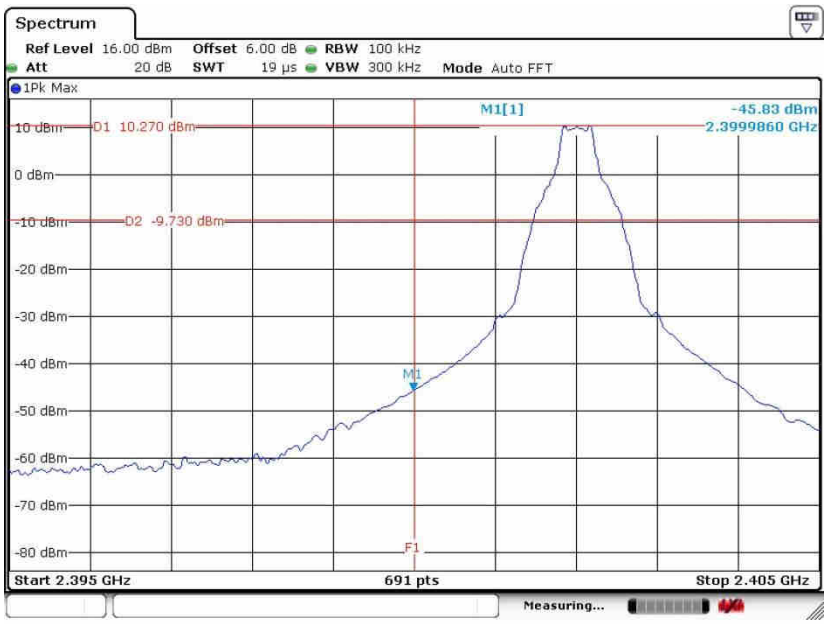
## 3.6.4 Test Setup



## 3.6.5 Test Result of Conducted Band Edges

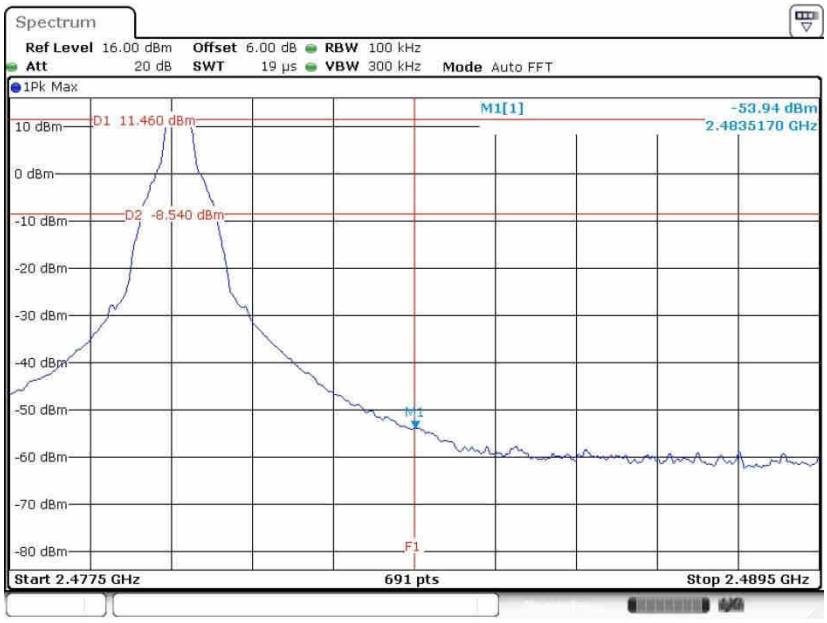
| | | | |
|---|---|---|---|
| **Test Mode :** | 1Mbps | **Temperature :** | 22~25℃ |
| **Test Channel :** | 00 and 78 | **Relative Humidity :** | 51~55% |
| | | **Test Engineer :** | weller liu |

**Low Band Edge Plot on Channel 00**




Date: 8.JUN.2019 10:28:50

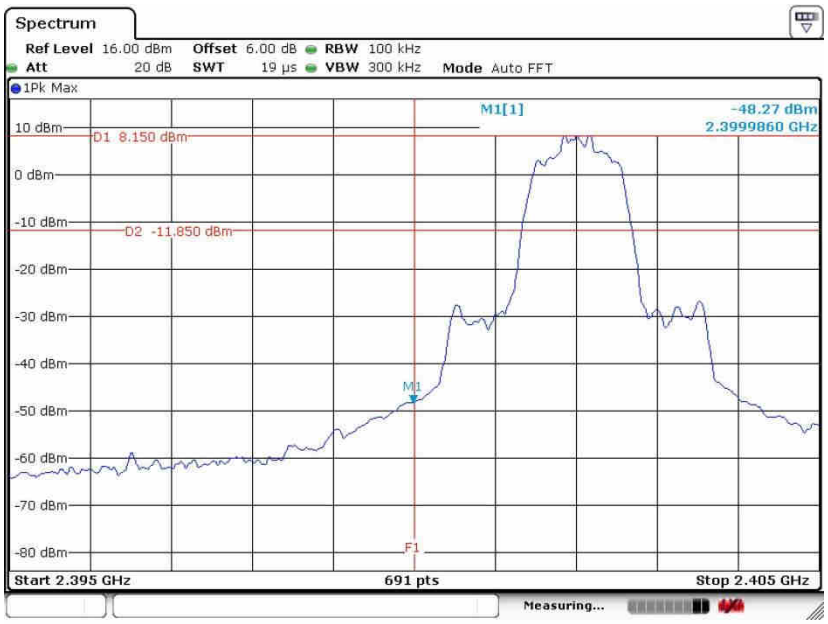
**High Band Edge Plot on Channel 78**




Date: 8.JUN.2019 10:37:01

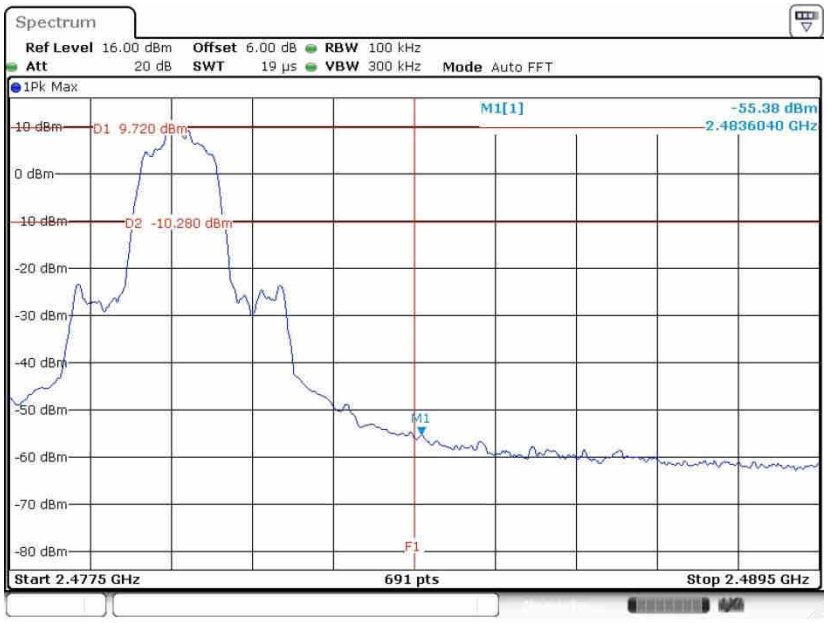
| | | | |
|---|---|---|---|
| **Test Mode :** | 2Mbps | **Temperature :** | 22~25℃ |
| **Test Channel :** | 00 and 78 | **Relative Humidity :** | 51~55% |
| | | **Test Engineer :** | weller liu |

**Low Band Edge Plot on Channel 00**




Date: 8.JUN.2019 10:41:20

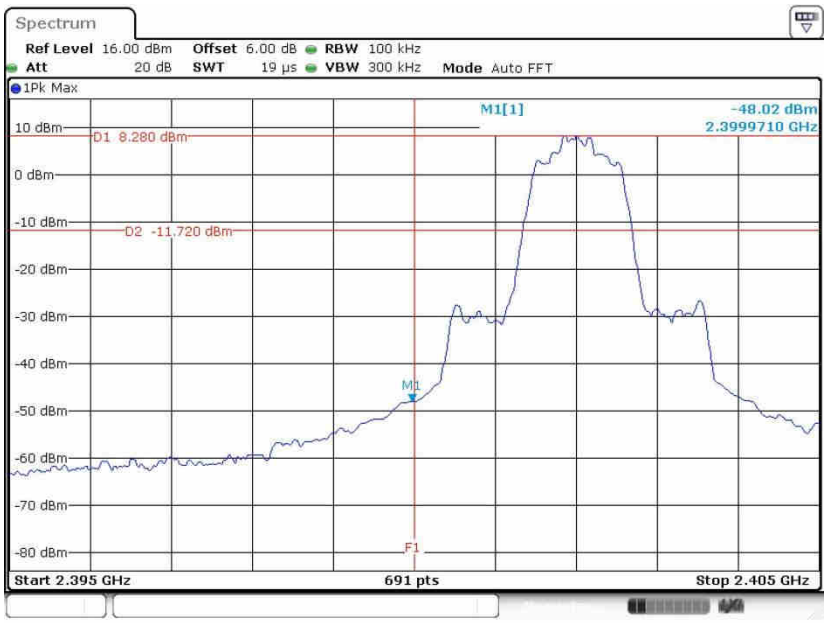
**High Band Edge Plot on Channel 78**




Date: 8.JUN.2019 10:50:36

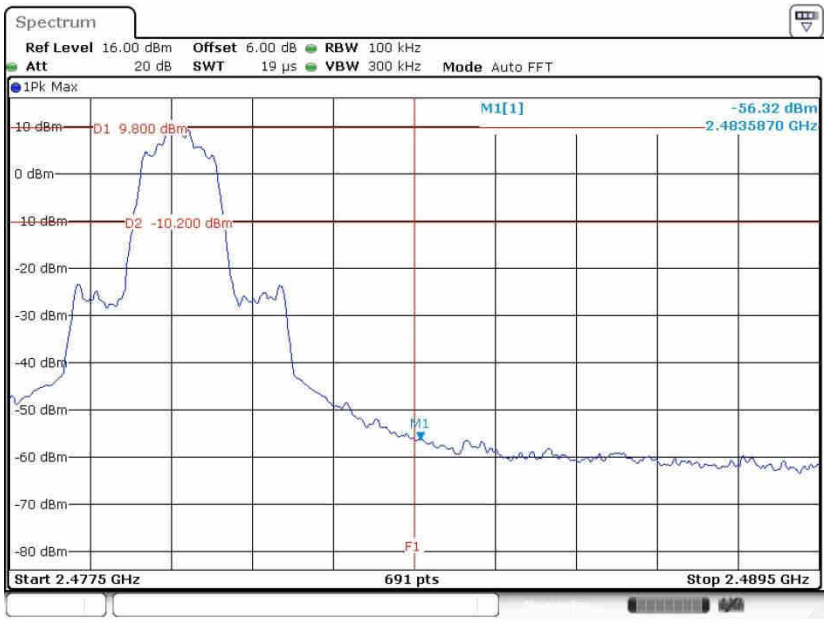
| | | | |
|---|---|---|---|
| **Test Mode :** | 3Mbps | **Temperature :** | 22~25℃ |
| **Test Channel :** | 00 and 78 | **Relative Humidity :** | 51~55% |
| | | **Test Engineer :** | weller liu |

