

ELECTROMAGNETIC EMISSION COMPLIANCE REPORT FOR LOW-POWER, NON-LICENSED TRANSMITTER

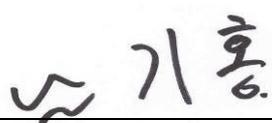
Test Report No. : OT-194-RWD-017
AGR No. : A192A-095R
Applicant : BLUECOM Co., Ltd.
Address : 116, Venture-ro, Yeonsu-gu, Incheon, 22013, South Korea
Manufacturer : BLUECOM Co., Ltd.
Address : 116, Venture-ro, Yeonsu-gu, Incheon, 22013, South Korea
Type of Equipment : Bluetooth Earbud
FCC ID. : U3WBCST90
Model Name : BCS-T90
Serial number : N/A
Total page of Report : 81 pages (including this page)
Date of Incoming : March 18, 2019
Date of issue : April 03, 2019

SUMMARY

The equipment complies with the regulation; *FCC PART 15 SUBPART C Section 15.247*

This test report only contains the result of a single test of the sample supplied for the examination.

It is not a generally valid assessment of the features of the respective products of the mass-production.

Reviewed by: 
Ki-Hong, Nam / Chief Engineer
ONETECH Corp.

Approved by: 
Keun-Young, Choi / Vice President
ONETECH Corp.

CONTENTS

| | PAGE |
|---|-------------|
| 1. VERIFICATION OF COMPLIANCE | 6 |
| 2. TEST SUMMARY | 7 |
| 2.1 TEST ITEMS AND RESULTS | 7 |
| 2.2 ADDITIONS, DEVIATIONS, EXCLUSIONS FROM STANDARDS | 7 |
| 2.3 RELATED SUBMITTAL(S) / GRANT(S) | 7 |
| 2.4 PURPOSE OF THE TEST | 7 |
| 2.5 TEST METHODOLOGY | 7 |
| 2.6 TEST FACILITY | 7 |
| 3. GENERAL INFORMATION | 8 |
| 3.1 PRODUCT DESCRIPTION | 8 |
| 3.2 ALTERNATIVE TYPE(S)/MODEL(S); ALSO COVERED BY THIS TEST REPORT | 8 |
| 4. EUT MODIFICATIONS | 8 |
| 5. SYSTEM TEST CONFIGURATION | 9 |
| 5.1 JUSTIFICATION | 9 |
| 5.2 PERIPHERAL EQUIPMENT | 9 |
| 5.3 MODE OF OPERATION DURING THE TEST | 9 |
| 5.4 CONFIGURATION OF TEST SYSTEM | 10 |
| 5.5 ANTENNA REQUIREMENT | 10 |
| 6. PRELIMINARY TEST | 11 |
| 6.1 AC POWER LINE CONDUCTED EMISSIONS TESTS | 11 |
| 6.2 GENERAL RADIATED EMISSIONS TESTS | 11 |
| 7. MINIMUM 20 DB BANDWIDTH | 12 |
| 7.1 OPERATING ENVIRONMENT | 12 |
| 7.2 TEST SET-UP | 12 |
| 7.3 TEST EQUIPMENT USED | 12 |
| 7.4 TEST DATA FOR 1 MBPS | 13 |
| 7.5 TEST DATA FOR 2 MBPS | 15 |
| 7.6 TEST DATA FOR 3 MBPS | 17 |
| 8. HOPPING FREQUENCY SEPARATION | 19 |
| 8.1 OPERATING ENVIRONMENT | 19 |
| 8.2 TEST SET-UP | 19 |

8.3 TEST EQUIPMENT USED 19

8.4 TEST DATA FOR 1 MBPS 20

8.5 TEST DATA FOR 2 MBPS 21

8.6 TEST DATA FOR 3 MBPS 22

9. NUMBER OF HOPPING CHANNELS 23

9.1 OPERATING ENVIRONMENT 23

9.2 TEST SET-UP 23

9.3 TEST EQUIPMENT USED 23

9.4 TEST DATA FOR 1 MBPS 24

9.5 TEST DATA FOR 2 MBPS 27

9.6 TEST DATA FOR 3 MBPS 30

10. TIME OF OCCUPANCY 33

10.1 OPERATING ENVIRONMENT 33

10.2 TEST SET-UP 33

10.3 TEST EQUIPMENT USED 33

10.4 TEST DATA FOR 1 MBPS 34

10.5 TEST DATA FOR 2 MBPS 37

10.6 TEST DATA FOR 3 MBPS 40

11. MAXIMUM PEAK OUTPUT POWER 43

11.1 OPERATING ENVIRONMENT 43

11.2 TEST SET-UP 43

11.3 TEST EQUIPMENT USED 43

11.4 TEST DATA FOR 1 MBPS 44

11.5 TEST DATA FOR 2 MBPS 46

11.6 TEST DATA FOR 3 MBPS 48

12. 100 KHZ BANDWIDTH OUTSIDE THE FREQUENCY BAND 50

12.1 OPERATING ENVIRONMENT 50

12.2 TEST SET-UP FOR CONDUCTED MEASUREMENT 50

12.3 TEST SET-UP FOR RADIATED MEASUREMENT 50

12.4 TEST EQUIPMENT USED 50

12.5 TEST DATA FOR CONDUCTED EMISSION 51

 12.5.1 Test data for 1 Mbps 51

 12.5.2 Test data for 2 Mbps 56

 12.5.3 Test data for 3 Mbps 61

12.6 TEST DATA FOR TRANSMITTING MODE RADIATED EMISSION 66

 12.6.1 Radiated Emission which fall in the Restricted Band 66

| | |
|---|-----------|
| 12.6.2 Spurious & Harmonic Radiated Emission above 1 GHz..... | 69 |
| 13. RADIATED EMISSION TEST | 72 |
| 13.1 OPERATING ENVIRONMENT | 72 |
| 13.2 TEST SET-UP | 72 |
| 13.3 TEST EQUIPMENT USED..... | 72 |
| 13.4 TEST DATA FOR TRANSMITTING MODE [BDR] | 73 |
| 13.4.1 Test data for 30 MHz ~ 960 MHz..... | 73 |
| 13.4.2 Test data for Below 30 MHz..... | 74 |
| 13.4.3 Test data for above 1 GHz | 74 |
| 13.5 TEST DATA FOR TRANSMITTING MODE [EDR] | 75 |
| 13.5.1 Test data for 30 MHz ~ 960 MHz..... | 75 |
| 13.5.2 Test data for Below 30 MHz..... | 76 |
| 13.5.3 Test data for above 1 GHz | 76 |
| 13.6 TEST DATA FOR CHARGING MODE | 77 |
| 13.6.1 Test data for 30 MHz ~ 960 MHz..... | 77 |
| 13.6.2 Test data for Below 30 MHz..... | 78 |
| 13.6.3 Test data for above 1 GHz | 78 |
| 14. CONDUCTED EMISSION TEST | 79 |
| 14.1 OPERATING ENVIRONMENT | 79 |
| 14.2 TEST SET-UP | 79 |
| 14.3 TEST EQUIPMENT USED..... | 79 |
| 14.4 TEST DATA FOR CHARGING MODE..... | 80 |

Revision History

| Rev. No. | Issue Report No. | Issued Date | Revisions | Section Affected |
|----------|------------------|----------------|-----------------|------------------|
| 0 | OT-194-RWD-017 | April 03, 2019 | Initial Release | All |
| | | | | |
| | | | | |

1. VERIFICATION OF COMPLIANCE

Applicant : BLUECOM Co., Ltd.
 Address : 116, Venture-ro, Yeonsu-gu, Incheon, 22013, South Korea
 Contact Person : Ki-eok, Park / Principal Engineer
 Telephone No. : +82-32-8100-582
 FCC ID : U3WBCST90
 Model Name : BCS-T90
 Brand Name : -
 Serial Number : N/A
 Date : April 03, 2019

| | |
|--|---|
| EQUIPMENT CLASS | DSS – PART 15 SPREAD SPECTRUM TRANSMITTER |
| E.U.T. DESCRIPTION | Bluetooth Earbud |
| THIS REPORT CONCERNS | Original Grant |
| MEASUREMENT PROCEDURES | ANSI C63.10: 2013 |
| TYPE OF EQUIPMENT TESTED | Pre-Production |
| KIND OF EQUIPMENT AUTHORIZATION REQUESTED | Certification |
| EQUIPMENT WILL BE OPERATED UNDER FCC RULES PART(S) | FCC PART 15 SUBPART C Section 15.247 |
| Modifications on the Equipment to Achieve Compliance | None |
| Final Test was Conducted On | 3 m, Semi Anechoic Chamber |

-. The above equipment was tested by ONETECH Corp. for compliance with the requirement set forth in the FCC Rules and Regulations. This said equipment in the configuration described in this report, shows the maximum emission levels emanating from equipment are within the compliance requirements.

2. TEST SUMMARY

2.1 Test items and results

| SECTION | TEST ITEMS | RESULTS |
|----------------------|---|------------------------|
| 15.247 (a) (1) | Carrier Frequency Separation | Met the Limit / PASS |
| 15.247 (a) (1) (iii) | Minimum Number of Hopping Channels | Met the Limit / PASS |
| 15.247 (a) (1) (iii) | Average Time of Occupancy | Met the Limit / PASS |
| 15.247 (b) (1) | Maximum Peak Conducted Output Power | Met the Limit / PASS |
| 15.247 (d) | 100 kHz Bandwidth Outside the Frequency Band | Met the Limit / PASS |
| 15.247 (d) | Radiated Emission which fall in the Restricted Band | Met the Limit / PASS |
| 15.209 | Radiated Emission Limits, General Requirement | Met the Limit / PASS |
| 15.207 | Conducted Limits | Met the Limit / PASS |
| 15.203 | Antenna Requirement | Met requirement / PASS |

2.2 Additions, deviations, exclusions from standards

No additions, deviations or exclusions have been made from standard.

2.3 Related Submittal(s) / Grant(s)

Original submittal only

2.4 Purpose of the test

To determine whether the equipment under test fulfills the requirements of the regulation stated in FCC PART 15 SUBPART C Section 15.247.

2.5 Test Methodology

Both conducted and radiated testing was performed according to the procedures in ANSI C63.10: 2013. Radiated testing was performed at a distance of 3 m from EUT to the antenna.

2.6 Test Facility

The Onetech Corp. has been designated to perform equipment testing in compliance with ISO/IEC 17025.

The Electromagnetic compatibility measurement facilities are located at 43-14, Jinsaegol-gil, Chowol-eup, Gwangju-si, Gyeonggi-do, 12735, Korea

-. Site Filing:

VCCI (Voluntary Control Council for Interference) – Registration No. R-4112/ C-14617/ G-10666 / T-1842

IC (Industry Canada) – Registration No. Site# 3736A-3

-. Site Accreditation:

KOLAS (Korea Laboratory Accreditation Scheme) - Accreditation NO. KT085

FCC (Federal Communications Commission) - Accreditation No. KR0013

RRA (Radio Research Agency) – Designation No. KR0013

3. GENERAL INFORMATION

3.1 Product Description

The BLUECOM Co., Ltd., Model BCS-T90 (referred to as the EUT in this report) is a Bluetooth Earbud. The product specification described herein was obtained from product data sheet or user’s manual.

| | | | |
|--|------------------|--|----------|
| DEVICE TYPE | Bluetooth Earbud | | |
| Temperature Range | -10 °C ~ 50 °C | | |
| OPERATING FREQUENCY | Bluetooth LE | 2 402 MHz ~ 2 480 MHz | |
| | Bluetooth | 2 402 MHz ~ 2 480 MHz | |
| MODULATION TYPE | Bluetooth LE | GFSK | |
| | Bluetooth | GFSK for 1Mbps, $\pi/4$ -DQPSK for 2Mbps, 8-DPSK for 3Mbps | |
| RF OUTPUT POWER' | Bluetooth LE | 9.80 dBm | |
| | Bluetooth | 1 Mbps | 9.36 dBm |
| | | 2 Mbps | 9.20 dBm |
| | | 3 Mbps | 9.55 dBm |
| ANTENNA TYPE | FPCB Antenna | | |
| ANTENNA GAIN | 3.00 dBi | | |
| List of each Osc. or crystal Freq.(Freq. \geq 1 MHz) | 32 MHz | | |
| RATED SUPPLY VOLTAGE | DC 3.6 V | | |

3.2 Alternative type(s)/model(s); also covered by this test report.

-. None

4. EUT MODIFICATIONS

-. None

5. SYSTEM TEST CONFIGURATION

5.1 Justification

This device was configured for testing in a typical way as a normal customer is supposed to be used. During the test, the following components were installed inside of the EUT.

| DEVICE TYPE | MANUFACTURER | MODEL/PART NUMBER | FCC ID |
|---------------|-------------------|-------------------|--------|
| Main Board | BLUECOM Co., Ltd. | BCS-T90G | N/A |
| Power Board | BLUECOM Co., Ltd. | N/A | N/A |
| Touch Board | BLUECOM Co., Ltd. | Stone_FPCB_Touch | N/A |
| Antenna Board | BLUECOM Co., Ltd. | BCS-T90 FPCB_ANT | N/A |
| Battery | N/A | GP1458-08N+PCM | N/A |

5.2 Peripheral equipment

Defined as equipment needed for correct operation of the EUT, but not considered as tested:

-. Charging mode

| Model | Manufacturer | Description | Connected to |
|---------------|-------------------|------------------------|--------------|
| BCS-T90 | BLUECOM Co., Ltd. | Bluetooth Earbud (EUT) | Cradle |
| BCS-T90C | BLUECOM Co., Ltd. | Cradle | EUT |
| SU10334-15004 | LG Electronics | Adaptor | - |

-. Transmitting Mode

| Model | Manufacturer | Description | Connected to |
|----------|-------------------|------------------------|--------------|
| BCS-T90 | BLUECOM Co., Ltd. | Bluetooth Earbud (EUT) | Notebook PC |
| Pavilion | HP | Notebook PC | EUT |

5.3 Mode of operation during the test

-. For Bluetooth function testing, software used to control the EUT for staying in continuous transmitting and receiving mode is programmed. The EUT was set at Low Channel (2 402 MHz), Middle Channel (2 441 MHz), and High Channel (2 480 MHz) with each data transfer rate, 1 Mbps, 2 Mbps, and 3 Mbps. To get a maximum radiated emission levels from the EUT, the EUT was moved throughout the XY, XZ, and YZ planes and the worst case is “XY” axis, but the worst data was recorded in this test report.

-. EUT is PCB with the same structure by the left and right. So, We tested for Right Earset

5.4 Configuration of Test System

Line Conducted Test: The EUT was tested in a Charging mode. The EUT was connected to USB and the power of USB was connected to Adaptor. All supporting equipments were connected to another LISN. Preliminary Power line Conducted Emission test was performed by using the procedure in ANSI C63.10: 2013 to determine the worse operating conditions.

Radiated Emission Test: Preliminary radiated emissions test were conducted using the procedure in ANSI C63.10: 2013 to determine the worse operating conditions. Final radiated emission tests were conducted at 3 meter Semi Anechoic Chamber.

The turntable was rotated through 360 degrees and the EUT was tested by positioned three orthogonal planes to obtain the highest reading on the field strength meter. Once maximum reading was determined, the search antenna was raised and lowered in both vertical and horizontal polarization.

5.5 Antenna Requirement

For intentional device, according to section 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.

Antenna Construction:

The antenna of the EUT is a FPCB Antenna on the main board in the EUT, so no consideration of replacement by the user.

