

FCC RF Test Report

For

Shenzhen Hangshi Technology Co.,Ltd

| | |
|------------------------------|---|
| Test Standards: | <u>Part 15C Subpart C §15.247</u> |
| Product Description: | <u>Bluetooth Keyboard</u> |
| Tested Model: | <u>HB220B</u> |
| Additional Model No.: | <u>HB220</u> |
| Brand Name: | <u>N/A</u> |
| FCC ID: | 2AKHJ-HB220B |
| Classification | Digital Spread Spectrum (DSS) |
| Report No.: | <u>EC1908013RF01</u> |
| Tested Date: | <u>2019-08-20 to 2019-08-29</u> |
| Issued Date: | <u>2019-08-29</u> |
| Prepared By: | <u>Victorique . Gao</u> Victorique Gao/ Engineer |
| Approved By: | <u>Bacon Wu</u> Bacon Wu / RF Manager |

Hunan Ecloud Testing Technology Co., Ltd.
Building A1, Changsha E Center, No. 18 Xiangtai Avenue, Liuyang Economic and
Technological Development Zone, Hunan, P.R.C
Tel.: +86-731-89634887 Fax.: +86-731-89634887
www.hn-ecloud.com

Note: The test results in this report apply exclusively to the tested model / sample. Without written approval of Hunan Ecloud Testing Technology Co., Ltd., the test report shall not be reproduced except in full.

Report Revise Record

| Report Version | Revise Time | Issued Date | Valid Version | Notes |
|----------------|-------------|-------------|---------------|-----------------|
| V1.0 | / | 2019.08.29 | Valid | Original Report |

TABLE OF CONTENTS

| | | |
|----------|---|-----------|
| 1 | TEST LABORATORY | 5 |
| 1.1 | Test facility | 5 |
| 2 | GENERAL DESCRIPTION..... | 6 |
| 2.1 | Applicant | 6 |
| 2.2 | Manufacturer | 6 |
| 2.3 | General Description Of EUT | 6 |
| 2.4 | Modification of EUT | 7 |
| 2.5 | Applicable Standards | 7 |
| 3 | TEST CONFIGURATION OF EQUIPMENT UNDER TEST..... | 8 |
| 3.1 | Descriptions of Test Mode | 8 |
| 3.2 | Test Mode | 9 |
| 3.3 | Support Equipment | 10 |
| 3.4 | Test Setup | 10 |
| 3.5 | Measurement Results Explanation Example | 13 |
| 4 | TEST RESULT | 14 |
| 4.1 | 20dB and 99% Bandwidth Measurement | 14 |
| 4.2 | Hopping Channel Separation Measurement | 19 |
| 4.3 | Number of Channel Measurement | 22 |
| 4.4 | Average Time of Occupancy Measurement | 24 |
| 4.5 | Peak Output Power Measurement | 31 |
| 4.6 | Conducted Band Edges Measurement..... | 34 |
| 4.7 | Conducted Spurious Emission Measurement | 38 |
| 4.8 | Radiated Band Edges and Spurious Emission Measurement | 42 |
| 4.9 | AC Conducted Emission Measurement..... | 72 |
| 4.10 | Antenna Requirements | 75 |
| 5 | LIST OF MEASURING EQUIPMENT..... | 76 |
| 6 | UNCERTAINTY OF EVALUATION..... | 77 |

Summary of Test Result

| FCC Rule | Description | Limit | Result | Remark |
|--------------------|--|----------------------------------|--------|--|
| 15.247(a)(1) | 20dB Bandwidth | NA | Pass | - |
| - | 99% Bandwidth | - | Pass | - |
| 15.247(a)(1) | Hopping Channel Separation | $\geq 2/3$ of 20dB BW | Pass | - |
| 15.247(a)(1) | Number of Channels | ≥ 15 Chs | Pass | - |
| 15.247(a)(1) | Average Time of Occupancy | ≤ 0.4 sec in 31.6sec period | Pass | - |
| 15.247(b)(1) | Peak Output Power | ≤ 125 mW | Pass | - |
| 15.247(d) | Conducted Band Edges | ≤ 20 dBc | Pass | - |
| 15.247(d) | Conducted Spurious Emission | ≤ 20 dBc | Pass | - |
| 15.247(d) | Radiated Band Edges and Radiated Spurious Emission | 15.209(a) & 15.247(d) | Pass | Under limit 6.06 dB at 203.63 MHz |
| 15.207 | AC Conducted Emission | 15.207(a) | Pass | Under limit 24.56 dB at 19.122 MHz |
| 15.203 & 15.247(b) | Antenna Requirement | N/A | Pass | - |

1 Test Laboratory

1.1 Test facility

CNAS (accreditation number: L11138)

Hunan Ecloud Testing Technology Co., Ltd. has obtained the accreditation of China National Accreditation Service for Conformity Assessment (CNAS).

FCC (Designation number: CN1244 , Test Firm Registration Number: 793308)

Hunan Ecloud Testing Technology Co., Ltd. has been listed on the US Federal Communications Commission list of test facilities recognized to perform electromagnetic emissions measurements.

ISED(CAB identifier: CN0012, ISED# :24347)

Hunan Ecloud Testing Technology Co., Ltd. has been listed on the Wireless Device Testing Laboratories list of innovation, Science and Economic Development Canada to test to Canadian radio equipment requirements.

A2LA (Certificate Code : 4895.01)

Hunan Ecloud Testing Technology Co., Ltd. has been listed by American Association for Laboratory Accreditation to perform electromagnetic emission measurement.

2 General Description

2.1 Applicant

Shenzhen Hangshi Technology Co.,Ltd

Hangshi Technology Park, Democracy West Industry Area, Shajing Town, Bao'an District, Shenzhen, China.

2.2 Manufacturer

Shenzhen Hangshi Technology Co.,Ltd

Hangshi Technology Park, Democracy West Industry Area, Shajing Town, Bao'an District, Shenzhen, China.

2.3 General Description Of EUT

| | |
|-------------------------------|--|
| Product | Bluetooth Keyboard |
| Model No. | HB220B |
| Additional No. | HB220 |
| Difference Description | HB220B have backlight , HB220 doesn't have backlight , and does not have any effect on any other RF functions. |
| FCC ID | 2AKHJ-HB220B |
| Power Supply | 5Vdc (adapter or host equipment) 3.7Vdc (Li-ion, polymer) |
| Modulation Technology | FHSS |
| Modulation Type | GFSK |
| Operating Frequency | 2402MHz~2480MHz |
| Number Of Channel | 79 |
| Max. Output Power | Bluetooth BR(1Mbps) : -2.610 dBm (0.0005 W) |
| Antenna Type | PCB Antenna type with 1.87dBi gain |
| HW Version | V1.0 |
| SW Version | V1.0 |
| I/O Ports | Refer to user's manual |
| Cable Supplied | USB cable: Unshielded, detachable, 1.0m |

NOTE:

1. For a more detailed features description, please refer to the manufacturer's specifications or the user's manual.
2. For the test results, the EUT had been tested with all conditions. But only the worst case was shown in test report.

2.4 Modification of EUT

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

2.5 Applicable Standards

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

- ♦ FCC Part 15 Subpart C §15.247
- ♦ ANSI C63.10-2013
- ♦ KDB 558074 D01 15.247 Meas Guidance v05r02

Remark:

1. This EUT has also been tested and complied with the requirements of FCC Part 15, Subpart B, recorded in a separate test report.

3 Test Configuration of Equipment Under Test

3.1 Descriptions of Test Mode

The transmitter has a maximum peak conducted output power as follows:

| Channel | Frequency | Mode | Bluetooth RF Output Power |
|---------|-----------|------|---------------------------|
| Ch00 | 2402MHz | GFSK | -2.610 |
| Ch39 | 2441MHz | GFSK | -3.494 |
| Ch78 | 2480MHz | GFSK | -5.620 |

Remark:

- 1.All the test data for each data rate were verified, but only the worst case was reported.
- 2.The data rate was set in 1Mbps for all the test items due to the highest RF output power.

3.2 Test Mode

3.2.1 Antenna Port Conducted Measurement

| Summary table of Test Cases | |
|-----------------------------|---|
| Test Item | Data Rate / Modulation |
| | Bluetooth BR 1Mbps GFSK |
| Conducted Test Cases | Mode 1: CH00_2402 MHz Mode 2: CH39_2441 MHz Mode 3: CH78_2480 MHz |

3.2.2 Radiated Emission Test (Below 1GHz)

| Radiated Test Cases | Bluetooth BR 1Mbps GFSK |
|---------------------|-------------------------|
| | Mode 1: CH00_2402 MHz |

Note : 1. Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, XYZ axis, antenna ports (if EUT with antenna diversity architecture) and packet type. X orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in X orientation.

2. Following channel(s) was (were) selected for the final test as listed above

3.2.3 Radiated Emission Test (Above 1GHz)

| Radiated Test Cases | Bluetooth BR 1Mbps GFSK |
|---------------------|-------------------------|
| | Mode 1: CH00_2402 MHz |
| | Mode 2: CH39_2441 MHz |
| | Mode 3: CH78_2480 MHz |

Note : 1. The fundamental of the EUT was investigated in three orthogonal orientations X, Y and Z it was determined that X orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in X orientation.

2. Following channel(s) was (were) selected for the final test as listed above

3. For frequency above 18GHz, the measured value is much lower than the limit, therefore, it is not reflected in the report.

3.2.4 Power Line Conducted Emission Test:

| | |
|-----------------------------|---|
| AC Conducted Emission | Mode 1 : Bluetooth Link + USB Cable (Charging from Adapter) |
|-----------------------------|---|

3.3 Support Equipment

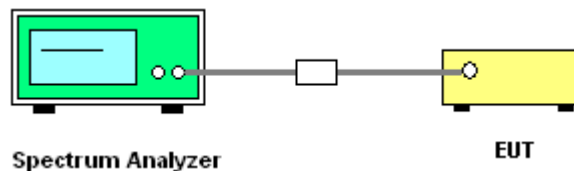
| Item | Equipment | Trade Name | Model Name | FCC ID | Data Cable | Power Cord |
|------|-----------|-------------|------------------|---------|------------|--|
| 1. | Adapter | Tongxingrui | TX-0501000-AD001 | DOC | N/A | N/A |
| 2. | USB Cable | N/A | N/A | N/A | N/A | unshielded 0.8m |
| 3. | Notebook | Lenovo | E470C | FCC DoC | N/A | shielded cable DC O/P 1.8 m unshielded AC I/P cable 1.2 m |

3.4 Test Setup

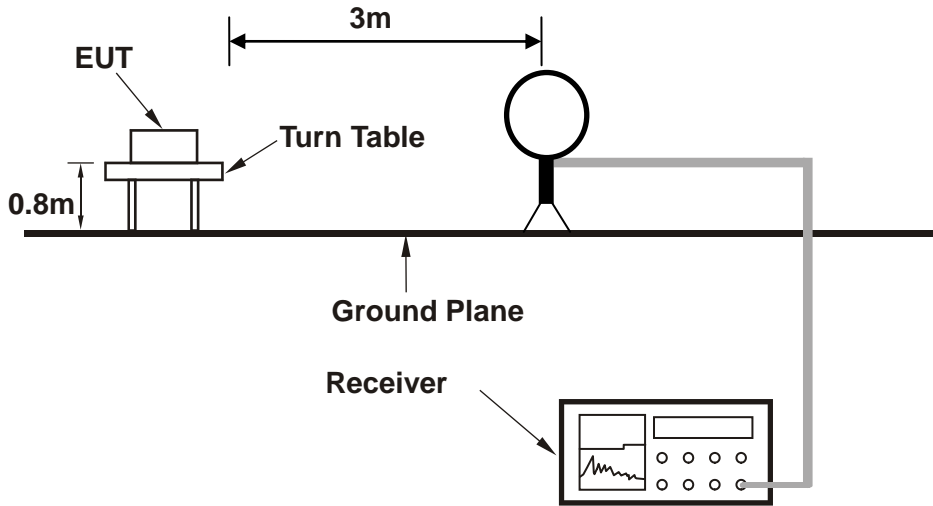
The EUT is continuously communicating to the Bluetooth tester during the tests.

EUT was set in the Hidden menu mode to enable BT communications.

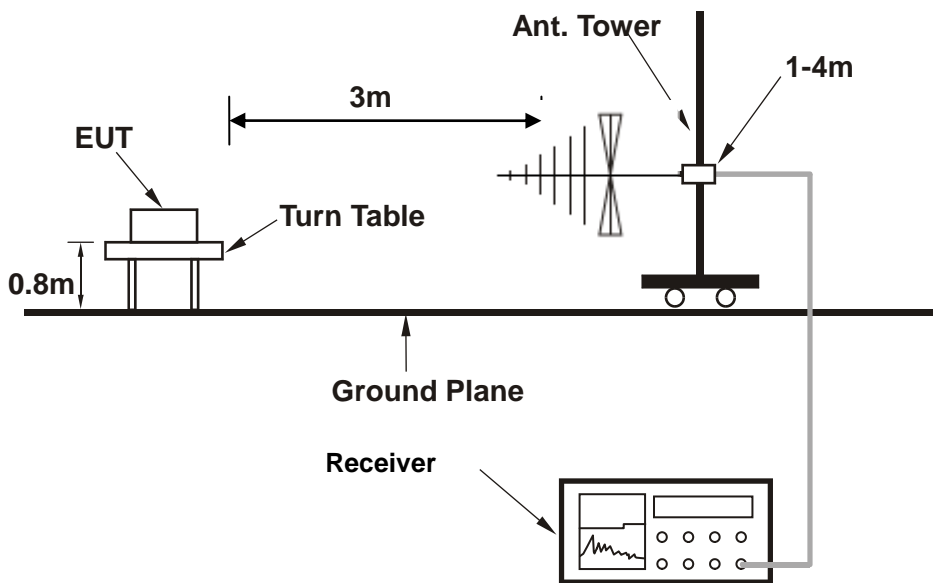
Setup diagram for Conducted Test



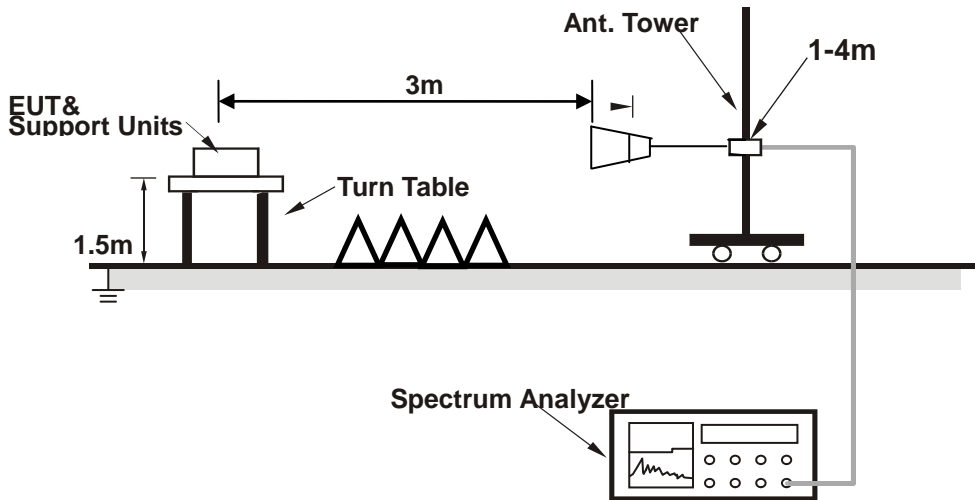
Setup diagram for Raidation(9KHz~30MHz) Test



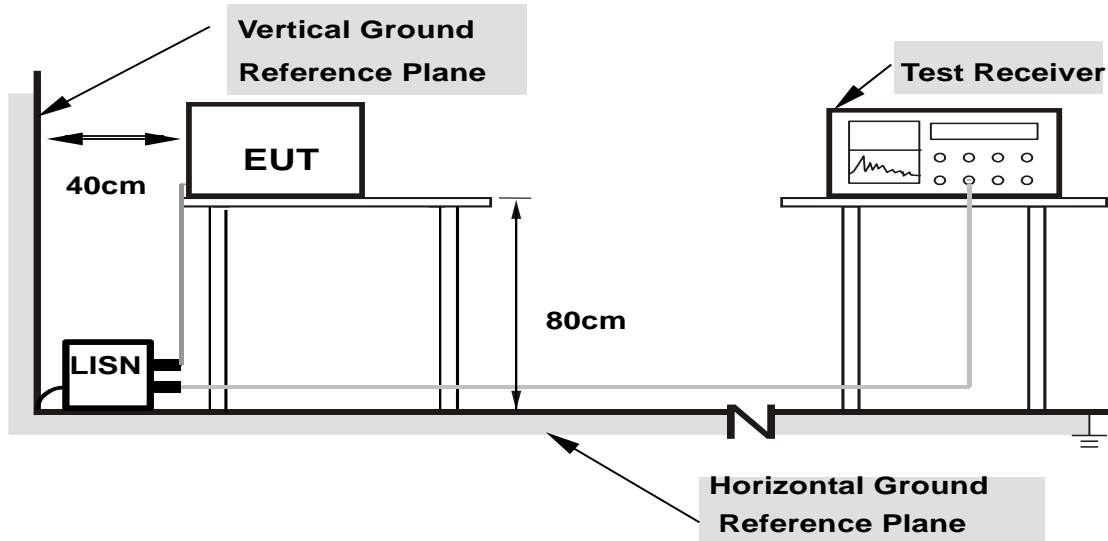
Setup diagram for Raidation(Below 1G) Test



Setup diagram for Raidation(Above1G) Test



Setup diagram for AC Conducted Emission Test



- Note: 1.Support units were connected to second LISN.**
2.Both of LISNs (AMN) are 80 cm from EUT and at least 80 from other units and other metal planes

3.5 Measurement Results Explanation Example

For all conducted test items:

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuator factor 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 and attenuator factor.

Offset = RF cable loss + attenuator factor.

Following shows an offset computation example with cable loss 5 dB and 10dB attenuator.

$$\begin{aligned} \text{Offset(dB)} &= \text{RF cable loss(dB)} + \text{attenuator factor(dB)}. \\ &= 5 + 10 = 15 \text{ (dB)} \end{aligned}$$

For all radiated test items:

Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level

4 Test Result

4.1 20dB and 99% Bandwidth Measurement

4.1.1 Limit of 20dB and 99% Bandwidth

None; for reporting purposes only.

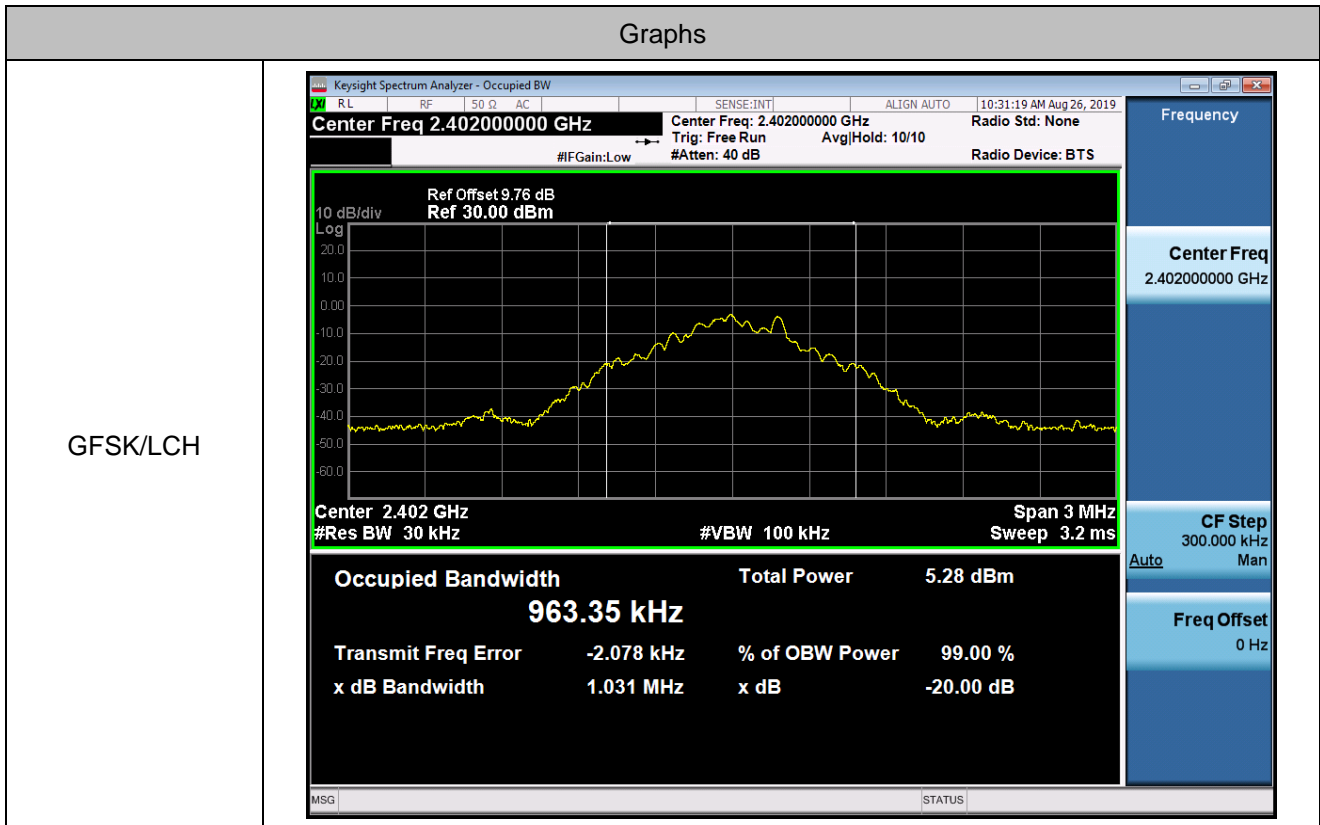
4.1.2 Test Procedures

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
3. 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 \geq 1% of the 20 dB bandwidth; VBW \geq RBW; Sweep = auto; Detector function = peak;
 - Trace = max hold.
4. 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 \geq 1% of the 99% bandwidth; VBW \geq RBW; Sweep = auto; Detector function = sample;
 - Trace = max hold.

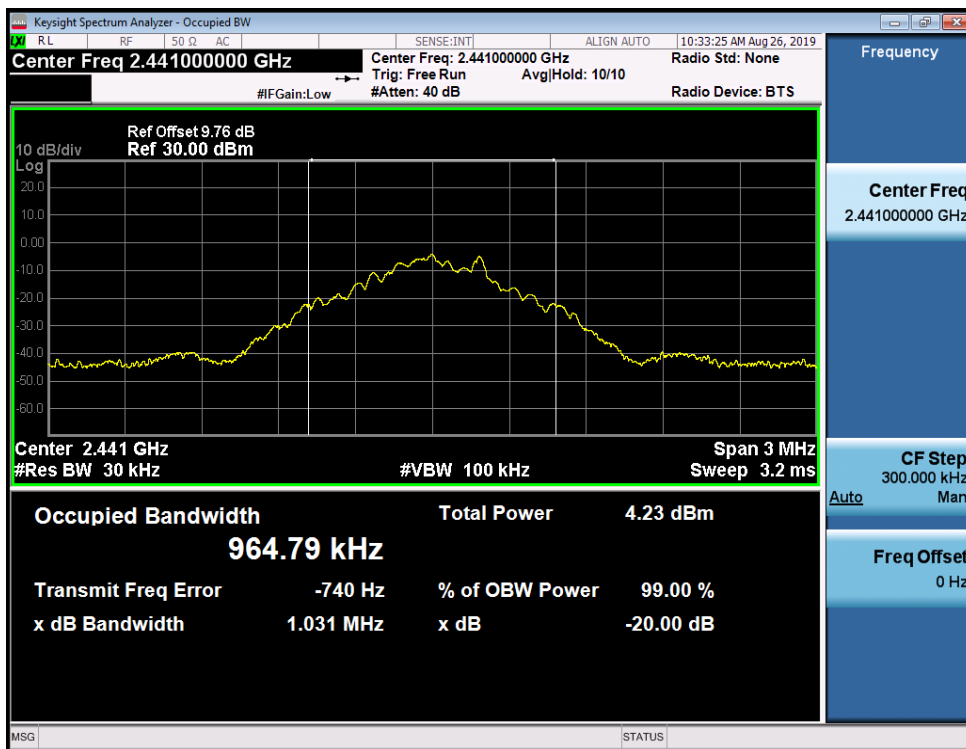
4.1.3 Test Result of 20dB Bandwidth and 99% Bandwidth

| Test Mode : | | Transmitting | Temperature : | 24~26°C | |
|-----------------|----------|----------------------|---------------------|---------|--|
| Test Engineer : | | Victorique Gao | Relative Humidity : | 50~53% | |
| Mode | Channel. | 20dB Bandwidth [MHz] | 99% OBW [MHz] | Verdict | |
| GFSK | LCH | 1.031 | 0.96335 | PASS | |
| GFSK | MCH | 1.028 | 0.96479 | PASS | |
| GFSK | HCH | 1.028 | 0.96296 | PASS | |