**Low Band Edge Plot on Channel 00**




Date: 8.JUN.2019 10:55:52

**High Band Edge Plot on Channel 78**

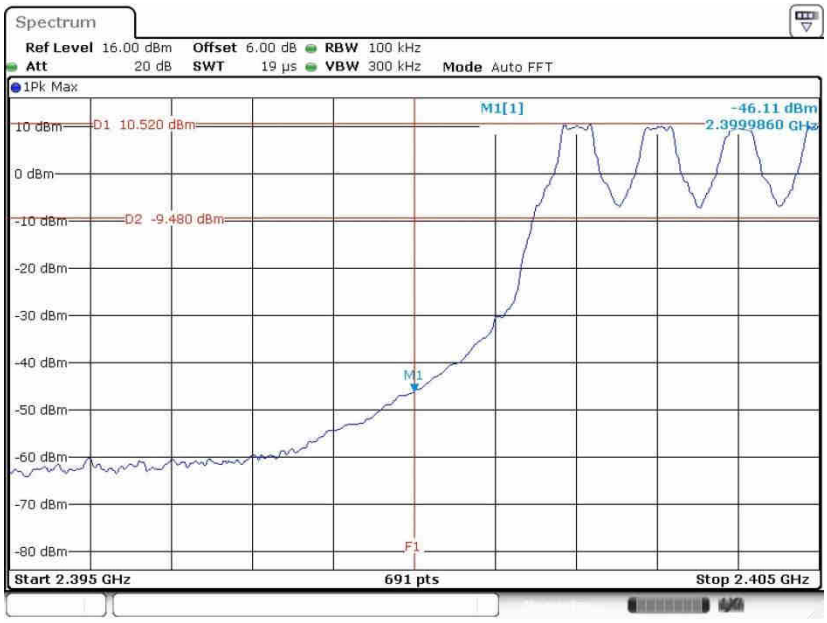



Date: 8.JUN.2019 11:10:03

## 3.6.6 Test Result of Conducted Hopping Mode Band Edges

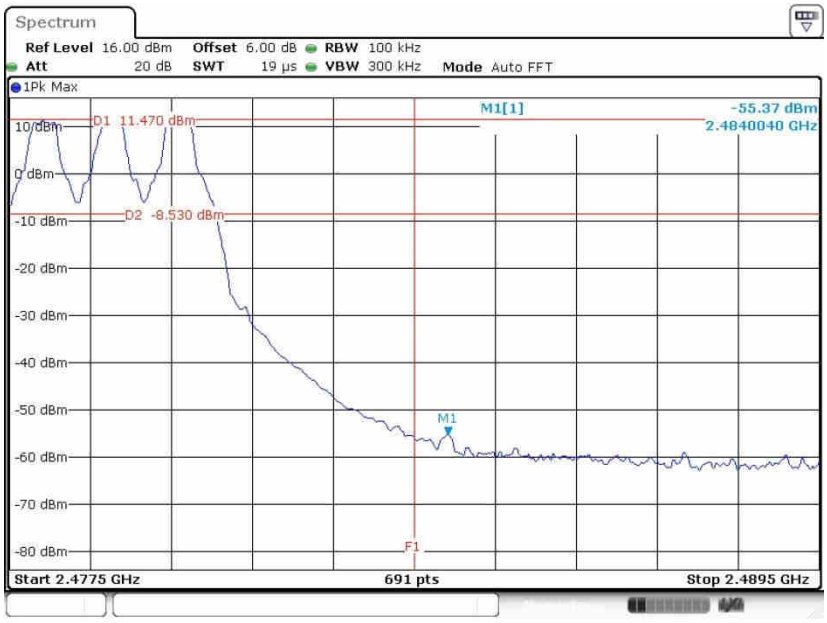
| | | | |
|---|---|---|---|
| **Test Mode :** | 1Mbps | **Temperature :** | 22~25℃ |
| **Test Engineer :** | weller liu | **Relative Humidity :** | 51~55% |

**Hopping Mode Low Band Edge Plot**




Date: 8.JUN.2019 10:29:18

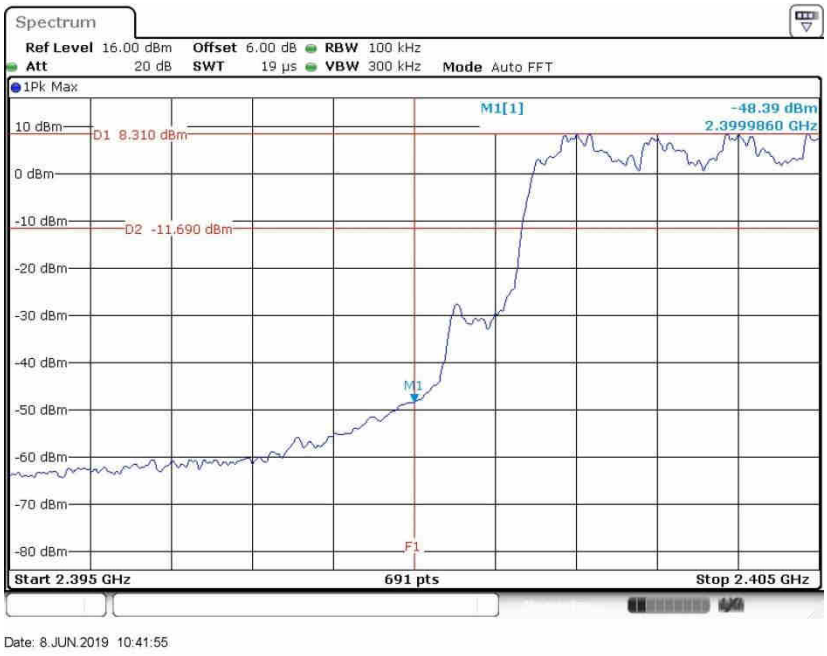
**Hopping Mode High Band Edge Plot**



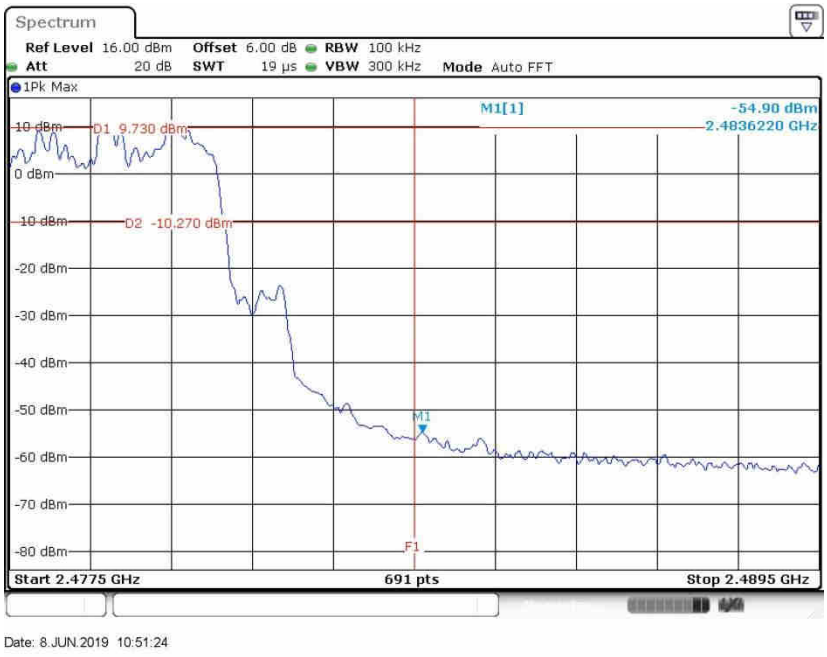

Date: 8.JUN.2019 10:37:18

| Test Mode : | 2Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

**Hopping Mode Low Band Edge Plot**

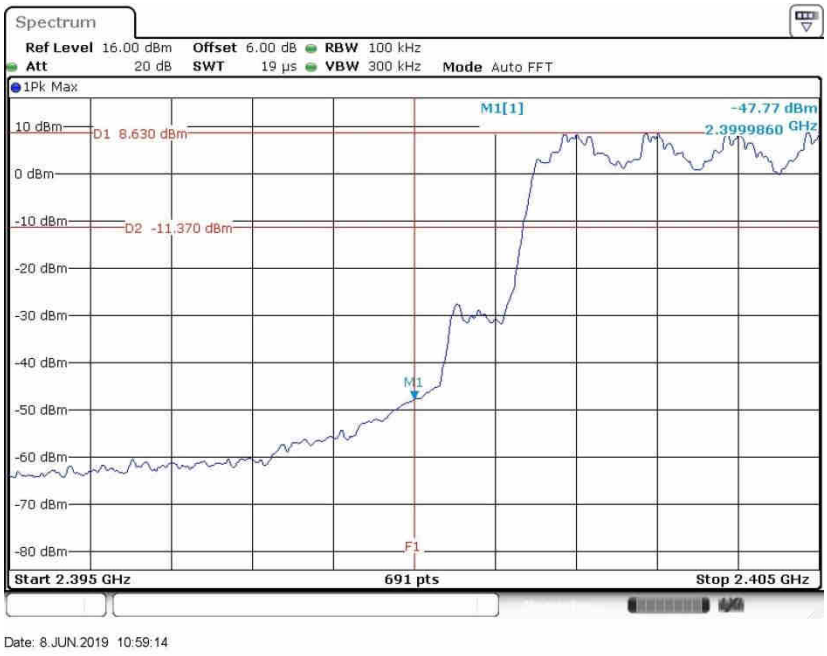



**Hopping Mode High Band Edge Plot**

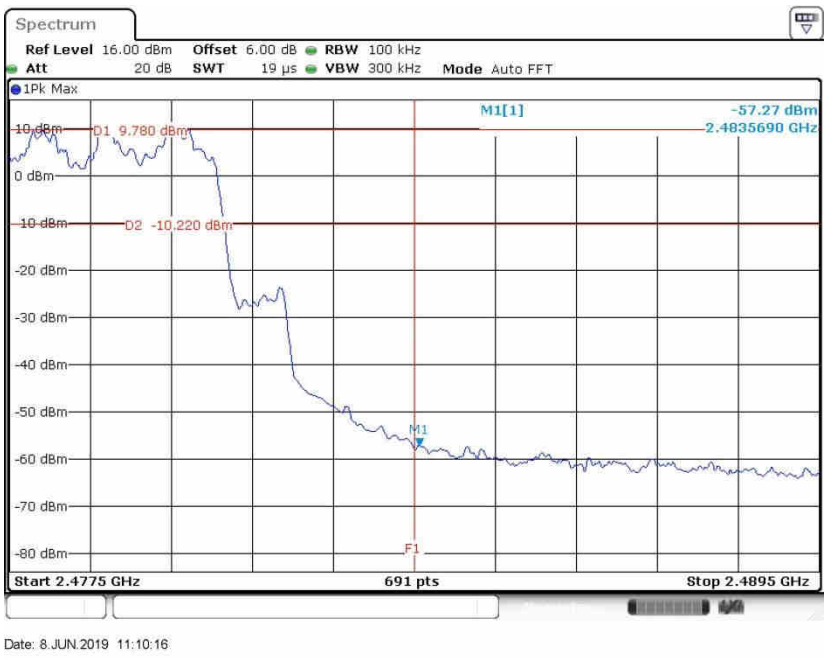


| Test Mode : | 3Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Engineer : | weller liu | Relative Humidity : | 51~55% |

### Hopping Mode Low Band Edge Plot




### Hopping Mode High Band Edge Plot



# 3.7 Conducted Spurious Emission Measurement

## 3.7.1 Limit of Spurious Emission Measurement

In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.

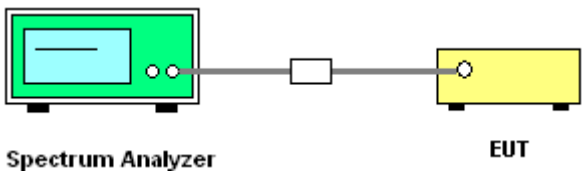
## 3.7.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

## 3.7.3 Test Procedure

1. The testing follows ANSI C63.10-2013 clause 7.8.8.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Set RBW = 100 kHz, VBW = 300kHz, scan up through 10th harmonic. All harmonics / spurs must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100 kHz RBW.
5. Measure and record the results in the test report.
6. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.