6. PRELIMINARY TEST

6.1 AC Power line Conducted Emissions Tests

During Preliminary Test, the following operating mode was investigated.

| Operation Mode | The Worse operating condition (Please check one only) |
|----------------|---|
| Charging mode | X |

6.2 General Radiated Emissions Tests

During Preliminary Test, the following operating mode was investigated.

| Operation Mode | The Worse operating condition (Please check one only) |
|-------------------|---|
| Transmitting Mode | X |

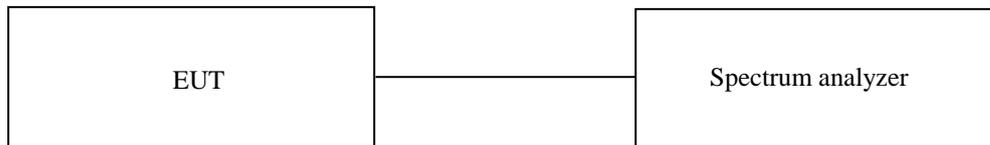
7. MINIMUM 20 dB BANDWIDTH

7.1 Operating environment

Temperature : 23 °C
 Relative humidity : 45 % R.H.

7.2 Test set-up

The antenna output of the EUT was connected to the spectrum analyzer. The resolution bandwidth is set to 10 kHz, and peak detection was used. The 20 dB bandwidth is defined as the total spectrum over which the power is higher than the peak power minus 20 dB.



7.3 Test equipment used

| Model Number | Manufacturer | Description | Serial Number | Last Cal. |
|--------------|-----------------|-----------------|---------------|--------------------|
| ■ - FSV40 | Rohde & Schwarz | Signal Analyzer | 101009 | Mar. 11, 2019 (1Y) |

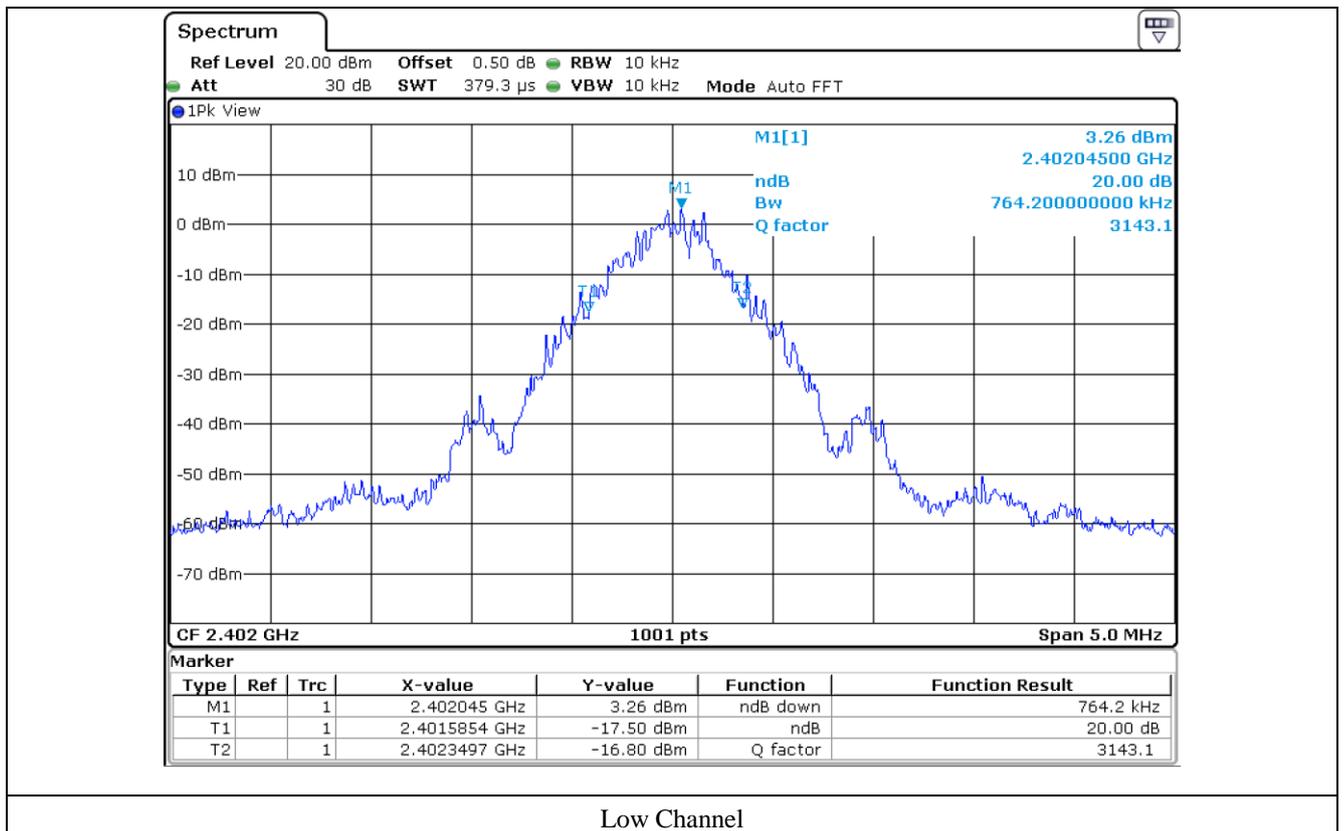
All test equipment used is calibrated on a regular basis.

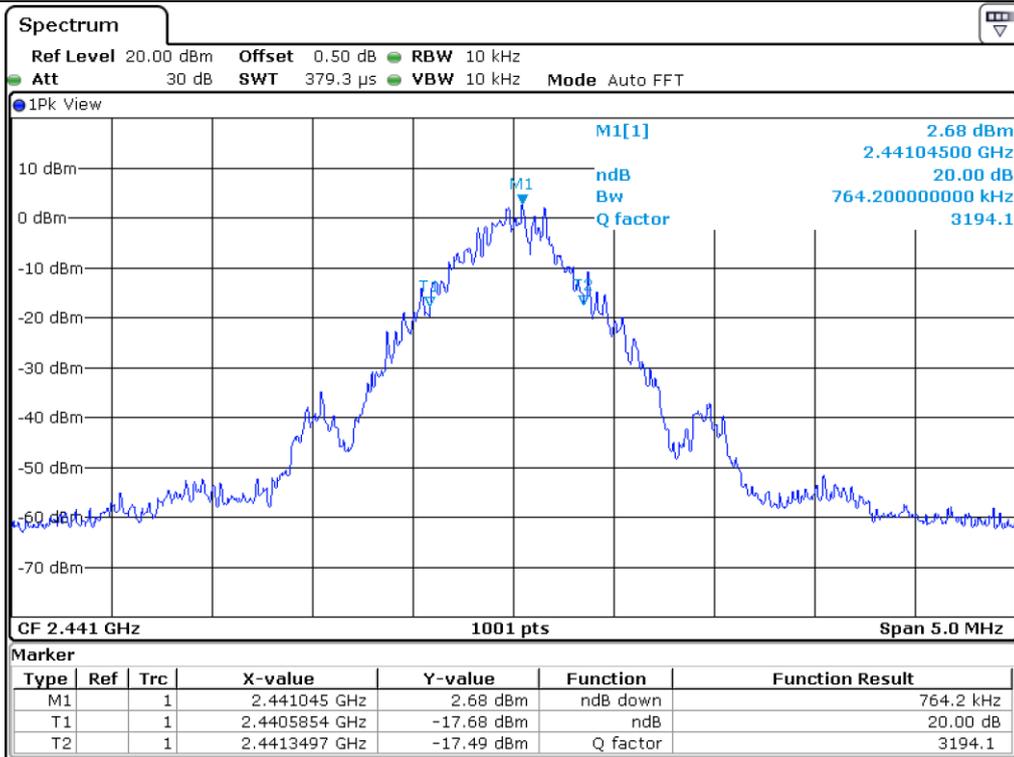
7.4 Test data for 1 Mbps

-. Test Date : March 18, 2019

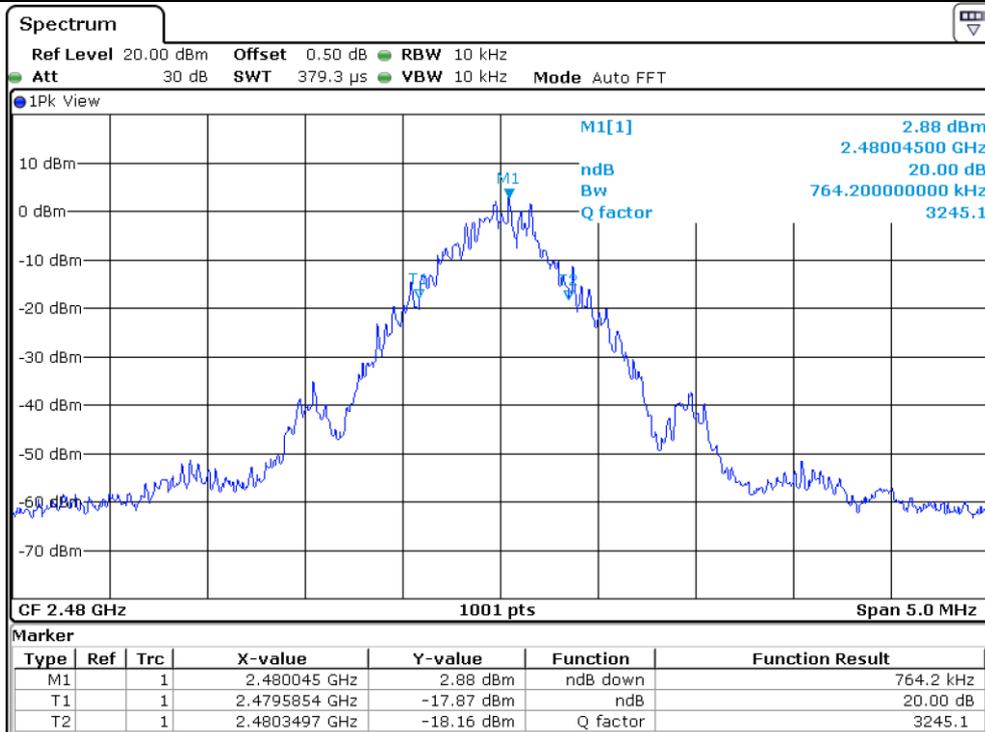
| CHANNEL | FREQUENCY (MHz) | 20 dB Bandwidth (kHz) |
|---------|-----------------|-----------------------|
| Low | 2 402.00 | 764.20 |
| Middle | 2 441.00 | 764.20 |
| High | 2 480.00 | 764.20 |