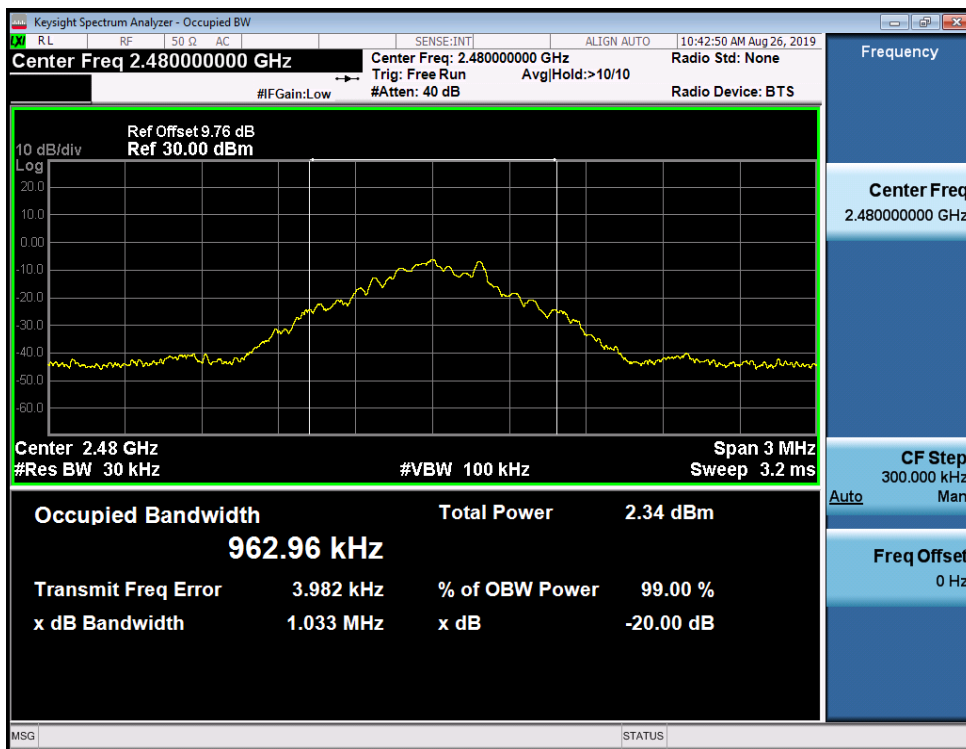
99% Bandwidth Plot



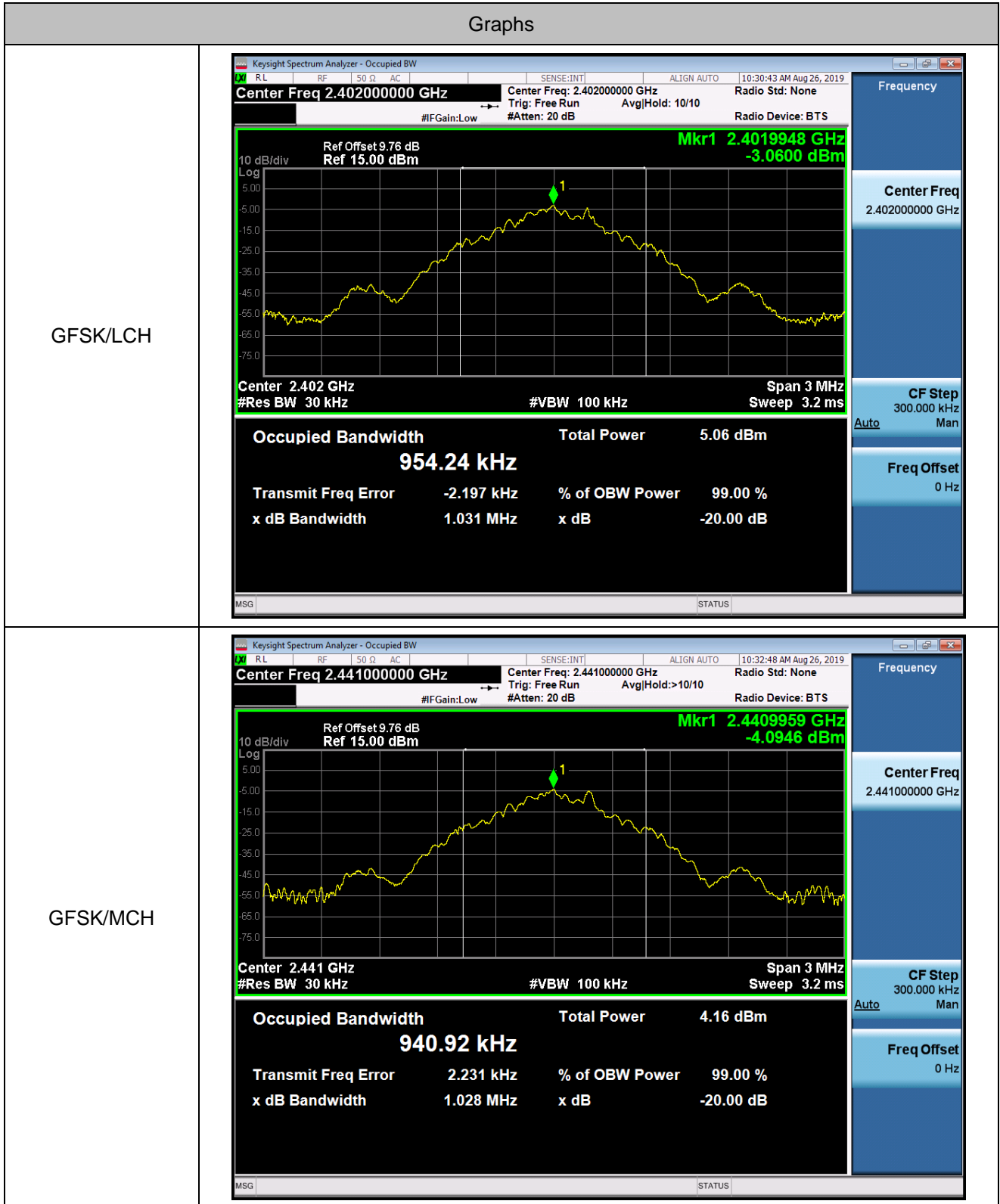
GFSK/MCH



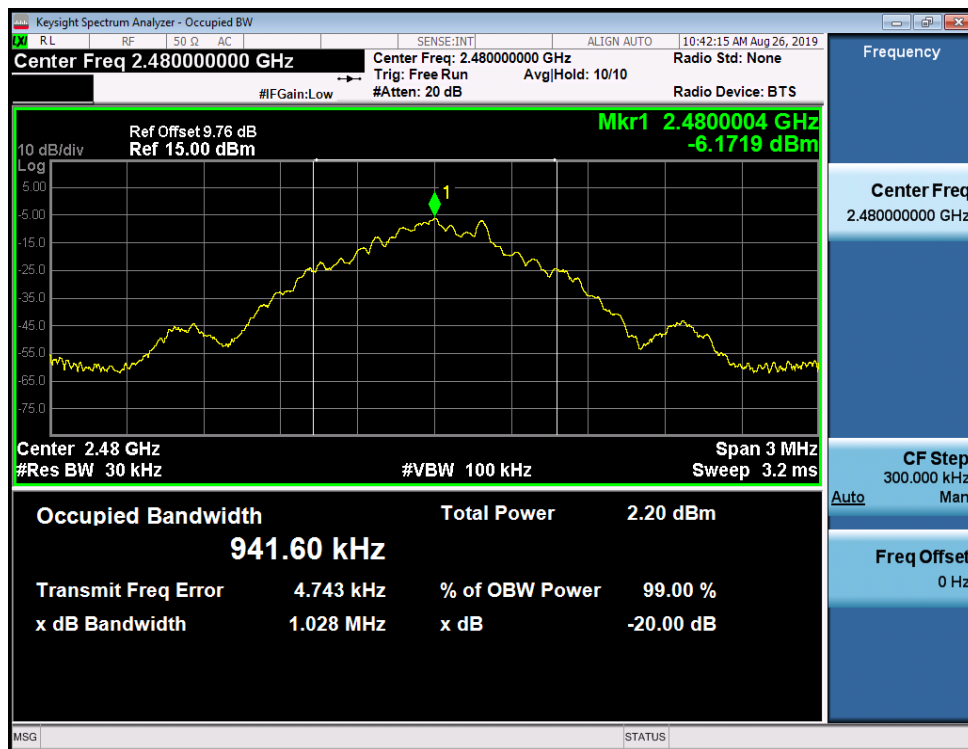
GFSK/HCH



20dB Bandwidth Plot



GFSK/HCH



4.2 Hopping Channel Separation Measurement

4.2.1 Limit of Hopping Channel Separation

FCC §15.247 (a) (1)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

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

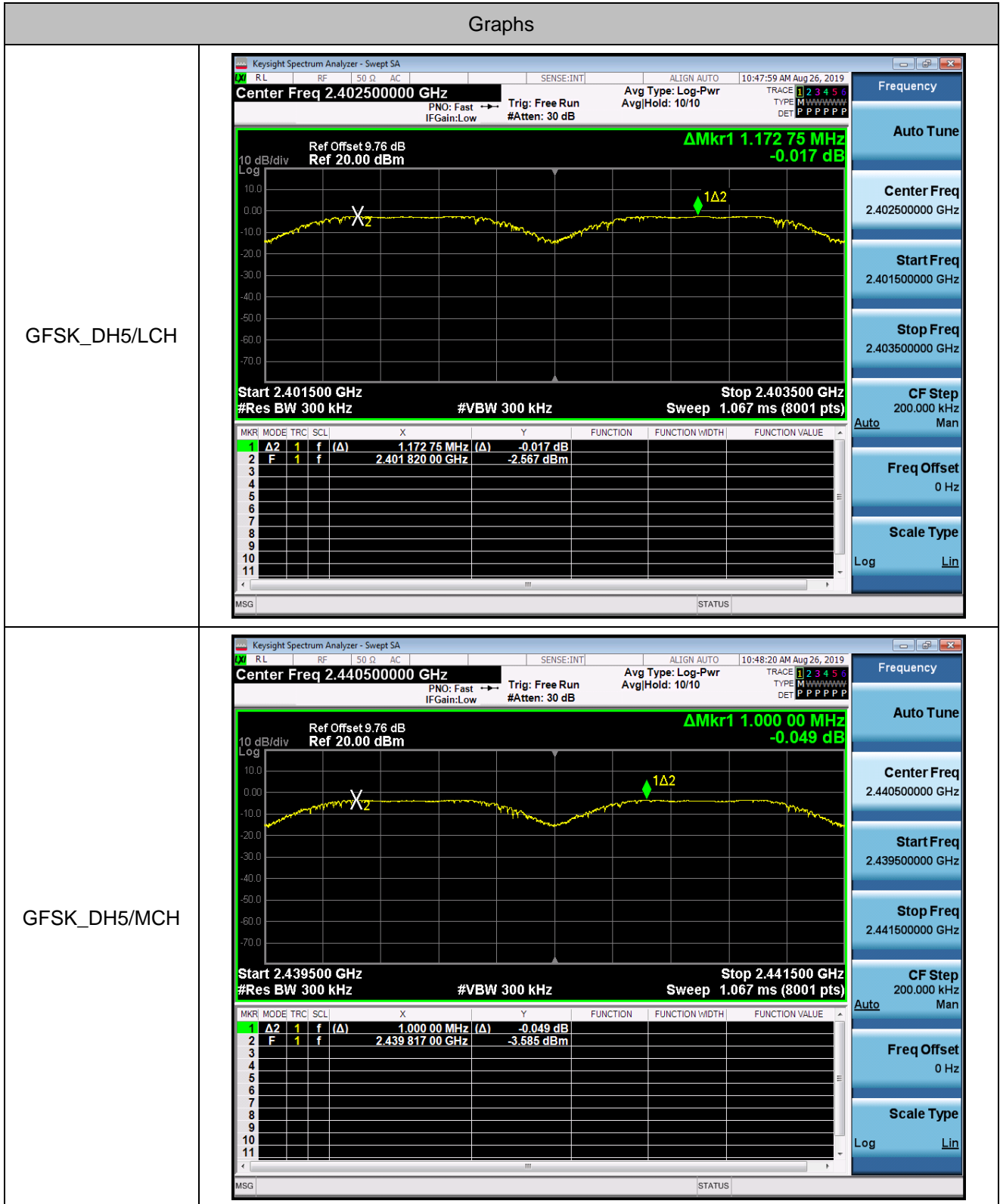
4.2.2 Test Procedures

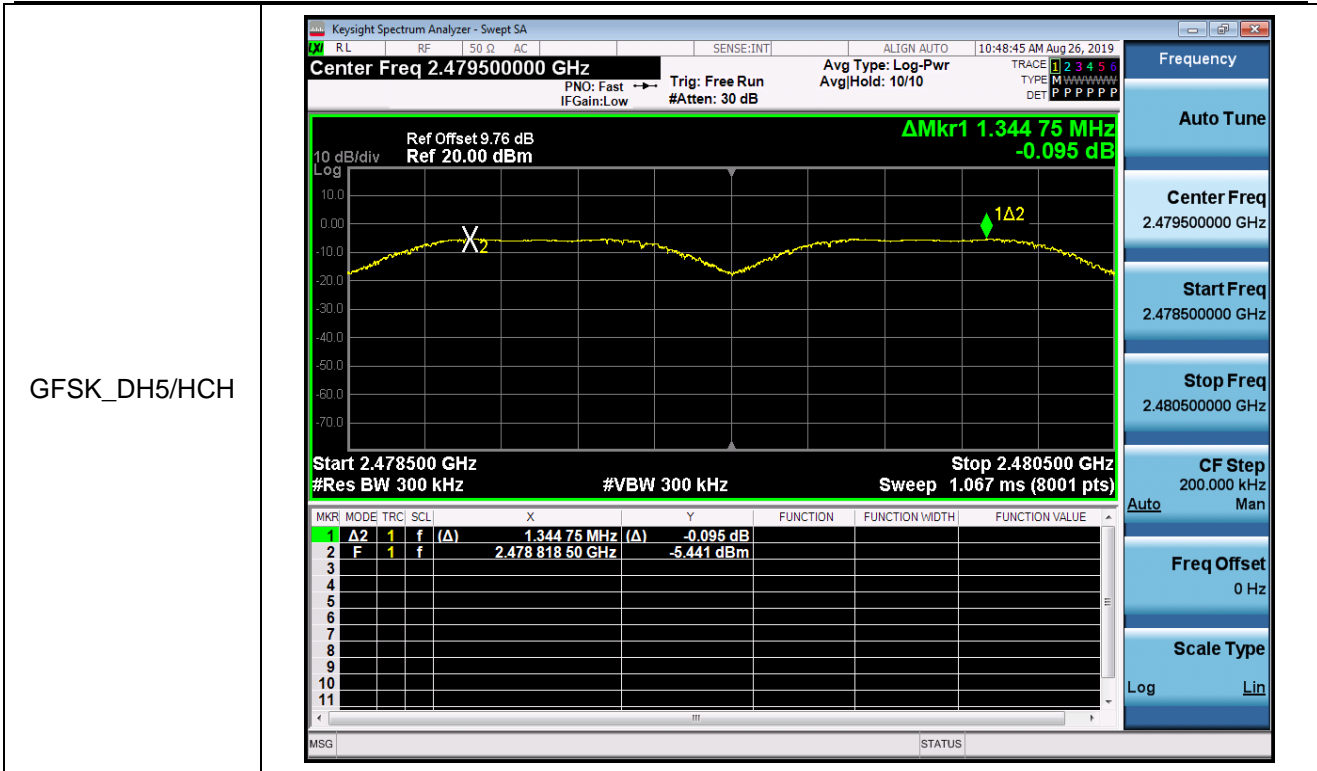
1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
3. The transmitter output is connected to a spectrum analyzer. The RBW is set to 300 kHz and the VBW is set to 300 kHz. The sweep time is coupled.

4.2.3 Test Result of Hopping Channel Separation

| Test Mode : | | Transmitting | Temperature : | 24~26°C |
|------------------------|----------|------------------------------------|----------------------------|---------|
| Test Engineer : | | Victorique Gao | Relative Humidity : | 50~53% |
| Mode | Channel. | Carrier Frequency Separation [MHz] | | Verdict |
| GFSK_DH5 | LCH | 1.173 | | PASS |
| GFSK_DH5 | MCH | 1.000 | | PASS |
| GFSK_DH5 | HCH | 1.345 | | PASS |

Hopping Frequency Separation Plot





4.3 Number of Channel Measurement

4.3.1 Limits of Number of Hopping Frequency

FCC§15.247(a)(1)(iii)

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

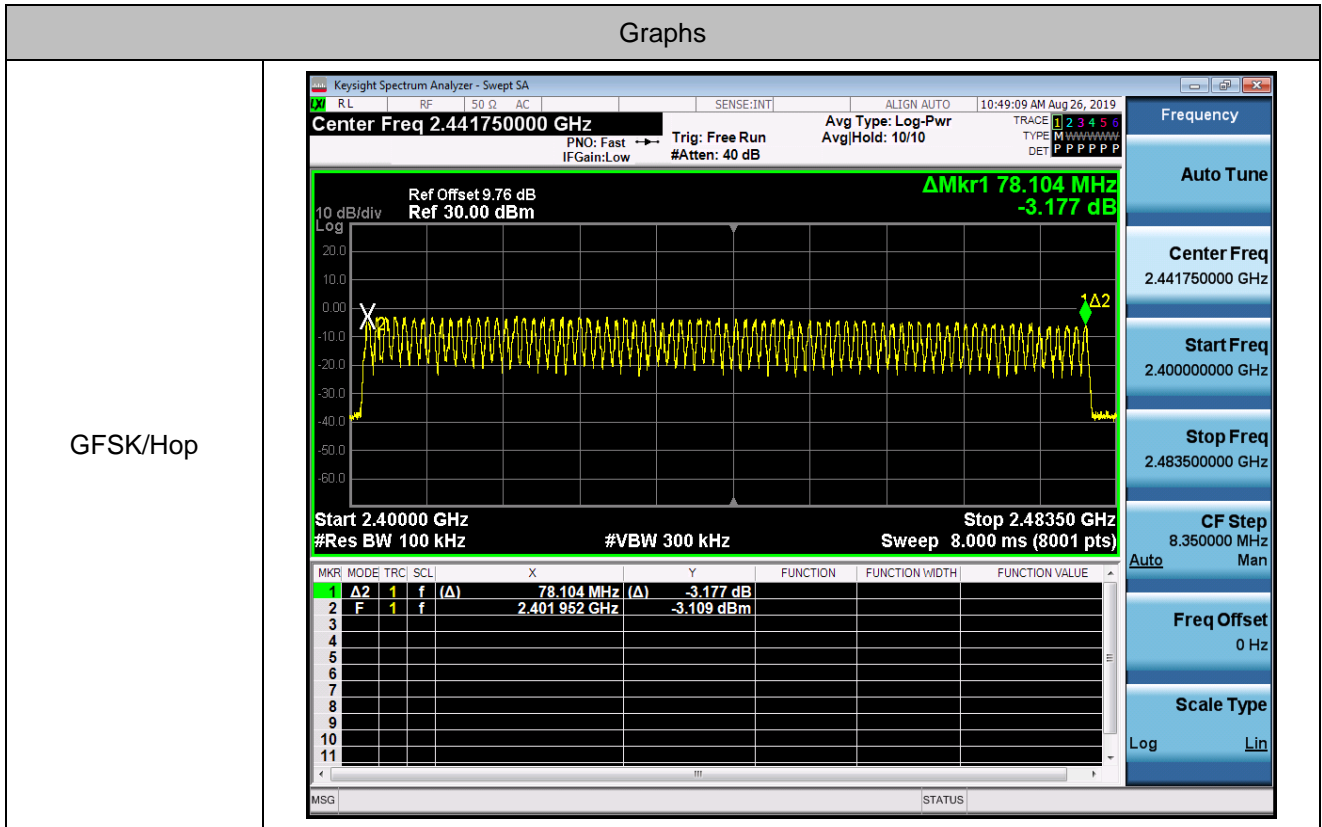
4.3.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
3. The transmitter output is connected to a spectrum analyzer. The span is set to cover the entire authorized band, in either a single sweep or in multiple contiguous sweeps. The RBW is set to a maximum of 1 % of the span. The analyzer is set to Max Hold.

4.3.3 Test Result of Number of Hopping Frequency

| | | | |
|------------------------|-----------------|----------------------------------|----------------|
| Test Mode : | Transmitting | Temperature : | 24~26°C |
| Test Engineer : | Victorique Gao | Relative Humidity : | 50~53% |
| Mode | Channel. | Number of Hopping Channel | Verdict |
| GFSK | Hop | 79 | PASS |

Number of Hopping Channels



4.4 Average Time of Occupancy Measurement

4.4.1 Limit of Average Time of Occupancy

FCC §15.247 (a) (1) (iii)

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.

4.4.2 Test Procedures

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
3. The transmitter output is connected to a spectrum analyzer. The span is set to 0 Hz, centered on a single, selected hopping channel. The width of a single pulse is measured in a fast scan. The number of pulses is measured in a 3.16 second scan, to enable resolution of each occurrence.
4. The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the period specified in the requirements.

The test period: $T = 0.4 \text{ Second/Channel} \times 79 \text{ Channel} = 31.6 \text{ s}$

Test channel: 2441MHz as blow:

DH1 time slot= Burst Width (ms)*(1600/ (2*79))*31.6

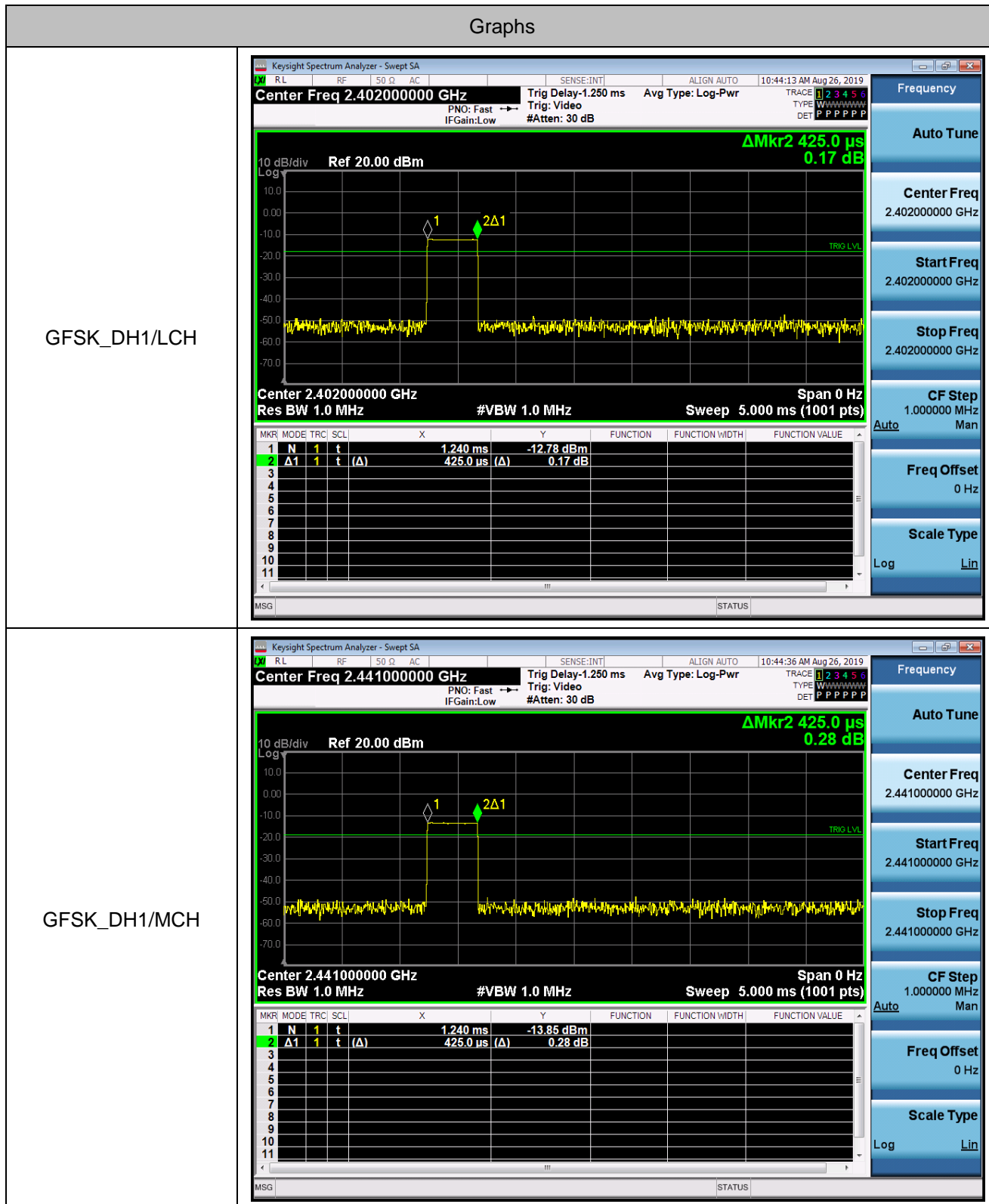
DH3 time slot= Burst Width (ms)*(1600/ (4*79))*31.6

DH5 time slot= Burst Width (ms)*(1600/ (6*79))*31.6

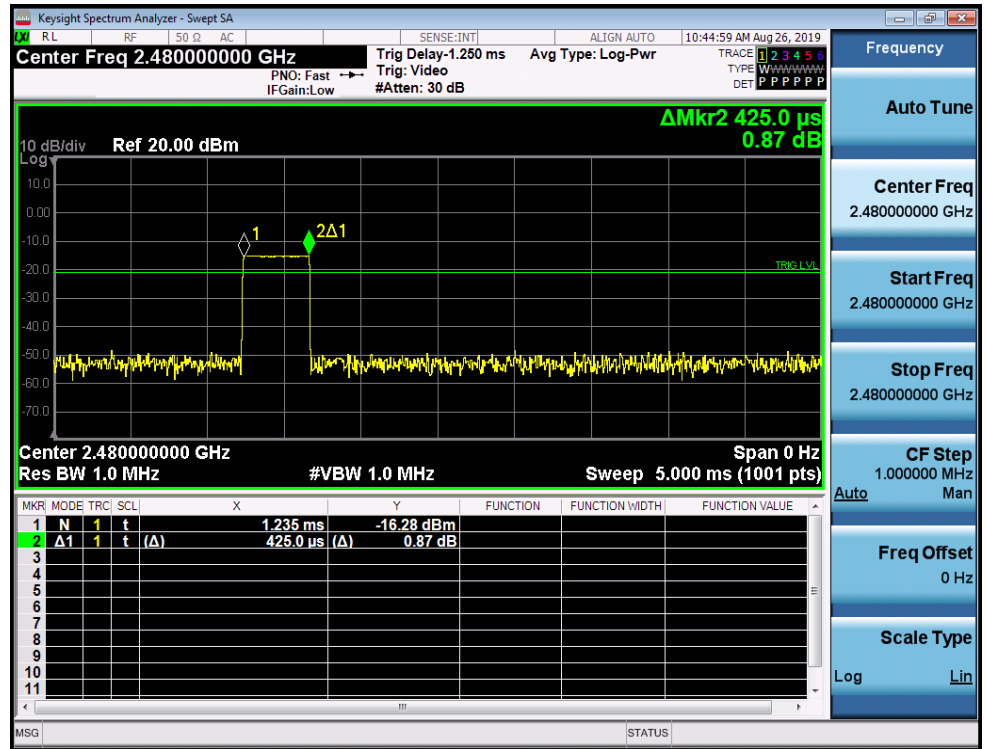
4.4.3 Test Result of Dwell Time

| Test Mode : | | Transmitting | | Temperature : | | 24~26°C | |
|------------------------|--------|----------------|----------------------------|----------------------------|---------------|---------|--|
| Test Engineer : | | Victorique Gao | | Relative Humidity : | | 50~53% | |
| Mode | Packet | Channel | Burst Width [ms/hop/ch] | Total Hops[hop*ch] | Dwell Time[s] | Verdict | |
| GFSK | DH1 | LCH | 0.43 | 320 | 0.138 | PASS | |
| GFSK | DH1 | MCH | 0.43 | 320 | 0.138 | PASS | |
| GFSK | DH1 | HCH | 0.43 | 320 | 0.138 | PASS | |
| GFSK | DH3 | LCH | 1.67 | 160 | 0.267 | PASS | |
| GFSK | DH3 | MCH | 1.67 | 160 | 0.267 | PASS | |
| GFSK | DH3 | HCH | 1.67 | 160 | 0.267 | PASS | |
| GFSK | DH5 | LCH | 2.91 | 106.67 | 0.31 | PASS | |
| GFSK | DH5 | MCH | 2.91 | 106.67 | 0.31 | PASS | |
| GFSK | DH5 | HCH | 2.91 | 106.67 | 0.31 | PASS | |