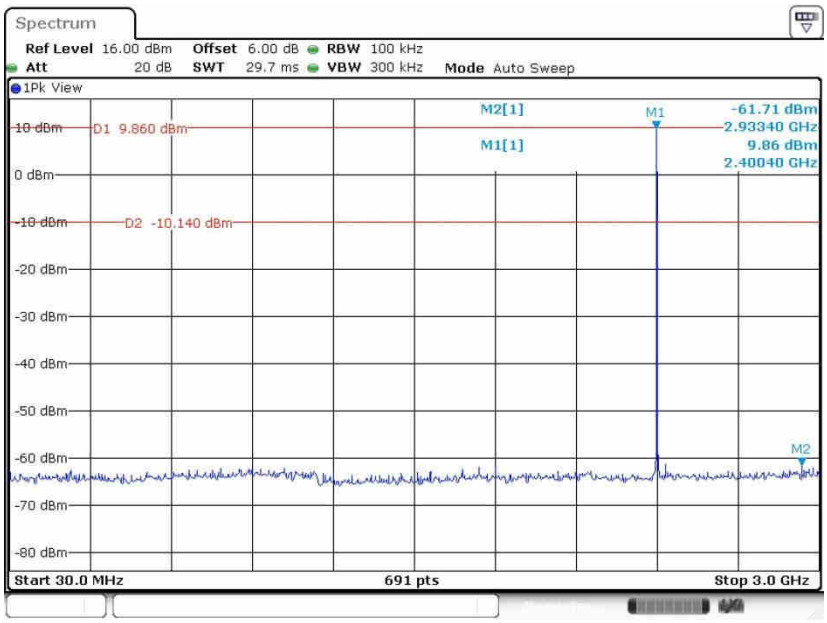
## 3.7.4 Test Setup



## 3.7.5 Test Result of Conducted Spurious Emission

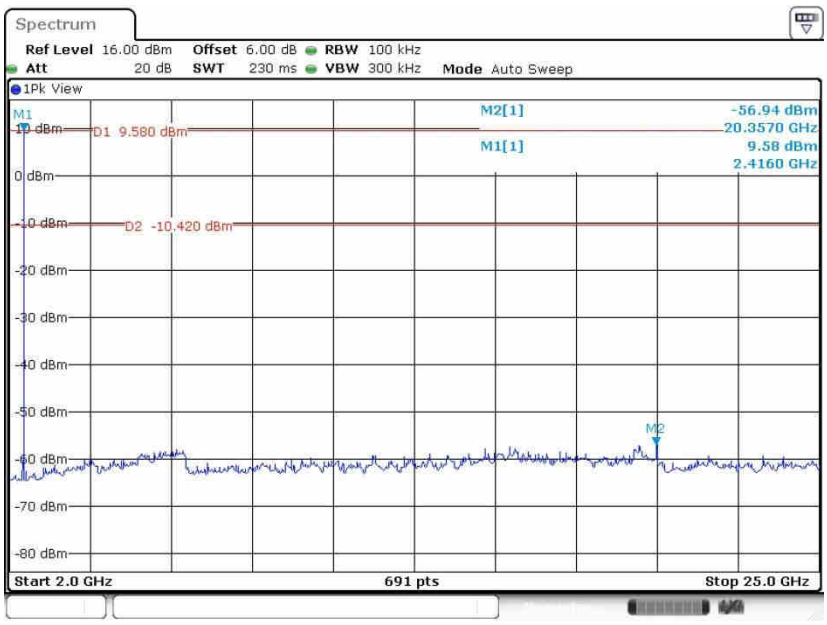
| Test Mode : | 1Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Channel : | 00 | Relative Humidity : | 51~55% |
| | | Test Engineer : | weller liu |

**CSE Plot on Ch 00 between 30MHz ~ 3 GHz**



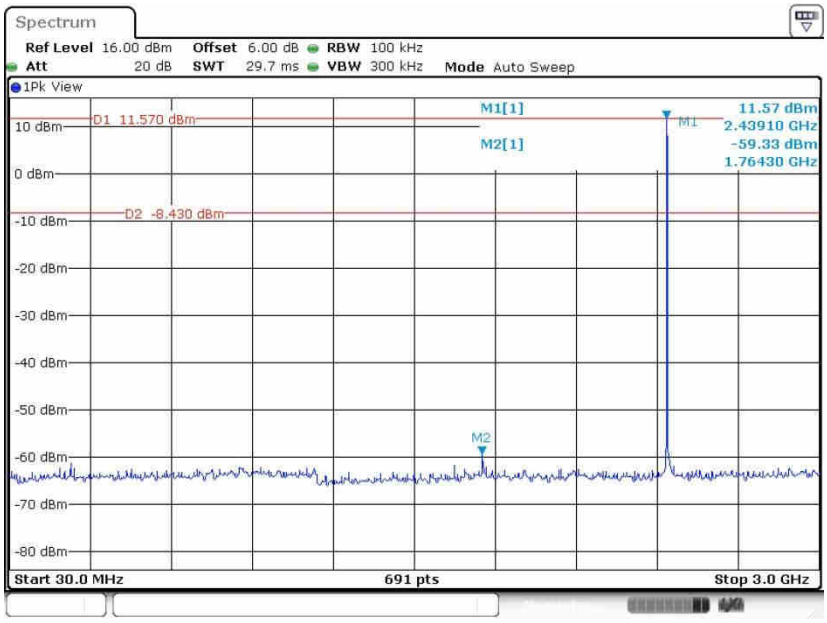

Date: 8.JUN.2019 10:31:19

**CSE Plot on Ch 00 between 2 GHz ~ 25 GHz**



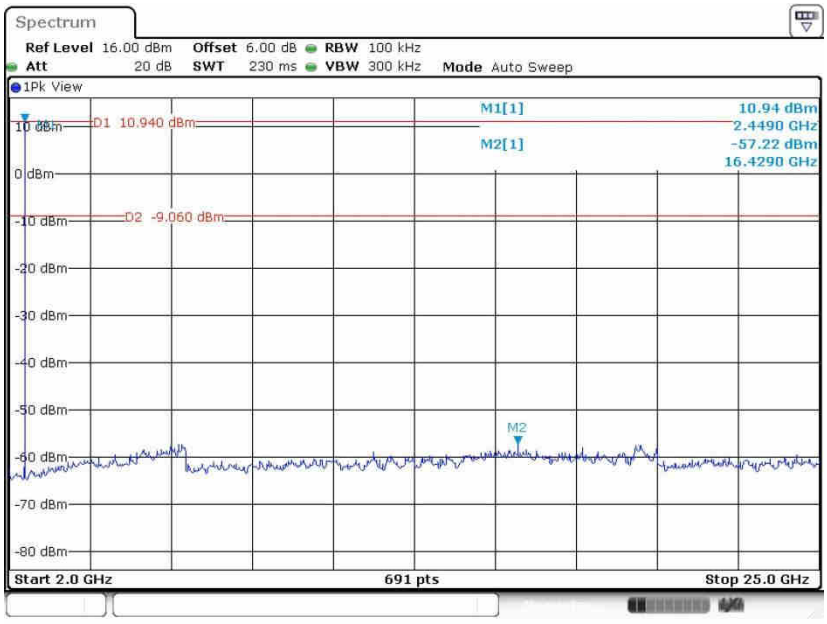

Date: 8.JUN.2019 10:31:48

**CSE Plot on Ch 39 between 30MHz ~ 3 GHz**



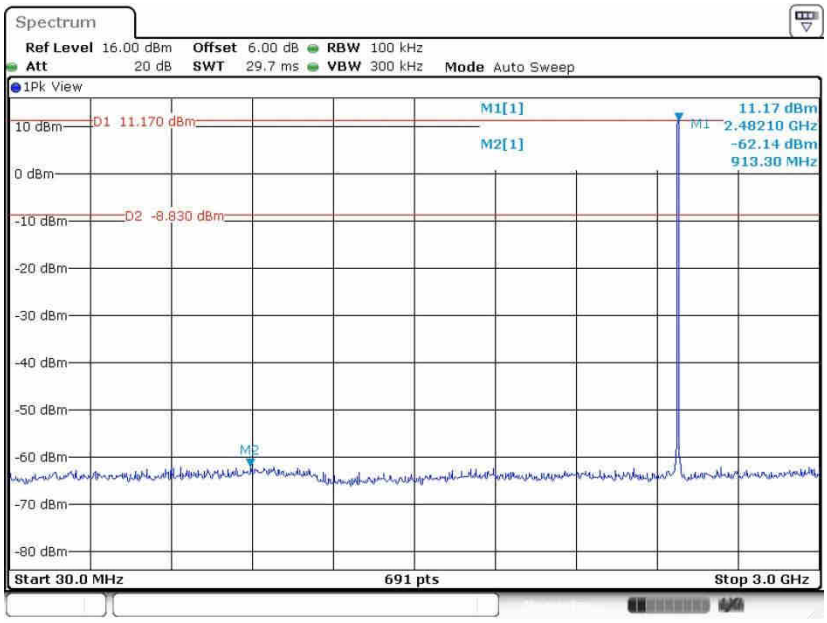

Date: 8.JUN.2019 10:34:48

**CSE Plot on Ch 39 between 2 GHz ~ 25 GHz**



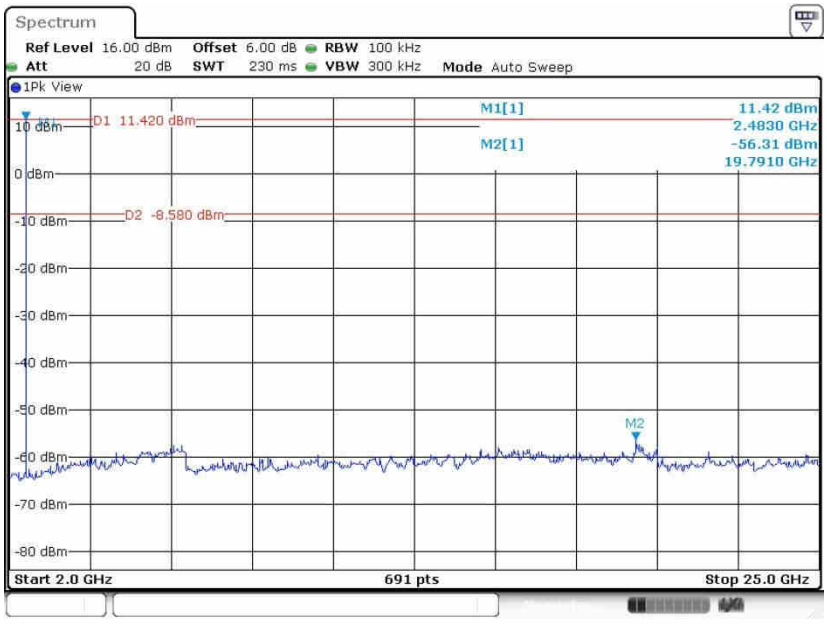

Date: 8.JUN.2019 10:35:16

**CSE Plot on Ch 78 between 30MHz ~ 3 GHz**




Date: 8.JUN.2019 10:38:23

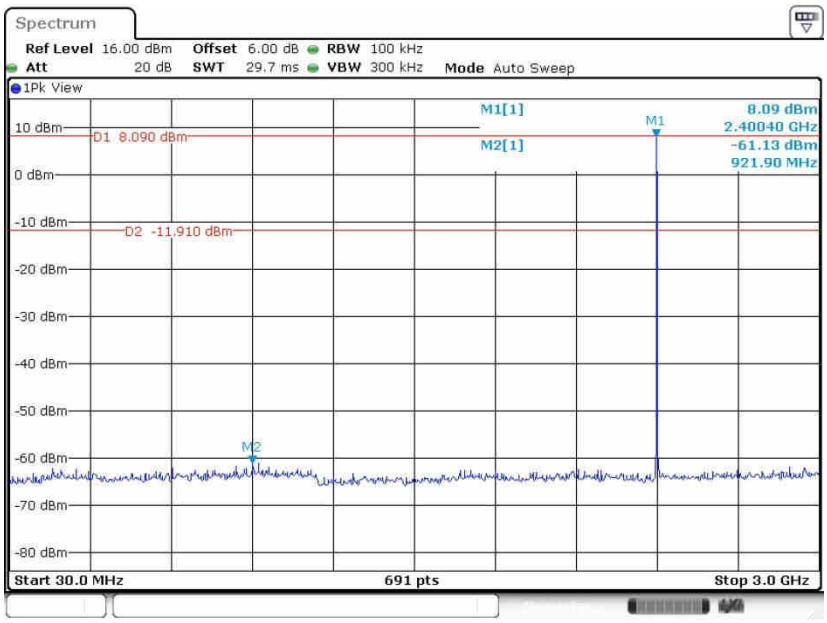
**CSE Plot on Ch 78 between 2 GHz ~ 25 GHz**