Tested by: Hyung-Kwon, Oh / Assistant Manager





Middle Channel



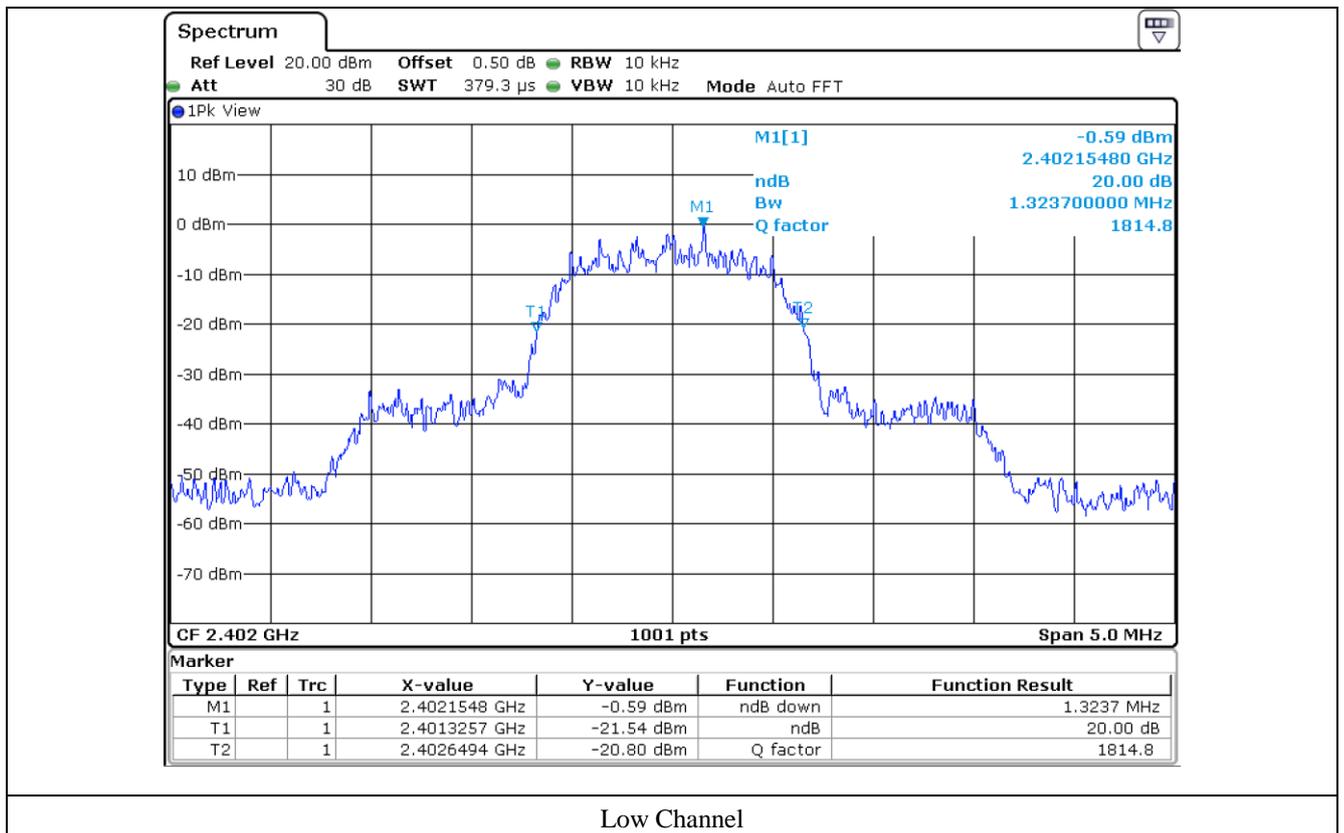
High Channel

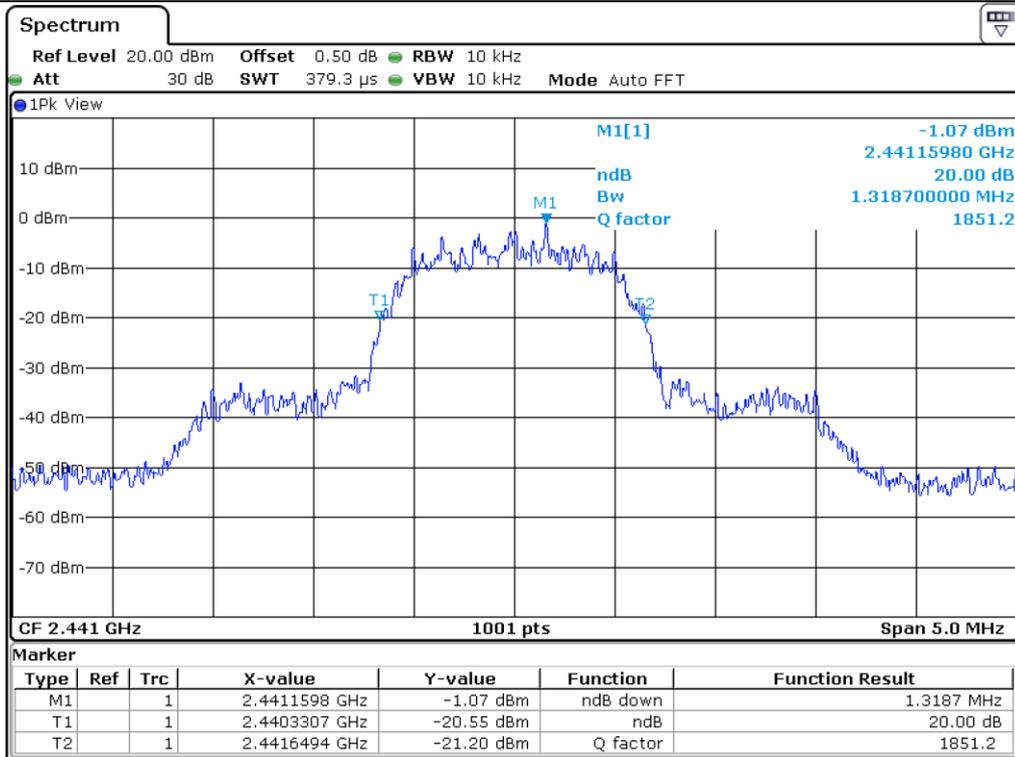
7.5 Test data for 2 Mbps

-. Test Date : March 18, 2019

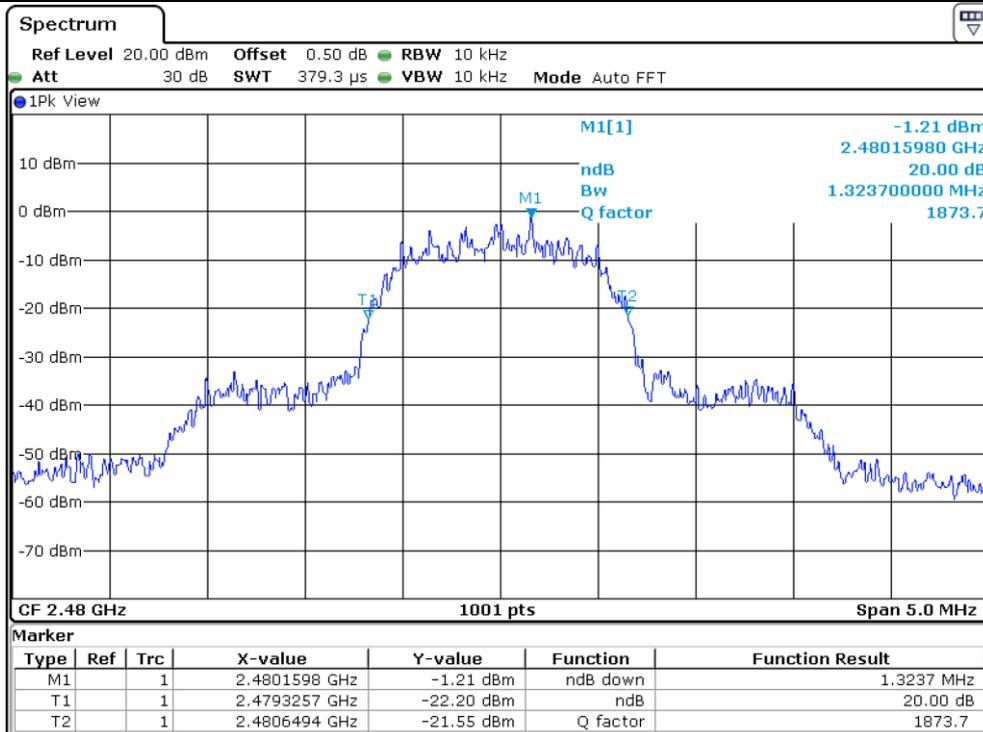
| CHANNEL | FREQUENCY (MHz) | 20 dB Bandwidth (kHz) |
|---------|-----------------|-----------------------|
| Low | 2 402.00 | 1 323.70 |
| Middle | 2 441.00 | 1 318.70 |
| High | 2 480.00 | 1 323.70 |

Tested by: Hyung-Kwon, Oh / Assistant Manager





Middle Channel



High Channel

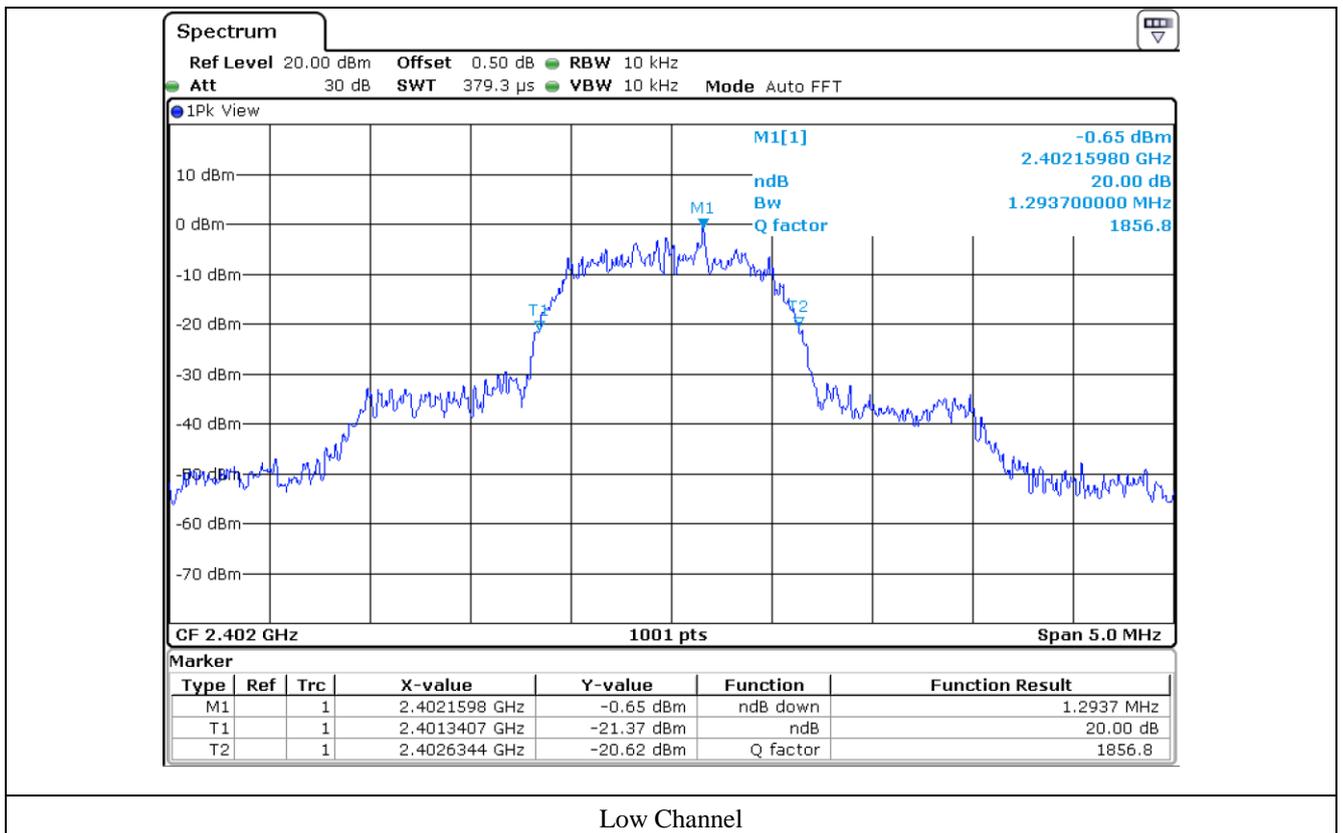
7.6 Test data for 3 Mbps

-. Test Date : March 18, 2019

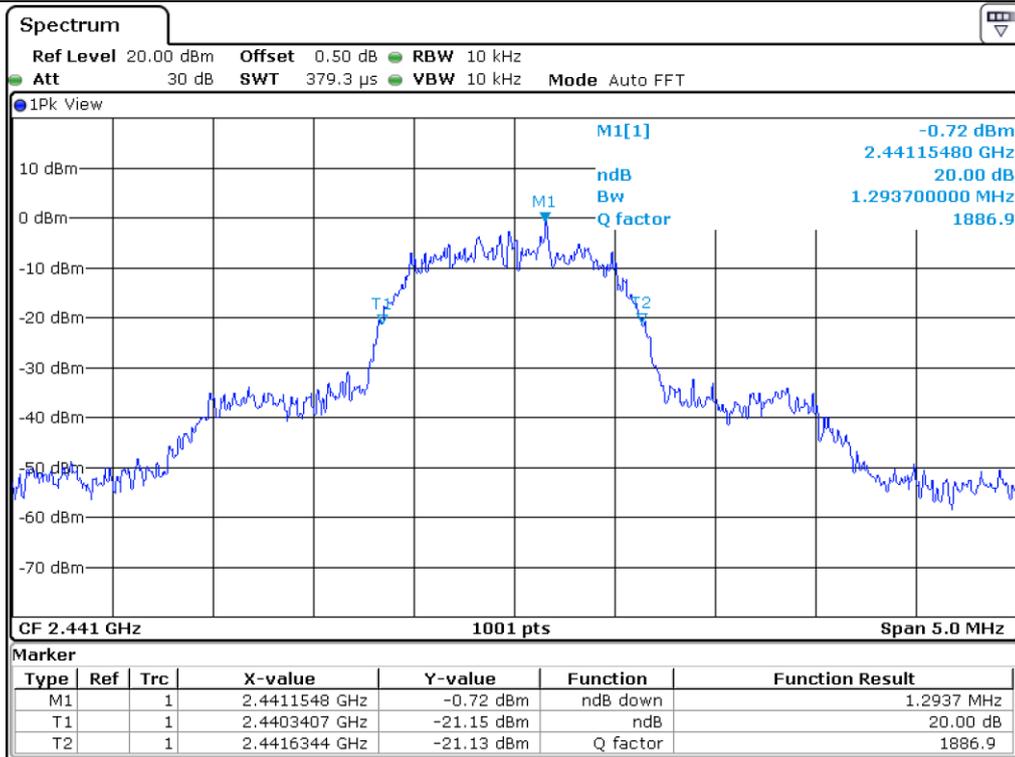
| CHANNEL | FREQUENCY (MHz) | 20 dB Bandwidth (kHz) |
|---------|-----------------|-----------------------|
| Low | 2 402.00 | 1 293.70 |
| Middle | 2 441.00 | 1 293.70 |
| High | 2 480.00 | 1 293.70 |



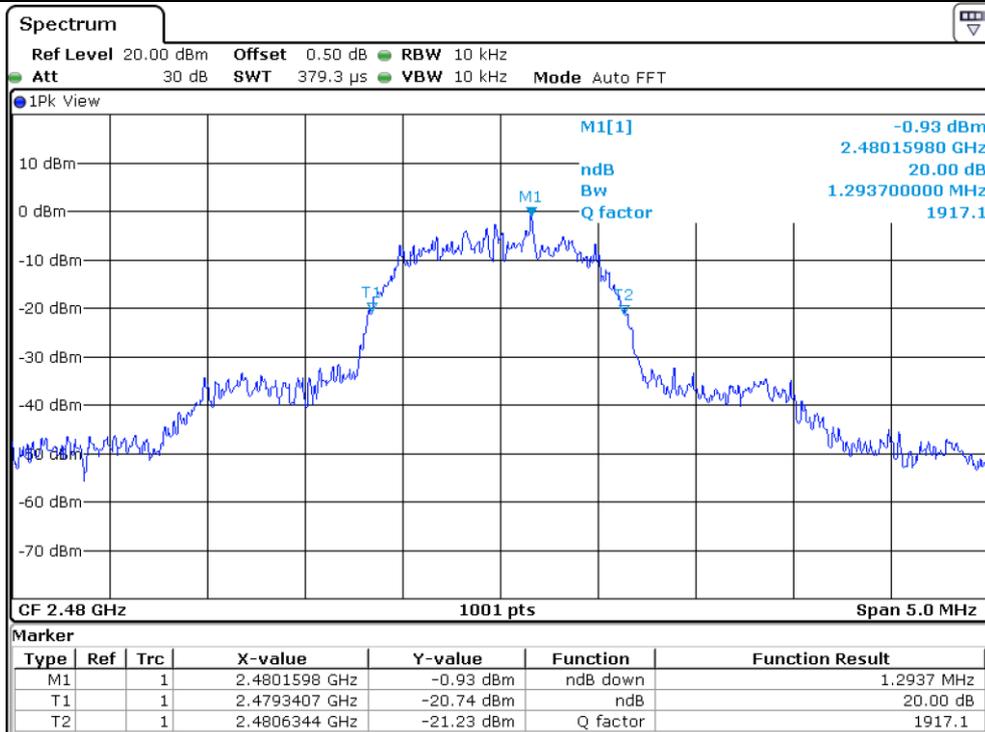
Tested by: Hyung-Kwon, Oh / Assistant Manager



Low Channel



Middle Channel



High Channel

8. HOPPING FREQUENCY SEPARATION

8.1 Operating environment

Temperature : 23 °C
 Relative humidity : 45 % R.H.

8.2 Test set-up

The antenna output of the EUT was connected to the spectrum analyzer. The frequency span is set to 5 MHz. The analyzer is set to peak hold then a pseudo-random hopping sequence of the transmitter is captured. The mark delta function was used to measure the frequency separation between two adjacent hopping channels.



8.3 Test equipment used

| Model Number | Manufacturer | Description | Serial Number | Last Cal. |
|--------------|-----------------|-----------------|---------------|--------------------|
| ■ - FSV40 | Rohde & Schwarz | Signal Analyzer | 101009 | Mar. 11, 2019 (1Y) |

All test equipment used is calibrated on a regular basis.

8.4 Test data for 1 Mbps

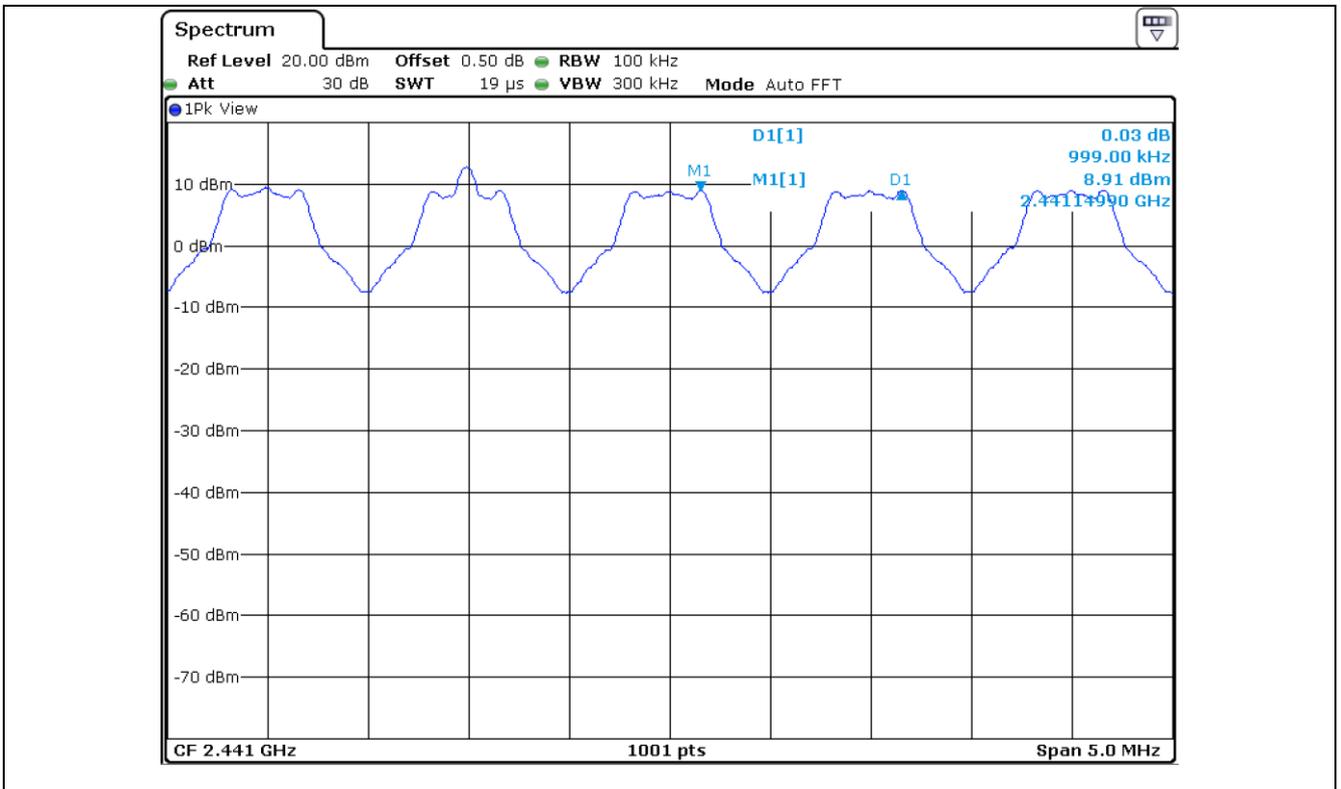
- Test Date : March 18, 2019

- Test Result : Pass

| MEASURED VLAUE (kHz) | Two-third of 20 dB Bandwidth (kHz) | LIMIT |
|----------------------|------------------------------------|----------------------------------|
| 999.00 | 509.47 | Separated by a minimum of 25 kHz |