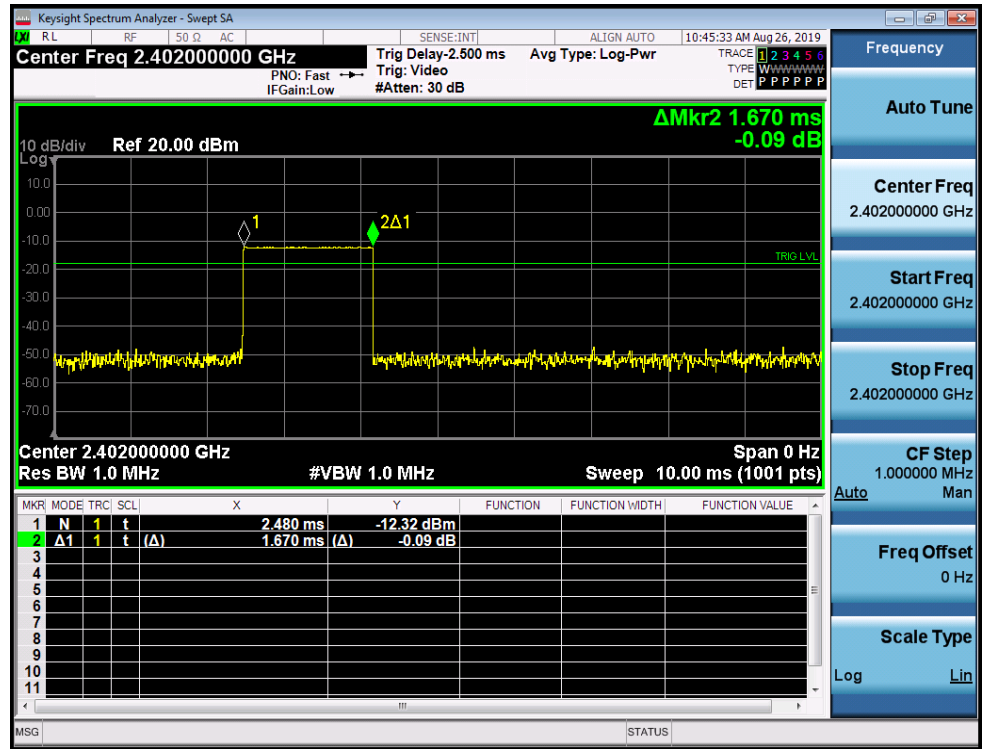
The Average Time of Occupancy Plot



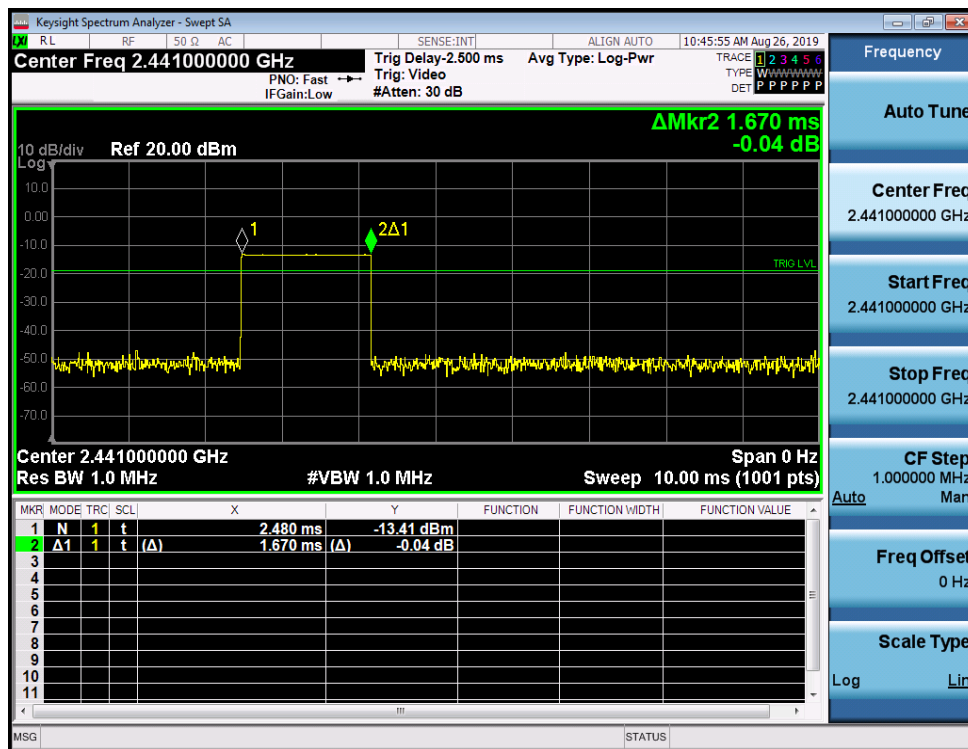
GFSK_DH1/HCH



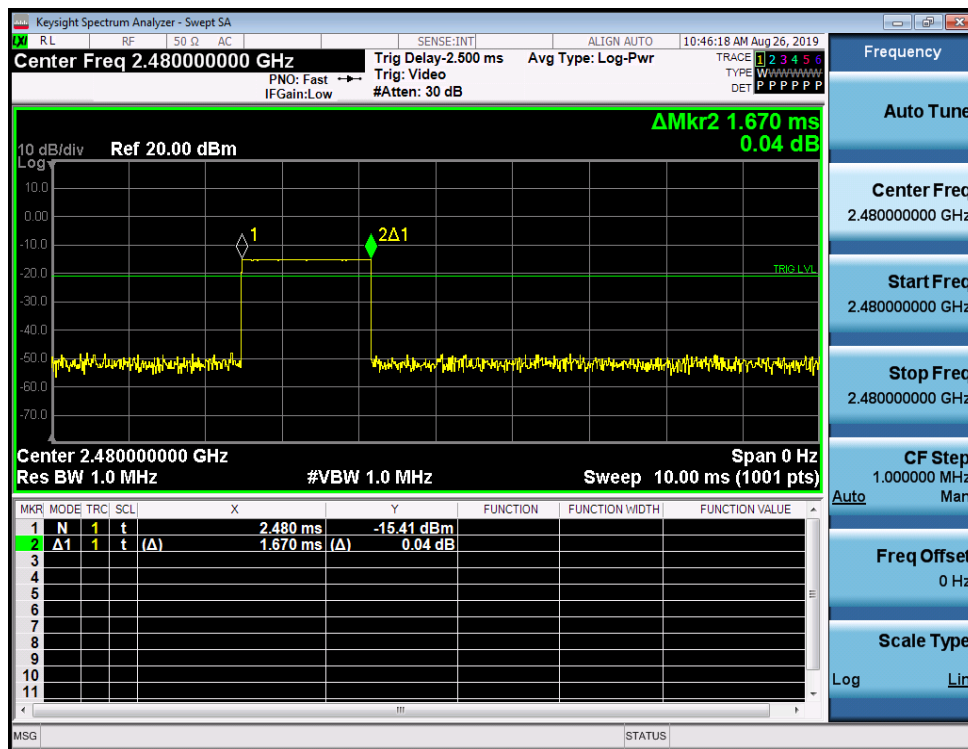
GFSK_DH3/LCH



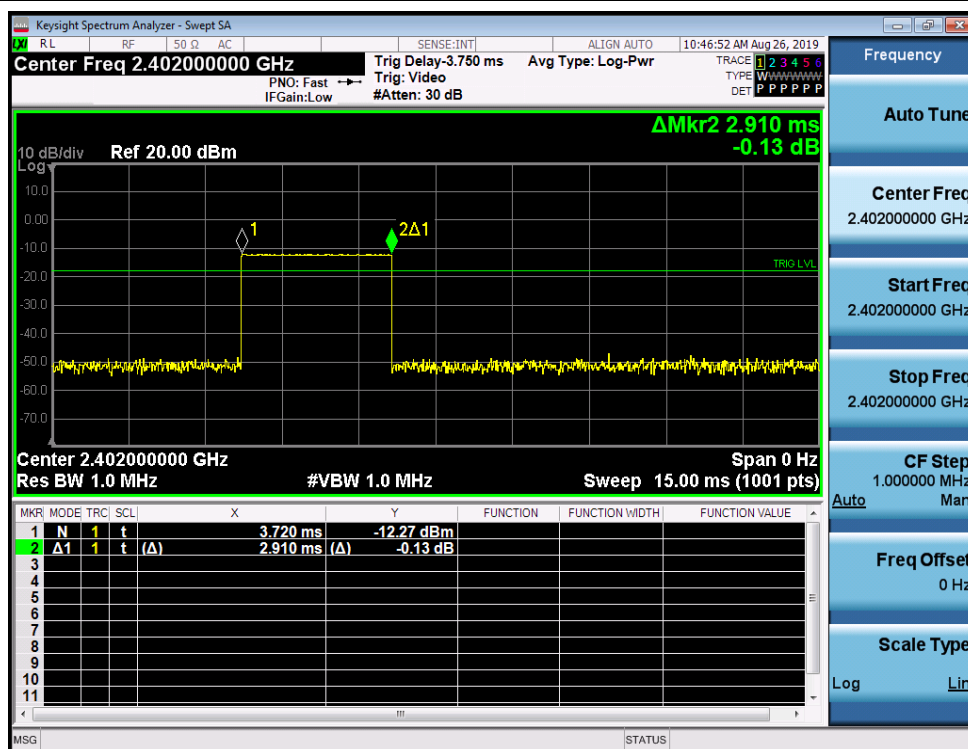
GFSK_DH3/MCH



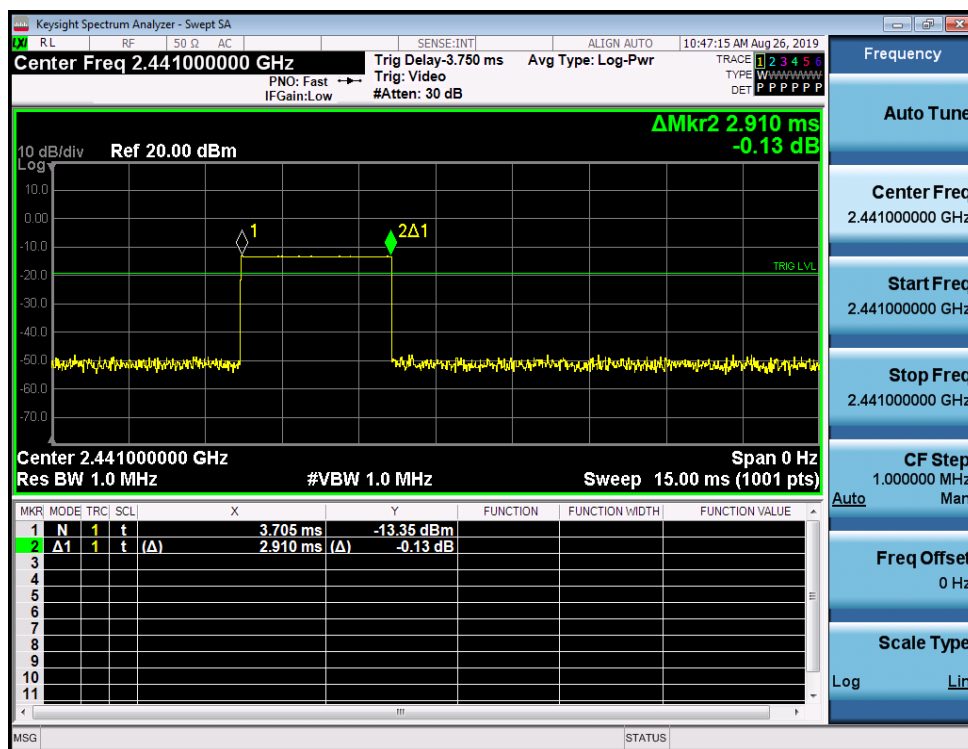
GFSK_DH3/HCH



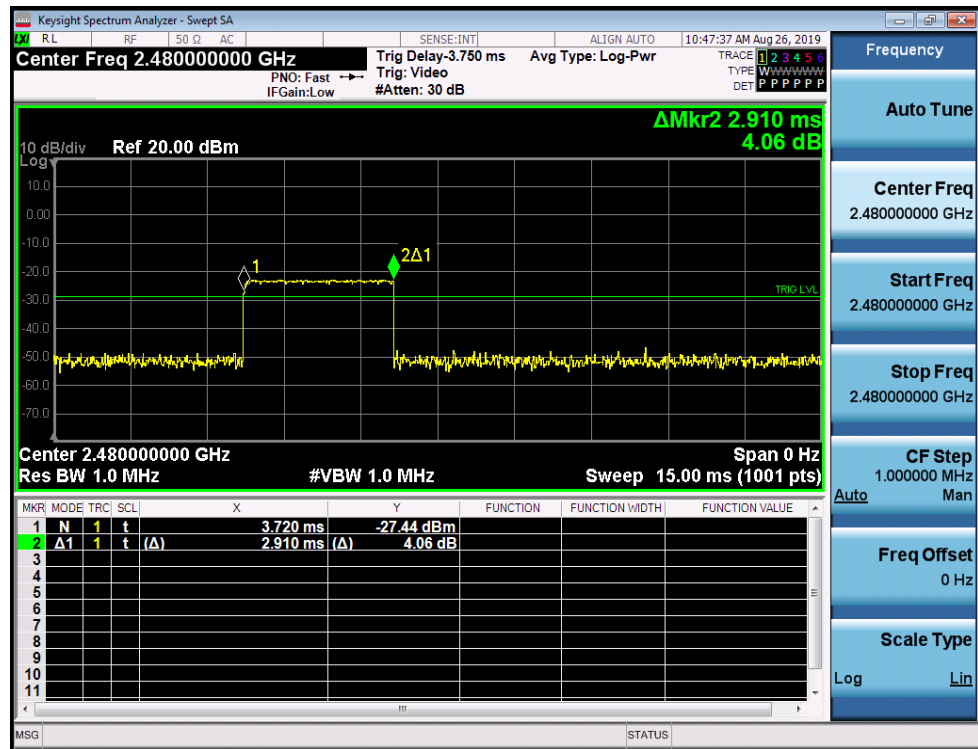
GFSK_DH5/LCH



GFSK_DH5/MCH



GFSK_DH5/HCH



4.5 Peak Output Power Measurement

4.5.1 Limit of Peak Output Power

Section 15.247 (b) 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.

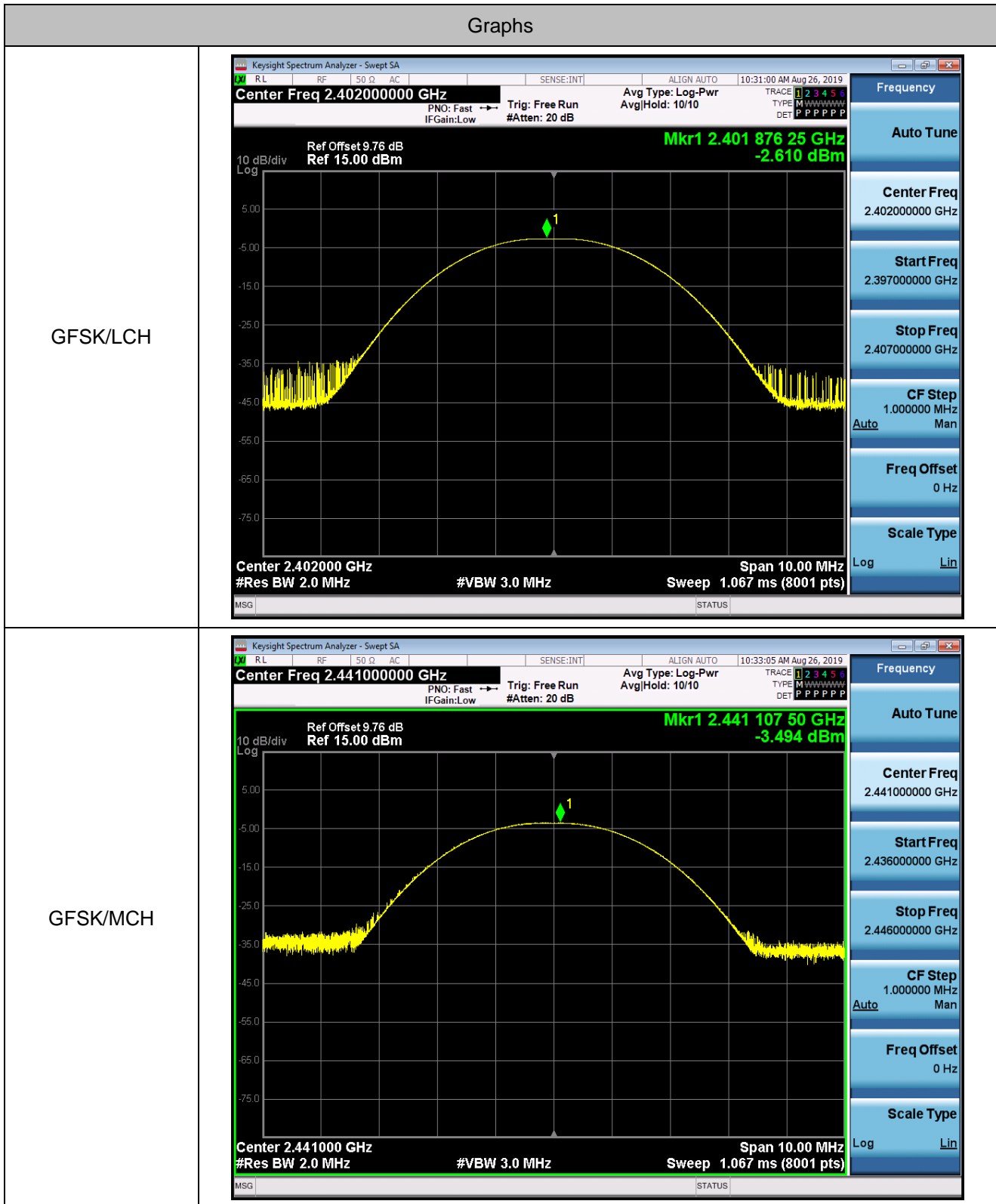
4.5.2 Test Procedures

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
3. The transmitter output is connected to a spectrum analyzer the analyzer bandwidth is set to a value greater than the 20 dB bandwidth of the EUT.

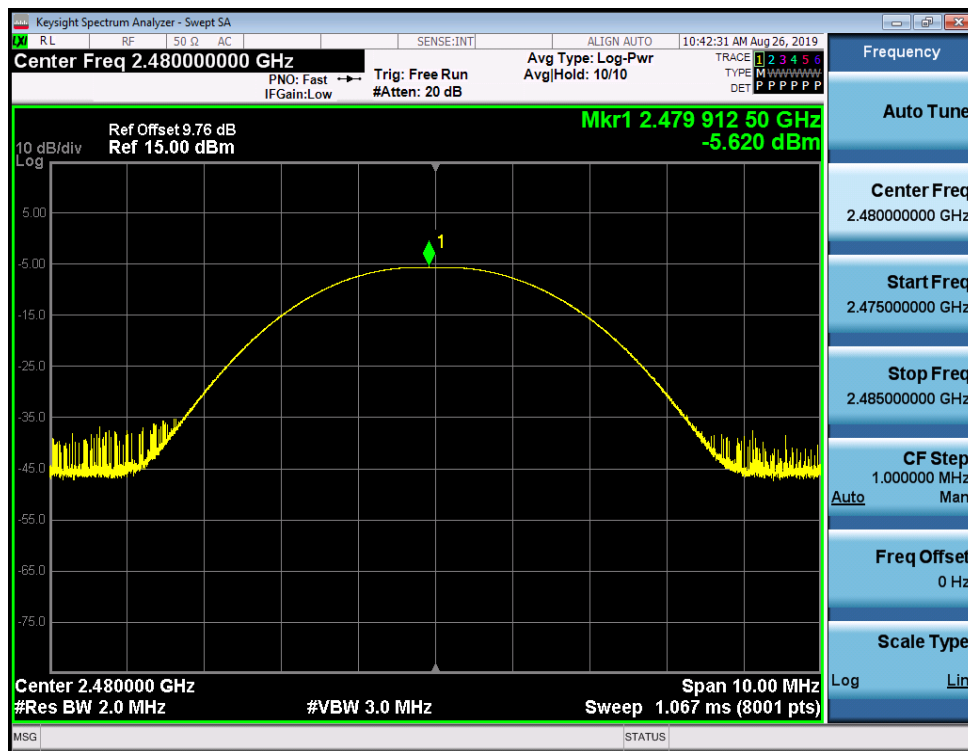
4.5.3 Test Result of Peak Output Power

| Test Mode : | Transmitting | Temperature : | 24~26°C |
|------------------------|----------------|---------------------------------|---------|
| Test Engineer : | Victorique Gao | Relative Humidity : | 50~53% |
| Mode | Channel. | Maximum Peak Output Power [dBm] | Verdict |
| GFSK | LCH | -2.610 | PASS |
| GFSK | MCH | -3.494 | PASS |
| GFSK | HCH | -5.620 | PASS |

Peak Output Power Polt



GFSK/HCH



4.6 Conducted Band Edges Measurement

4.6.1 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.

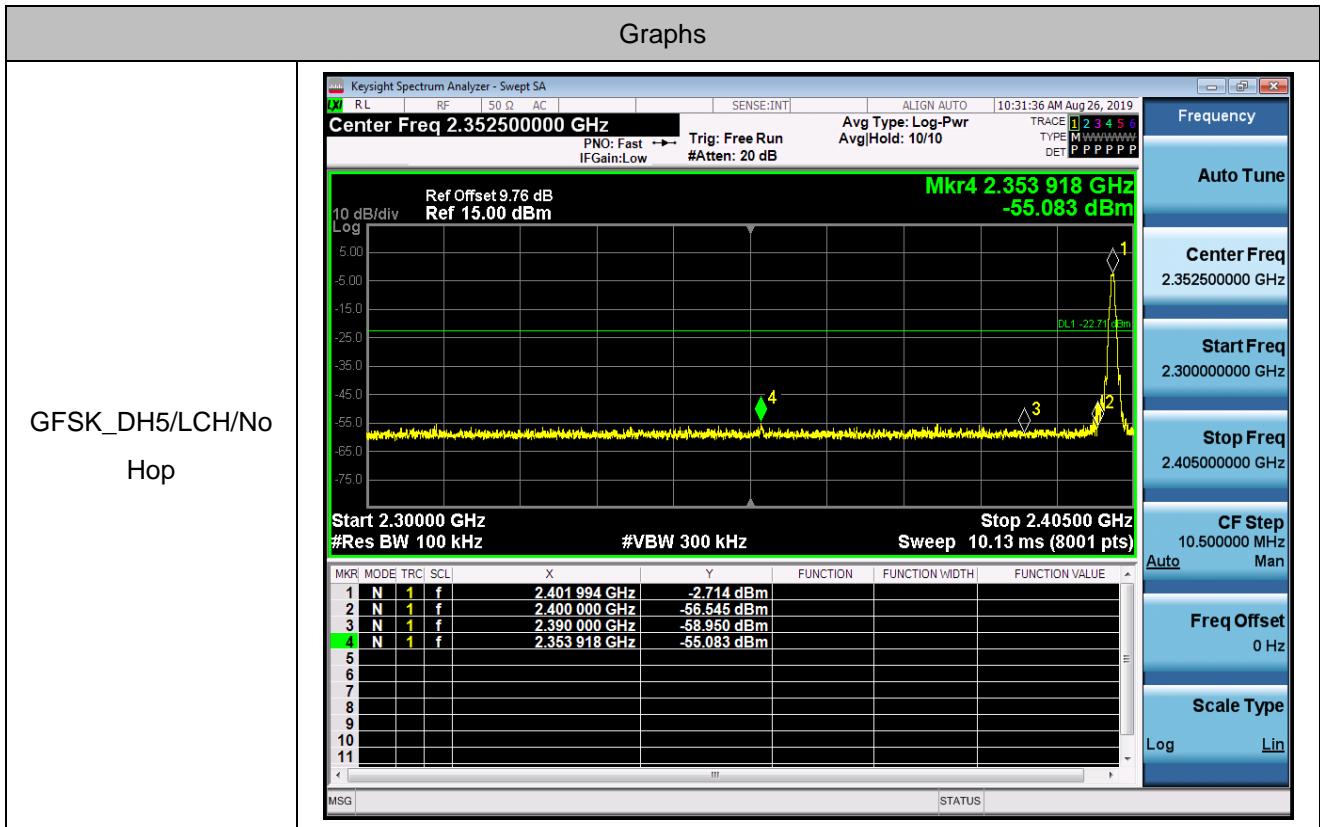
4.6.2 Test Procedures

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
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 1~3.