Date: 8.JUN.2019 10:38:53

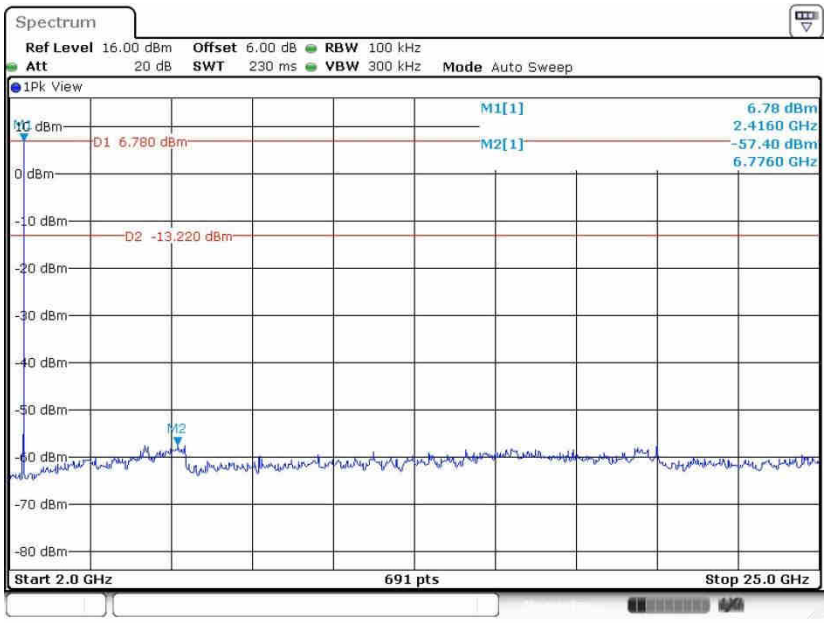
| Test Mode : | 2Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Channel : | 39 | Relative Humidity : | 51~55% |
| | | Test Engineer : | weller liu |

**CSE Plot on Ch 00 between 30MHz ~ 3 GHz**



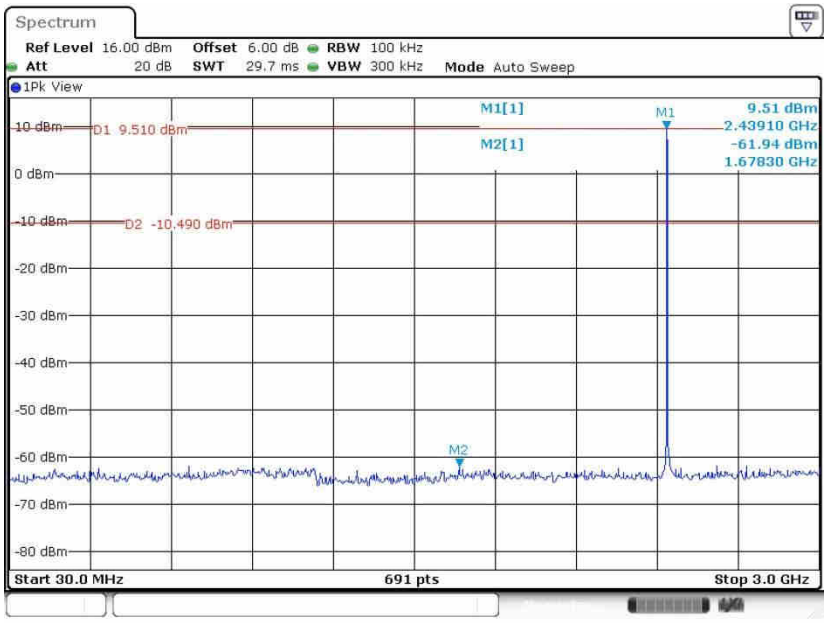

Date: 8.JUN.2019 10:44:34

**CSE Plot on Ch 00 between 2 GHz ~ 25 GHz**



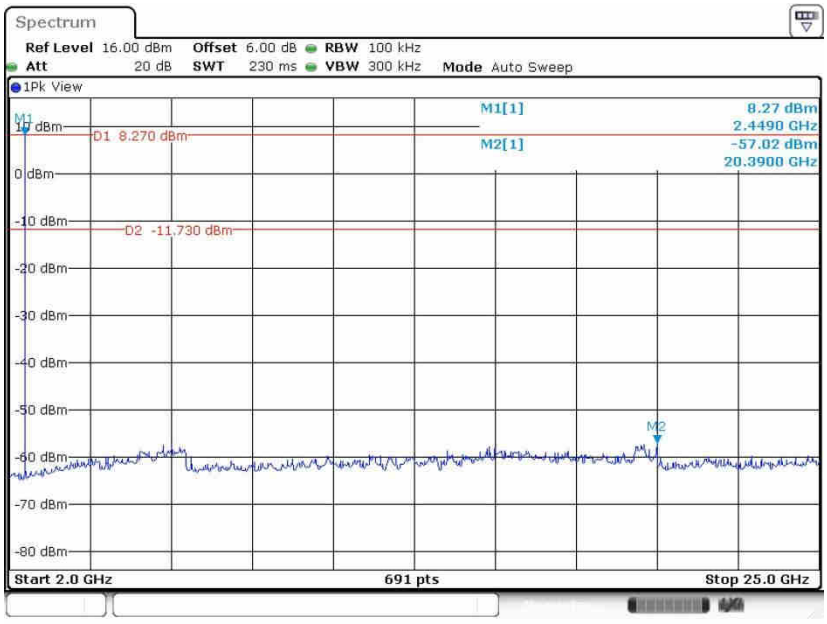

Date: 8.JUN.2019 10:45:00

**CSE Plot on Ch 39 between 30MHz ~ 3 GHz**



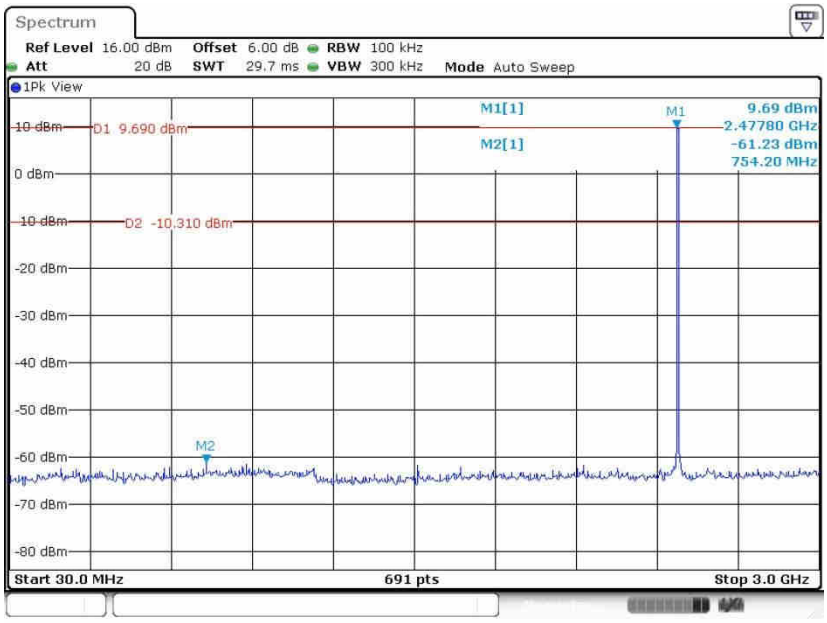

Date: 8.JUN.2019 10:48:24

**CSE Plot on Ch 39 between 2 GHz ~ 25 GHz**



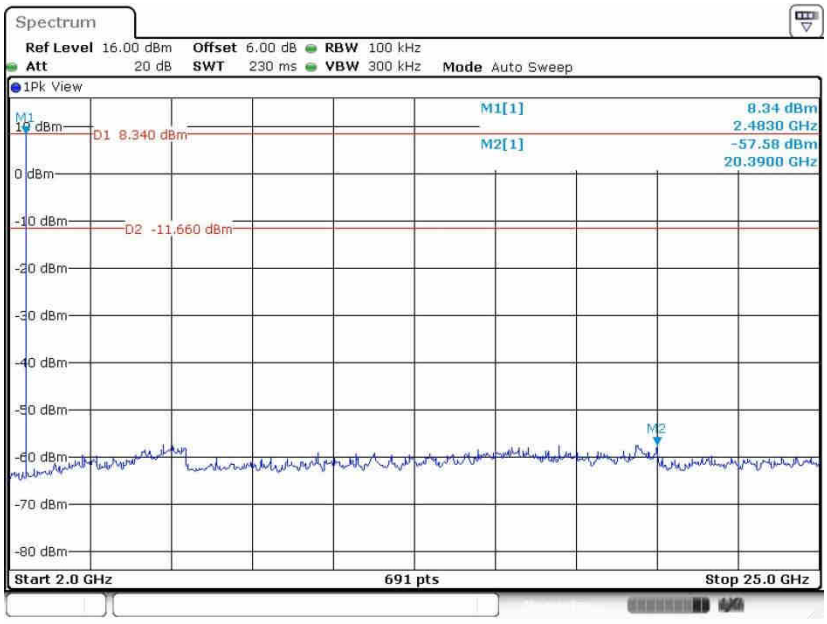

Date: 8.JUN.2019 10:48:54

**CSE Plot on Ch 78 between 30MHz ~ 3 GHz**




Date: 8.JUN.2019 10:53:21

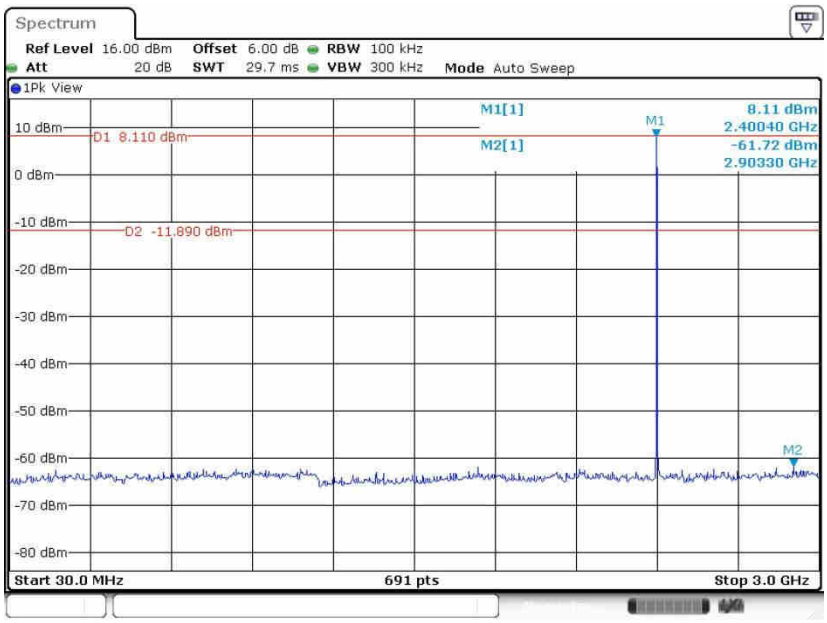
**CSE Plot on Ch 78 between 2 GHz ~ 25 GHz**




Date: 8.JUN.2019 10:53:48

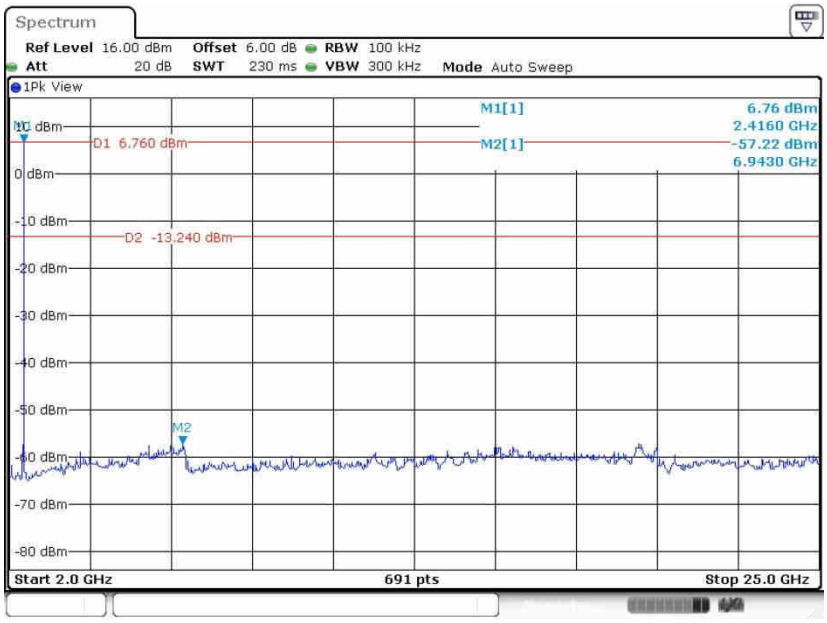
| Test Mode : | 3Mbps | Temperature : | 22~25℃ |
|---|---|---|---|
| Test Channel : | 39 | Relative Humidity : | 51~55% |
| | | Test Engineer : | weller liu |