Tested by: Hyung-Kwon, Oh / Assistant Manager



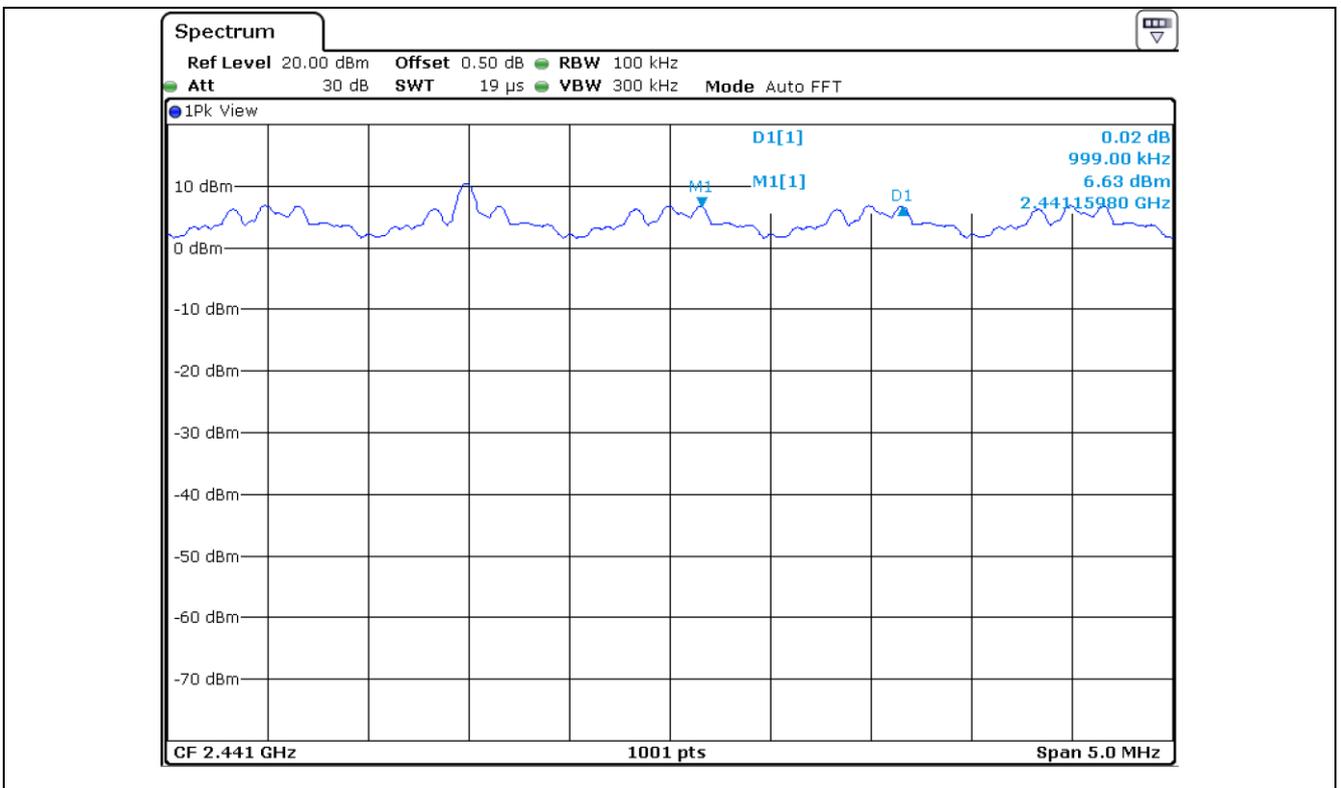
8.5 Test data for 2 Mbps

- Test Date : March 18, 2019

- Test Result : Pass

| MEASURED VLAUE (kHz) | Two-third of 20 dB Bandwidth (kHz) | LIMIT |
|----------------------|------------------------------------|----------------------------------|
| 999.00 | 882.47 | Separated by a minimum of 25 kHz |

Tested by: Hyung-Kwon, Oh / Assistant Manager



8.6 Test data for 3 Mbps

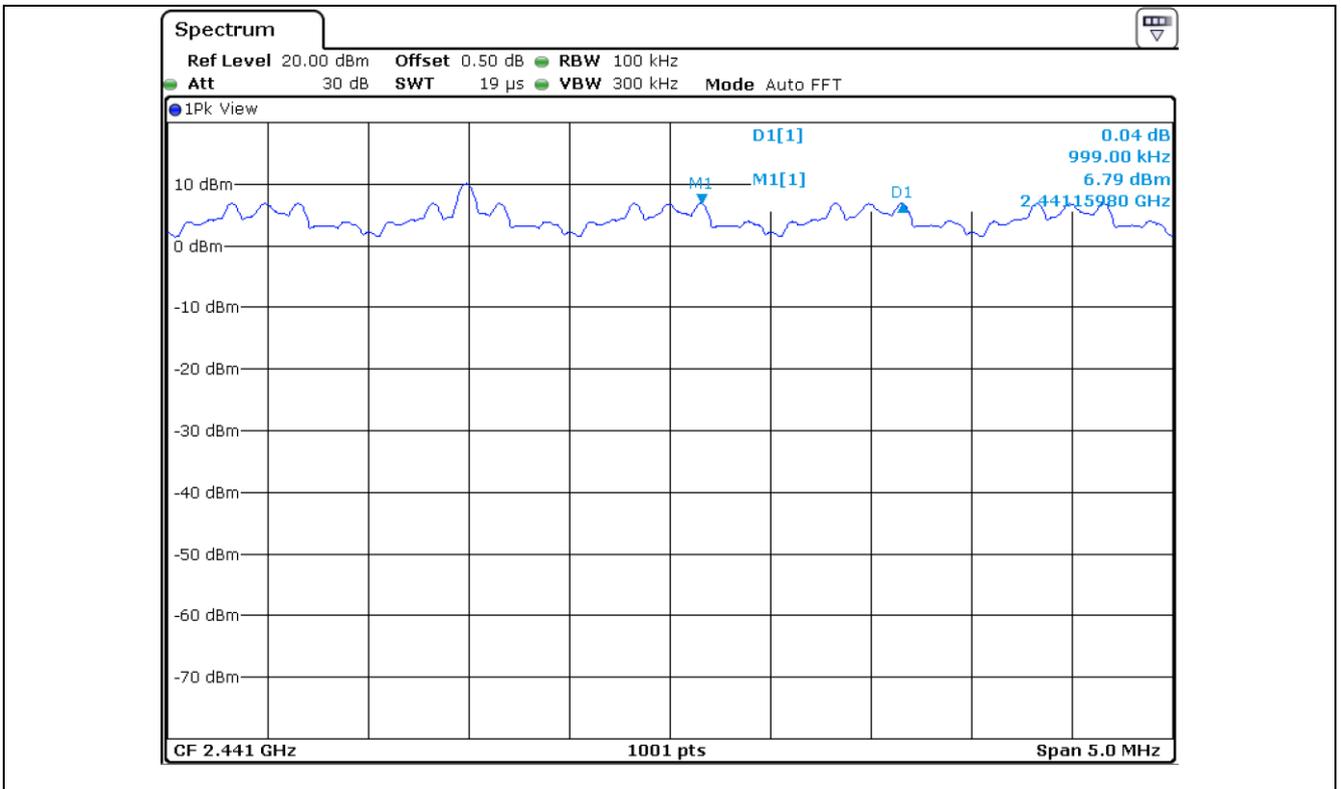
- Test Date : March 18, 2019

- Test Result : Pass

| MEASURED VLAUE (kHz) | Two-third of 20 dB Bandwidth (kHz) | LIMIT |
|----------------------|------------------------------------|----------------------------------|
| 999.00 | 862.47 | Separated by a minimum of 25 kHz |



Tested by: Hyung-Kwon, Oh / Assistant Manager



9. NUMBER OF HOPPING CHANNELS

9.1 Operating environment

Temperature : 23 °C
 Relative humidity : 45 % R.H.

9.2 Test set-up

The antenna output of the EUT was connected to the spectrum analyzer. The frequency span is set to 100 MHz and the resolution bandwidth is set to 100 kHz. The analyzer is set to peak hold and then complete pseudo-random hopping sequence of the transmitter is captured.



9.3 Test equipment used

| Model Number | Manufacturer | Description | Serial Number | Last Cal. |
|--------------|-----------------|-----------------|---------------|--------------------|
| ■ - FSV40 | Rohde & Schwarz | Signal Analyzer | 101009 | Mar. 11, 2019 (1Y) |

All test equipment used is calibrated on a regular basis.

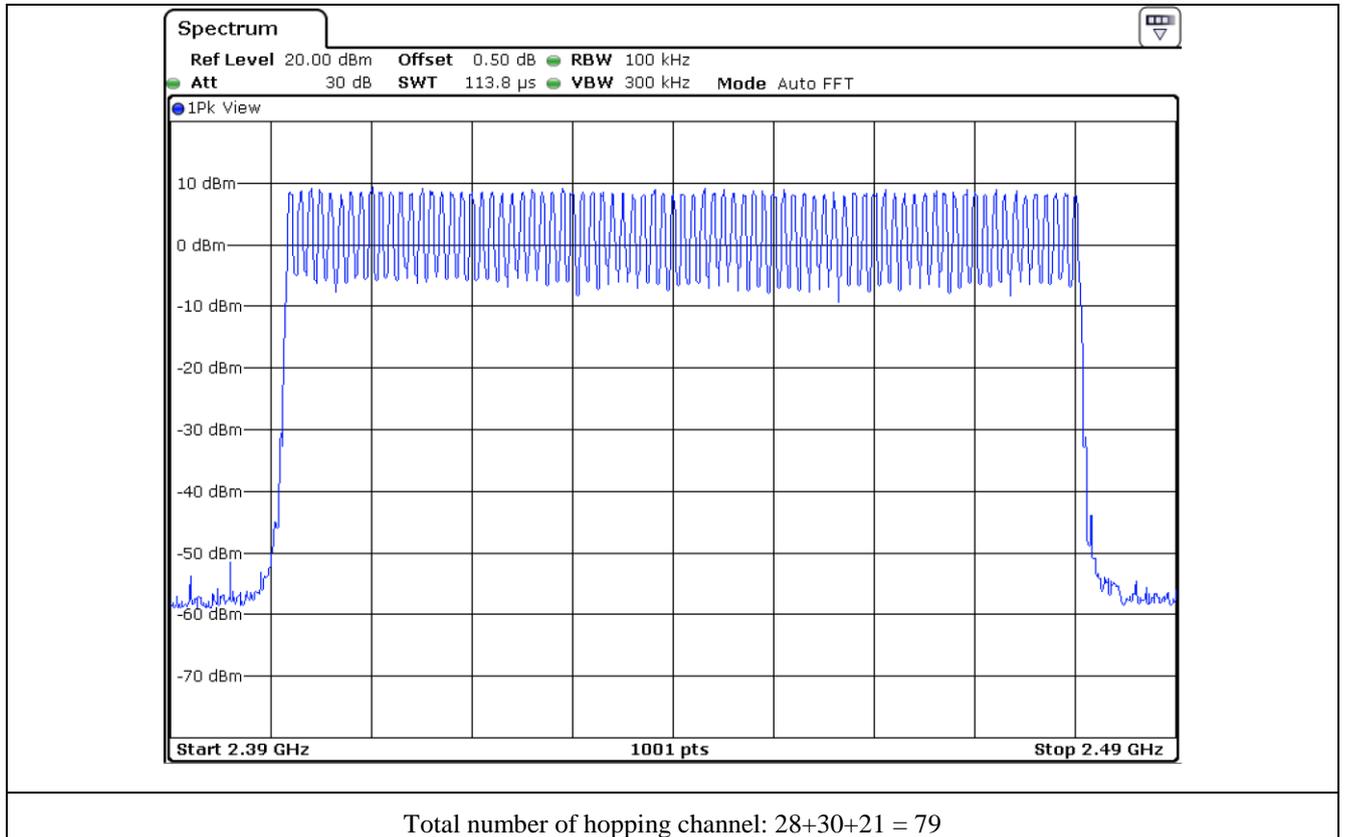
9.4 Test data for 1 Mbps

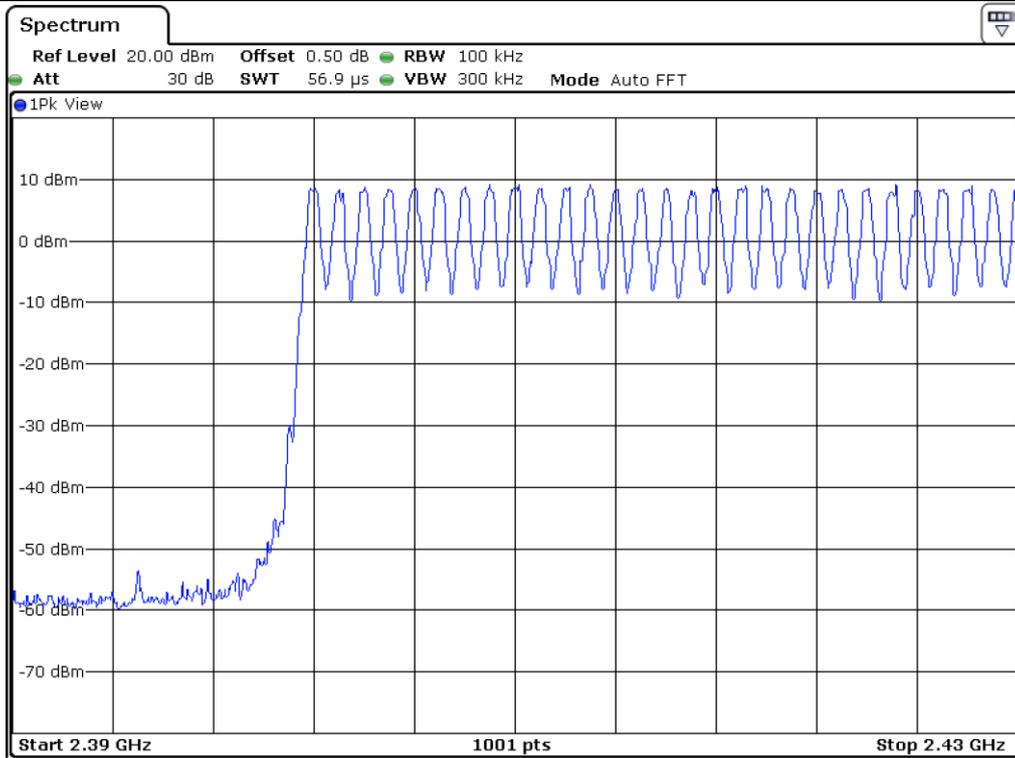
- Test Date : March 18, 2019
- Test Result : Pass

| Data Transfer Rate | Measured value (Number) | Limit (Number) | Margin (Number) |
|--------------------|-------------------------|----------------|-----------------|
| 1 Mbps | 79 | Minimum of 15 | 64 |