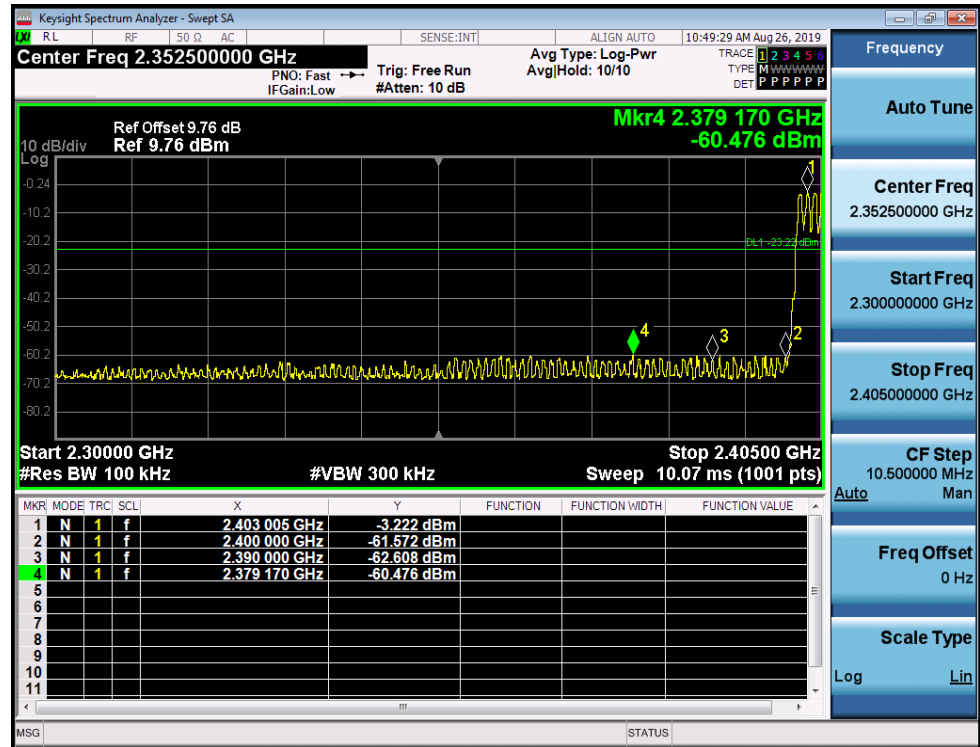
4.6.3 Test Result of Conducted Band Edges

| Test Mode : | | Transmitting | | Temperature : | | 24~26°C | |
|-----------------|---------|-------------------------|---------------------|---------------------|--------------------------|-------------|---------|
| Test Engineer : | | Victorique Gao | | Relative Humidity : | | 50~53% | |
| Mode | Channel | Carrier Frequency [MHz] | Carrier Power [dBm] | Frequency Hopping | Max Spurious Level [dBm] | Limit [dBm] | Verdict |
| GFSK_DH5 | LCH | 2402 | -2.714 | Off | -55.083 | -22.71 | PASS |
| | | | -3.222 | On | -60.476 | -23.22 | PASS |
| GFSK_DH5 | HCH | 2480 | -5.738 | Off | -56.314 | -25.74 | PASS |
| | | | -5.660 | On | -62.558 | -25.66 | PASS |

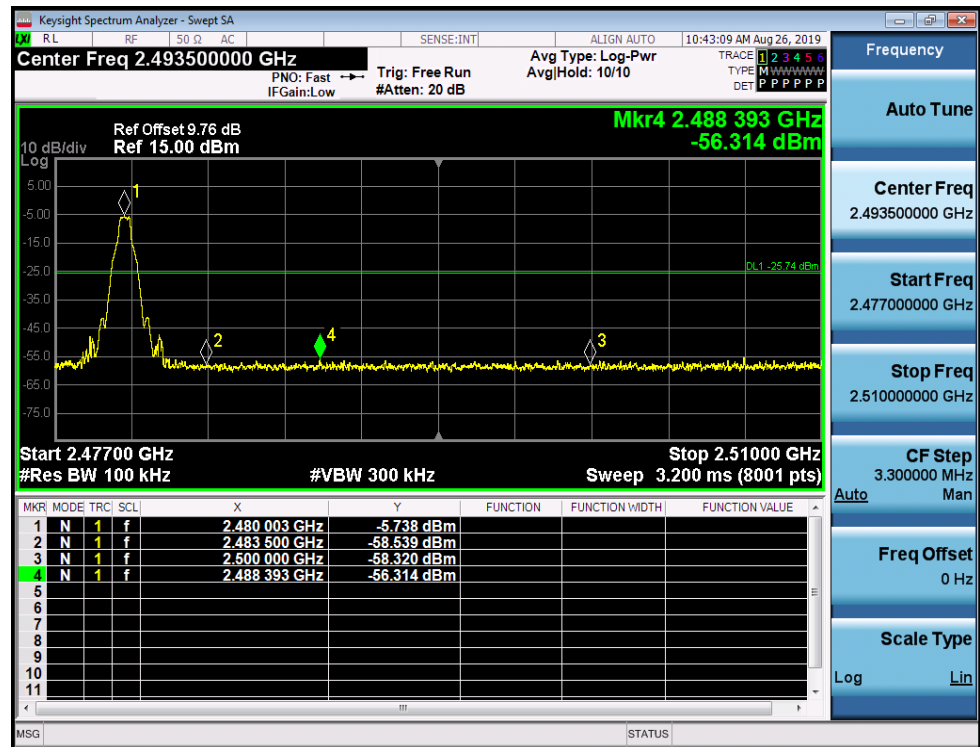
Conducted Band Edge Polt



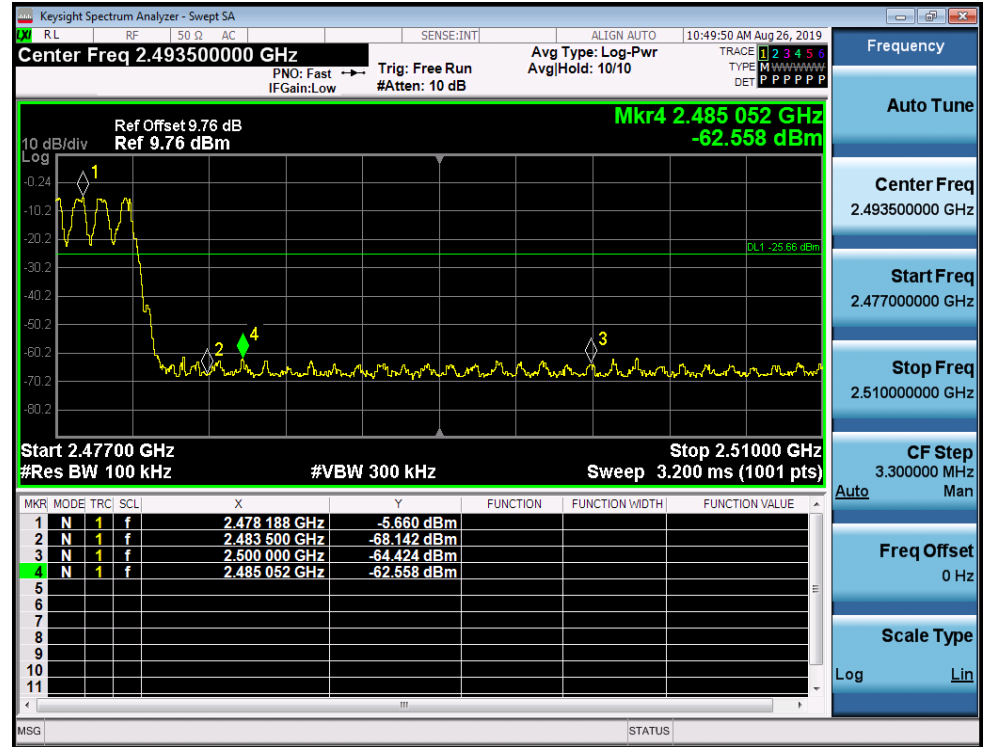
GFSK_DH5/LCH/Hop



GFSK_DH5/HCH/No Hop



GFSK_DH5/HCH/Hop



4.7 Conducted Spurious Emission Measurement

4.7.1 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.

4.7.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
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. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.

4.7.3 Test Result of Conducted Spurious Emission

| Test Mode : | Transmitting | Temperature : | 24~26°C | |
|------------------------|----------------|----------------------------|----------|---------|
| Test Engineer : | Victorique Gao | Relative Humidity : | 50~53% | |
| Mode | Channel | Pref [dBm] | Puw[dBm] | Verdict |
| GFSK | LCH | -2.688 | <Limit | PASS |
| GFSK | MCH | -3.722 | <Limit | PASS |
| GFSK | HCH | -5.741 | <Limit | PASS |

Conducted Spurious Emission Polt

GFSK_DH5_LCH_Graphs

Pref



Puw



GFSK_DH5_MCH_Graphs

Pref



Puw



GFSK_DH5_HCH_Graphs

Pref



Puw



4.8 Radiated Band Edges and Spurious Emission Measurement

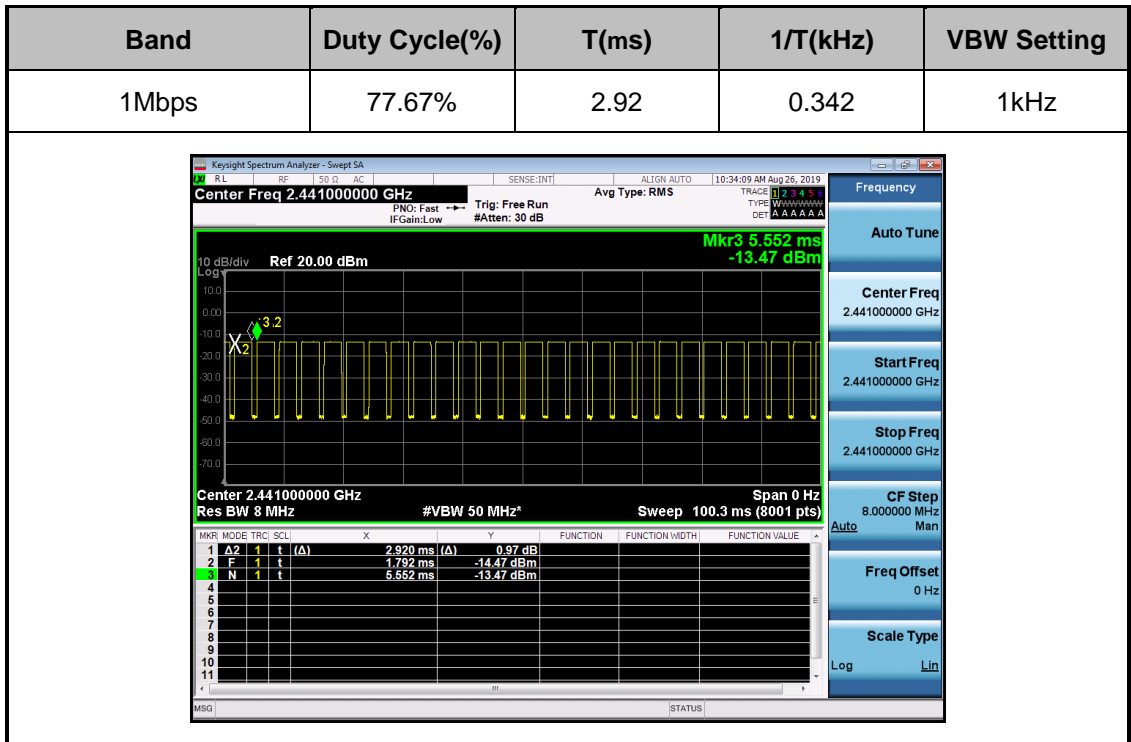
4.8.1 Limit of Radiated Band Edges and Spurious Emission

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 FCC section 15.209 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 |

4.8.2 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 measurement distance is 3 meter.
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 $f > 1$ GHz ; VBW = RBW; Sweep = auto; Detector function = peak; Trace = max hold for peak
 - (3) For average measurement:
 VBW = 10 Hz, when duty cycle is no less than 98 percent.
 VBW $\geq 1/T$, when duty cycle is less than 98 percent where T is the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.

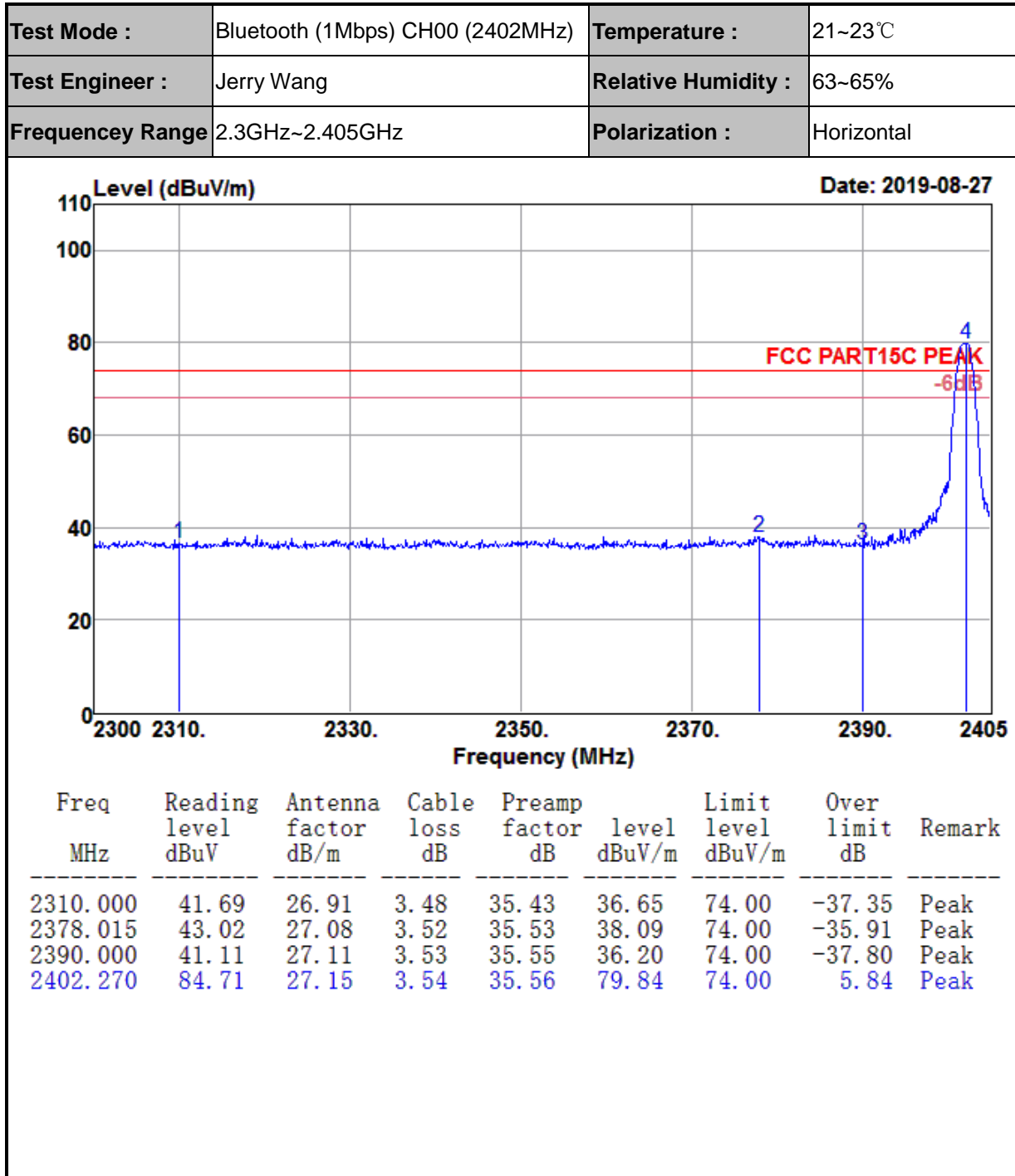


6. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level

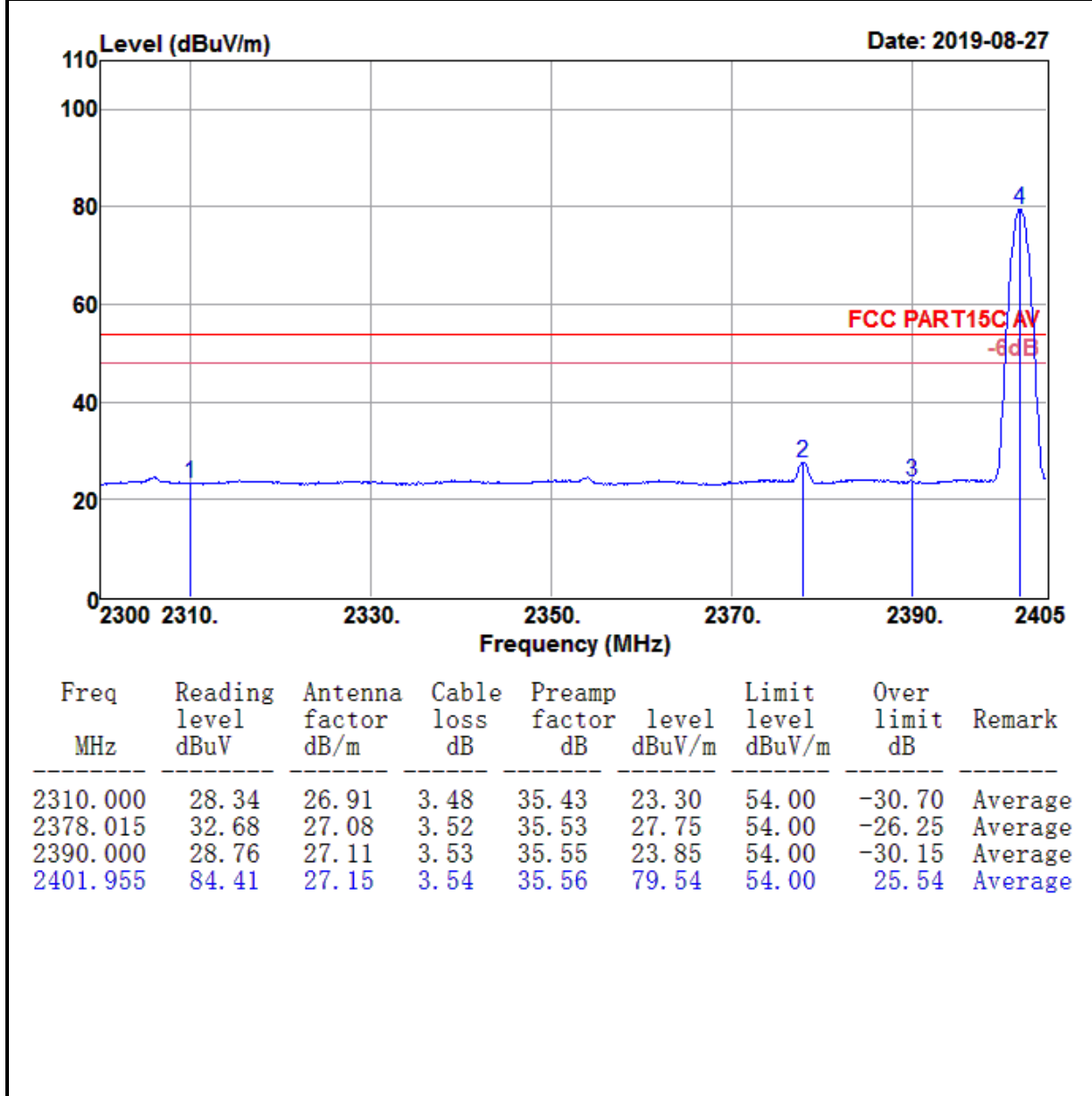
4.8.3 Test Results of Radiated Spurious Emissions (9 kHz ~ 30 MHz)

The low frequency, which started from 9 kHz to 30MHz, was pre-scanned and the result which was 20dB lower than the limit line per 15.31(o) was not reported.

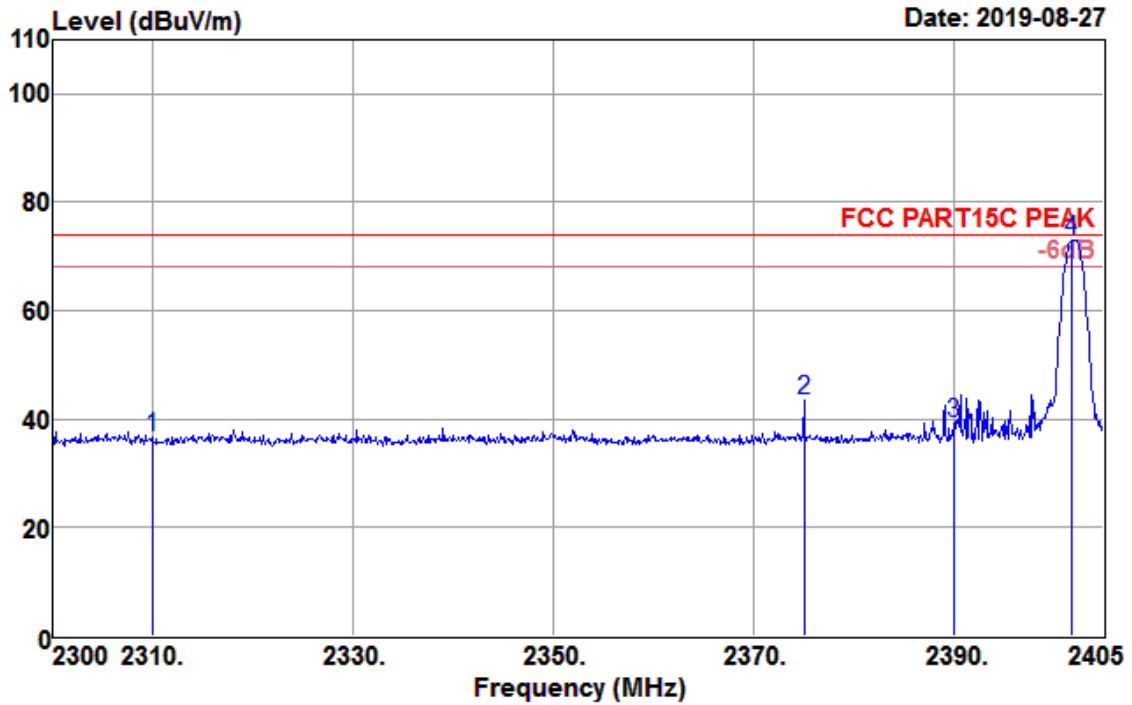
4.8.4 Test Result of Radiated Spurious at Band Edges



| | | | |
|------------------------|----------------------------------|----------------------------|------------|
| Test Mode : | Bluetooth (1Mbps) CH00 (2402MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 2.3GHz~2.405GHz | Polarization : | Horizontal |

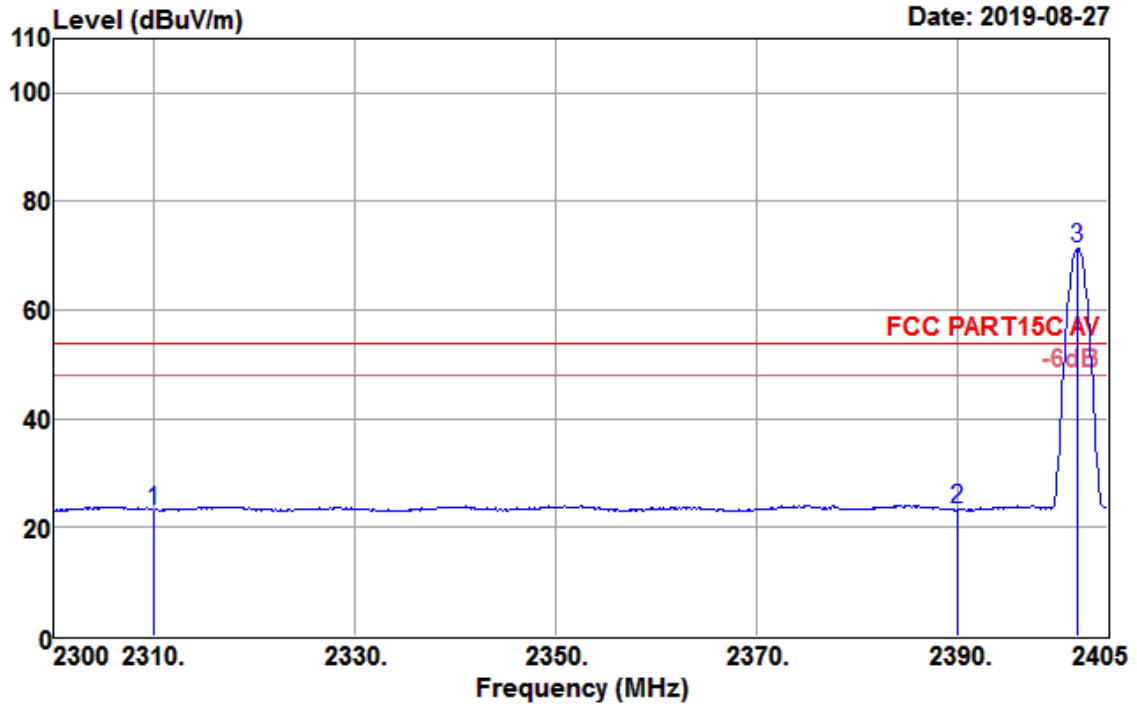


| | | | |
|------------------------|----------------------------------|----------------------------|----------|
| Test Mode : | Bluetooth (1Mbps) CH00 (2402MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 2.3GHz~2.405GHz | Polarization : | Vertical |