**CSE Plot on Ch 00 between 30MHz ~ 3 GHz**



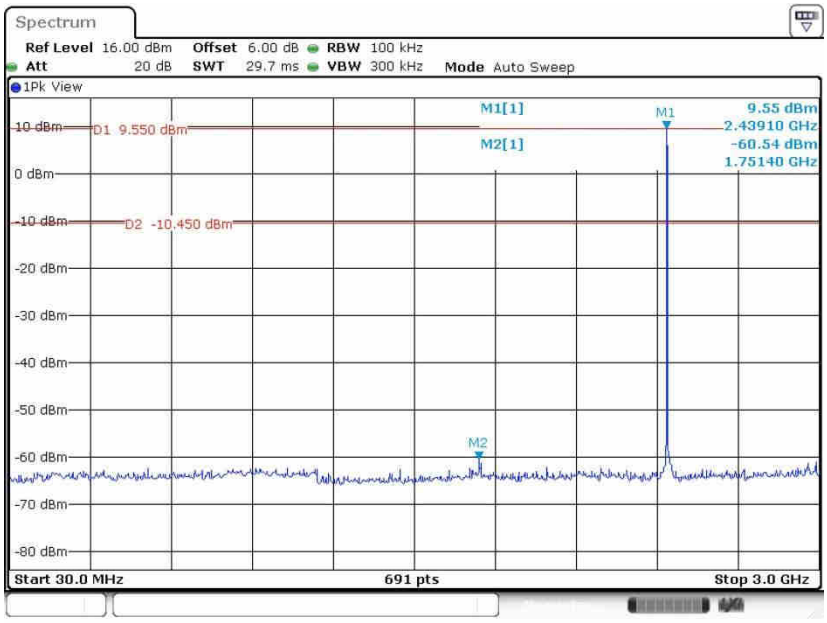

Date: 8.JUN.2019 11:00:24

**CSE Plot on Ch 00 between 2 GHz ~ 25 GHz**



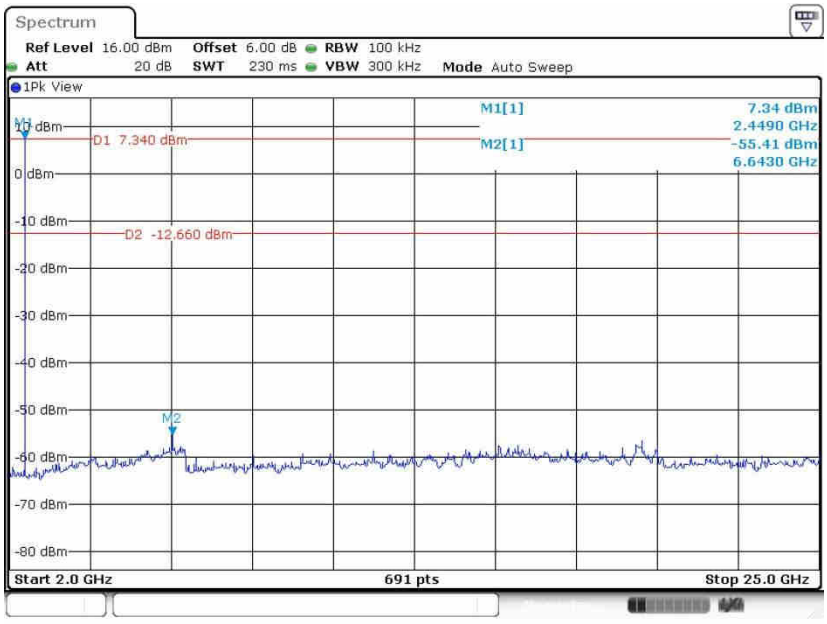

Date: 8.JUN.2019 11:00:53

**CSE Plot on Ch 39 between 30MHz ~ 3 GHz**



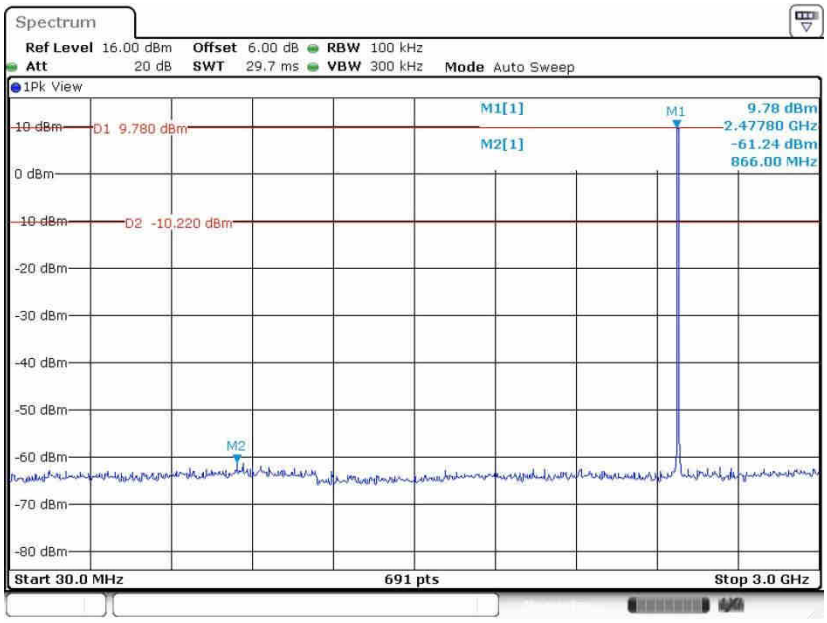

Date: 8.JUN.2019 11:07:28

**CSE Plot on Ch 39 between 2 GHz ~ 25 GHz**



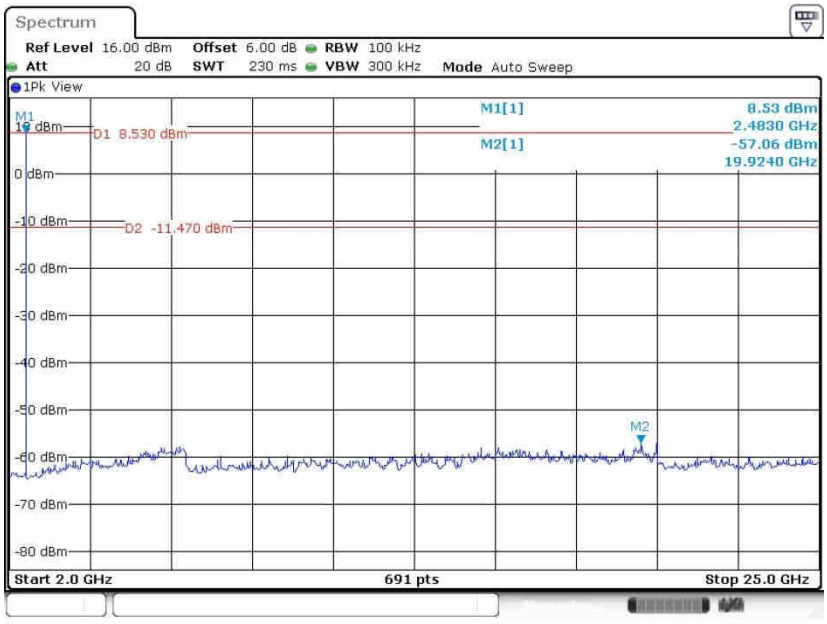

Date: 8.JUN.2019 11:08:05

**CSE Plot on Ch 78 between 30MHz ~ 3 GHz**




Date: 8.JUN.2019 11:11:37

**CSE Plot on Ch 78 between 2 GHz ~ 25 GHz**




Date: 8.JUN.2019 11:12:04

# 3.8 Radiated Band Edges and Spurious Emission Measurement

## 3.8.1 Limit of Radiated Band Edges and Spurious Emission

In any 100 kHz bandwidth outside the intentional radiator frequency band, all harmonics/spurious must be at least 20 dB below the highest emission level within the authorized band. In addition, radiated emissions which fall in the restricted bands must also comply with the limits as below.

| Frequency (MHz) | Field Strength (microvolts/meter) | Measurement Distance (meters) |
|---|---|---|
| 0.009 – 0.490 | 2400/F(kHz) | 300 |
| 0.490 – 1.705 | 24000/F(kHz) | 30 |
| 1.705 – 30.0 | 30 | 30 |
| 30 – 88 | 100 | 3 |
| 88 – 216 | 150 | 3 |
| 216 - 960 | 200 | 3 |
| Above 960 | 500 | 3 |

## 3.8.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

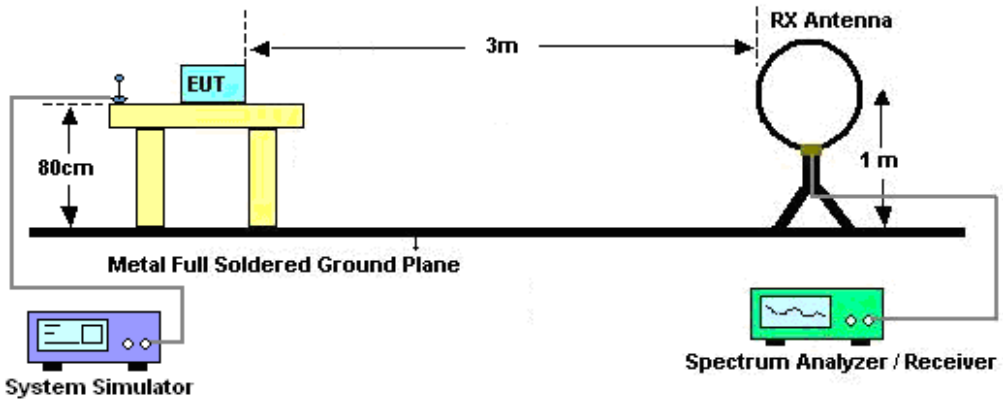
### 3.8.3 Test Procedures

1. The EUT was placed on a turntable with 0.8 meter for frequency below 1GHz and 1.5 meter for frequency above 1GHz respectively above ground.
2. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower.
3. For each suspected emission, the EUT was arranged to its worst case and then tune the Antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level to comply with the guidelines.
4. Set to the maximum power setting and enable the EUT transmit continuously.
5. Use the following spectrum analyzer settings:
   (1) Span shall wide enough to fully capture the emission being measured;
   (2) Set RBW=100 kHz for f < 1 GHz, RBW=1MHz for f>1GHz ; VBW ≥ RBW; Sweep = auto; Detector function = peak; Trace = max hold for peak
   (3) For average measurement: use duty cycle correction factor method per 15.35(c).
   Duty cycle = On time/100 milliseconds
   On time = $N_1*L_1+N_2*L_2+...+N_{n-1}*LN_{n-1}+N_n*L_n$
   Where $N_1$ is number of type 1 pulses, $L_1$ is length of type 1 pulses, etc.
   Average Emission Level = Peak Emission Level + 20*log(Duty cycle)
6. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level
7. For testing below 1GHz, if the emission level of the EUT in peak mode was 3 dB lower than the limit specified, then peak values of EUT will be reported, otherwise, the emissions will be repeated one by one using the CISPR quasi-peak method and reported.
8. For testing above 1GHz, the emission level of the EUT in peak mode was 20dB lower than average limit (that means the emission level in average mode also complies with the limit in average mode), then peak values of EUT will be reported, otherwise, the emissions will be measured in average mode again and reported.