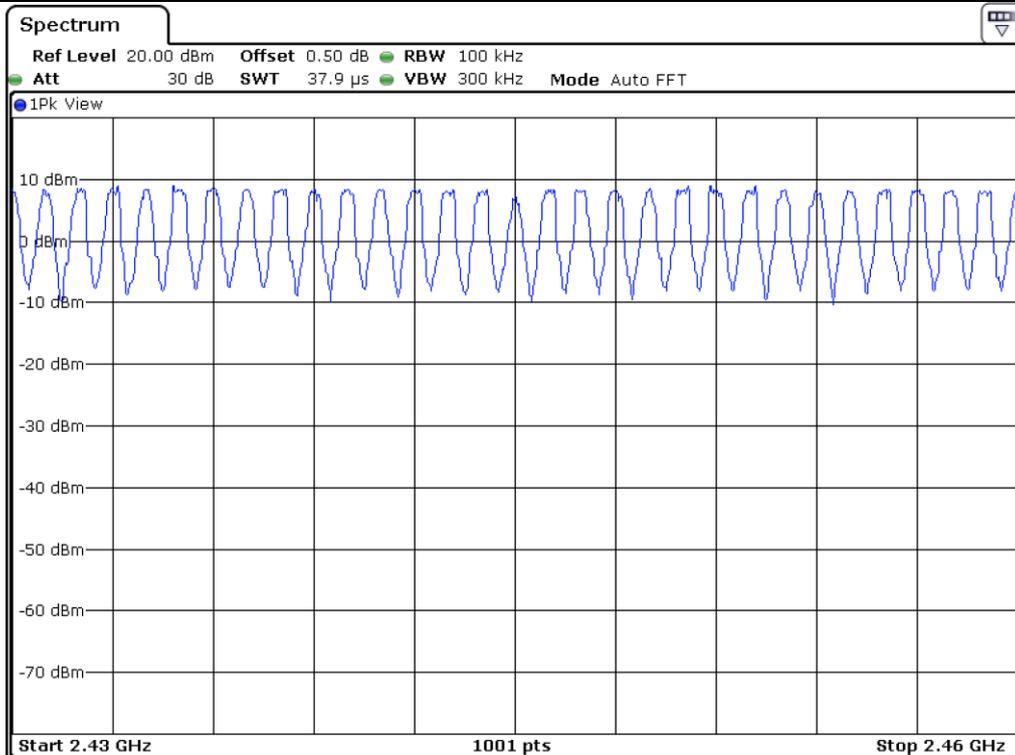


Tested by: Hyung-Kwon, Oh / Assistant Manager

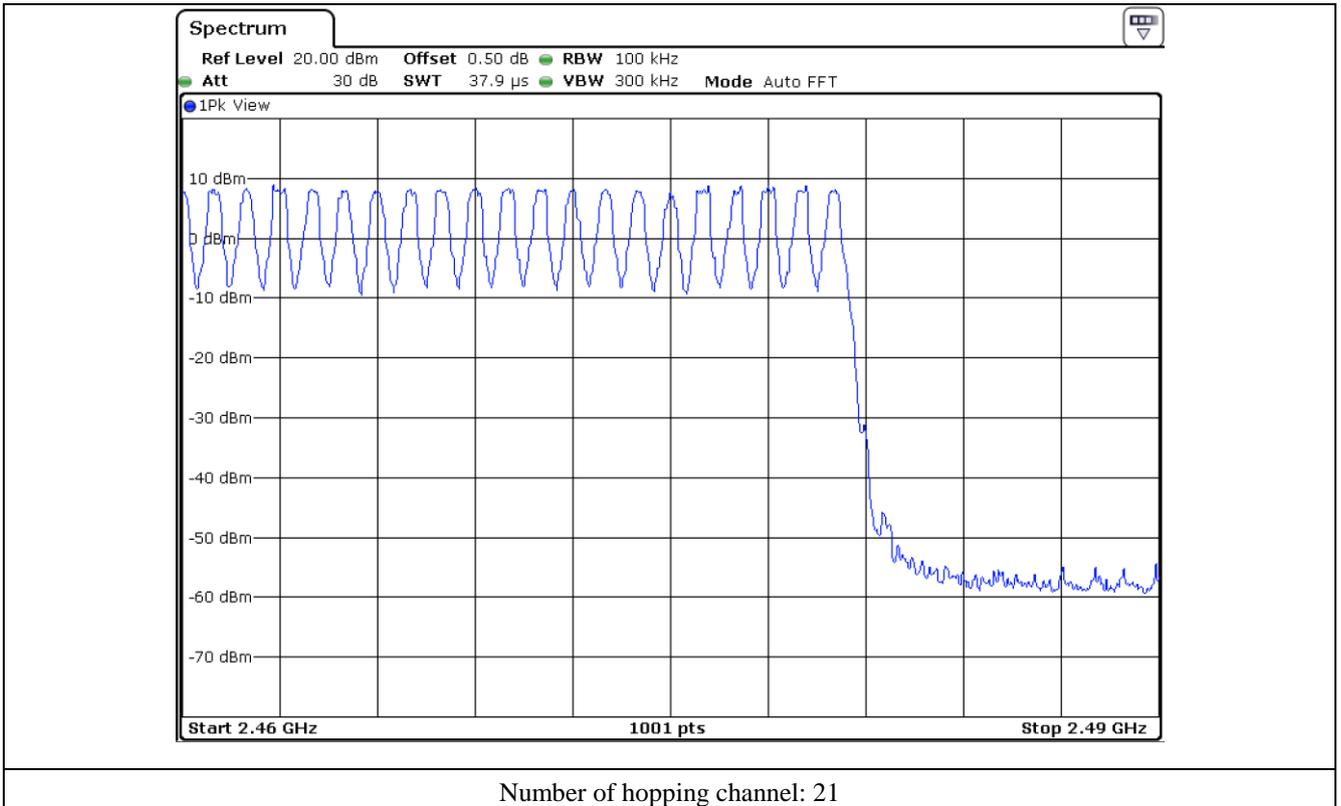




Number of hopping channel: 28



Number of hopping channel: 30



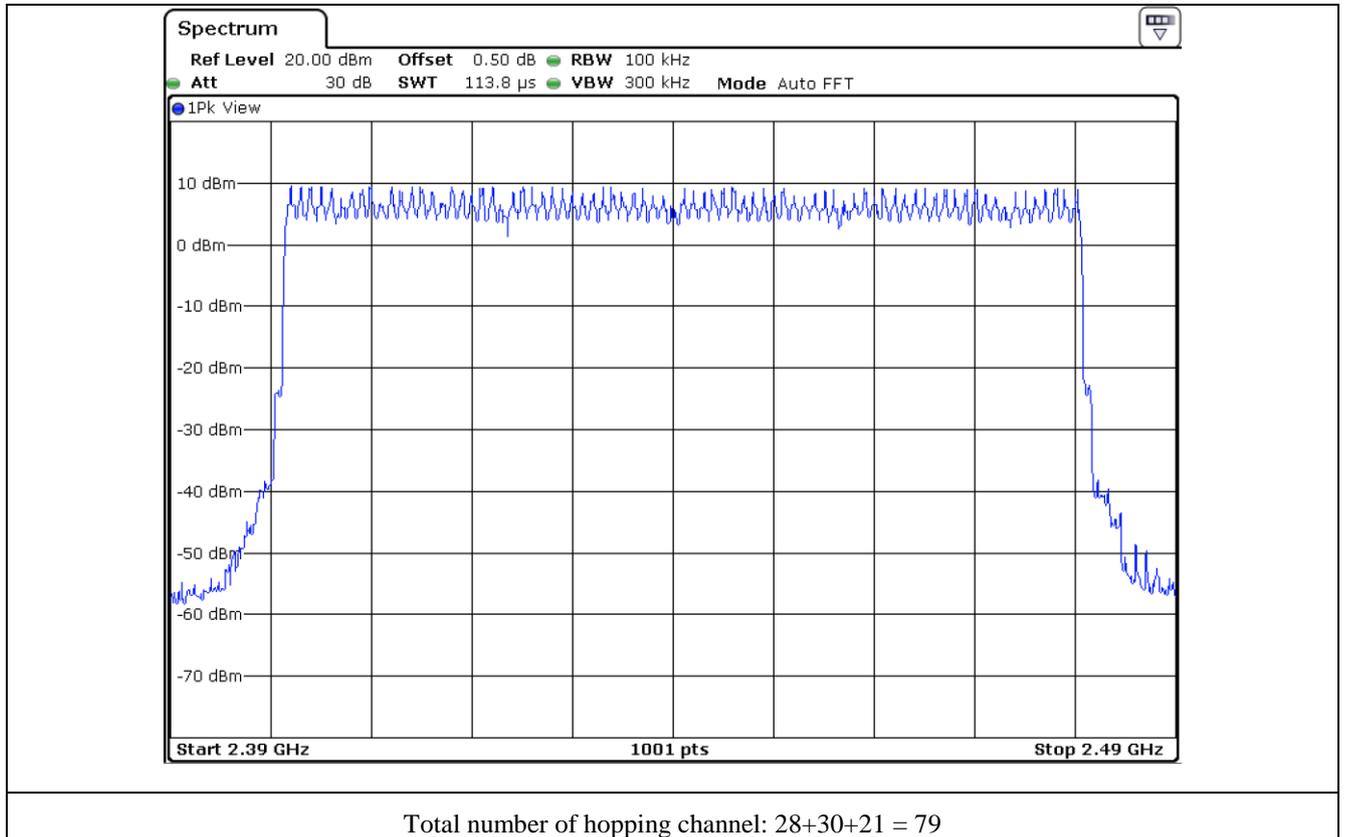
9.5 Test data for 2 Mbps

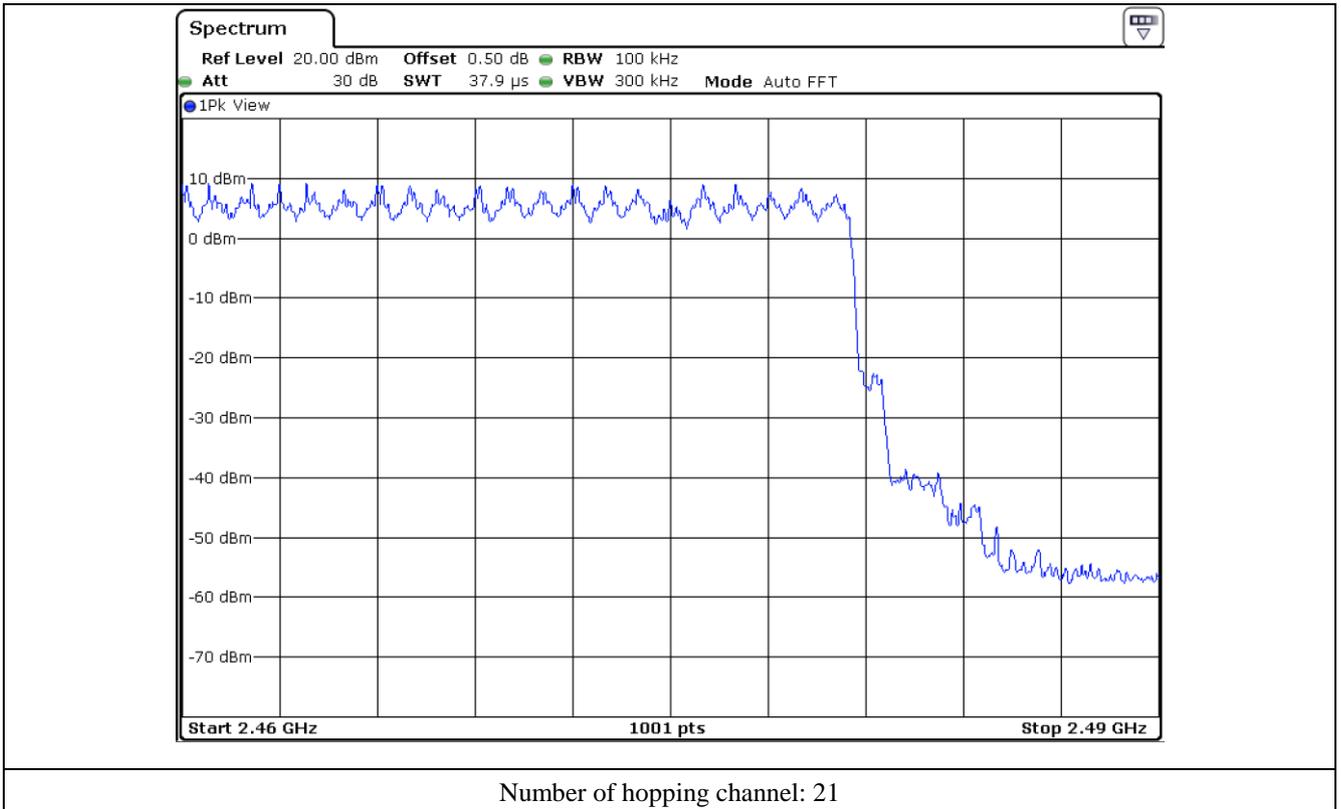
- Test Date : March 18, 2019
- Test Result : Pass

| Data Transfer Rate | Measured value (Number) | Limit (Number) | Margin (Number) |
|--------------------|-------------------------|----------------|-----------------|
| 2 Mbps | 79 | Minimum of 15 | 64 |