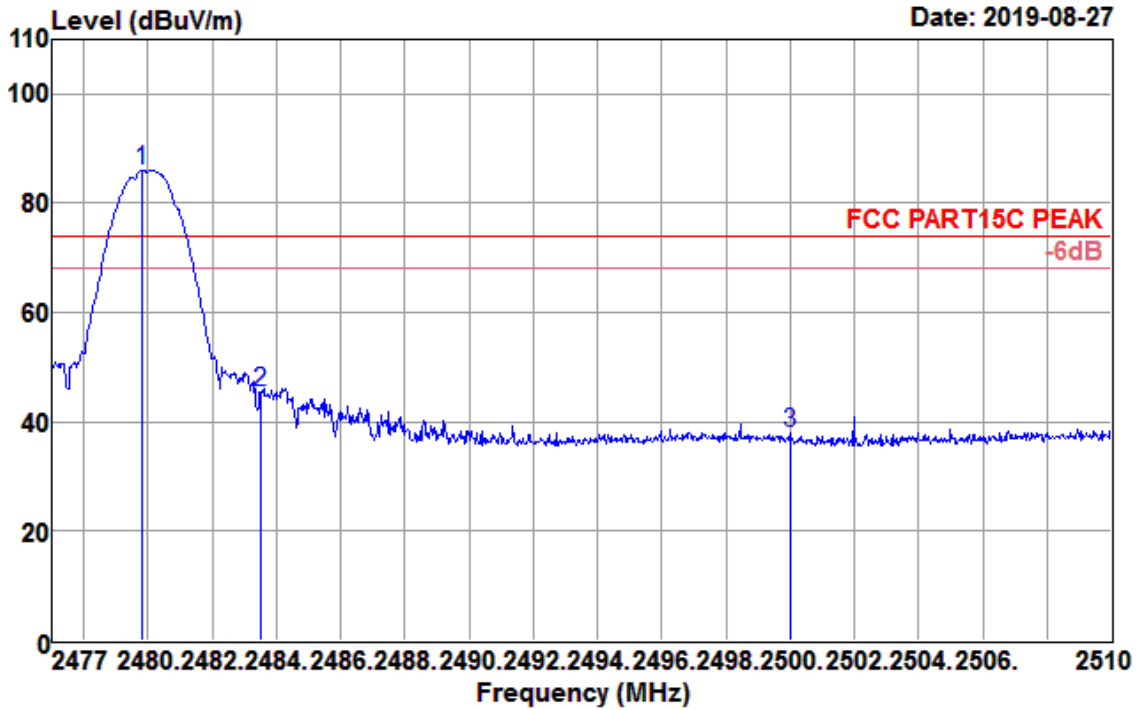
| Freq MHz | Reading level dBuV | Antenna factor dB/m | Cable loss dB | Preamp factor dB | level dBuV/m | Limit level dBuV/m | Over limit dB | Remark |
|-------------|--------------------------|---------------------------|---------------------|------------------------|-----------------|--------------------------|---------------------|--------|
| 2310.000 | 41.65 | 26.91 | 3.48 | 35.43 | 36.61 | 74.00 | -37.39 | Peak |
| 2375.075 | 48.40 | 27.08 | 3.52 | 35.53 | 43.47 | 74.00 | -30.53 | Peak |
| 2390.000 | 44.21 | 27.11 | 3.53 | 35.55 | 39.30 | 74.00 | -34.70 | Peak |
| 2401.850 | 77.98 | 27.14 | 3.54 | 35.56 | 73.10 | 74.00 | -0.90 | Peak |

| | | | |
|------------------------|----------------------------------|----------------------------|----------|
| Test Mode : | Bluetooth (1Mbps) CH00 (2402MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 2.3GHz~2.405GHz | Polarization : | Vertical |



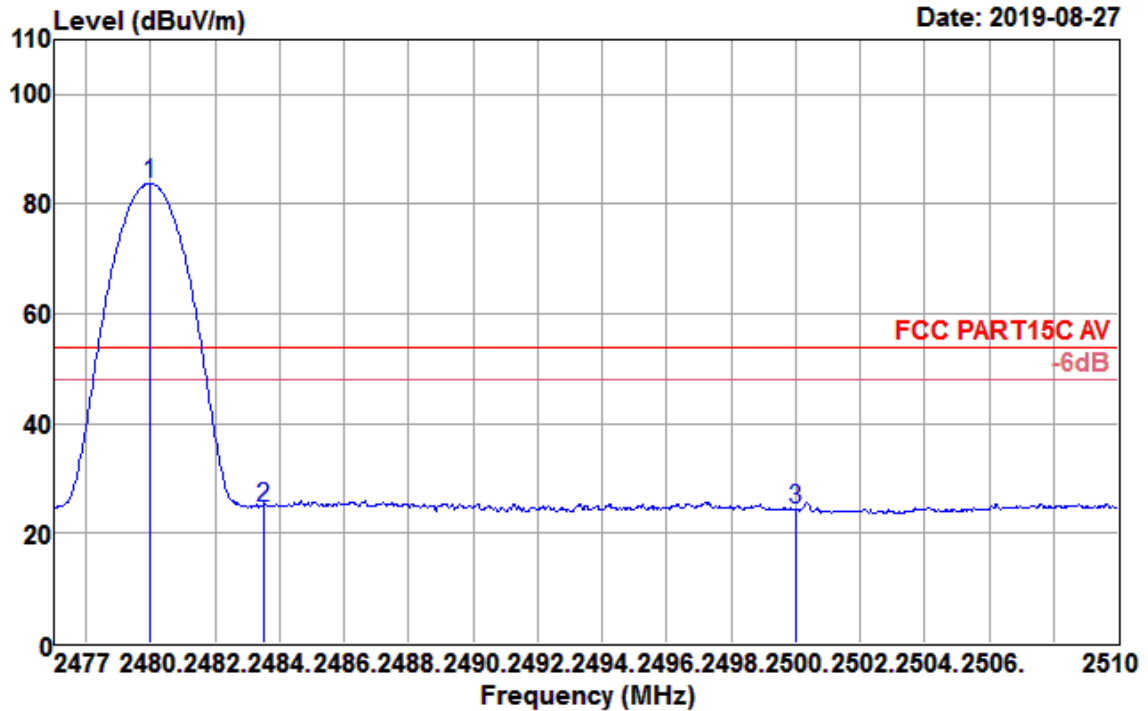
| Freq MHz | Reading level dBUV | Antenna factor dB/m | Cable loss dB | Preamp factor dB | level dBUV/m | Limit level dBUV/m | Over limit dB | Remark |
|-------------|--------------------------|---------------------------|---------------------|------------------------|-----------------|--------------------------|---------------------|---------|
| 2310.000 | 28.21 | 26.91 | 3.48 | 35.43 | 23.17 | 54.00 | -30.83 | Average |
| 2390.000 | 28.13 | 27.11 | 3.53 | 35.55 | 23.22 | 54.00 | -30.78 | Average |
| 2402.060 | 76.20 | 27.15 | 3.54 | 35.56 | 71.33 | 54.00 | 17.33 | Average |

| | | | |
|------------------------|----------------------------------|----------------------------|------------|
| Test Mode : | Bluetooth (1Mbps) CH78 (2480MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 2.477GHz~2.510GHz | Polarization : | Horizontal |



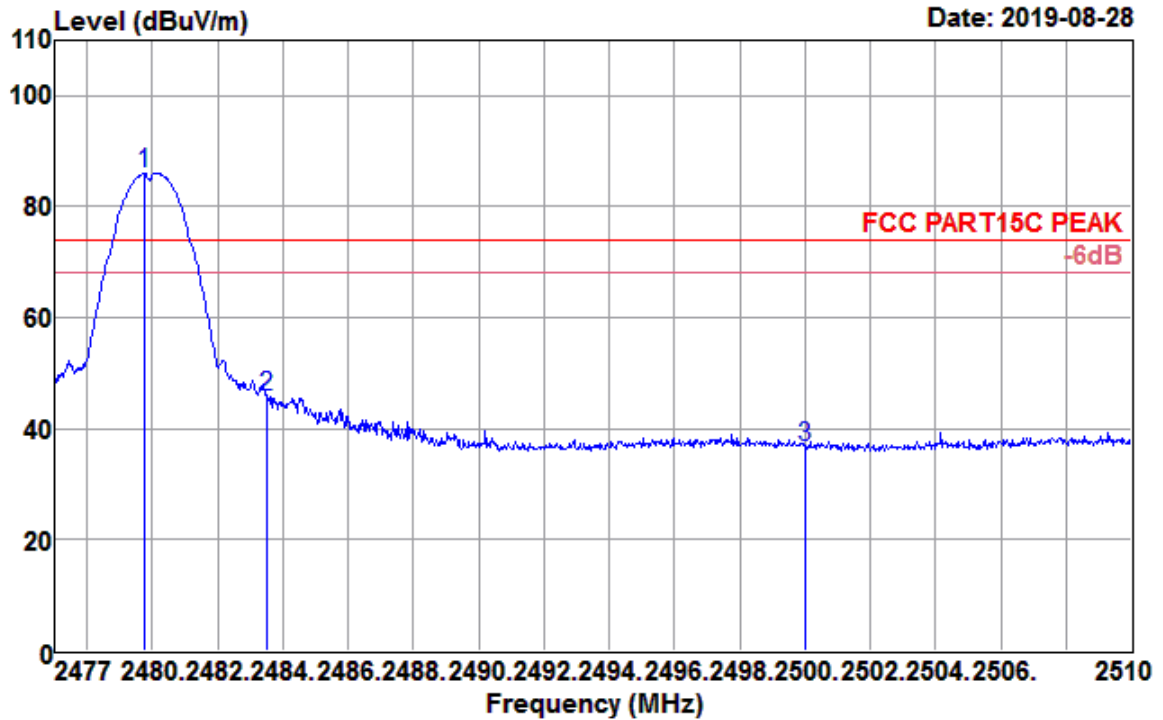
| Freq MHz | Reading level dBuV | Antenna factor dB/m | Cable loss dB | Preamp factor dB | level dBuV/m | Limit level dBuV/m | Over limit dB | Remark |
|-------------|--------------------------|---------------------------|---------------------|------------------------|-----------------|--------------------------|---------------------|--------|
| 2479.805 | 90.62 | 27.35 | 3.59 | 35.67 | 85.89 | 74.00 | 11.89 | Peak |
| 2483.501 | 50.10 | 27.36 | 3.59 | 35.68 | 45.37 | 74.00 | -28.63 | Peak |
| 2500.000 | 42.56 | 27.40 | 3.60 | 35.70 | 37.86 | 74.00 | -36.14 | Peak |

| | | | |
|------------------------|----------------------------------|----------------------------|------------|
| Test Mode : | Bluetooth (1Mbps) CH78 (2480MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 2.477GHz~2.510GHz | Polarization : | Horizontal |



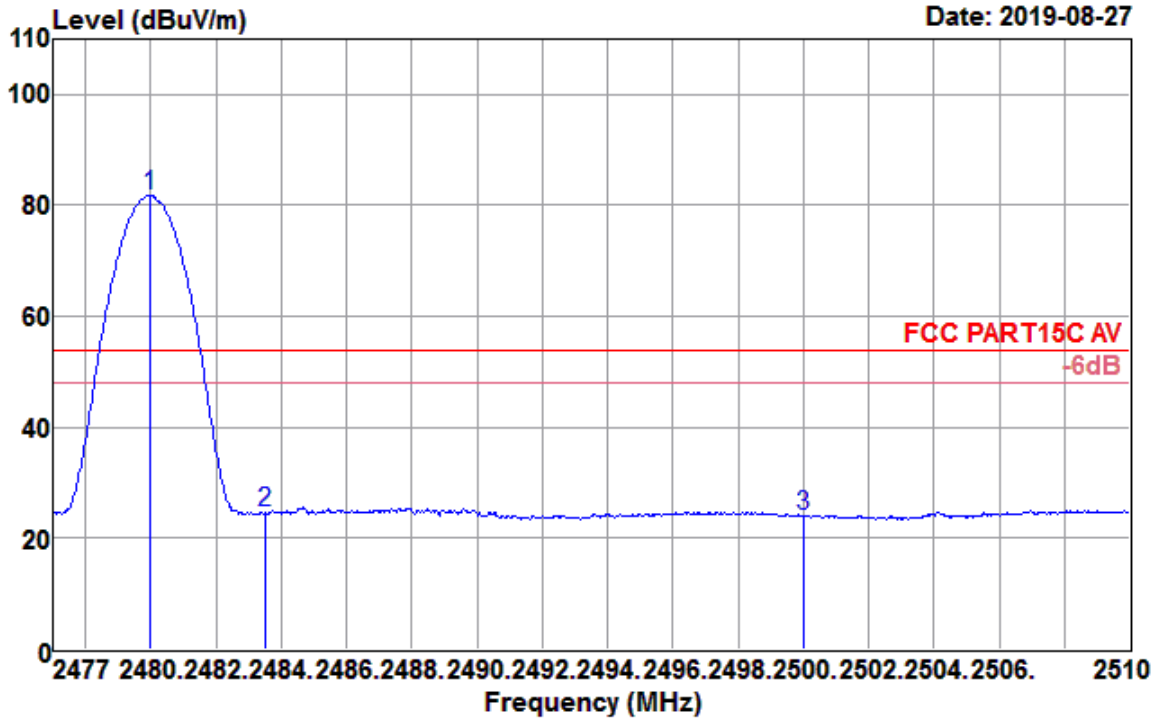
| Freq MHz | Reading level dBuV | Antenna factor dB/m | Cable loss dB | Preamp factor dB | level dBuV/m | Limit level dBuV/m | Over limit dB | Remark |
|-------------|--------------------------|---------------------------|---------------------|------------------------|-----------------|--------------------------|---------------------|---------|
| 2479.970 | 88.52 | 27.35 | 3.59 | 35.67 | 83.79 | 54.00 | 29.79 | Average |
| 2483.500 | 29.55 | 27.36 | 3.59 | 35.68 | 24.82 | 54.00 | -29.18 | Average |
| 2500.000 | 29.12 | 27.40 | 3.60 | 35.70 | 24.42 | 54.00 | -29.58 | Average |

| | | | |
|------------------------|----------------------------------|----------------------------|----------|
| Test Mode : | Bluetooth (1Mbps) CH78 (2480MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 2.477GHz~2.510GHz | Polarization : | Vertical |



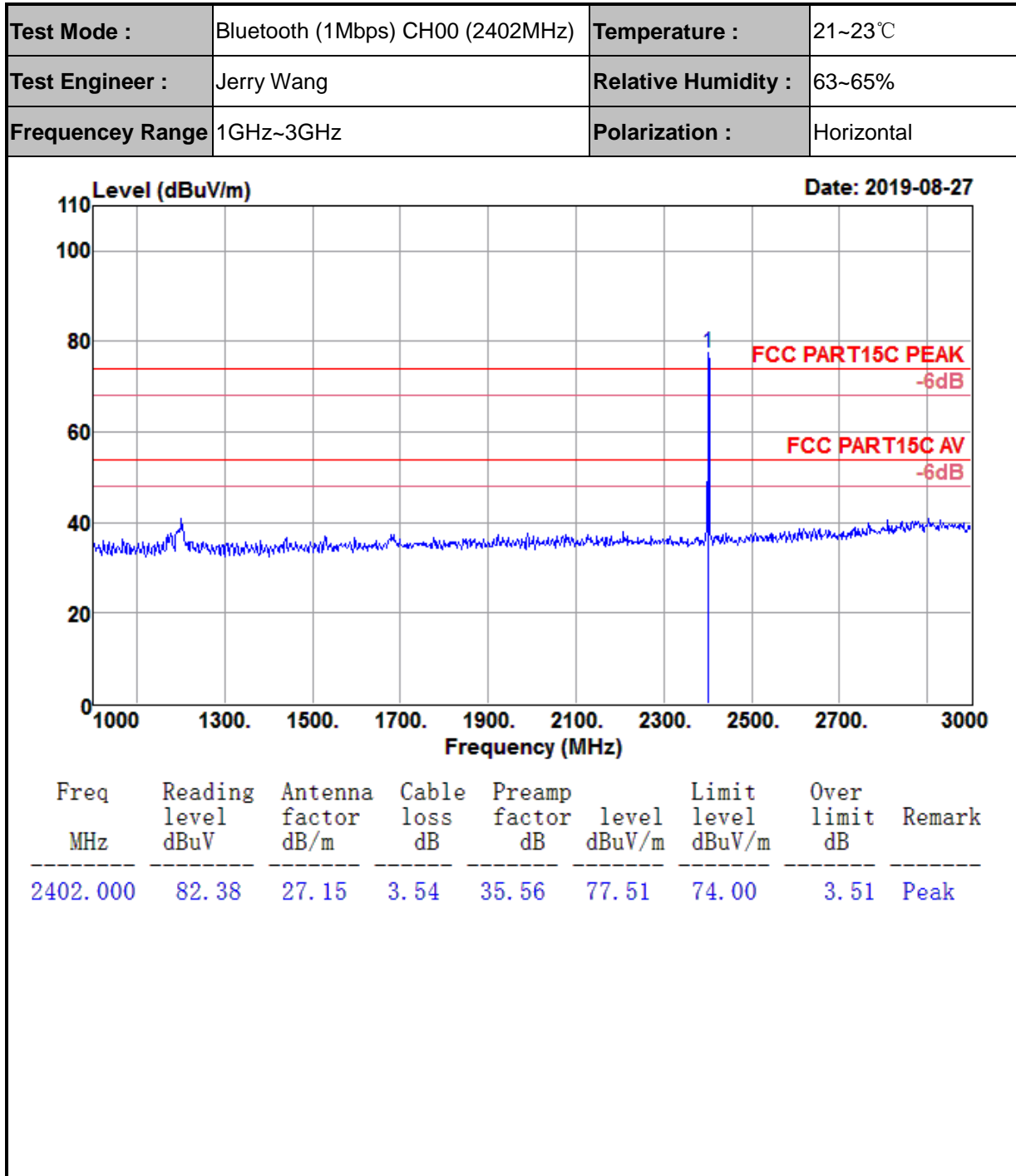
| Freq MHz | Reading level dBUV | Antenna factor dB/m | Cable loss dB | Preamp factor dB | level dBUV/m | Limit level dBUV/m | Over limit dB | Remark |
|-------------|--------------------------|---------------------------|---------------------|------------------------|-----------------|--------------------------|---------------------|--------|
| 2479.772 | 90.68 | 27.35 | 3.59 | 35.67 | 85.95 | 74.00 | 11.95 | Peak |
| 2483.500 | 50.62 | 27.36 | 3.59 | 35.68 | 45.89 | 74.00 | -28.11 | Peak |
| 2500.000 | 41.48 | 27.40 | 3.60 | 35.70 | 36.78 | 74.00 | -37.22 | Peak |

| | | | |
|------------------------|----------------------------------|----------------------------|----------|
| Test Mode : | Bluetooth (1Mbps) CH78 (2480MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 2.477GHz~2.510GHz | Polarization : | Vertical |

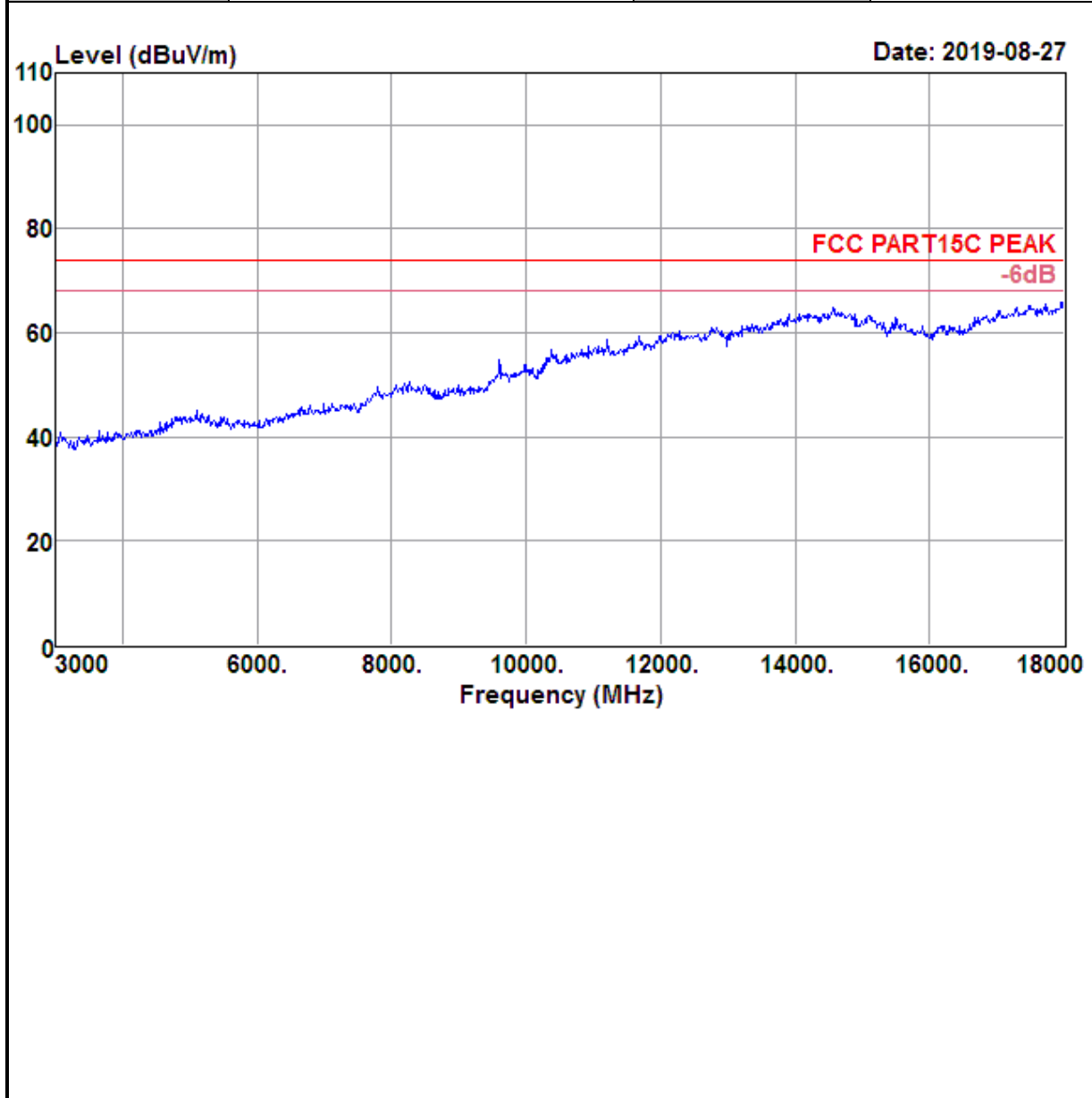


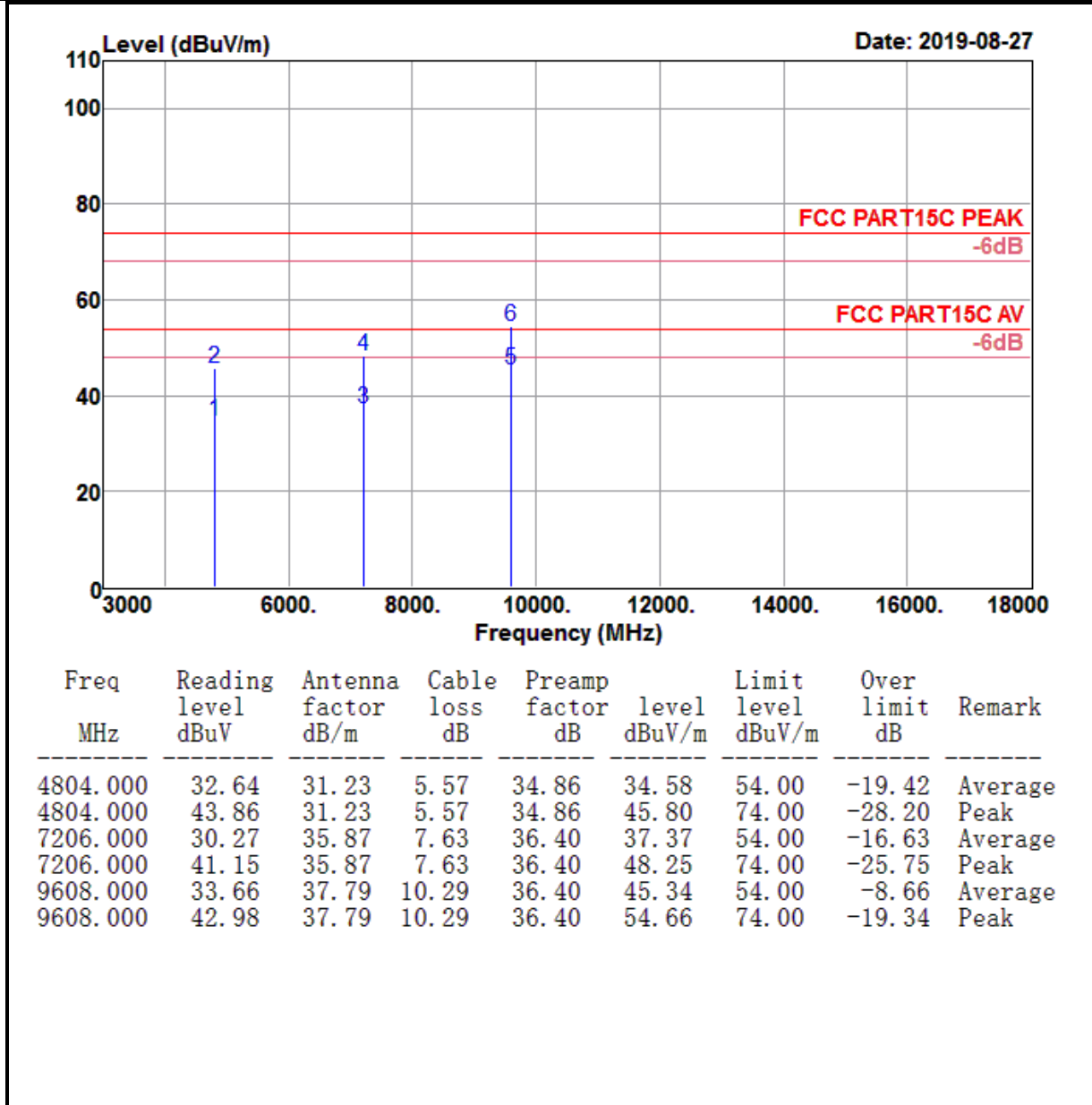
| Freq MHz | Reading level dBuV | Antenna factor dB/m | Cable loss dB | Preamp factor dB | level dBuV/m | Limit level dBuV/m | Over limit dB | Remark |
|-------------|--------------------------|---------------------------|---------------------|------------------------|-----------------|--------------------------|---------------------|---------|
| 2479.970 | 86.46 | 27.35 | 3.59 | 35.67 | 81.73 | 54.00 | 27.73 | Average |
| 2483.500 | 29.40 | 27.36 | 3.59 | 35.68 | 24.67 | 54.00 | -29.33 | Average |
| 2500.000 | 28.71 | 27.40 | 3.60 | 35.70 | 24.01 | 54.00 | -29.99 | Average |