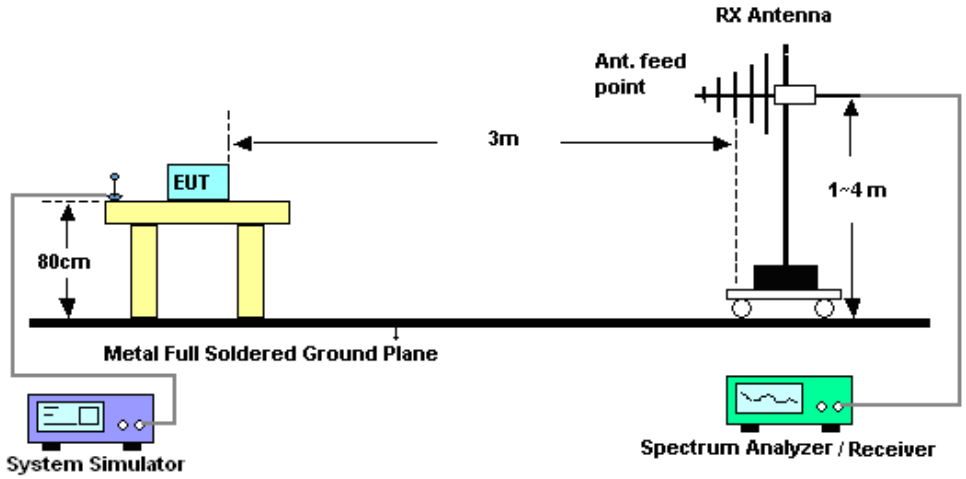
Note: The average levels were calculated from the peak level corrected with duty cycle correction factor (-24.79dB) derived from 20log (dwell time/100ms). This correction is only for signals that hop with the fundamental signal, such as band-edge and harmonic. Other spurious signals that are independent of the hopping signal would not use this correction.

### 3.8.4 Test Setup

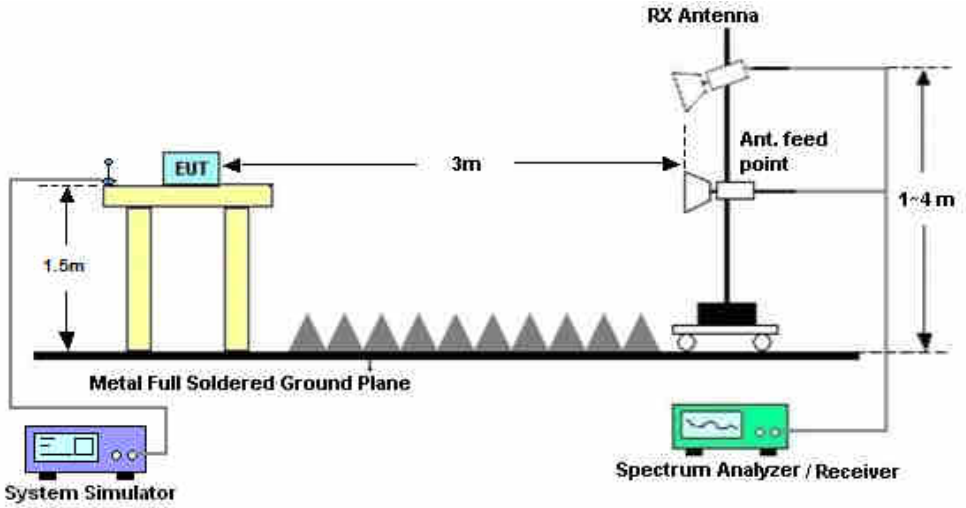
**For radiated emissions below 30MHz**




**For radiated emissions from 30MHz to 1GHz**




**For radiated emissions above 1GHz**



### 3.8.5 Test Results of Radiated Spurious Emissions (9 kHz ~ 30 MHz)

The low frequency, which started from 9 kHz to 30MHz, was pre-scanned and the result which was 20dB lower than the limit line was not reported.

There is a comparison data of both open-field test site and semi-Anechoic chamber, and the result came out very similar.

### 3.8.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix B.

### 3.8.7 Test Result of Radiated Spurious Emission (30MHz ~ 10$^{th}$ Harmonic)

Please refer to Appendix B.

### 3.8.8 Duty cycle correction factor for average measurement

Please refer to Appendix C.

# 3.9 AC Conducted Emission Measurement

## 3.9.1 Limit of AC Conducted Emission

For equipment that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table.

| Frequency of emission (MHz) | Conducted limit (dBμV) | |
|---|---|---|
| | 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.

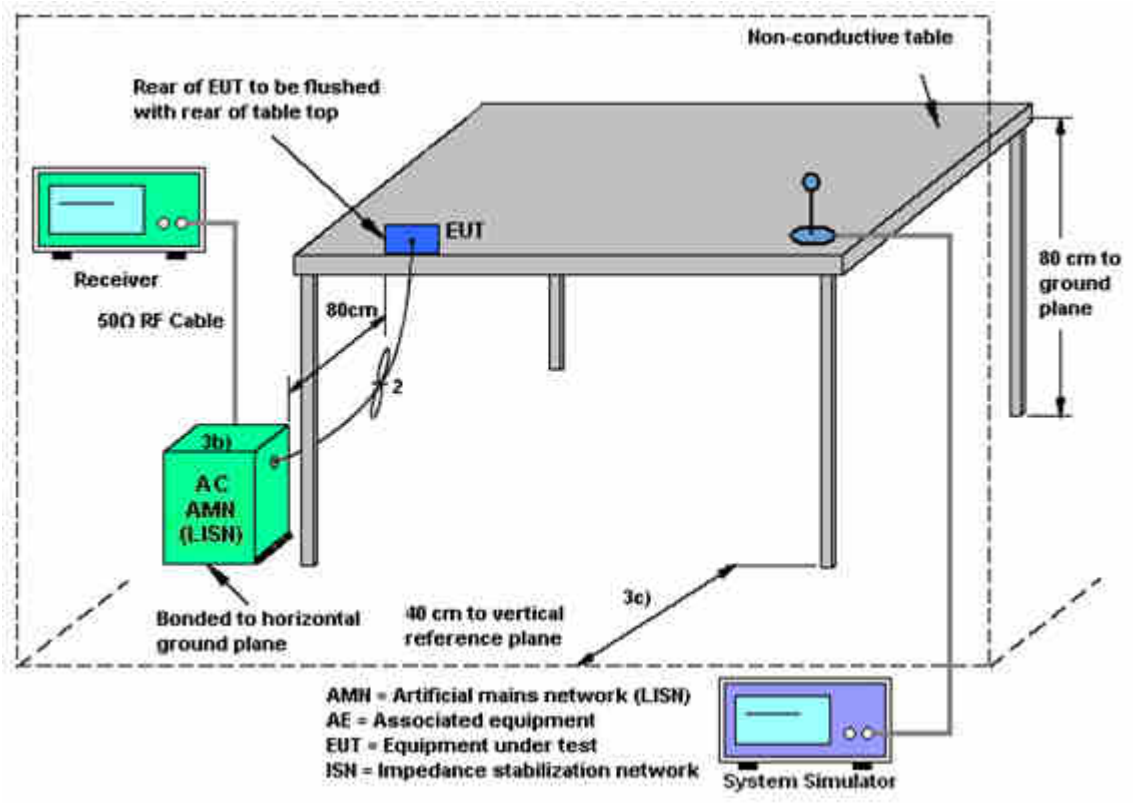
## 3.9.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

## 3.9.3 Test Procedures

1. The EUT was placed 0.4 meter from the conducting wall of the shielding room was kept at least 80 centimeters from any other grounded conducting surface.
2. Connect EUT to the power mains through a line impedance stabilization network (LISN).
3. All the support units are connecting to the other LISN.
4. The LISN provides 50 ohm coupling impedance for the measuring instrument.
5. The FCC states that a 50 ohm, 50 microhenry LISN should be used.
6. Both sides of AC line were checked for maximum conducted interference.
7. The frequency range from 150 kHz to 30 MHz was searched.
8. Set the test-receiver system to Peak Detect Function and specified bandwidth (IF Bandwidth = 9kHz) with Maximum Hold Mode. Then measurement is also conducted by Average Detector and Quasi-Peak Detector Function respectively.

### 3.9.4 Test Setup




### 3.9.5 Test Result of AC Conducted Emission

Please refer to Appendix A.

# 3.10 Antenna Requirements

## 3.10.1 Standard Applicable

If directional gain of transmitting antennas is greater than 6dBi, the power shall be reduced by the same level in dB comparing to gain minus 6dBi. 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 rule.

## 3.10.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

## 3.10.3 Antenna Gain

The antenna peak gain of EUT is less than 6 dBi. Therefore, it is not necessary to reduce maximum peak output power limit.

# 4 List of Measuring Equipment

| Instrument | Manufacturer | Model No. | Serial No. | Characteristics | Calibration Date | Test Date | Due Date | Remark |
|---|---|---|---|---|---|---|---|---|
| Spectrum Analyzer | R&S | FSV40 | 101040 | 10Hz~40GHz | Aug. 07, 2018 | Jun. 04, 2019~ Jun. 08, 2019 | Aug. 06, 2019 | Conducted (TH01-KS) |
| Power Senor | Anritsu | MA2411B | 0917070 | 300MHz~40GHz | Jan. 14, 2019 | Jun. 04, 2019~ Jun. 08, 2019 | Jan. 13, 2020 | Conducted (TH01-KS) |
| Power Meter | Anritsu | ML2495A | 1005002 | 50MHz Bandwidth | Jan. 14, 2019 | Jun. 04, 2019~ Jun. 08, 2019 | Jan. 13, 2020 | Conducted (TH01-KS) |
| EMI Test Receiver | Keysight | N9038A | MY56400023 | 3Hz~8.5GHz;Max 30dBm | Oct. 12, 2018 | Jun. 09, 2019 | Oct. 11, 2019 | Radiation (03CH06-KS) |
| EXA Spectrum Analyzer | Keysight | N9010B | MY57471084 | 10Hz-44GHz | Jun. 25, 2018 | Jun. 09, 2019 | Jun. 24, 2019 | Radiation (03CH06-KS) |
| Loop Antenna | R&S | HFH2-Z2 | 100321 | 9kHz~30MHz | Oct. 19, 2018 | Jun. 09, 2019 | Oct. 18, 2019 | Radiation (03CH06-KS) |
| Bilog Antenna | TeseQ | CBL6111D | 44483 | 30MHz-1GHz | Dec. 28, 2018 | Jun. 09, 2019 | Dec. 27, 2019 | Radiation (03CH06-KS) |
| Double Ridge Horn Antenna | ETS-Lindgren | 3117 | 75957 | 1GHz~18GHz | Oct. 20, 2018 | Jun. 09, 2019 | Oct. 19, 2019 | Radiation (03CH06-KS) |
| SHF-EHF Horn | Com-power | AH-840 | 101070 | 18GHz~40GHz | Jan. 05, 2019 | Jun. 09, 2019 | Jan. 04, 2020 | Radiation (03CH06-KS) |
| Amplifier | SONOMA | 310N | 187289 | 9KHz ~1GHZ | Aug. 06, 2018 | Jun. 09, 2019 | Aug. 05, 2019 | Radiation (03CH06-KS) |
| Amplifier | MITEQ | TTA1840-35-HG | 2014749 | 18~40GHz | Jan. 14, 2019 | Jun. 09, 2019 | Jan. 13, 2020 | Radiation (03CH06-KS) |
| high gain Amplifier | MITEQ | AMF-7D-00101800-30-10P | 2025788 | 1Ghz-18Ghz | Apr. 17, 2019 | Jun. 09, 2019 | Apr. 16, 2020 | Radiation (03CH06-KS) |
| Amplifier | Keysight | 83017A | MY53270203 | 500MHz~26.5GHz | Apr. 15, 2019 | Jun. 09, 2019 | Apr. 14, 2020 | Radiation (03CH06-KS) |
| AC Power Source | Chroma | 61601 | F104090004 | N/A | NCR | Jun. 09, 2019 | NCR | Radiation (03CH06-KS) |
| Turn Table | ChamPro | EM 1000-T | 060762-T | 0~360 degree | NCR | Jun. 09, 2019 | NCR | Radiation (03CH06-KS) |
| Antenna Mast | ChamPro | EM 1000-A | 060762-A | 1 m~4 m | NCR | Jun. 09, 2019 | NCR | Radiation (03CH06-KS) |
| EMI Receiver | R&S | ESCI7 | 100768 | 9kHz~7GHz; | Apr. 16, 2019 | Jun. 17, 2019 | Apr. 15, 2020 | Conduction (CO01-KS) |
| AC LISN | MessTec | AN3016 | 060103 | 9kHz~30MHz | Oct. 12, 2018 | Jun. 17, 2019 | Oct. 11, 2019 | Conduction (CO01-KS) |
| AC LISN (for auxiliary equipment) | MessTec | AN3016 | 060105 | 9kHz~30MHz | Nov. 19, 2018 | Jun. 17, 2019 | Nov. 18, 2019 | Conduction (CO01-KS) |
| AC Power Source | Chroma | 61602 | ABP000000811 | AC 0V~300V, 45Hz~1000Hz | Oct. 12, 2018 | Jun. 17, 2019 | Oct. 11, 2019 | Conduction (CO01-KS) |

NCR: No Calibration Required

# 5 Uncertainty of Evaluation

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI 63.10-2013. All the measurement uncertainty value were shown with a coverage K=2 to indicate 95% level of confidence. The measurement data show herein meets or exceeds the CISPR measurement uncertainty values specified in CISPR 16-4-2 and can be compared directly to specified limit to determine compliance.