Tested by: Hyung-Kwon, Oh / Assistant Manager



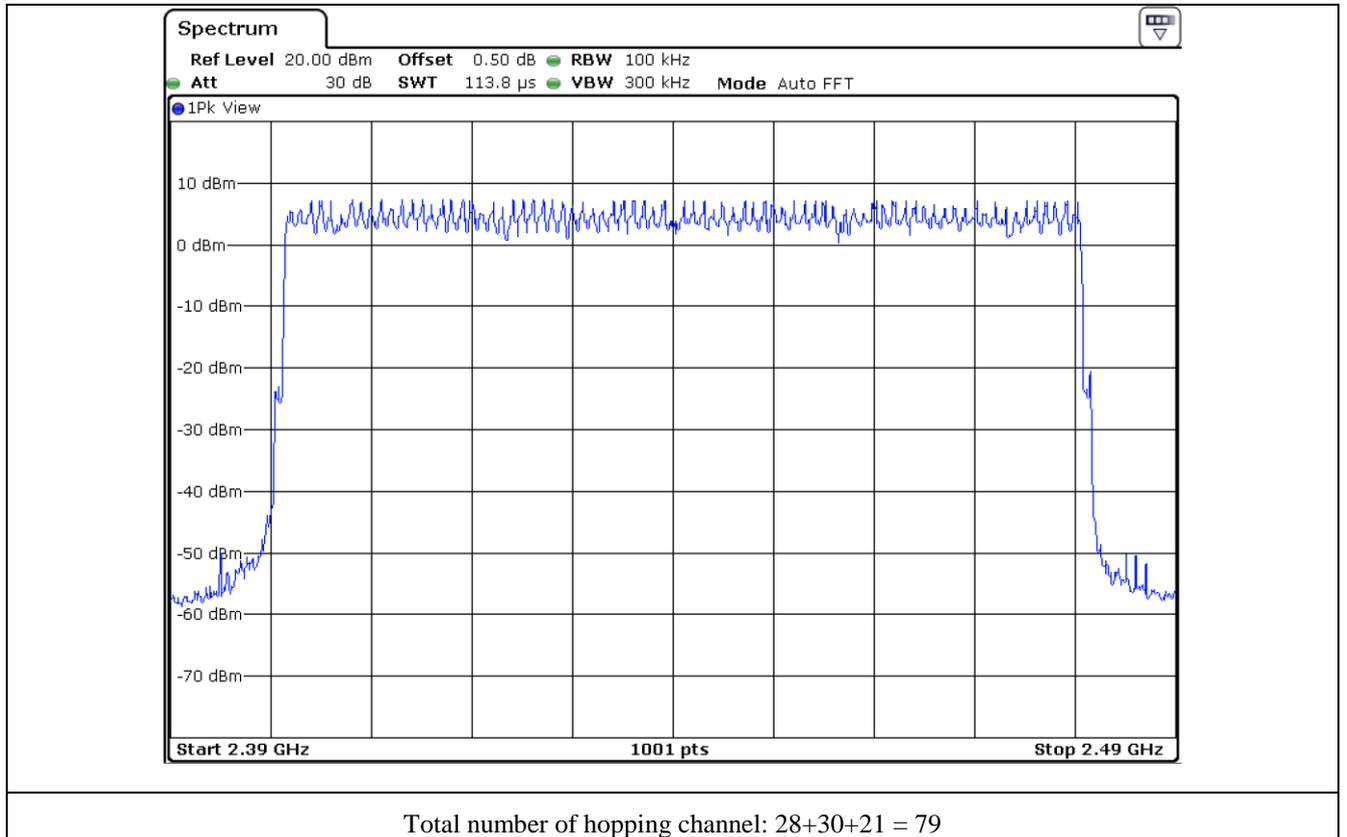


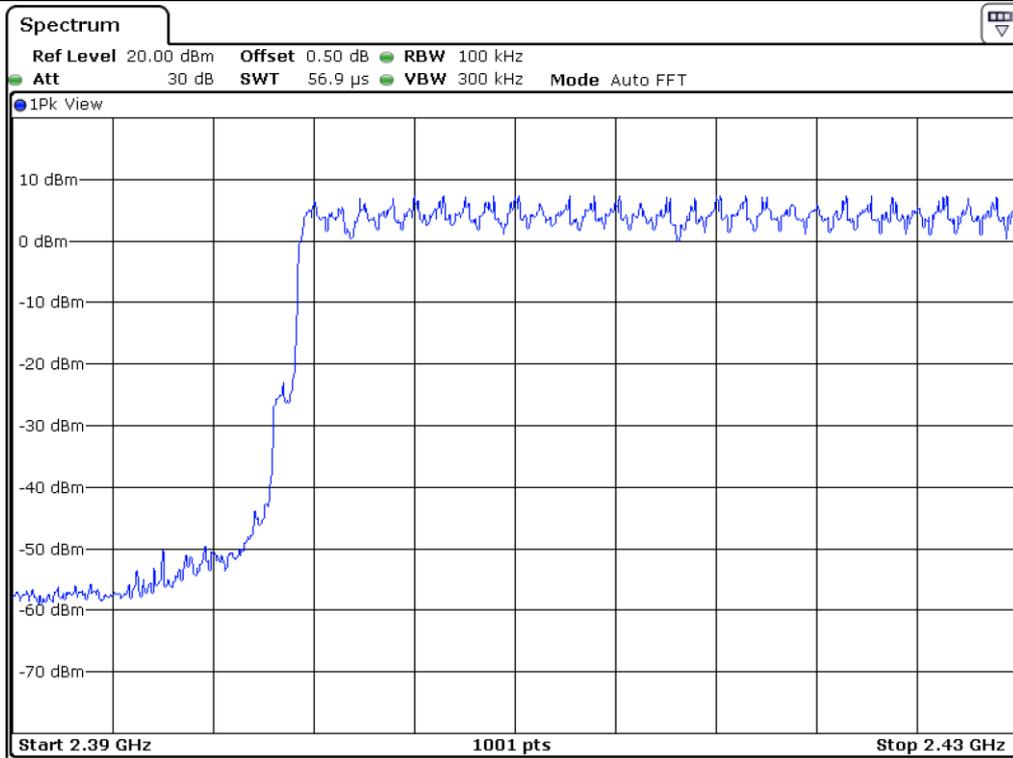
9.6 Test data for 3 Mbps

- Test Date : March 18, 2019
- Test Result : Pass

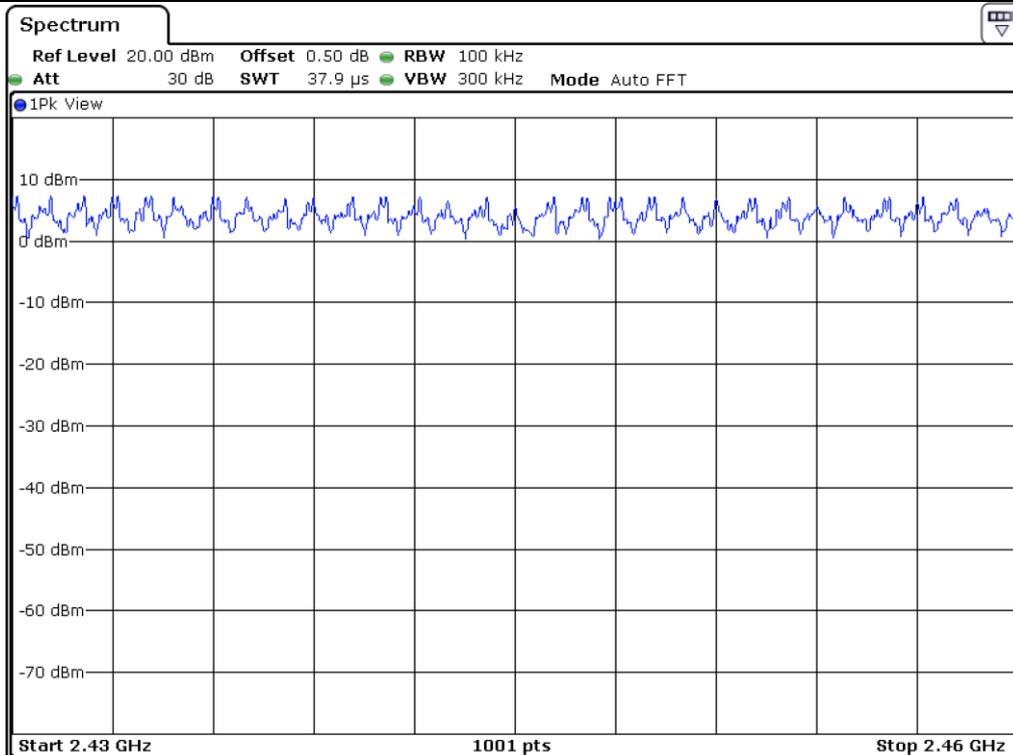
| Data Transfer Rate | Measured value (Number) | Limit (Number) | Margin (Number) |
|--------------------|-------------------------|----------------|-----------------|
| 3 Mbps | 79 | Minimum of 15 | 64 |

Tested by: Hyung-Kwon, Oh / Assistant Manager

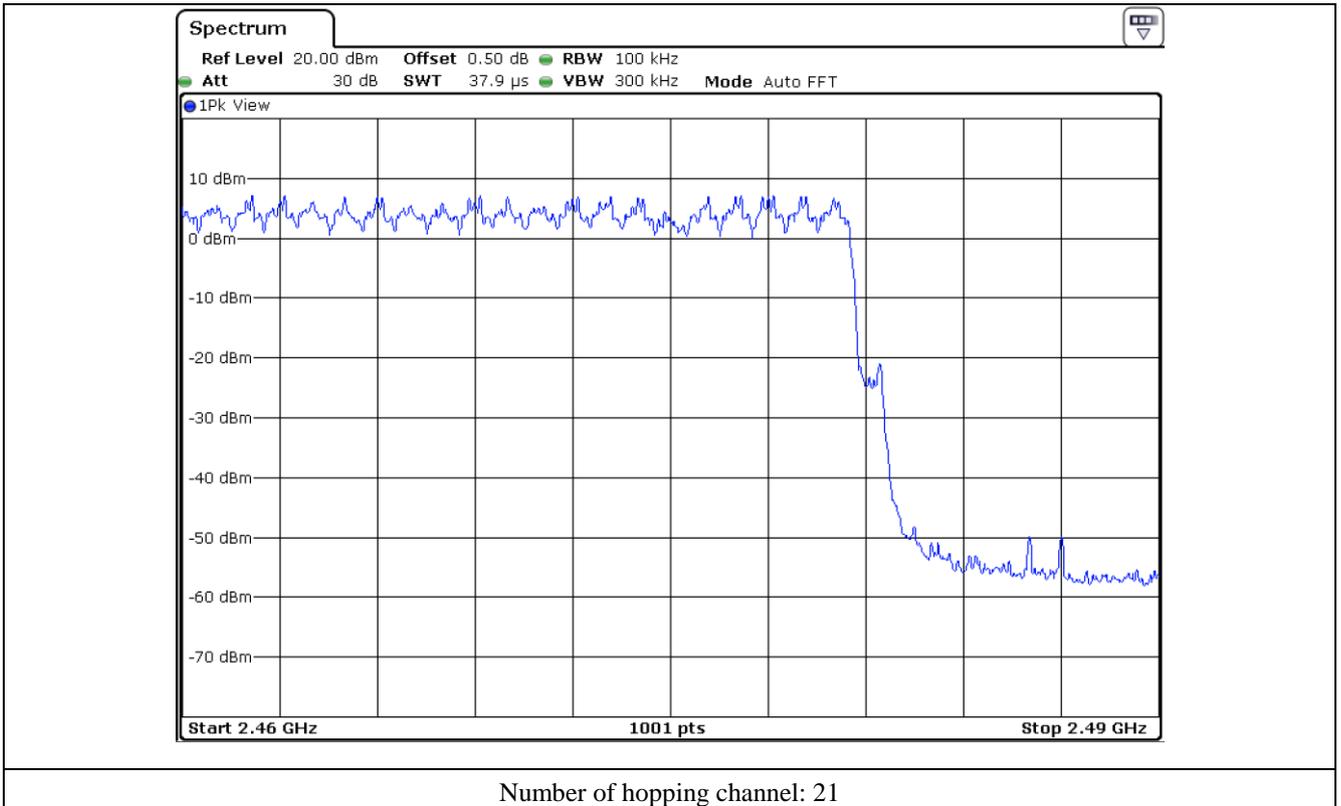




Number of hopping channel: 28



Number of hopping channel: 30



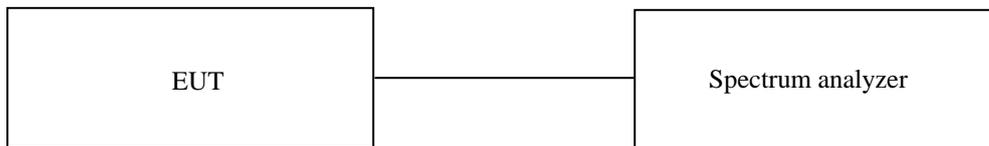
10. TIME OF OCCUPANCY

10.1 Operating environment

Temperature : 23 °C
 Relative humidity : 45 % R.H.

10.2 Test set-up

The antenna output of the EUT was connected to the spectrum analyzer. The transmitter is set to operate in its normal frequency hopping mode. The center frequency of the spectrum analyzer is set to one of hopping channels near the center of the operating band and span is set to zero Hz. The sweep time is set to display one complete pulse. The mark delta function is used to measure the duration of the pulses.



10.3 Test equipment used

| Model Number | Manufacturer | Description | Serial Number | Last Cal. |
|--------------|-----------------|-----------------|---------------|--------------------|
| ■ - FSV40 | Rohde & Schwarz | Signal Analyzer | 101009 | Mar. 11, 2019 (1Y) |

All test equipment used is calibrated on a regular basis.

10.4 Test data for 1 Mbps

- Test Date : March 18, 2019

The system makes worst case 1 600 hops per second or 1 time slot has a length of 625 μs with 79 channels.

For DH1 packet type, the EUT needs 1 time slot for transmitting and 1 time slot for receiving and for DH3 packet type, the EUT needs 3 times slots for transmitting and 1 time slot for receiving, and DH5 packet needs 5 times slots for transmitting and 1 time slot for receiving. So The EUT has each channel for 10.13 times per second (= 1 600/2/79) for DH1, and 5.06 times (= 1 600/4/79) for DH3, and 3.38 times (= 1 600/6/79) for DH5.

| Packet Type | Pulse Time (ms) | Hops per second with channels | Period Time (ms) | Total Dwell Time (ms) | Limit (ms) | Test Result |
|-------------|-----------------|-------------------------------|------------------|-----------------------|------------|-------------|
| DH1 | 0.375 | 10.13 | 31.60 | 120.04 | 400 | PASS |
| DH3 | 1.630 | 5.06 | 31.60 | 260.63 | 400 | |
| DH5 | 2.900 | 3.38 | 31.60 | 309.74 | 400 | |

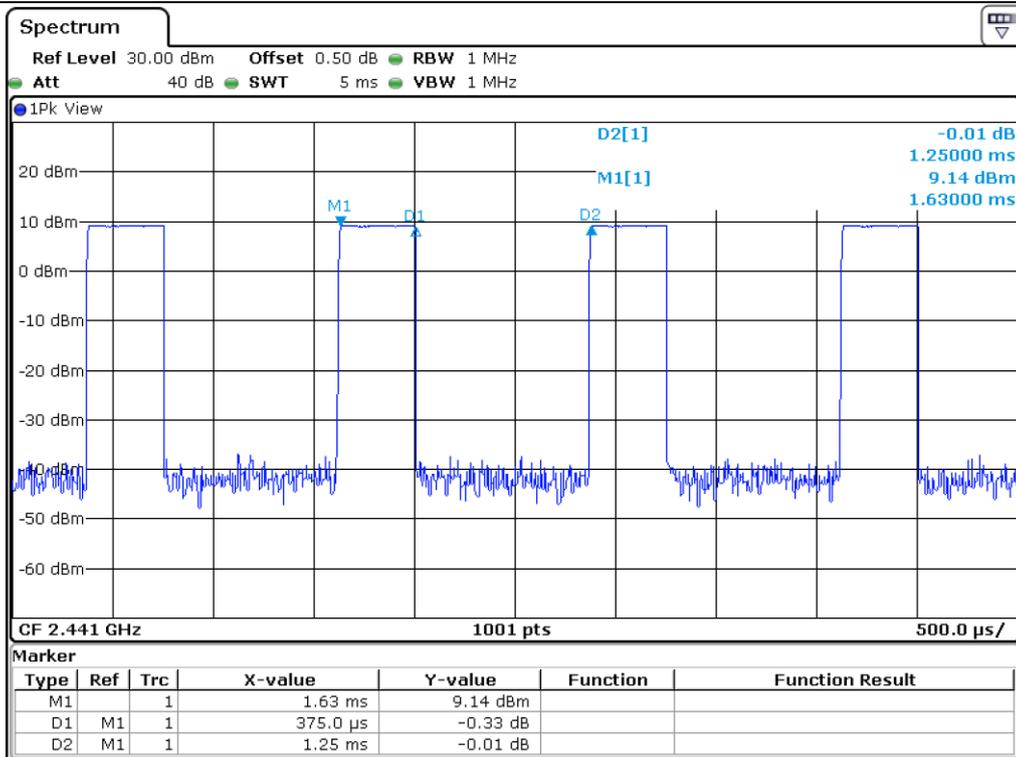
Total dwell time is calculated as following.

Total Dwell Time = Pulse time * Hops per second with channels * period time

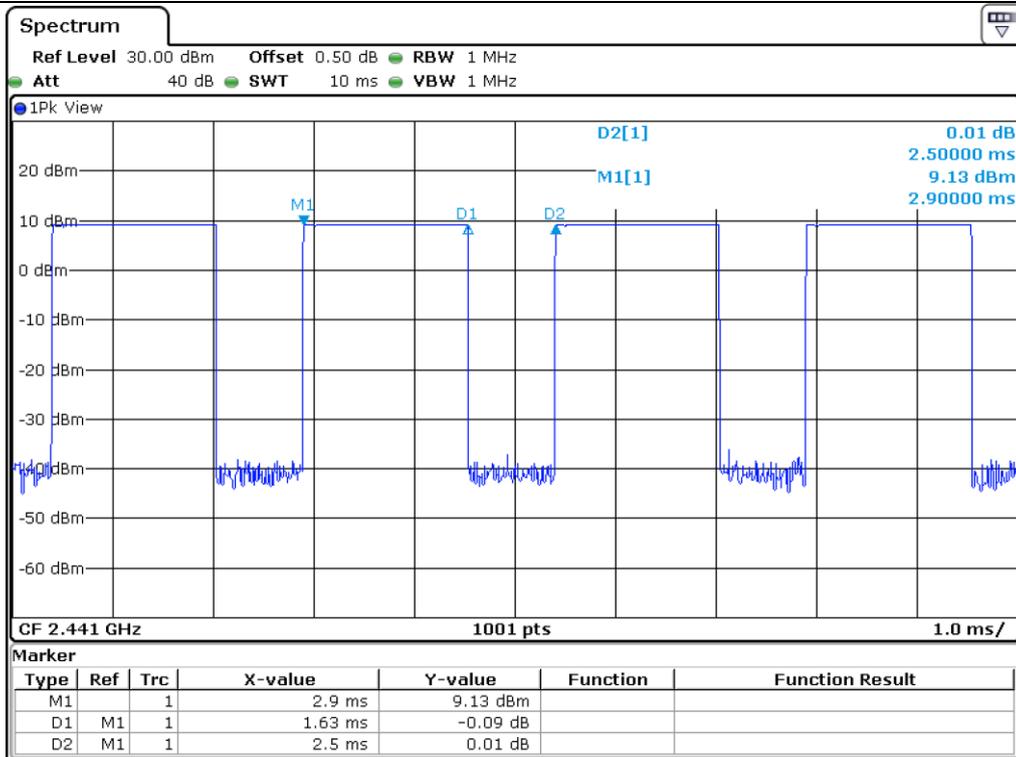
Remark: See next page for an overview sweep performed with peak detector.