4.8.5 Test Result of Radiated Spurious Emission (1GHz ~ 10th Harmonic)



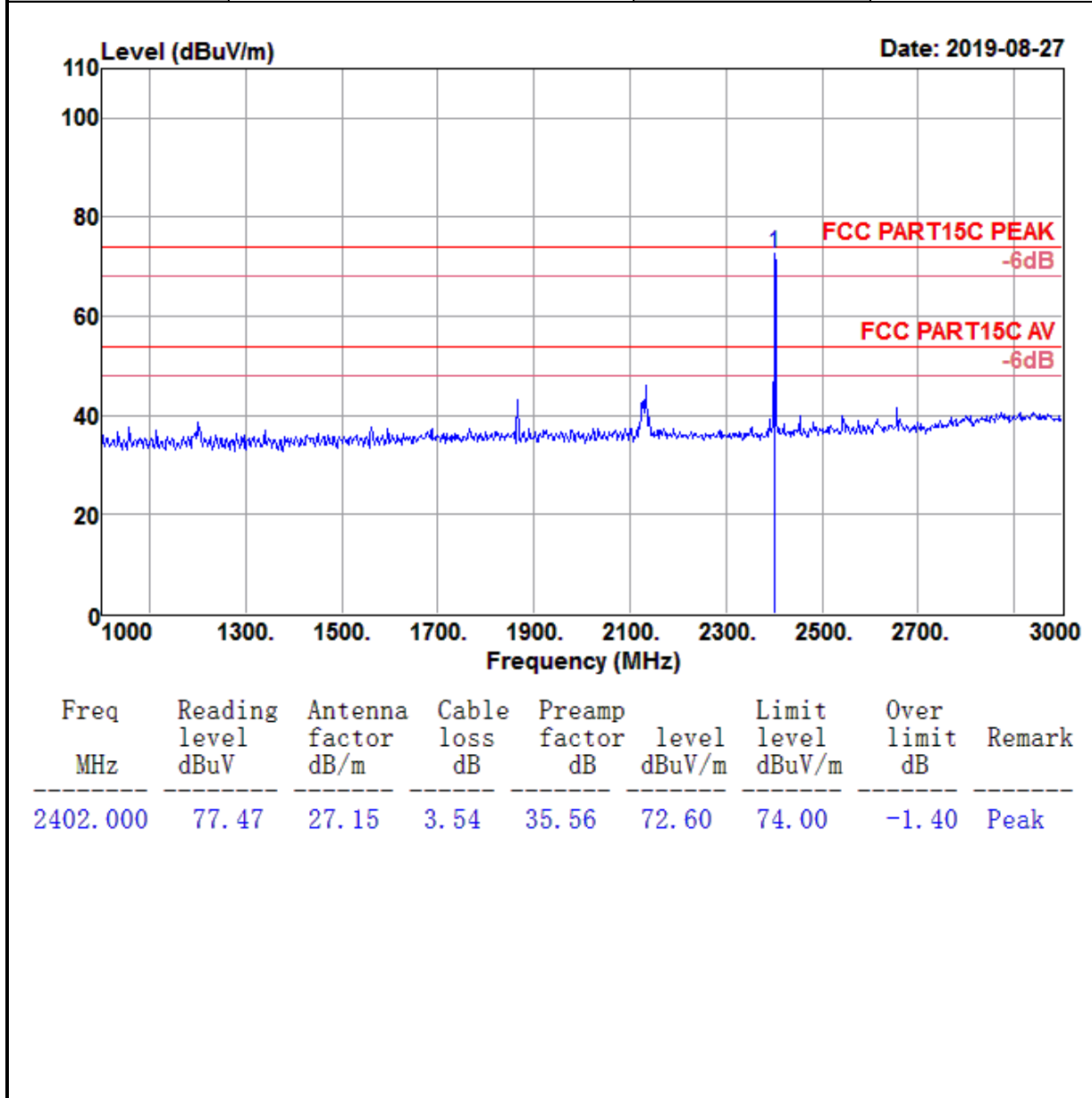
| | | | |
|------------------------|----------------------------------|----------------------------|------------|
| Test Mode : | Bluetooth (1Mbps) CH00 (2402MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 3GHz~18GHz | Polarization : | Horizontal |



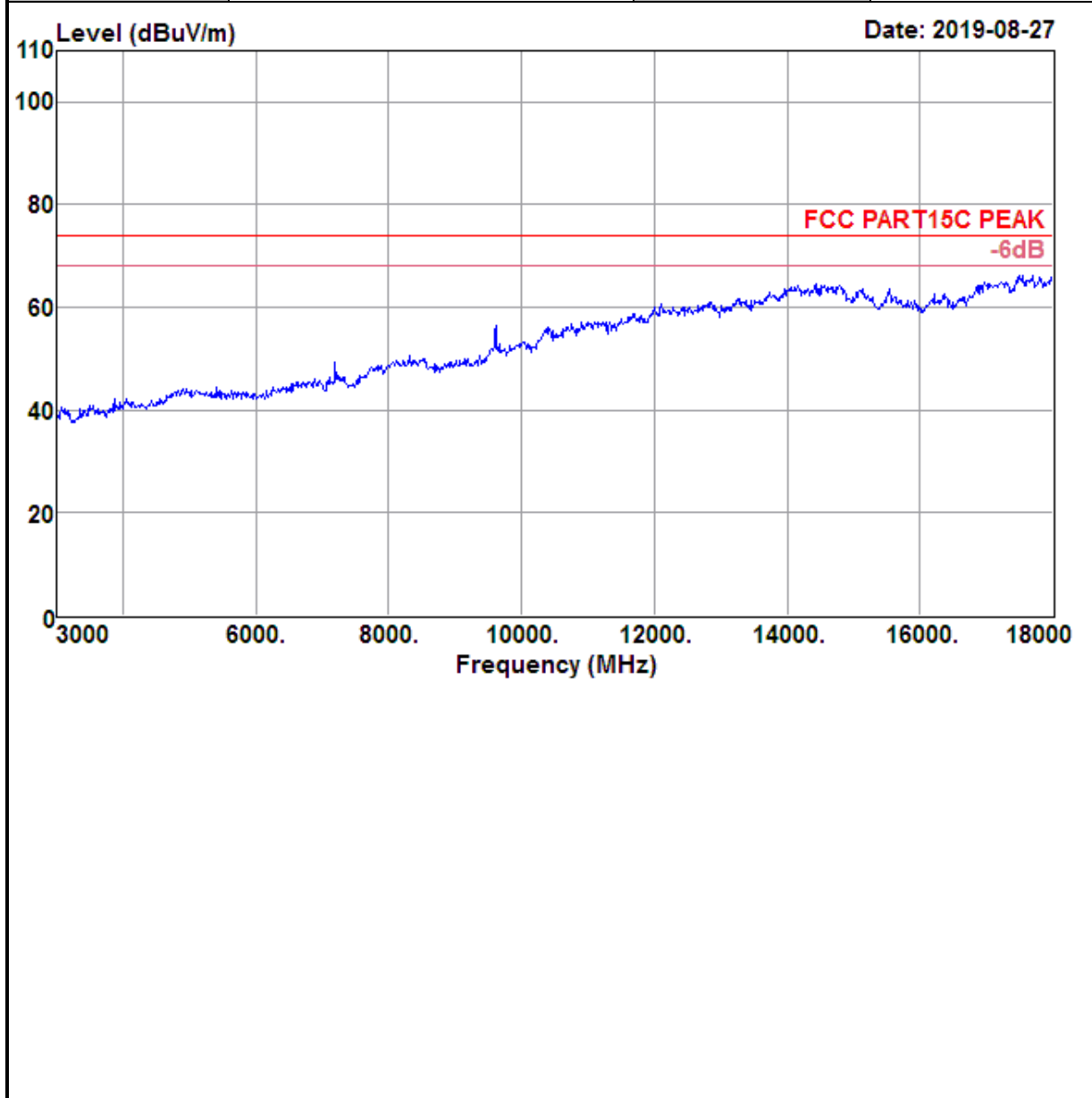


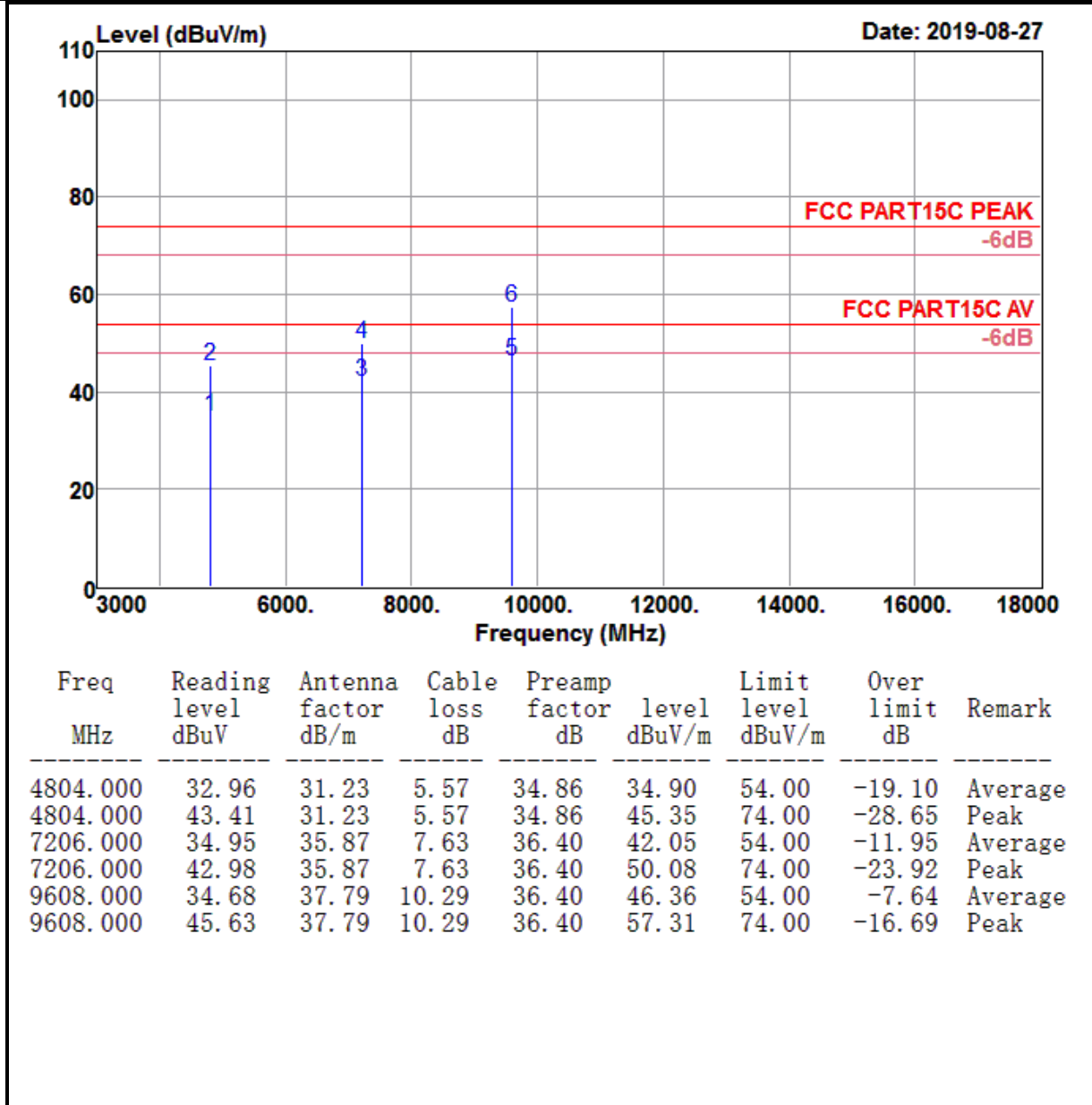
Note: Emission was scanned up to 26GHz; No emissions were detected above the noise floor which was at least 20dB below the specification limit.

| | | | |
|------------------------|----------------------------------|----------------------------|----------|
| Test Mode : | Bluetooth (1Mbps) CH00 (2402MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 1GHz~3GHz | Polarization : | Vertical |



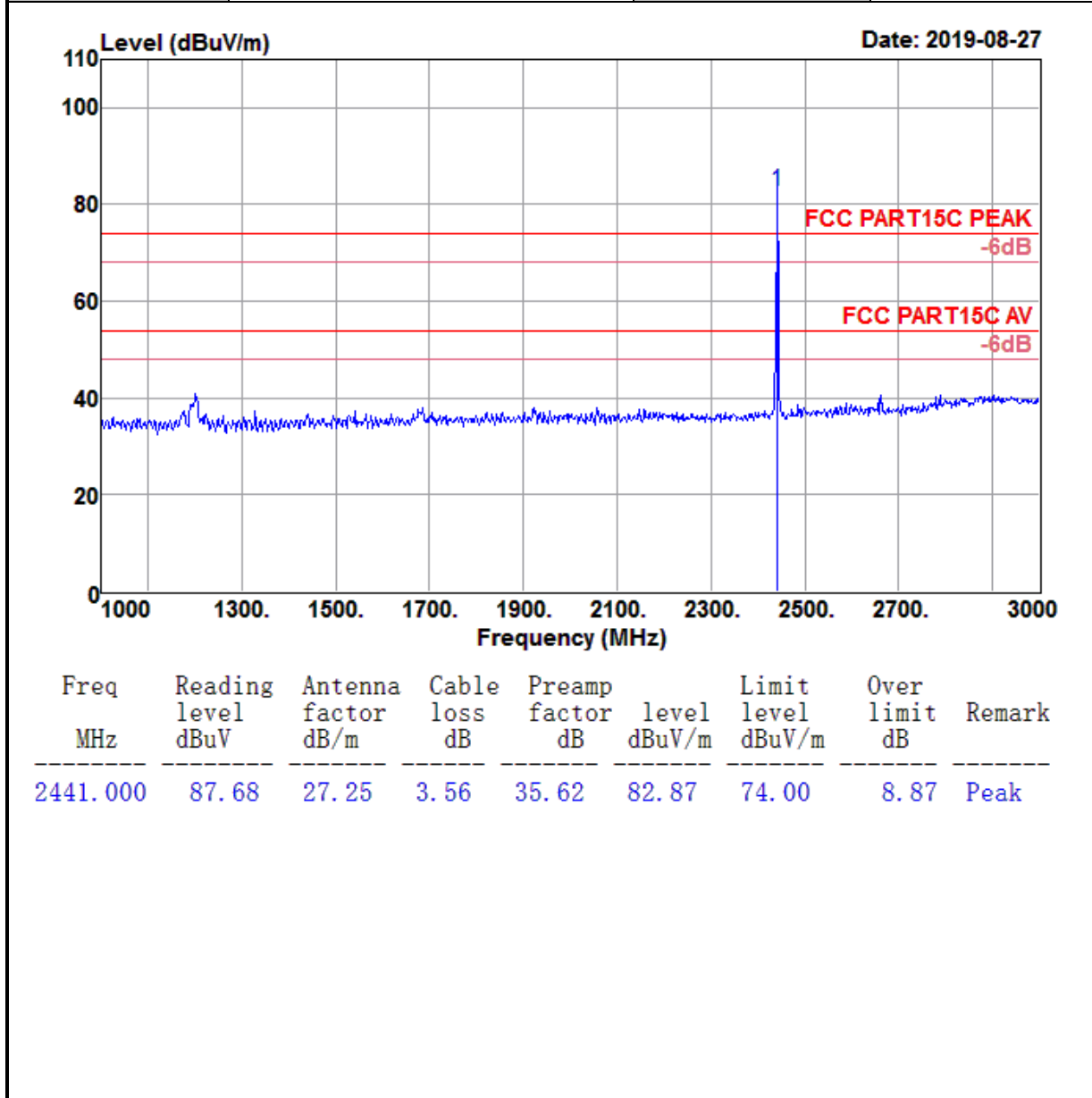
| | | | |
|------------------------|----------------------------------|----------------------------|----------|
| Test Mode : | Bluetooth (1Mbps) CH00 (2402MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 3GHz~18GHz | Polarization : | Vertical |



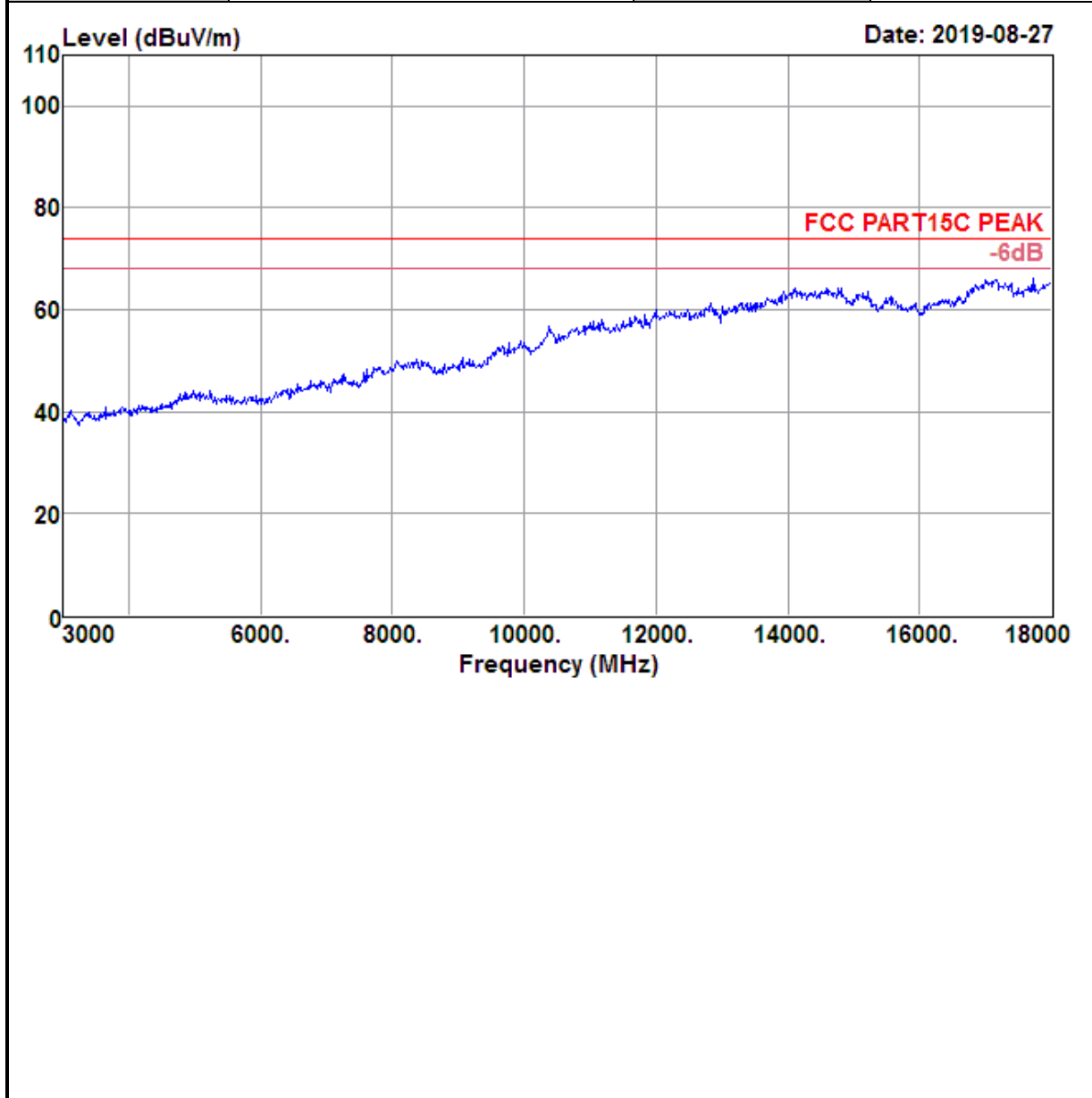


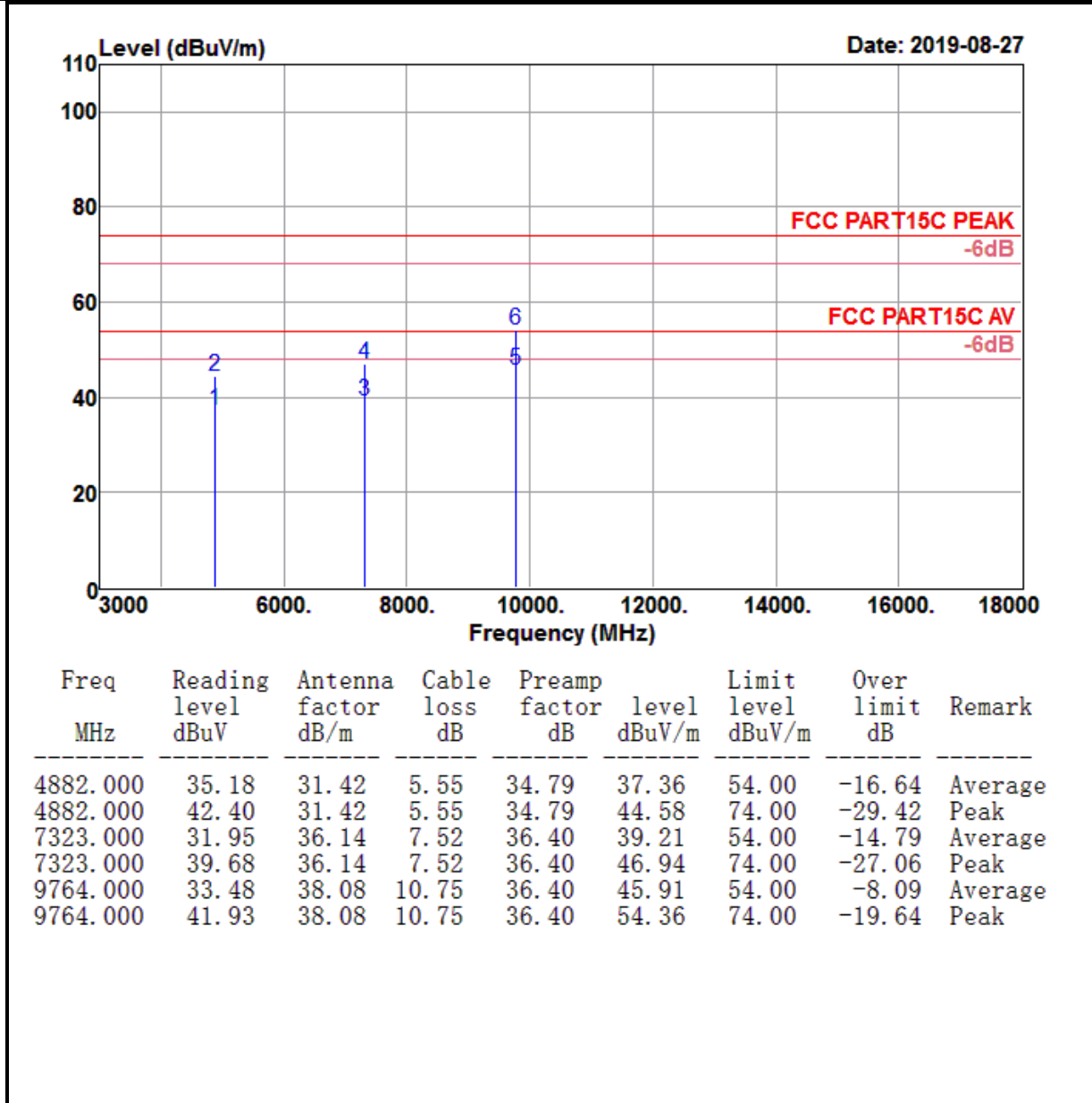
Note: Emission was scanned up to 26GHz; No emissions were detected above the noise floor which was at least 20dB below the specification limit.

| | | | |
|------------------------|----------------------------------|----------------------------|------------|
| Test Mode : | Bluetooth (1Mbps) CH39 (2441MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 1GHz~3GHz | Polarization : | Horizontal |



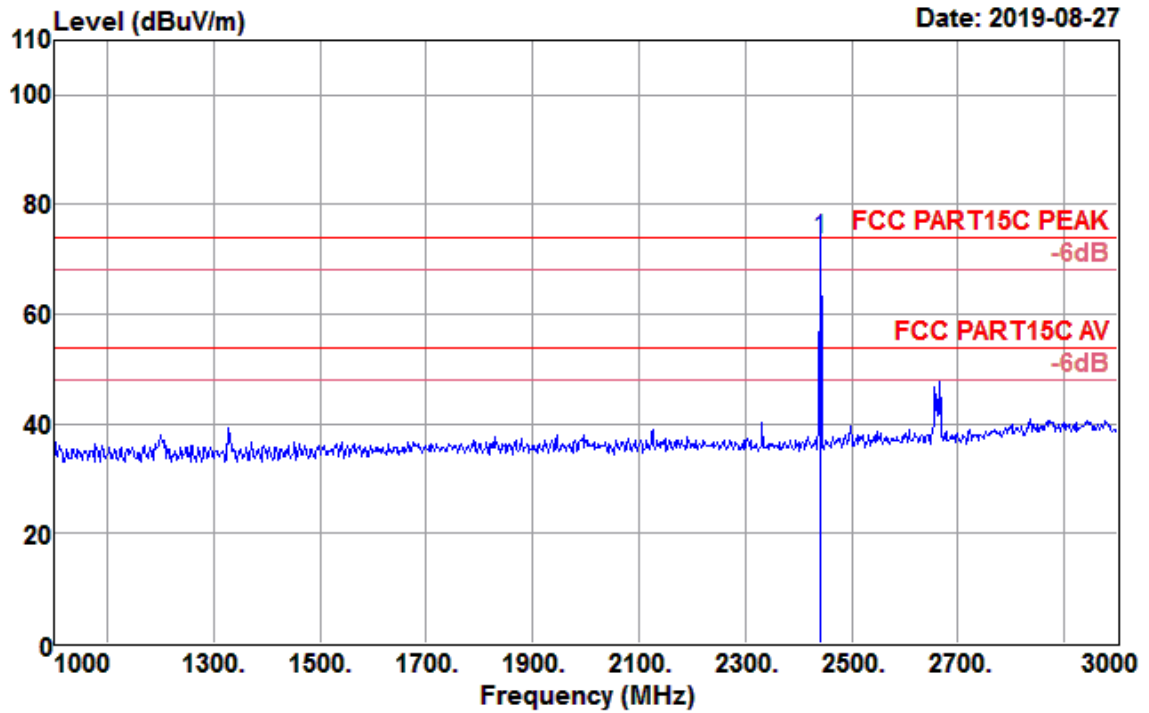
| | | | |
|------------------------|----------------------------------|----------------------------|------------|
| Test Mode : | Bluetooth (1Mbps) CH39 (2441MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 3GHz~18GHz | Polarization : | Horizontal |





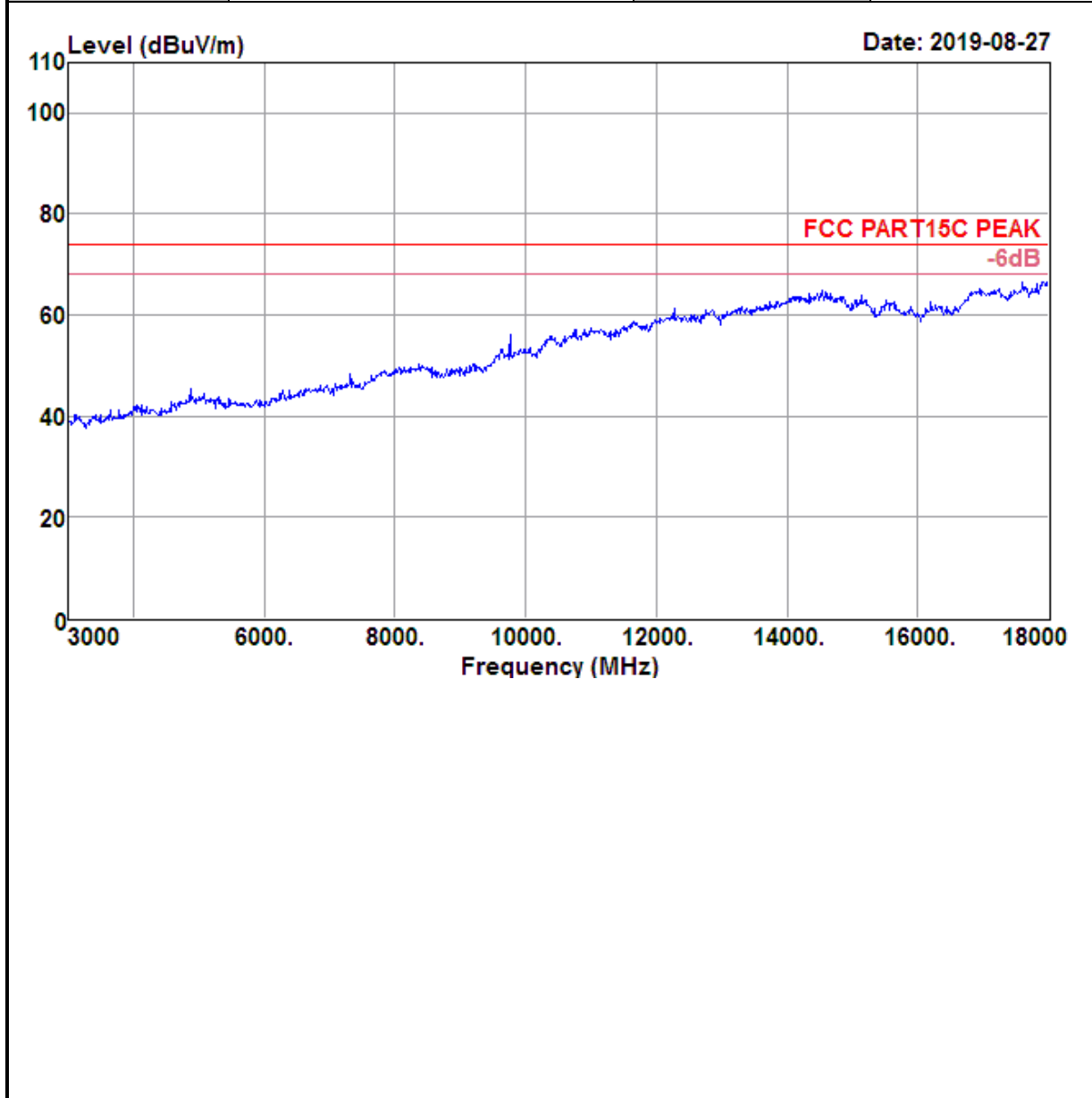
Note: Emission was scanned up to 26GHz; No emissions were detected above the noise floor which was at least 20dB below the specification limit.