**Uncertainty of Conducted Emission Measurement (150 kHz ~ 30 MHz)**

| | |
|---|---|
| **Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))** | **2.9dB** |

**Uncertainty of Radiated Emission Measurement (30 MHz ~ 1000 MHz)**

| | |
|---|---|
| **Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))** | **5.0dB** |

**Uncertainty of Radiated Emission Measurement (1000 MHz ~ 18000 MHz)**

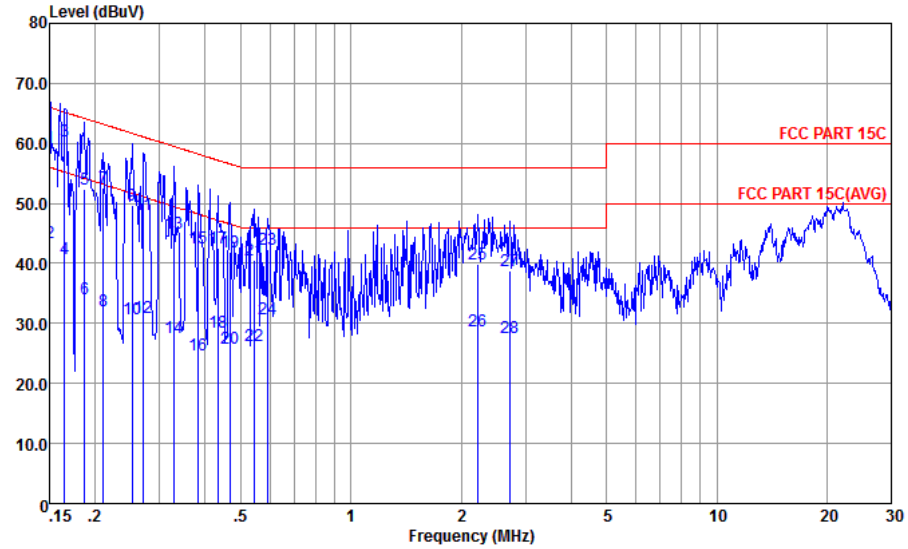
| | |
|---|---|
| **Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))** | **5.0dB** |

**Uncertainty of Radiated Emission Measurement (18000 MHz ~ 40000 MHz)**

| | |
|---|---|
| **Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))** | **5.0dB** |

# Appendix A. AC Conducted Emission Test Results

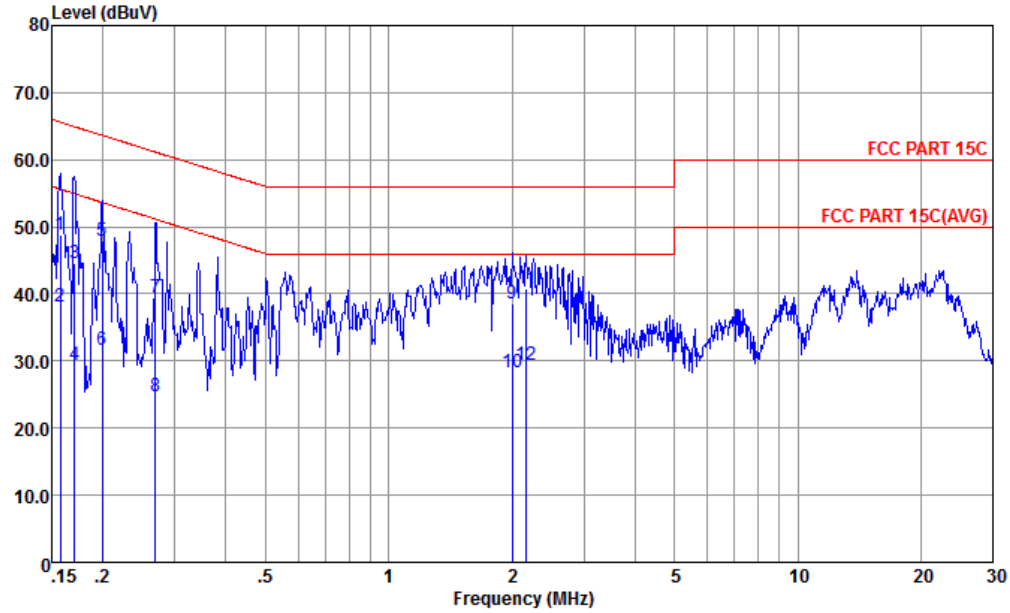
| | | | |
|---|---|---|---|
| **Test Engineer :** | Amos Zhang | **Temperature :** | 25.3~26.2℃ |
| | | **Relative Humidity :** | 38~40% |
| **Test Voltage :** | 120Vac / 60Hz | **Phase :** | Line |




Site : CO01-KS
Condition : FCC PART 15C LISN-L-181119-060105 LINE

| | | Freq | Level | Over Limit | Limit Line | Read Level | LISN Factor | Cable Loss | Remark |
|---|---|---|---|---|---|---|---|---|---|
| | | MHz | dBuV | dB | dBuV | dBuV | dB | dB | |
| 1 | | 0.150 | 59.17 | -6.83 | 66.00 | 48.60 | 0.09 | 10.48 | QP |
| 2 | | 0.150 | 43.47 | -12.53 | 56.00 | 32.90 | 0.09 | 10.48 | Average |
| 3 | * | 0.165 | 60.44 | -4.77 | 65.21 | 49.90 | 0.10 | 10.44 | QP |
| 4 | | 0.165 | 40.84 | -14.37 | 55.21 | 30.30 | 0.10 | 10.44 | Average |
| 5 | | 0.187 | 52.40 | -11.75 | 64.15 | 41.90 | 0.11 | 10.39 | QP |
| 6 | | 0.187 | 34.00 | -20.15 | 54.15 | 23.50 | 0.11 | 10.39 | Average |
| 7 | | 0.211 | 52.68 | -10.50 | 63.18 | 42.20 | 0.12 | 10.36 | QP |
| 8 | | 0.211 | 32.08 | -21.10 | 53.18 | 21.60 | 0.12 | 10.36 | Average |
| 9 | | 0.252 | 49.66 | -12.03 | 61.69 | 39.20 | 0.13 | 10.33 | QP |
| 10 | | 0.252 | 30.66 | -21.03 | 51.69 | 20.20 | 0.13 | 10.33 | Average |
| 11 | | 0.272 | 48.06 | -13.01 | 61.07 | 37.60 | 0.14 | 10.32 | QP |
| 12 | | 0.272 | 31.06 | -20.01 | 51.07 | 20.60 | 0.14 | 10.32 | Average |
| 13 | | 0.329 | 45.04 | -14.45 | 59.49 | 34.60 | 0.15 | 10.29 | QP |
| 14 | | 0.329 | 27.64 | -21.85 | 49.49 | 17.20 | 0.15 | 10.29 | Average |
| 15 | | 0.383 | 42.63 | -15.58 | 58.21 | 32.20 | 0.16 | 10.27 | QP |
| 16 | | 0.383 | 24.63 | -23.58 | 48.21 | 14.20 | 0.16 | 10.27 | Average |
| 17 | | 0.433 | 42.62 | -14.58 | 57.20 | 32.20 | 0.16 | 10.26 | QP |
| 18 | | 0.433 | 28.62 | -18.58 | 47.20 | 18.20 | 0.16 | 10.26 | Average |
| 19 | | 0.466 | 41.91 | -14.67 | 56.58 | 31.50 | 0.17 | 10.24 | QP |
| 20 | | 0.466 | 25.91 | -20.67 | 46.58 | 15.50 | 0.17 | 10.24 | Average |
| 21 | | 0.546 | 40.61 | -15.39 | 56.00 | 30.19 | 0.18 | 10.24 | QP |
| 22 | | 0.546 | 26.31 | -19.69 | 46.00 | 15.89 | 0.18 | 10.24 | Average |
| 23 | | 0.592 | 42.32 | -13.68 | 56.00 | 31.90 | 0.18 | 10.24 | QP |
| 24 | | 0.592 | 30.72 | -15.28 | 46.00 | 20.30 | 0.18 | 10.24 | Average |
| 25 | | 2.225 | 39.95 | -16.05 | 56.00 | 29.50 | 0.22 | 10.23 | QP |
| 26 | | 2.225 | 28.65 | -17.35 | 46.00 | 18.20 | 0.22 | 10.23 | Average |
| 27 | | 2.721 | 38.67 | -17.33 | 56.00 | 28.20 | 0.23 | 10.24 | QP |
| 28 | | 2.721 | 27.57 | -18.43 | 46.00 | 17.10 | 0.23 | 10.24 | Average |

| | | | |
|---|---|---|---|
| **Test Engineer :** | Amos Zhang | **Temperature :** | 25.3~26.2℃ |
| | | **Relative Humidity :** | 38~40% |
| **Test Voltage :** | 120Vac / 60Hz | **Phase :** | Neutral |




Site : CO01-KS
Condition : FCC PART 15C LISN-N-181119-060105 NEUTRAL

| | | Freq | Level | Over Limit | Limit Line | Read Level | LISN Factor | Cable Loss | Remark |
|---|---|---|---|---|---|---|---|---|---|
| | | MHz | dBuV | dB | dBuV | dBuV | dB | dB | |
| 1 | | 0.157 | 48.84 | -16.76 | 65.60 | 38.20 | 0.18 | 10.46 | QP |
| 2 | | 0.157 | 38.14 | -17.46 | 55.60 | 27.50 | 0.18 | 10.46 | Average |
| 3 | | 0.170 | 44.50 | -20.44 | 64.94 | 33.89 | 0.18 | 10.43 | QP |
| 4 | | 0.170 | 29.40 | -25.54 | 54.94 | 18.79 | 0.18 | 10.43 | Average |
| 5 | | 0.200 | 47.84 | -15.78 | 63.62 | 37.31 | 0.17 | 10.36 | QP |
| 6 | | 0.200 | 31.64 | -21.98 | 53.62 | 21.11 | 0.17 | 10.36 | Average |
| 7 | | 0.269 | 39.39 | -21.77 | 61.16 | 28.91 | 0.16 | 10.32 | QP |
| 8 | | 0.269 | 24.79 | -26.37 | 51.16 | 14.31 | 0.16 | 10.32 | Average |
| 9 | | 2.001 | 38.58 | -17.42 | 56.00 | 28.20 | 0.15 | 10.23 | QP |
| 10 | | 2.001 | 28.28 | -17.72 | 46.00 | 17.90 | 0.15 | 10.23 | Average |
| 11 | * | 2.167 | 40.68 | -15.32 | 56.00 | 30.30 | 0.15 | 10.23 | QP |
| 12 | | 2.167 | 29.48 | -16.52 | 46.00 | 19.10 | 0.15 | 10.23 | Average |