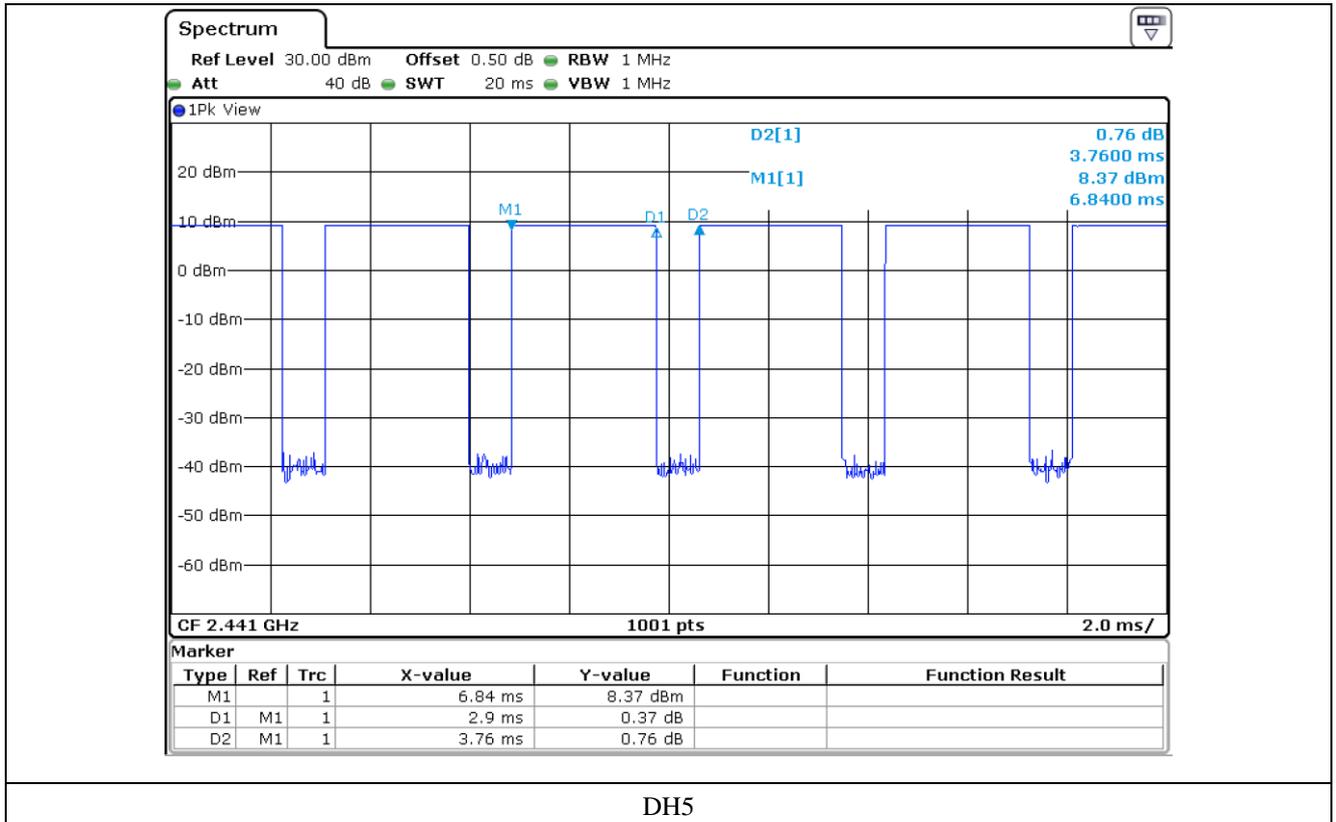
Tested by: Hyung-Kwon, Oh / Assistant Manager



DH1



DH3



10.5 Test data for 2 Mbps

- Test Date : March 18, 2019

The system makes worst case 1 600 hops per second or 1 time slot has a length of 625 μs with 79 channels.

For DH1 packet type, the EUT needs 1 time slot for transmitting and 1 time slot for receiving and for DH3 packet type, the EUT needs 3 times slots for transmitting and 1 time slot for receiving, and DH5 packet needs 5 times slots for transmitting and 1 time slot for receiving. So The EUT has each channel for 10.13 times per second (= 1 600/2/79) for DH1, and 5.06 times (= 1 600/4/79) for DH3, and 3.38 times (= 1 600/6/79) for DH5.

| Packet Type | Pulse Time (ms) | Hops per second with channels | Period Time (ms) | Total Dwell Time (ms) | Limit (ms) | Test Result |
|-------------|-----------------|-------------------------------|------------------|-----------------------|------------|-------------|
| DH1 | 0.385 | 10.13 | 31.60 | 123.24 | 400 | PASS |
| DH3 | 1.640 | 5.06 | 31.60 | 262.23 | 400 | |
| DH5 | 2.900 | 3.38 | 31.60 | 309.74 | 400 | |

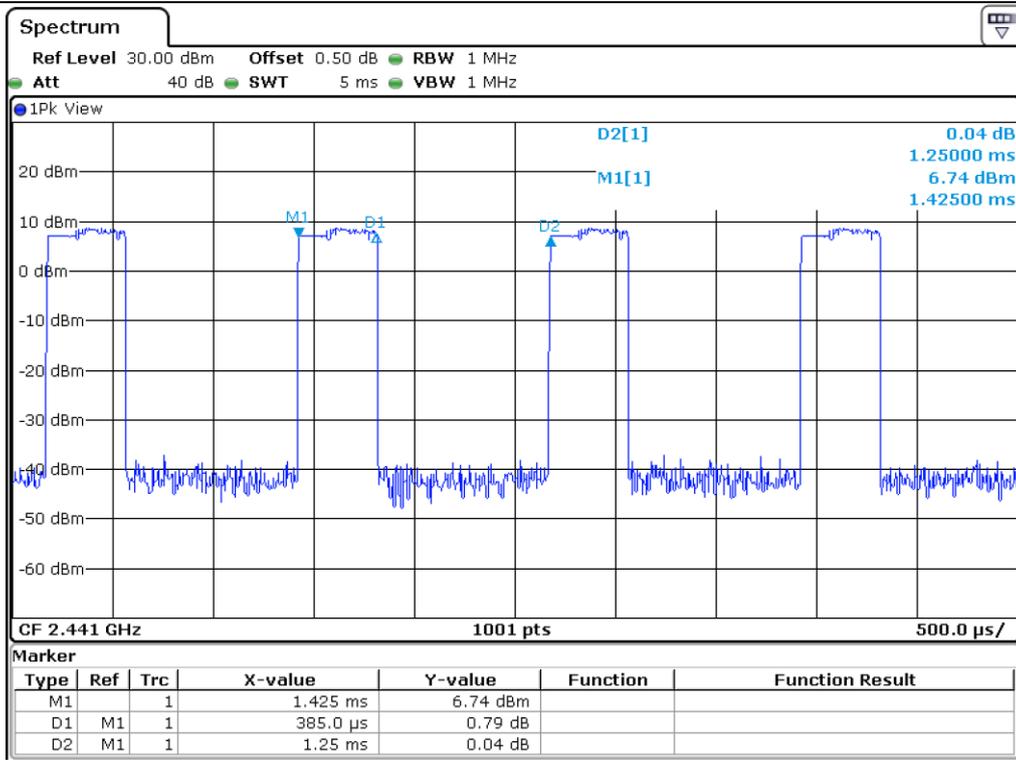
Total dwell time is calculated as following.

Total Dwell Time = Pulse time * Hops per second with channels * period time

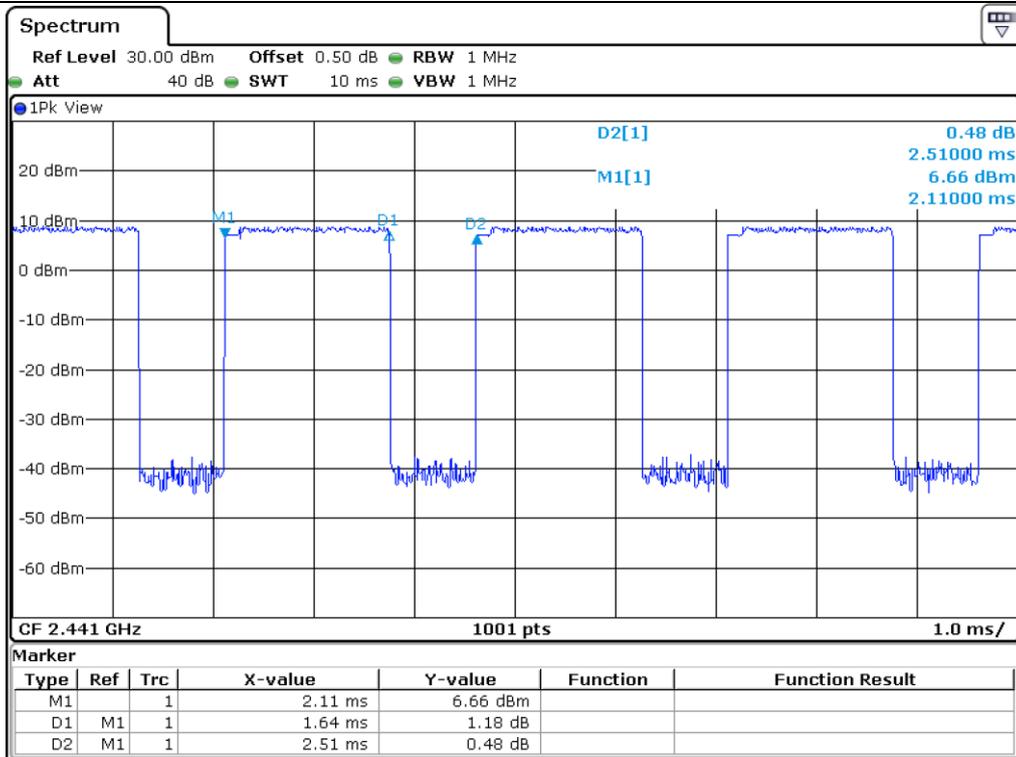
Remark: See next page for an overview sweep performed with peak detector.



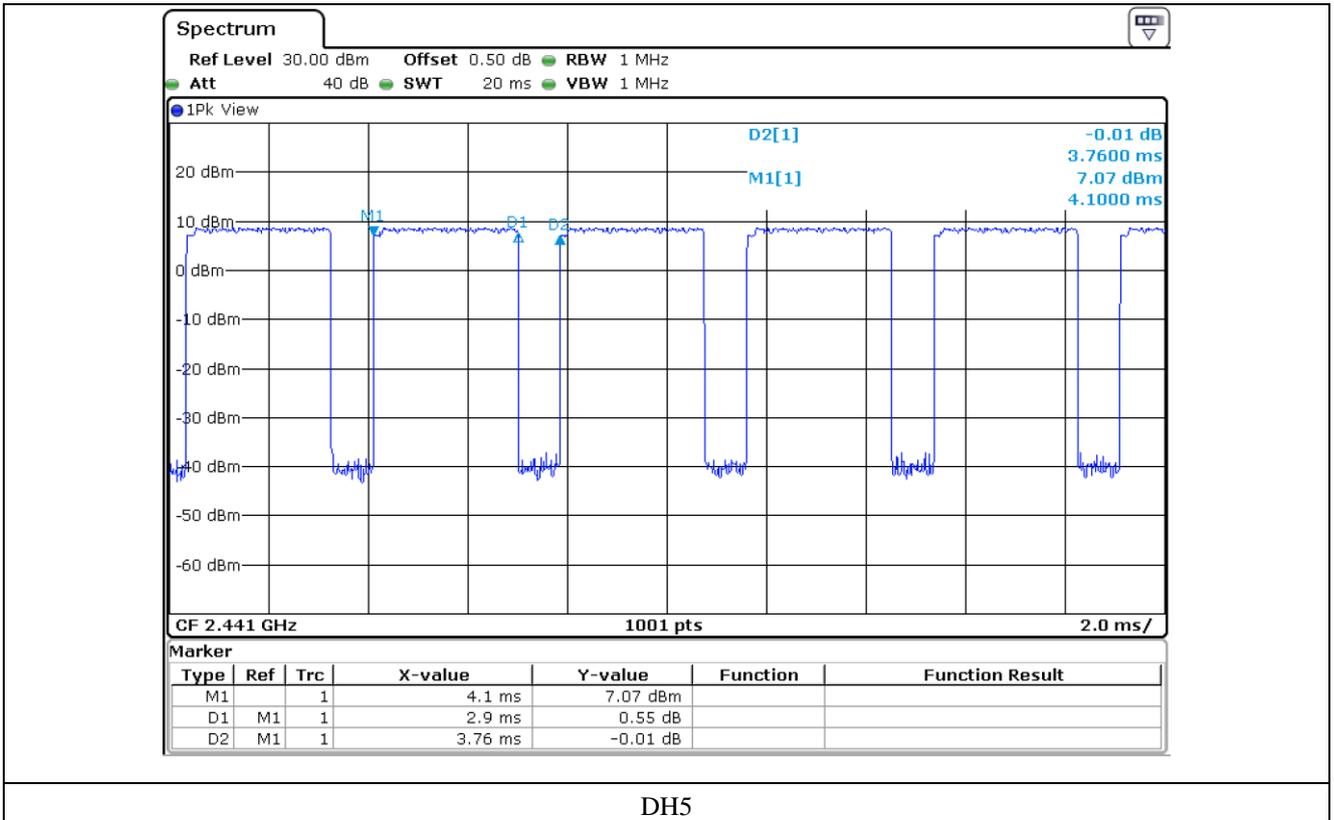
Tested by: Hyung-Kwon, Oh / Assistant Manager



DH1



DH3



10.6 Test data for 3 Mbps

-. Test Date : March 18, 2019

The system makes worst case 1 600 hops per second or 1 time slot has a length of 625 μs with 79 channels.