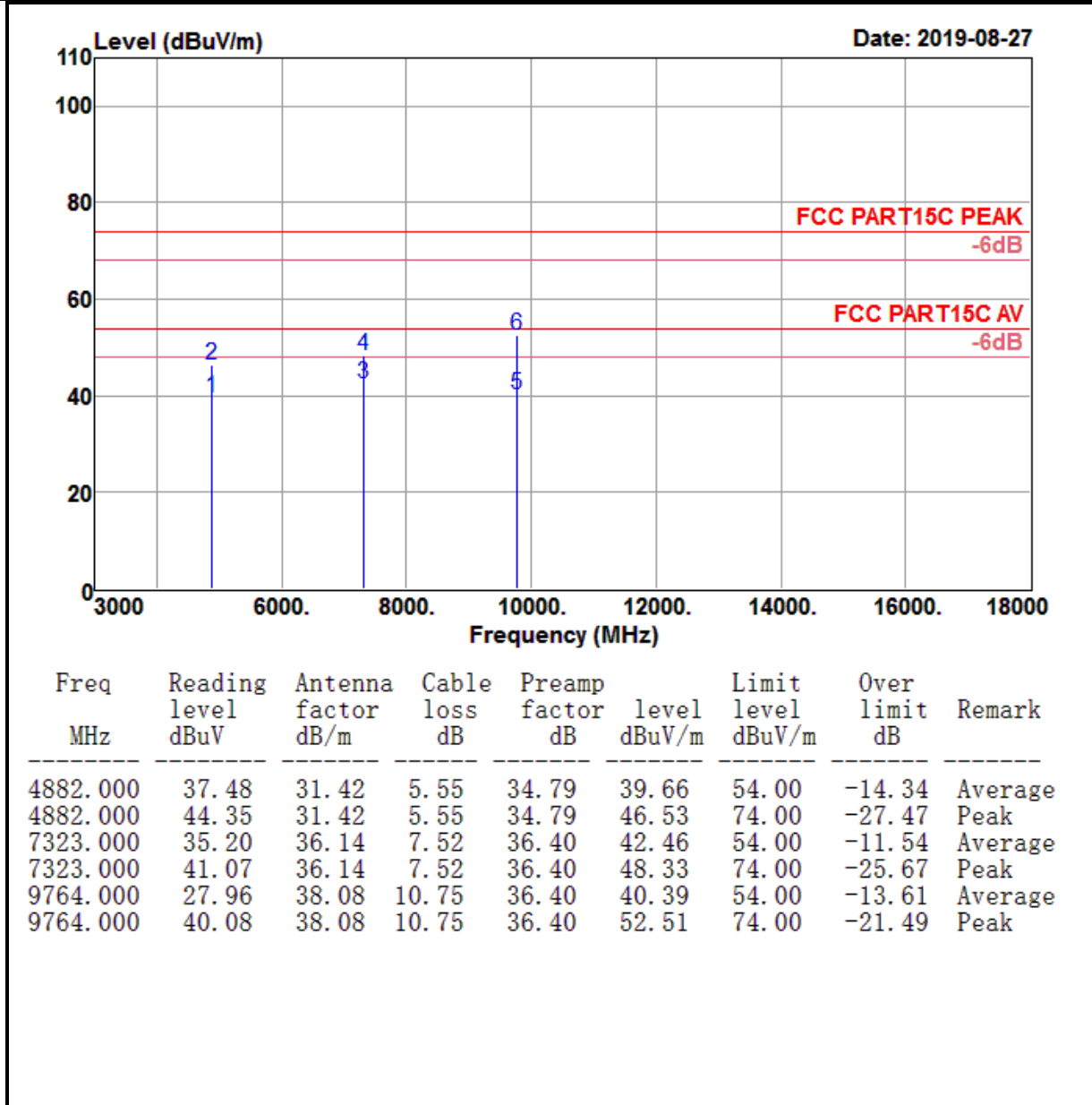
| | | | |
|------------------------|----------------------------------|----------------------------|----------|
| Test Mode : | Bluetooth (1Mbps) CH39 (2441MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 1GHz~3GHz | Polarization : | Vertical |



| Freq MHz | Reading level dBUV | Antenna factor dB/m | Cable loss dB | Preamp factor dB | level dBUV/m | Limit level dBUV/m | Over limit dB | Remark |
|-------------|--------------------------|---------------------------|---------------------|------------------------|-----------------|--------------------------|---------------------|--------|
| 2441.000 | 78.50 | 27.25 | 3.56 | 35.62 | 73.69 | 74.00 | -0.31 | Peak |

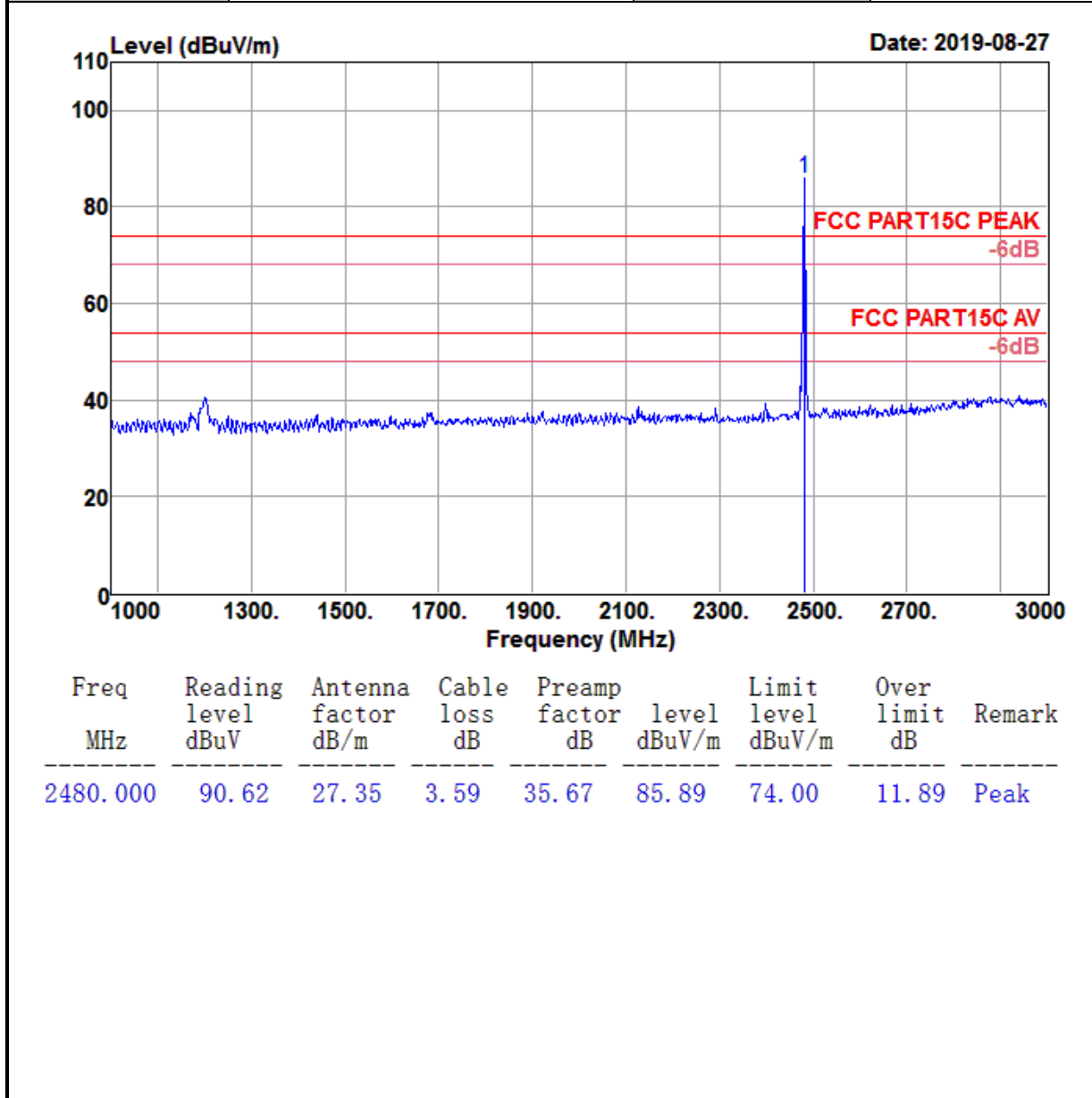
| | | | |
|------------------------|----------------------------------|----------------------------|----------|
| Test Mode : | Bluetooth (1Mbps) CH39 (2441MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 3GHz~18GHz | Polarization : | Vertical |



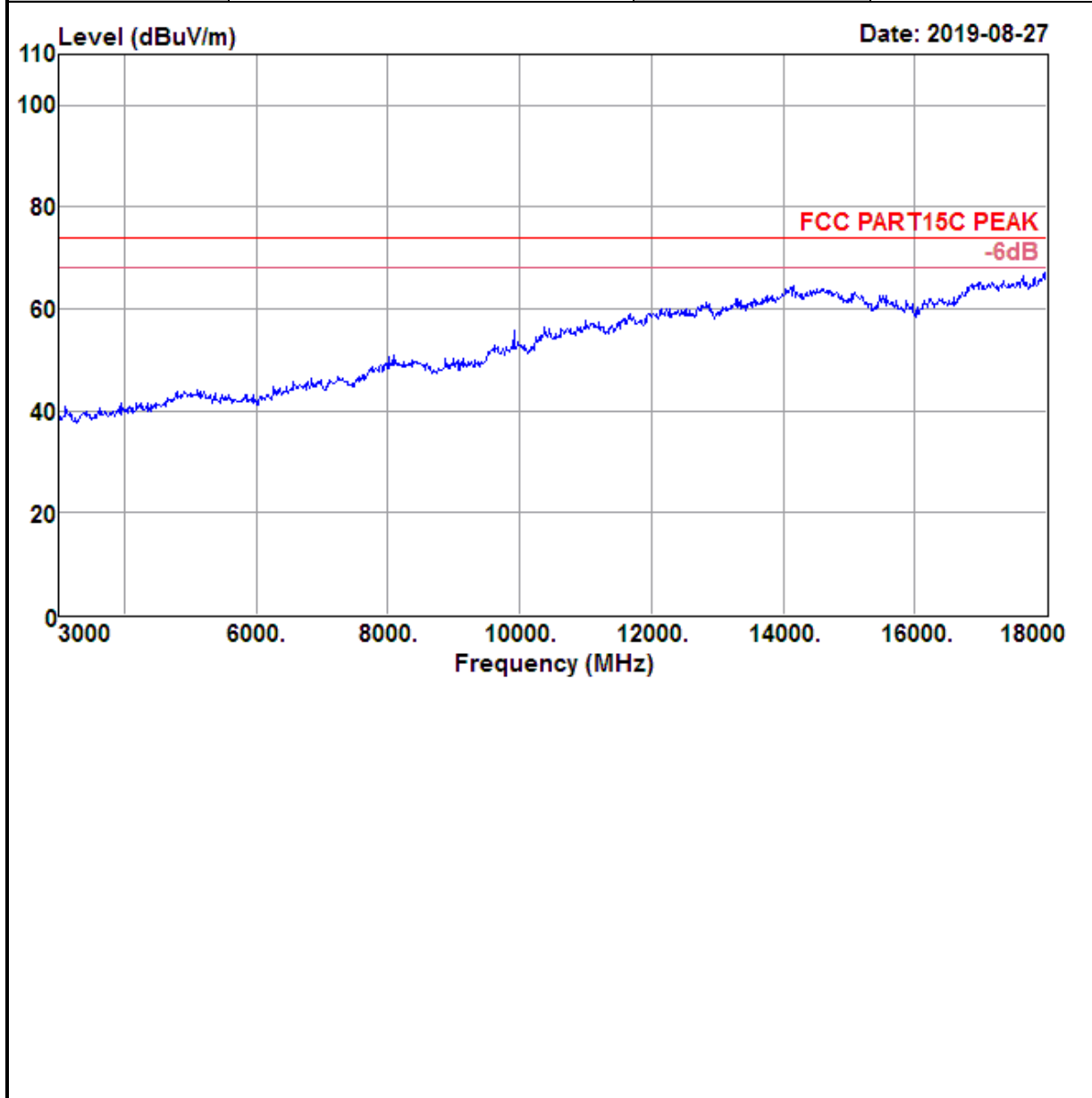


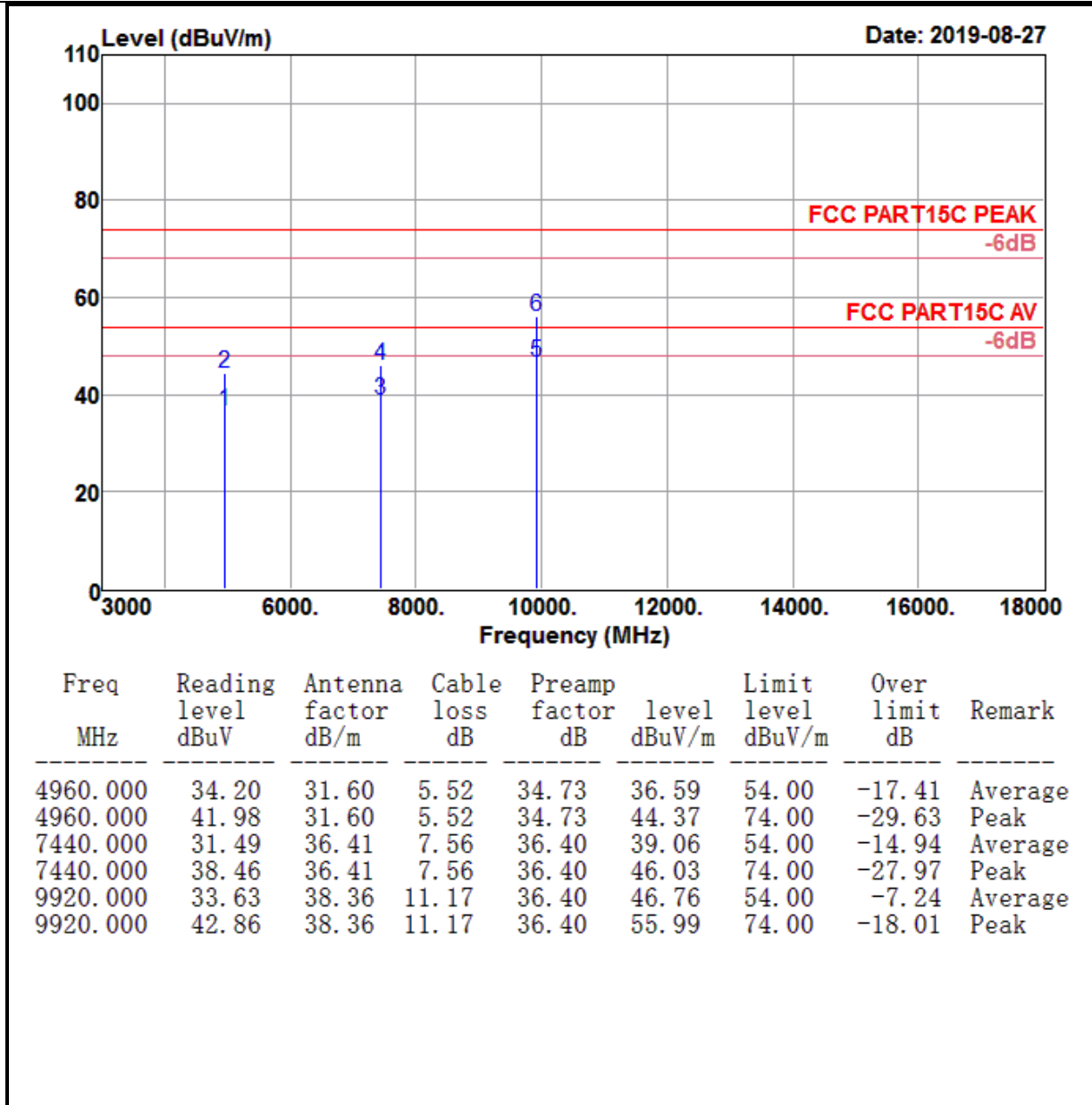
Note: Emission was scanned up to 26GHz; No emissions were detected above the noise floor which was at least 20dB below the specification limit.

| | | | |
|------------------------|----------------------------------|----------------------------|------------|
| Test Mode : | Bluetooth (1Mbps) CH78 (2480MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 1GHz~3GHz | Polarization : | Horizontal |



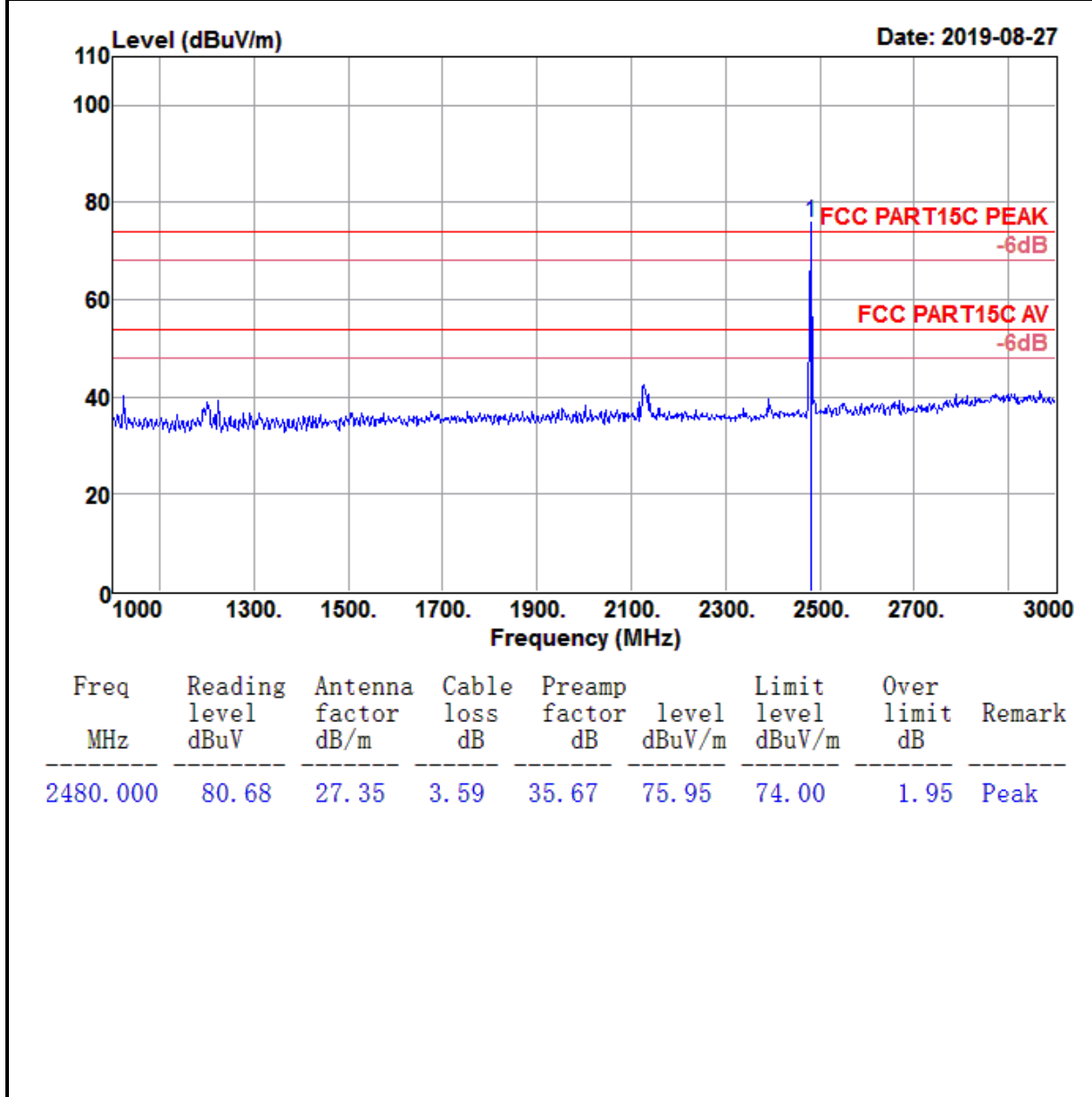
| | | | |
|------------------------|----------------------------------|----------------------------|------------|
| Test Mode : | Bluetooth (1Mbps) CH78 (2480MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 3GHz~18GHz | Polarization : | Horizontal |