# Appendix B. Radiated Spurious Emission

**2.4GHz 2400~2483.5MHz**

**BT (Band Edge @ 3m)**

| BT | Note | Frequency | Level | Over Limit | Limit Line | Read Level | Antenna Factor | Cable Loss | Preamp Factor | Ant Pos | Table Pos | Peak Avg. | Pol. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ( MHz ) | ( dBμV/m ) | ( dB ) | ( dBμV/m ) | ( dBμV ) | ( dB/m ) | ( dB ) | ( dB ) | ( cm ) | ( deg ) | (P/A) | (H/V) |
| BT CH00 2402MHz | | 2366.55 | 53.28 | -20.72 | 74 | 47.27 | 32.07 | 5.36 | 31.42 | 109 | 106 | P | H |
| | | 2366.55 | 28.49 | -25.51 | 54 | - | - | - | - | - | - | A | H |
| | * | 2402 | 102.73 | - | - | 96.73 | 32 | 5.41 | 31.41 | 109 | 106 | P | H |
| | * | 2402 | 77.94 | - | - | - | - | - | - | - | - | A | H |
| | | 2342.89 | 53.66 | -20.34 | 74 | 47.68 | 32.1 | 5.31 | 31.43 | 370 | 45 | P | V |
| | | 2342.89 | 28.87 | -25.13 | 54 | - | - | - | - | - | - | A | V |
| | * | 2402 | 99.46 | - | - | 93.46 | 32 | 5.41 | 31.41 | 370 | 45 | P | V |
| | * | 2402 | 74.67 | - | - | - | - | - | - | - | - | A | V |
| BT CH 78 2480MHz | | 2483.69 | 59.15 | -14.85 | 74 | 52.82 | 32.27 | 5.45 | 31.39 | 109 | 106 | P | H |
| | | 2483.69 | 34.36 | -19.64 | 54 | - | - | - | - | - | - | A | H |
| | * | 2480 | 107.04 | - | - | 100.71 | 32.27 | 5.45 | 31.39 | 109 | 106 | P | H |
| | * | 2480 | 82.25 | - | - | - | - | - | - | - | - | A | H |
| | | 2483.55 | 57.34 | -16.66 | 74 | 51.01 | 32.27 | 5.45 | 31.39 | 370 | 45 | P | V |
| | | 2483.55 | 32.55 | -21.45 | 54 | - | - | - | - | - | - | A | V |
| | * | 2480 | 104.14 | - | - | 97.81 | 32.27 | 5.45 | 31.39 | 370 | 45 | P | V |
| | * | 2480 | 79.35 | - | - | - | - | - | - | - | - | A | V |
| **Remark** | 1. No other spurious found.<br>2. All results are PASS against Peak and Average limit line. | | | | | | | | | | | | |

**2.4GHz 2400~2483.5MHz**

**BT (Harmonic @ 3m)**

| BT | Note | Frequency ( MHz ) | Level ( dBμV/m ) | Over Limit ( dB ) | Limit Line ( dBμV/m ) | Read Level ( dBμV ) | Antenna Factor ( dB/m ) | Cable Loss ( dB ) | Preamp Factor ( dB ) | Ant Pos ( cm ) | Table Pos ( deg ) | Peak Avg. (P/A) | Pol. (H/V) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BT CH 00 2402MHz | | 4806 | 37.58 | -36.42 | 74 | 57.02 | 34.2 | 7.95 | 61.59 | 100 | 360 | P | H |
| | | 4806 | 37.28 | -36.72 | 74 | 56.72 | 34.2 | 7.95 | 61.59 | 100 | 360 | P | V |
| BT CH 39 2441MHz | | 4884 | 38.52 | -35.48 | 74 | 57.98 | 34.13 | 8.02 | 61.61 | 100 | 360 | P | H |
| | | 7320 | 39.94 | -34.06 | 74 | 55.83 | 36.6 | 9.85 | 62.34 | 100 | 360 | P | H |
| | | 4884 | 39.23 | -34.77 | 74 | 58.69 | 34.13 | 8.02 | 61.61 | 100 | 360 | P | V |
| | | 7320 | 39.44 | -34.56 | 74 | 55.33 | 36.6 | 9.85 | 62.34 | 100 | 360 | P | V |
| BT CH 78 2480MHz | | 4962 | 38.26 | -35.74 | 74 | 57.7 | 34.1 | 8.1 | 61.64 | 100 | 360 | P | H |
| | | 7440 | 38.51 | -35.49 | 74 | 54.51 | 36.4 | 10 | 62.4 | 100 | 360 | P | H |
| | | 4962 | 37.16 | -36.84 | 74 | 56.6 | 34.1 | 8.1 | 61.64 | 100 | 360 | P | V |
| | | 7440 | 38.78 | -35.22 | 74 | 54.78 | 36.4 | 10 | 62.4 | 100 | 360 | P | V |
| **Remark** | 1. No other spurious found.<br>2. All results are PASS against Peak and Average limit line. | | | | | | | | | | | | |

## Emission below 1GHz

### 2.4GHz BT (LF)

| BT | Note | Frequency | Level | Over | Limit | Read | Antenna | Cable | Preamp | Ant | Table | Peak | Pol. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Limit | Line | Level | Factor | Loss | Factor | Pos | Pos | Avg. | |
| | | ( MHz ) | ( dBμV/m ) | ( dB ) | ( dBμV/m ) | (dBμV) | ( dB/m ) | ( dB ) | ( dB ) | ( cm ) | ( deg ) | (P/A) | (H/V) |
| 2.4GHz BT LF | | 74.62 | 19.25 | -20.75 | 40 | 38.6 | 12.7 | 0.86 | 32.91 | - | - | P | H |
| | | 117.3 | 31.42 | -12.08 | 43.5 | 45.24 | 18.01 | 1.1 | 32.93 | - | - | P | H |
| | | 195.87 | 31.49 | -12.01 | 43.5 | 47.35 | 15.54 | 1.51 | 32.91 | 100 | 0 | P | H |
| | | 256.98 | 28.33 | -17.67 | 46 | 40.11 | 19.46 | 1.75 | 32.99 | - | - | P | H |
| | | 508.21 | 20.44 | -25.56 | 46 | 27.7 | 23.59 | 2.4 | 33.25 | - | - | P | H |
| | | 871.96 | 23.64 | -22.36 | 46 | 26.56 | 26.39 | 3.16 | 32.47 | - | - | P | H |
| | | 44.55 | 30.95 | -9.05 | 40 | 46.98 | 16.3 | 0.63 | 32.96 | 100 | 360 | P | V |
| | | 74.62 | 27.33 | -12.67 | 40 | 46.68 | 12.7 | 0.86 | 32.91 | - | - | P | V |
| | | 126.03 | 19.88 | -23.62 | 43.5 | 33.74 | 17.93 | 1.15 | 32.94 | - | - | P | V |
| | | 259.89 | 28.86 | -17.14 | 46 | 40.31 | 19.8 | 1.75 | 33 | - | - | P | V |
| | | 563.5 | 22.04 | -23.96 | 46 | 28.64 | 24.19 | 2.53 | 33.32 | - | - | P | V |
| | | 877.78 | 25.17 | -20.83 | 46 | 28.02 | 26.41 | 3.18 | 32.44 | - | - | P | V |
| **Remark** | 1. No other spurious found.<br>2. All results are PASS against limit line. | | | | | | | | | | | | |

**Note symbol**

| | |
|---|---|
| * | **Fundamental Frequency** which can be ignored. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency. |
| ! | Test result is **over limit** line. |
| P/A | **P**eak or **A**verage |
| H/V | **H**orizontal or **V**ertical |

## A calculation example for radiated spurious emission is shown as below:

| WIFI | Note | Frequency | Level | Over | Limit | Read | Antenna | Cable | Preamp | Ant | Table | Peak | Pol. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ant. | | | | Limit | Line | Level | Factor | Loss | Factor | Pos | Pos | Avg. | |
| 1+2 | | ( MHz ) | ( dBμV/m ) | ( dB ) | ( dBμV/m ) | ( dBμV ) | ( dB/m ) | ( dB ) | ( dB ) | ( cm ) | ( deg ) | (P/A) | (H/V) |
| 802.11b CH 01 2412MHz | | 2390 | 55.45 | -18.55 | 74 | 54.51 | 32.22 | 4.58 | 35.86 | 103 | 308 | P | H |
| | | 2390 | 43.54 | -10.46 | 54 | 42.6 | 32.22 | 4.58 | 35.86 | 103 | 308 | A | H |

1. Level(dBμV/m) =

Antenna Factor(dB/m) + Cable Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)

2. Over Limit(dB) = Level(dBμV/m) – Limit Line(dBμV/m)

**For Peak Limit @ 2390MHz:**

1. Level(dBμV/m)

= Antenna Factor(dB/m) + Cable Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)

= 32.22(dB/m) + 4.58(dB) + 54.51(dBμV) – 35.86 (dB)

= 55.45 (dBμV/m)

2. Over Limit(dB)

= Level(dBμV/m) – Limit Line(dBμV/m)

= 55.45(dBμV/m) – 74(dBμV/m)

= -18.55(dB)

**For Average Limit @ 2390MHz:**

1. Level(dBμV/m)

= Antenna Factor(dB/m) + Cable Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)

= 32.22(dB/m) + 4.58(dB) + 42.6(dBμV) – 35.86 (dB)

= 43.54 (dBμV/m)

2. Over Limit(dB)

= Level(dBμV/m) – Limit Line(dBμV/m)

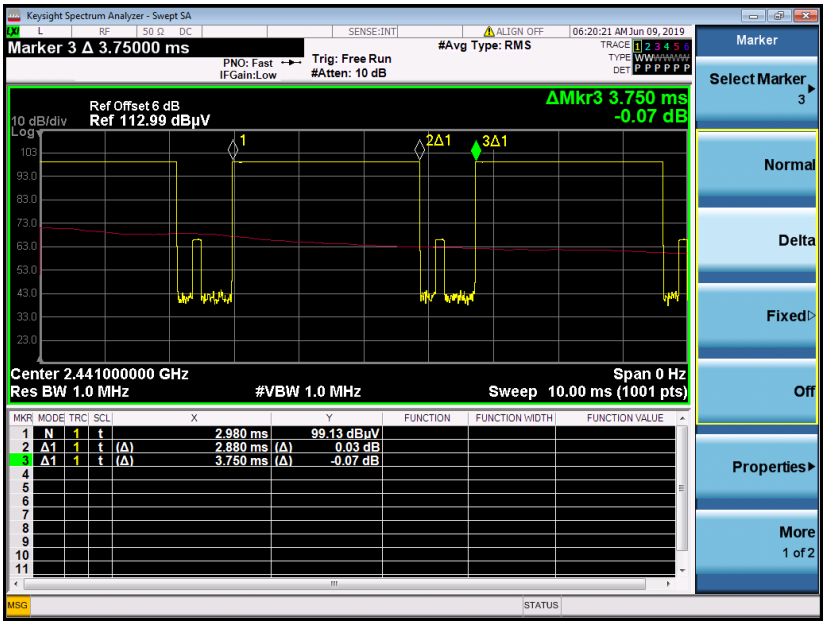
= 43.54(dBμV/m) – 54(dBμV/m)

= -10.46(dB)

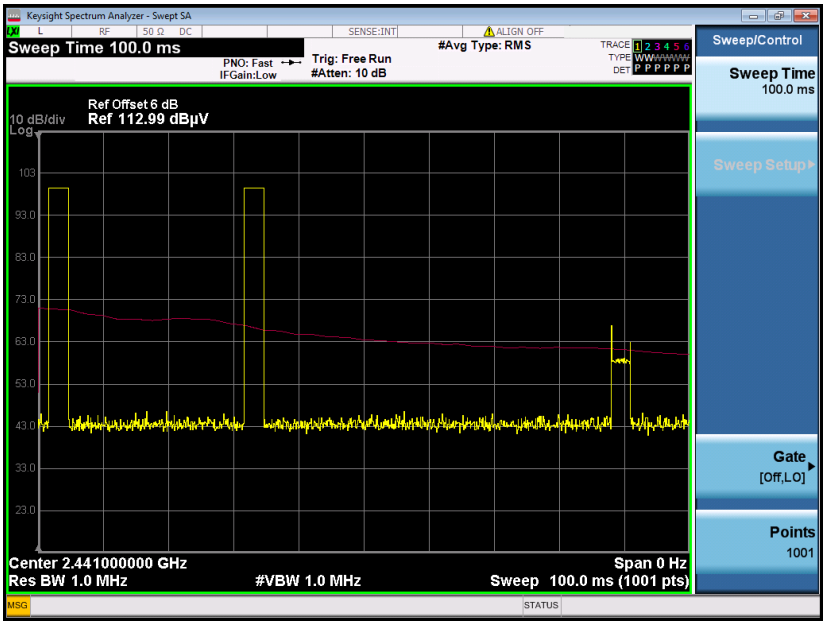
**Both peak and average measured complies with the limit line, so test result is "PASS".**

# Appendix C. Duty Cycle Plots

**DH5 on time (One Pulse) Plot on Channel 39**




**DH5 on time (Count Pulses) Plot on Channel 39**




**Note:**

1. Worst case Duty cycle = on time/100 milliseconds = 2 * 2.88 / 100 = 5.76 %
2. Worst case Duty cycle correction factor = 20*log(Duty cycle) = -24.79 dB
3. DH5 has the highest duty cycle worst case and is reported.