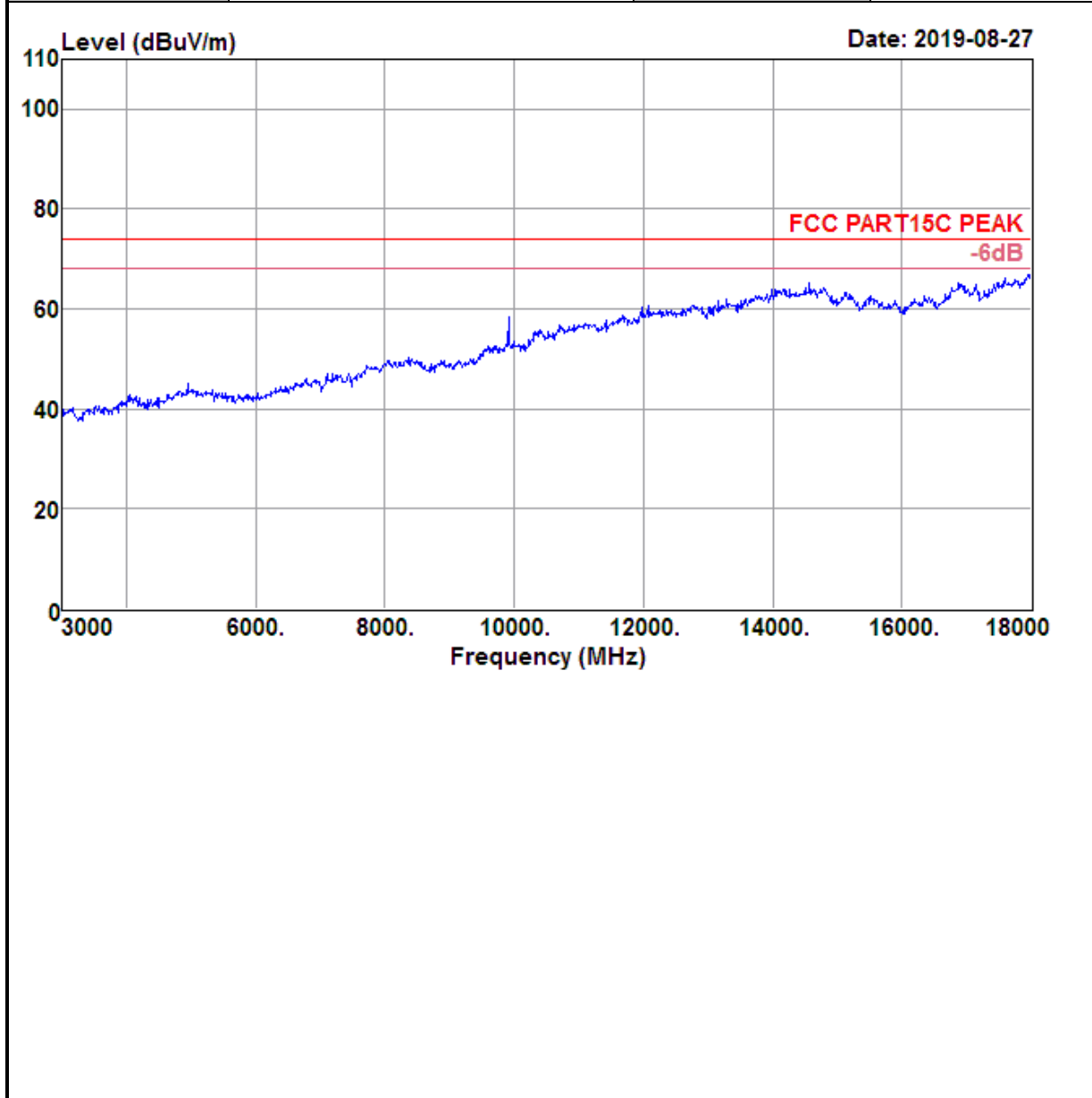


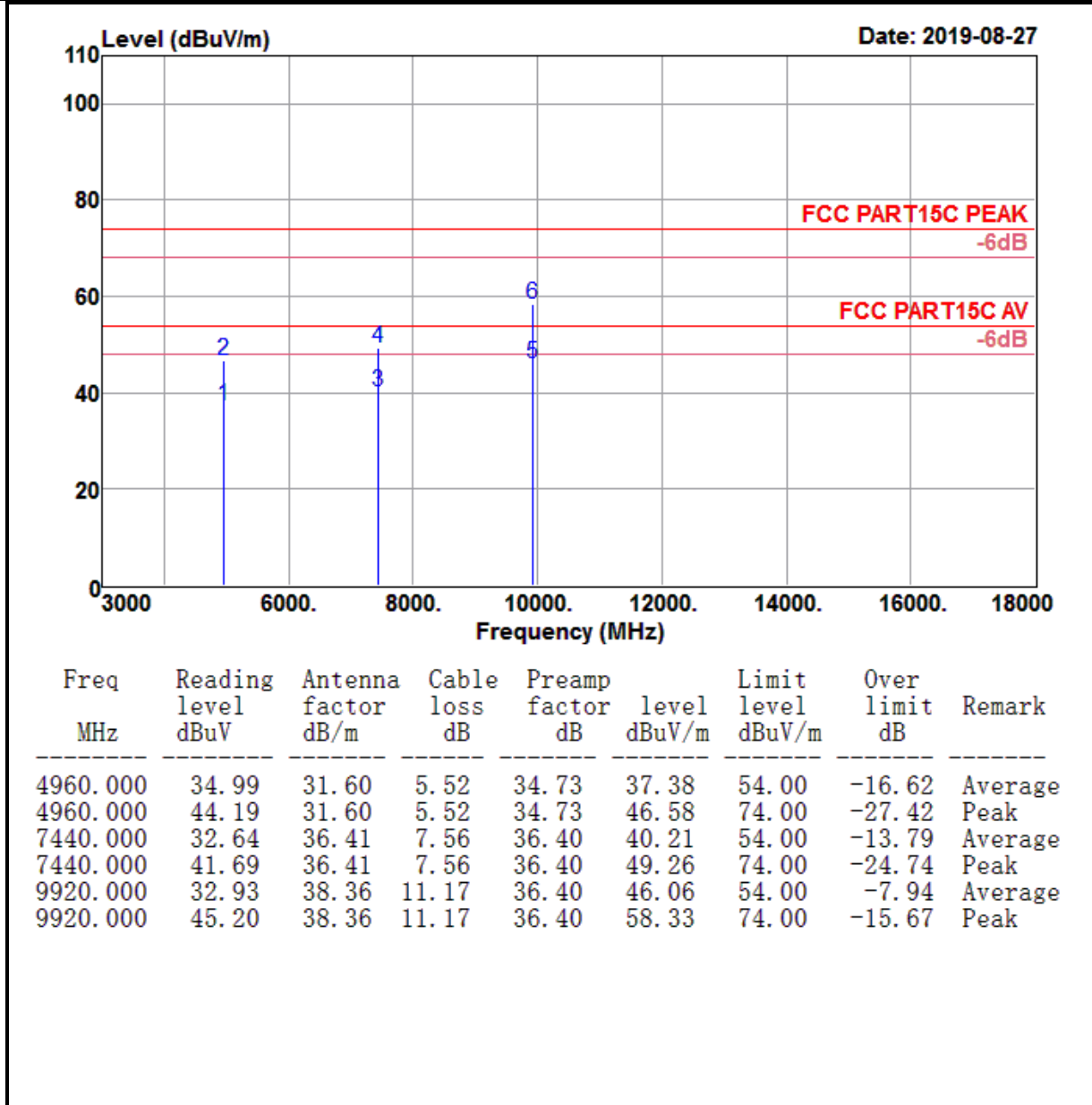
Note: Emission was scanned up to 26GHz; No emissions were detected above the noise floor which was at least 20dB below the specification limit.

| | | | |
|------------------------|----------------------------------|----------------------------|----------|
| Test Mode : | Bluetooth (1Mbps) CH78 (2480MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 1GHz~3GHz | Polarization : | Vertical |



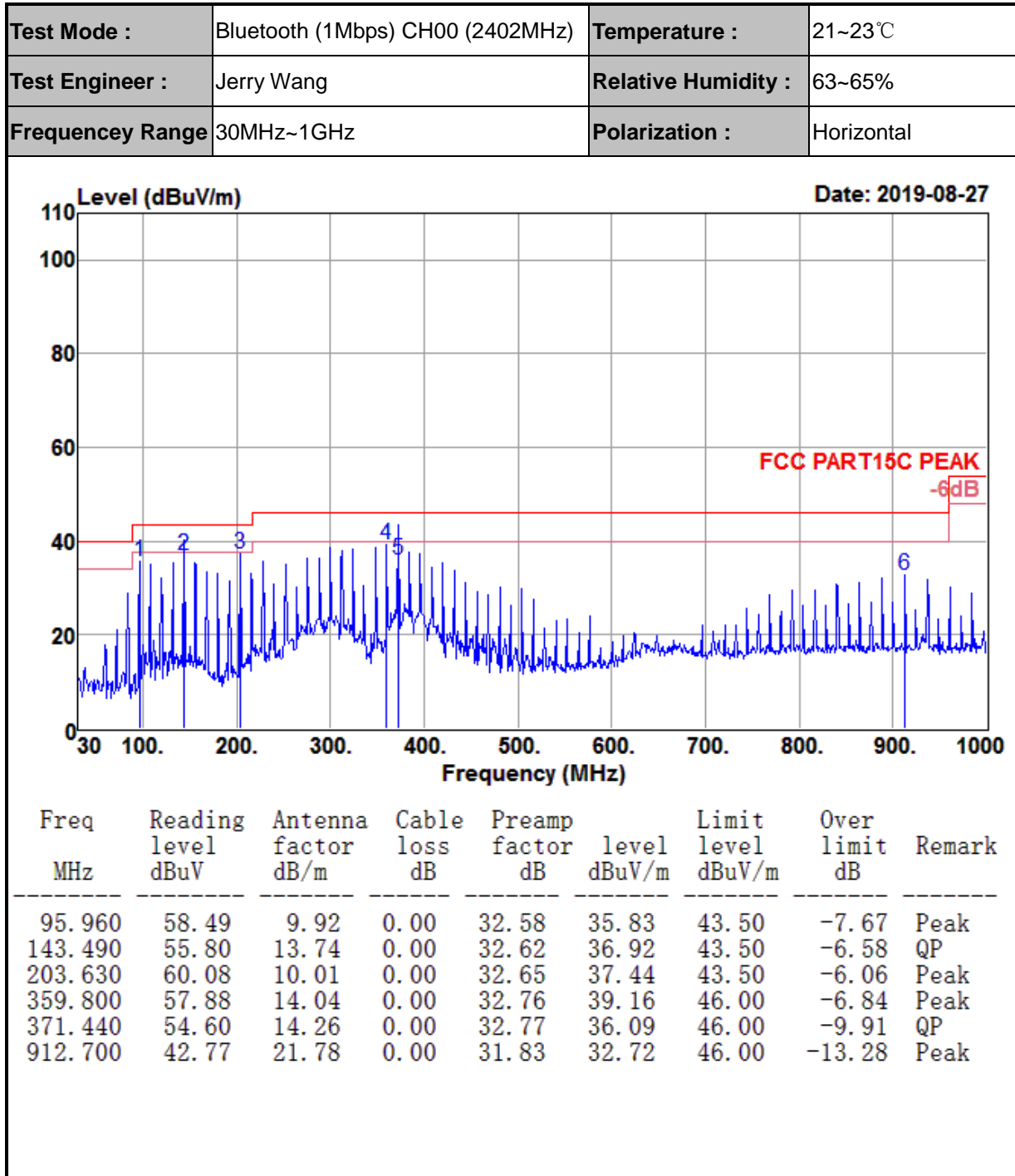
| | | | |
|------------------------|----------------------------------|----------------------------|----------|
| Test Mode : | Bluetooth (1Mbps) CH78 (2480MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 3GHz~18GHz | Polarization : | Vertical |



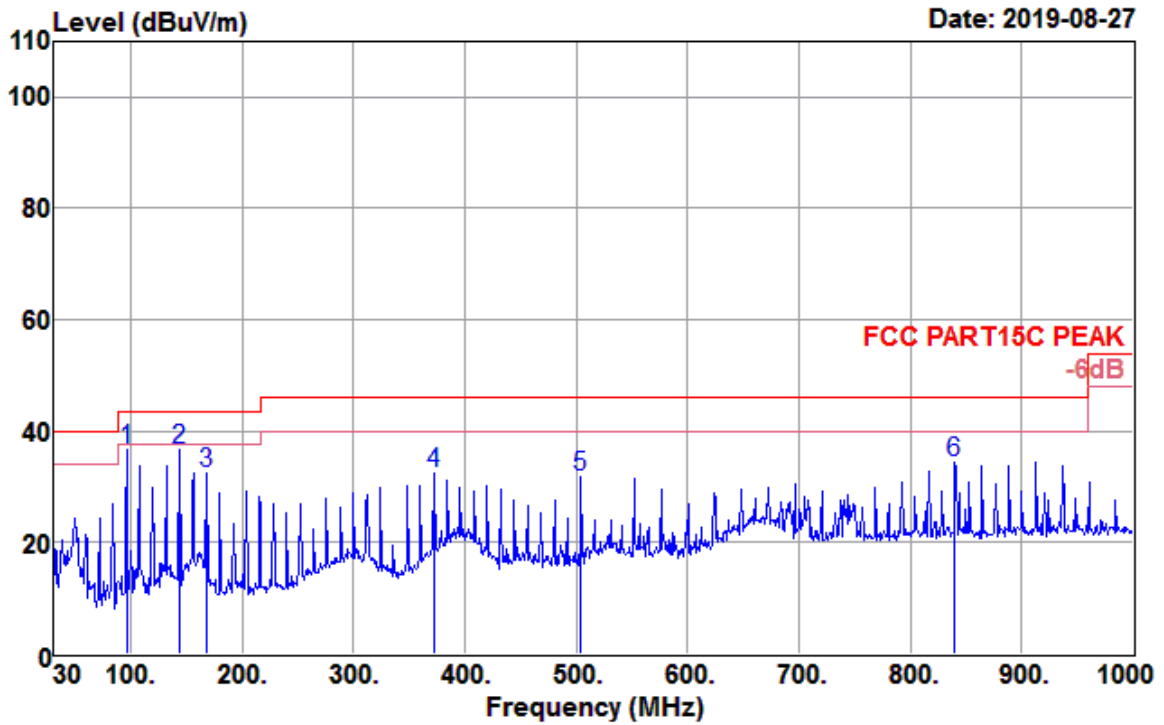


Note: Emission was scanned up to 26GHz; No emissions were detected above the noise floor which was at least 20dB below the specification limit.

4.8.6 Test Result of Radiated Spurious Emission (30MHz ~ 1GHz)



| | | | |
|------------------------|----------------------------------|----------------------------|----------|
| Test Mode : | Bluetooth (1Mbps) CH00 (2402MHz) | Temperature : | 21~23℃ |
| Test Engineer : | Jerry Wang | Relative Humidity : | 63~65% |
| Frequency Range | 30MHz~1GHz | Polarization : | Vertical |



| Freq MHz | Reading level dBuV | Antenna factor dB/m | Cable loss dB | Preamp factor dB | level dBuV/m | Limit level dBuV/m | Over limit dB | Remark |
|-------------|--------------------------|---------------------------|---------------------|------------------------|-----------------|--------------------------|---------------------|--------|
| 95.960 | 57.57 | 9.92 | 1.90 | 32.58 | 36.81 | 43.50 | -6.69 | Peak |
| 143.490 | 53.47 | 13.74 | 2.13 | 32.62 | 36.72 | 43.50 | -6.78 | Peak |
| 167.740 | 49.55 | 13.43 | 2.23 | 32.63 | 32.58 | 43.50 | -10.92 | Peak |
| 371.440 | 47.89 | 14.26 | 3.16 | 32.77 | 32.54 | 46.00 | -13.46 | Peak |
| 504.330 | 44.50 | 16.58 | 3.65 | 32.89 | 31.84 | 46.00 | -14.16 | Peak |
| 839.950 | 40.36 | 21.16 | 4.74 | 31.94 | 34.32 | 46.00 | -11.68 | Peak |

4.9 AC Conducted Emission Measurement

4.9.1 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 (dB μ V) | |
|-----------------------------|------------------------------|-----------|
| | Quasi-peak | Average |
| 0.15-0.5 | 66 to 56* | 56 to 46* |
| 0.5-5 | 56 | 46 |
| 5-30 | 60 | 50 |

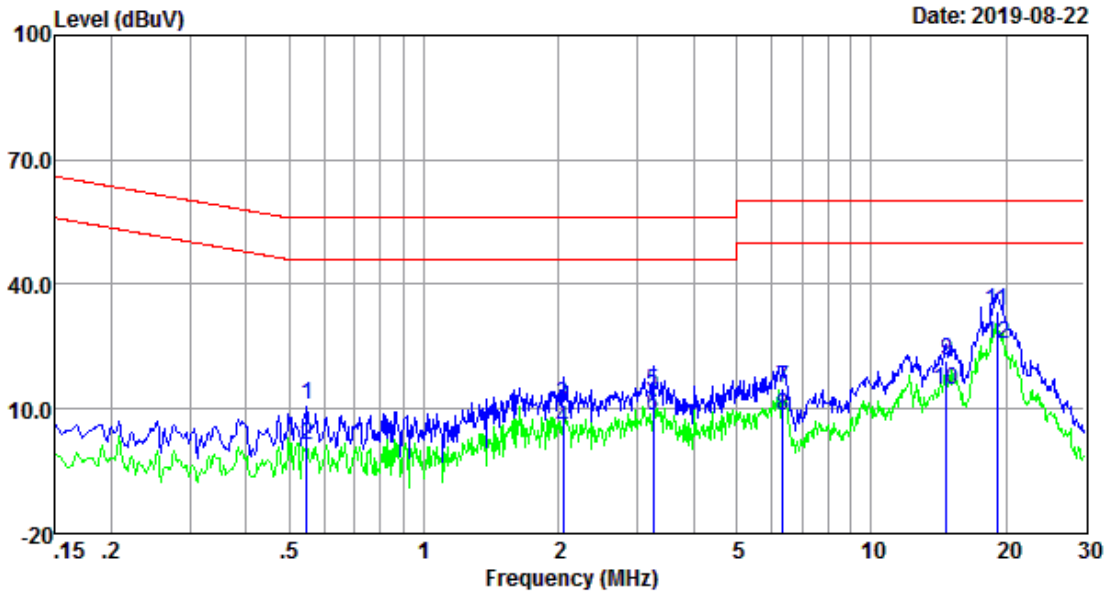
*Decreases with the logarithm of the frequency.

4.9.2 Test Procedures

7. 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.
8. Connect EUT to the power mains through a line impedance stabilization network (LISN).
9. All the support units are connecting to the other LISN.
10. The LISN provides 50 ohm coupling impedance for the measuring instrument.
11. The FCC states that a 50 ohm, 50 microhenry LISN should be used.
12. Both sides of AC line were checked for maximum conducted interference.
13. The frequency range from 150 kHz to 30 MHz was searched.
14. 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.

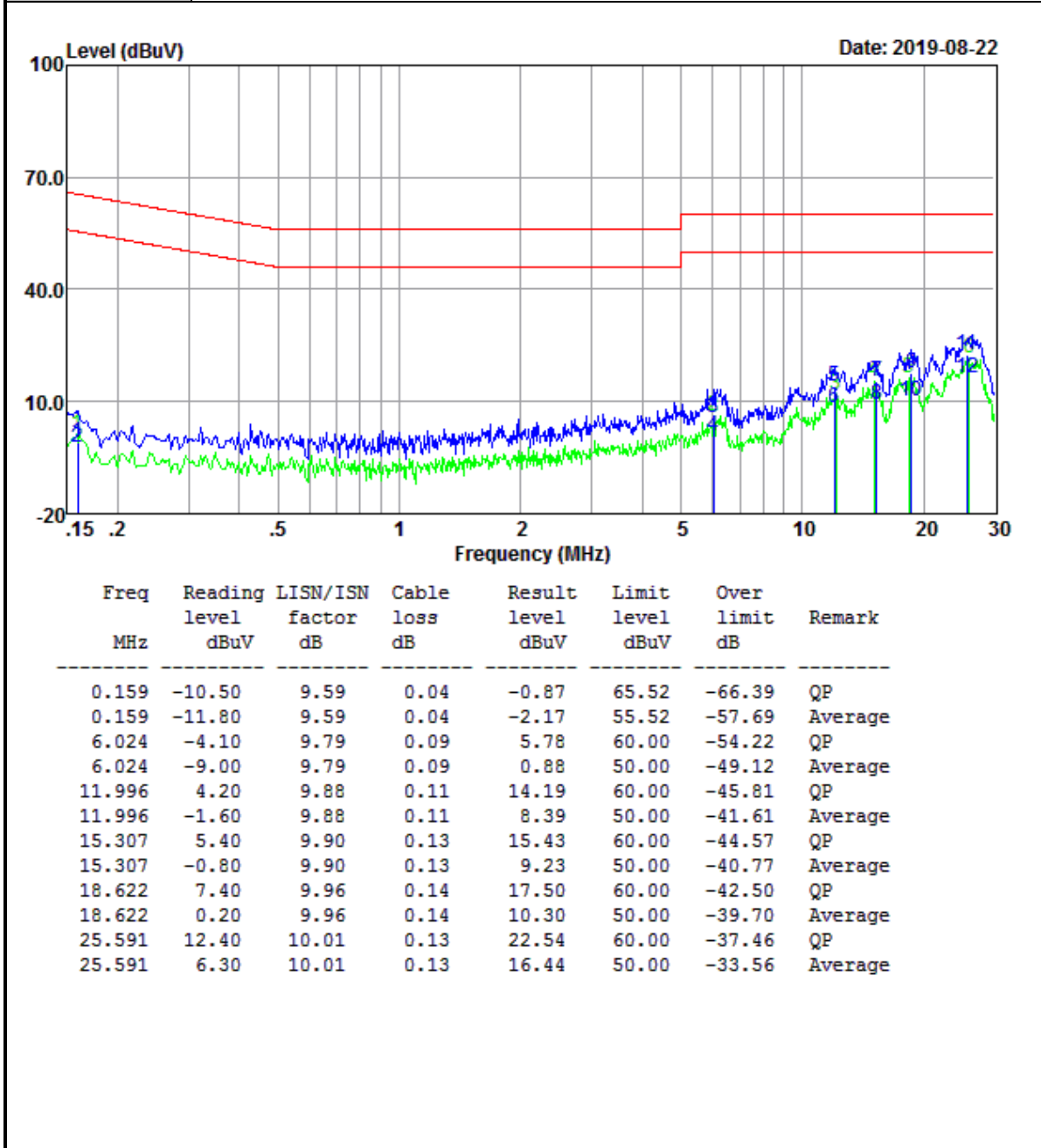
4.9.3 Test Result of AC Conducted Emission

| | | | |
|------------------------|--|----------------------------|------|
| Test Mode : | Mode 1 | Temperature : | 23°C |
| Test Engineer : | Jerry Wang | Relative Humidity : | 61% |
| Test Voltage : | 120Vac / 60Hz | Phase : | Line |
| Function Type : | Bluetooth Link + USB Cable (Charging from Adapter) | | |



| Freq MHz | Reading level dBuV | LISN/ISN factor dB | Cable loss dB | Result level dBuV | Limit level dBuV | Over limit dB | Remark |
|-------------|--------------------------|--------------------------|---------------------|-------------------------|------------------------|---------------------|---------|
| 0.546 | 1.10 | 9.73 | 0.04 | 10.87 | 56.00 | -45.13 | QP |
| 0.546 | -8.70 | 9.73 | 0.04 | 1.07 | 46.00 | -44.93 | Average |
| 2.044 | 1.20 | 9.80 | 0.06 | 11.06 | 56.00 | -44.94 | QP |
| 2.044 | -4.80 | 9.80 | 0.06 | 5.06 | 46.00 | -40.94 | Average |
| 3.258 | 4.30 | 9.82 | 0.07 | 14.19 | 56.00 | -41.81 | QP |
| 3.258 | -1.60 | 9.82 | 0.07 | 8.29 | 46.00 | -37.71 | Average |
| 6.352 | 4.79 | 9.90 | 0.09 | 14.78 | 60.00 | -45.22 | QP |
| 6.352 | -1.61 | 9.90 | 0.09 | 8.38 | 50.00 | -41.62 | Average |
| 14.750 | 11.30 | 10.01 | 0.13 | 21.44 | 60.00 | -38.56 | QP |
| 14.750 | 4.60 | 10.01 | 0.13 | 14.74 | 50.00 | -35.26 | Average |
| 19.122 | 23.30 | 10.00 | 0.14 | 33.44 | 60.00 | -26.56 | QP |
| 19.122 | 15.30 | 10.00 | 0.14 | 25.44 | 50.00 | -24.56 | Average |

| | | | |
|------------------------|--|----------------------------|---------|
| Test Mode : | Mode 1 | Temperature : | 23°C |
| Test Engineer : | Jerry Wang | Relative Humidity : | 61% |
| Test Voltage : | 120Vac / 60Hz | Phase : | Neutral |
| Function Type : | Bluetooth Link + USB Cable (Charging from Adapter) | | |



4.10 Antenna Requirements

4.10.1 Standard Applicable

According to antenna requirement of §15.203.

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be re-placed by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded..

And according to §15.247(4)(1), system operating in the 2400-2483.5MHz bands that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6dBi.

4.10.2 Antenna Connected Construction

An embedded-in antenna design is used.

4.10.3 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.

5 List of Measuring Equipment

| Instrument | Manufacturer | Model No. | Serial No. | Calibration Date | Due Date | Remark |
|----------------------------|--------------|------------|------------|------------------|------------|-----------|
| Spectrum Analyzer | Keysight | N9010A | MY56070788 | 2019/1/23 | 2020/1/22 | Conducted |
| Power Sensor | Keysight | U2021XA | MY56510025 | 2019/1/23 | 2020/1/22 | Conducted |
| Power Sensor | Keysight | U2021XA | MY57030005 | 2019/1/23 | 2020/1/22 | Conducted |
| Power Sensor | Keysight | U2021XA | MY56510018 | 2019/1/23 | 2020/1/22 | Conducted |
| Power Sensor | Keysight | U2021XA | MY56480002 | 2019/1/23 | 2020/1/22 | Conducted |
| Thermal Chamber | Sanmtest | SMC-408-CD | 2435 | 2019/05/09 | 2020/05/08 | Conducted |
| Base Station | R&S | CMW 270 | 101231 | 2019/1/23 | 2020/1/22 | Conducted |
| Signal Generator (Blocker) | Keysight | N5171B | MY56200661 | 2019/1/23 | 2020/1/22 | Conducted |

| Instrument | Manufacturer | Model No. | Serial No. | Calibration Date | Due Date | Remark |
|-------------------|---------------|---------------|------------|------------------|------------|-----------|
| Spectrum Analyzer | R&S | FSV 40 | 101433 | 2019/2/18 | 2020/2/17 | Radiation |
| Amplifier | Sonoma | 310 | 363917 | 2019/1/22 | 2020/1/21 | Radiation |
| Amplifier | Schwarzbeck | BBV 9718 | 327 | 2019/1/22 | 2020/1/21 | Radiation |
| Amplifier | Narda | TTA1840-35-HG | 2034380 | 2019/05/15 | 2020/05/14 | Radiation |
| Broadband Antenna | Schwarzbeck | VULB 9168 | 9168-757 | 2017-03-03 | 2020-03-02 | Radiation |
| Horn Antenna | Schwarzbeck | BBHA 9120 D | 1677 | 2017-03-03 | 2020-03-02 | Radiation |
| Horn Antenna | COM-POWER | AH-1840 | 101117 | 2018-06-20 | 2021-06-19 | Radiation |
| Test Software | Auidx | E3 | 6.111221a | N/A | N/A | Radiation |
| Filter | Micro-Tronics | BRM 50702 | G266 | N/A | N/A | Radiation |

N/A: No Calibration Required

6 Uncertainty of Evaluation

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:

| MEASUREMENT | FREQUENCY | UNCERTAINTY |
|---------------------|---------------|-------------|
| Conducted emissions | 9kHz~30MHz | 2.60dB |
| Radiated emission | 30MHz ~ 1GMHz | 5.05dB |
| | 1GHz ~ 18GHz | 5.06 dB |
| | 18GHz ~ 40GHz | 3.65dB |

This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of $k=2$.

-----End of the report-----