For DH1 packet type, the EUT needs 1 time slot for transmitting and 1 time slot for receiving and for DH3 packet type, the EUT needs 3 times slots for transmitting and 1 time slot for receiving, and DH5 packet needs 5 times slots for transmitting and 1 time slot for receiving. So The EUT has each channel for 10.13 times per second (= 1 600/2/79) for DH1, and 5.06 times (= 1 600/4/79) for DH3, and 3.38 times (= 1 600/6/79) for DH5.

| Packet Type | Pulse Time (ms) | Hops per second with channels | Period Time (ms) | Total Dwell Time (ms) | Limit (ms) | Test Result |
|-------------|-----------------|-------------------------------|------------------|-----------------------|------------|-------------|
| DH1 | 0.390 | 10.13 | 31.60 | 124.84 | 400 | PASS |
| DH3 | 1.640 | 5.06 | 31.60 | 262.23 | 400 | |
| DH5 | 2.880 | 3.38 | 31.60 | 307.61 | 400 | |

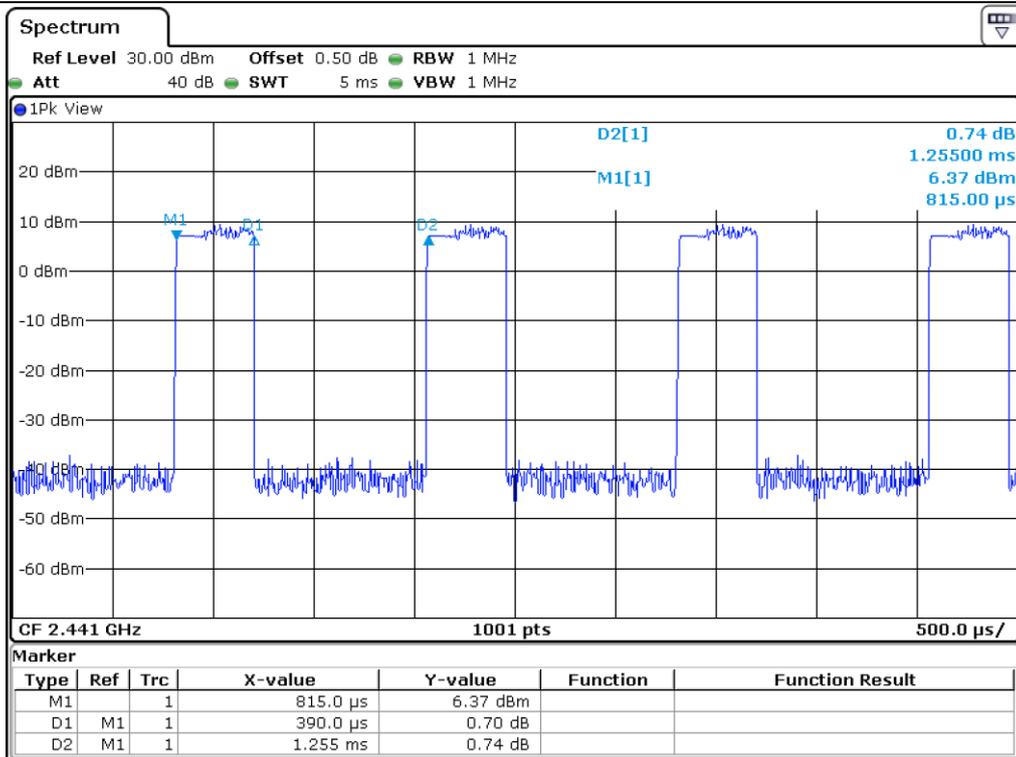
Total dwell time is calculated as following.

Total Dwell Time = Pulse time * Hops per second with channels * period time

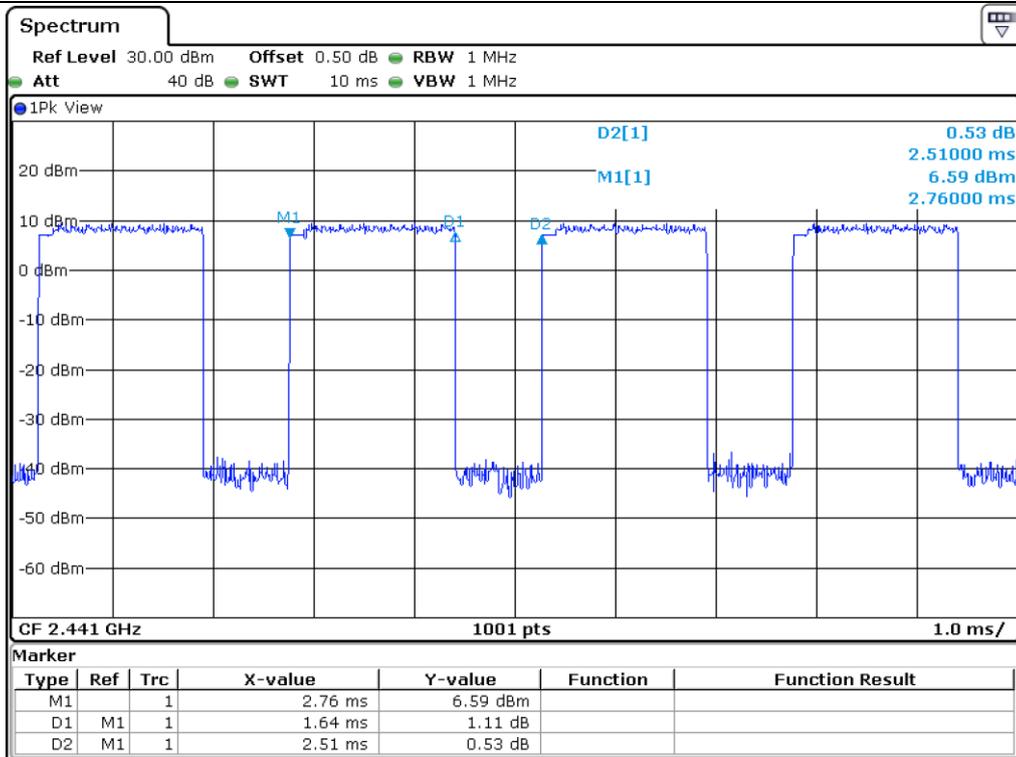
Remark: See next page for an overview sweep performed with peak detector.



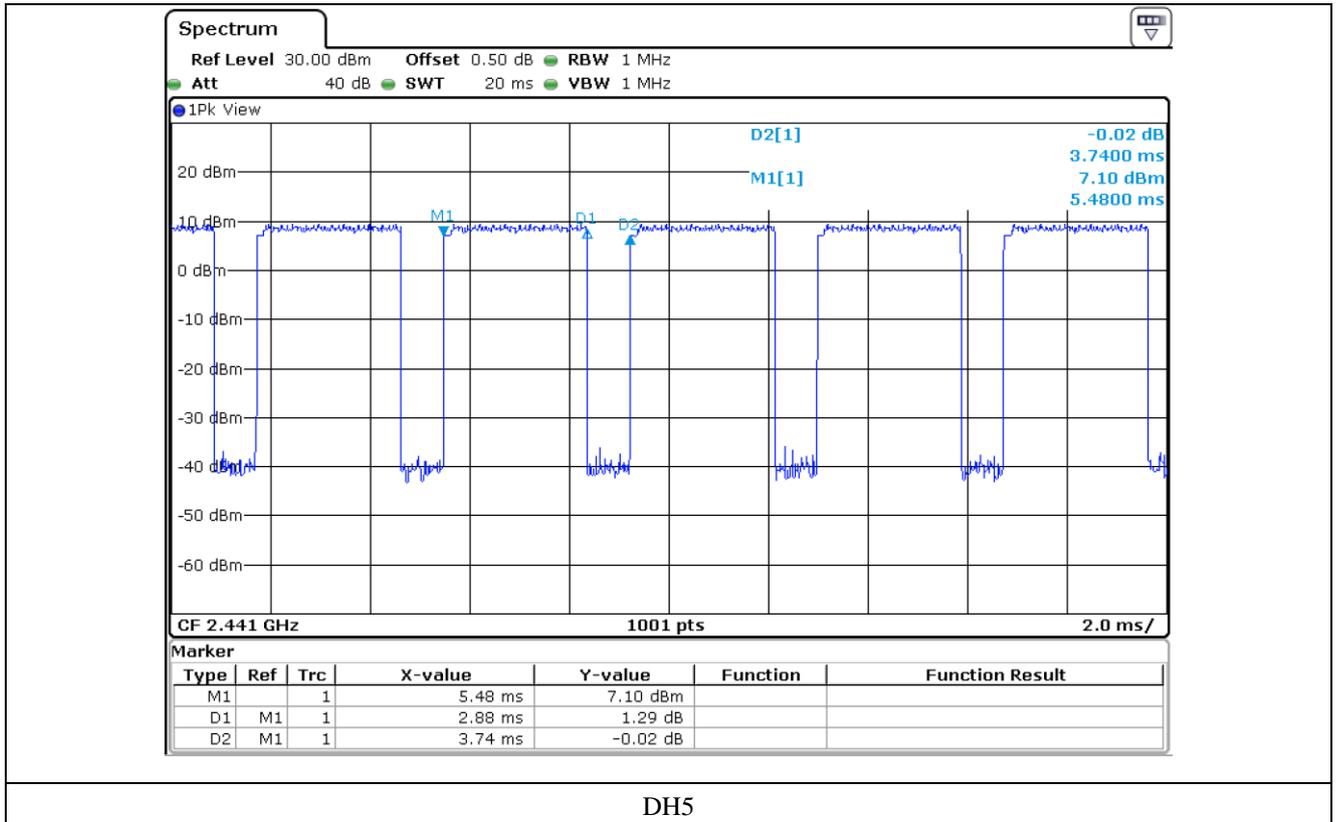
Tested by: Hyung-Kwon, Oh / Assistant Manager



DH1



DH3



11. MAXIMUM PEAK OUTPUT POWER

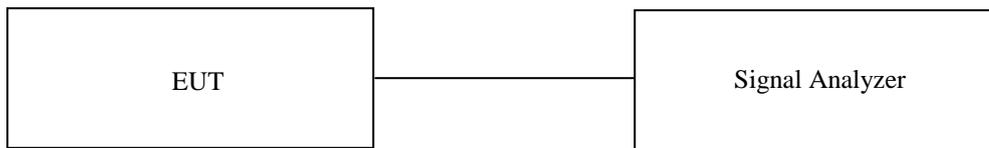
11.1 Operating environment

Temperature : 23 °C
 Relative humidity : 45 % R.H.

11.2 Test set-up

The antenna output of the EUT was connected to the spectrum analyzer.

The resolution bandwidth is set to \geq DTS Bandwidth, the video bandwidth is set to 3 times the resolution bandwidth.



11.3 Test equipment used

| Model Number | Manufacturer | Description | Serial Number | Last Cal. |
|--------------|-----------------|-----------------|---------------|--------------------|
| ■ - FSV40 | Rohde & Schwarz | Signal Analyzer | 101009 | Mar. 11, 2019 (1Y) |

All test equipment used is calibrated on a regular basis.

11.4 Test data for 1 Mbps

- Test Date : March 18, 2019

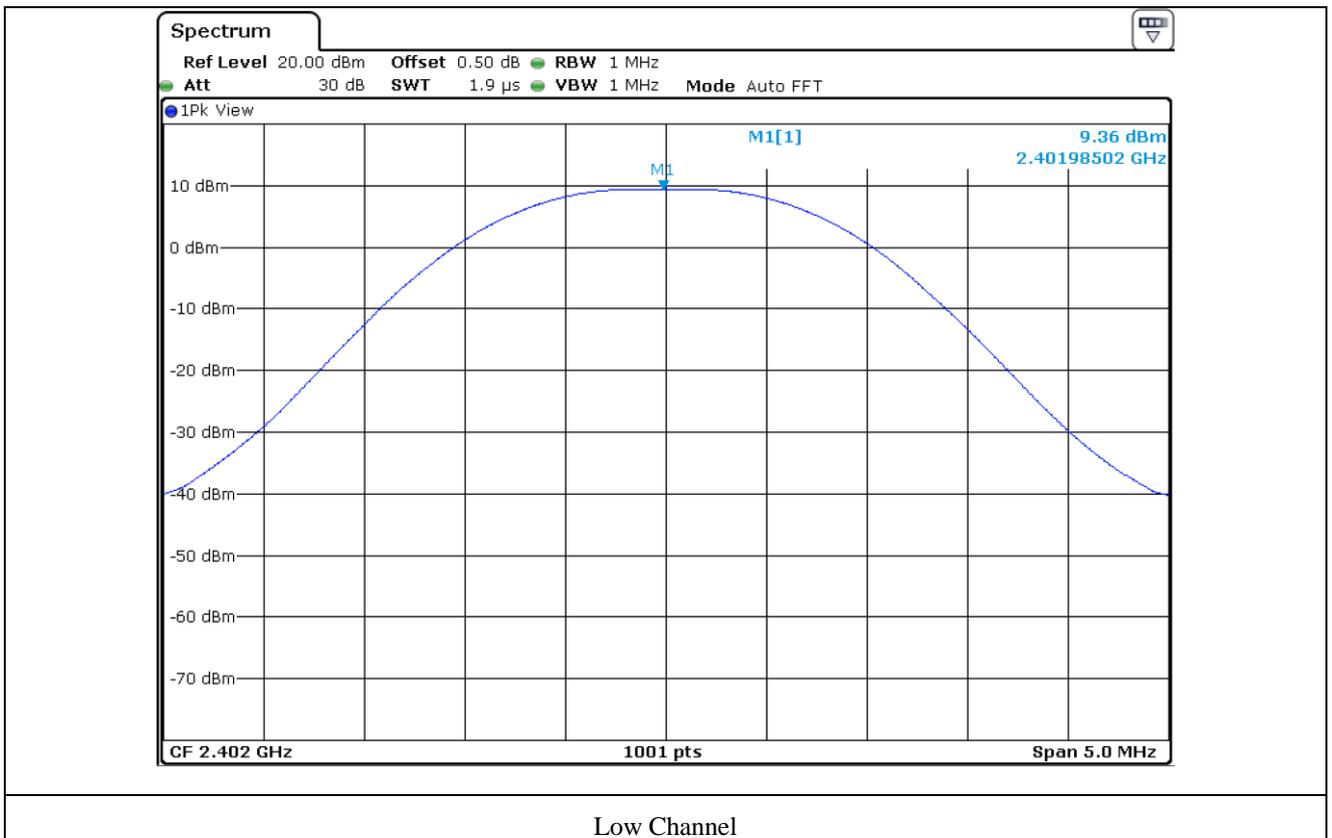
- Test Result : Pass

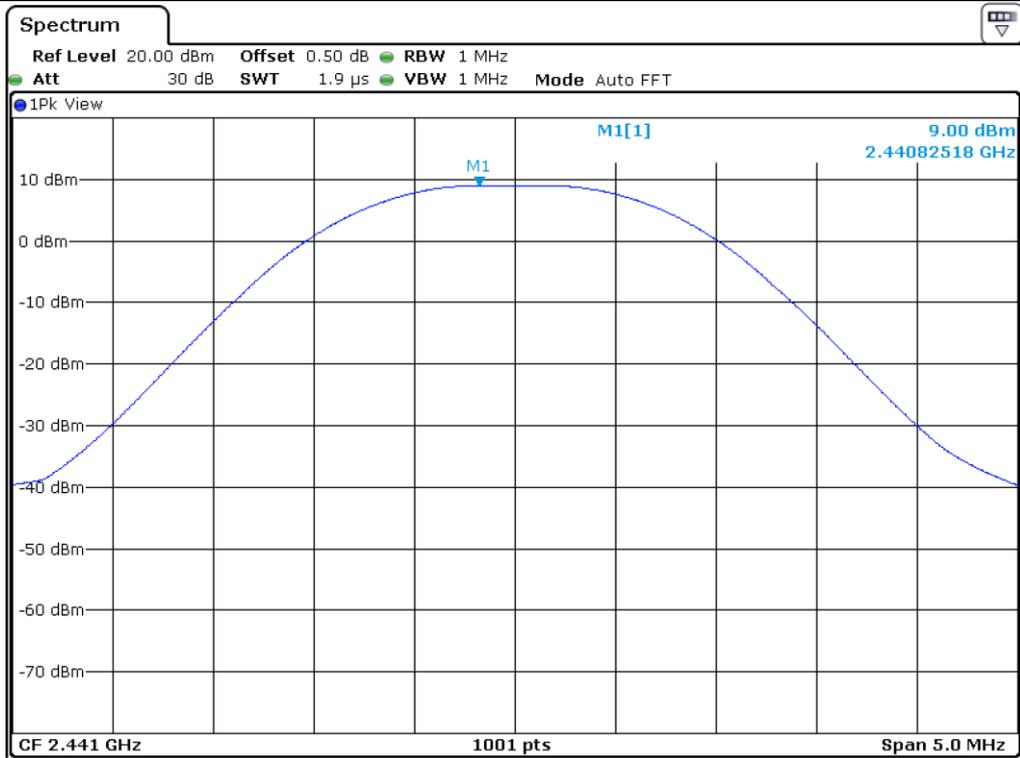
| CHANNEL | FREQUENCY (MHz) | MEASURED VLAUE (dBm) | LIMIT (dBm) | MARGIN (dB) |
|---------|-----------------|----------------------|-------------|-------------|
| LOW | 2 402.00 | 9.36 | 30.00 | 20.64 |
| MIDDLE | 2 441.00 | 9.00 | 30.00 | 21.00 |
| HIGH | 2 480.00 | 8.48 | 30.00 | 21.52 |

Remark. Margin = Limit – Measured Value (=Receiver Reading + Cable Loss)

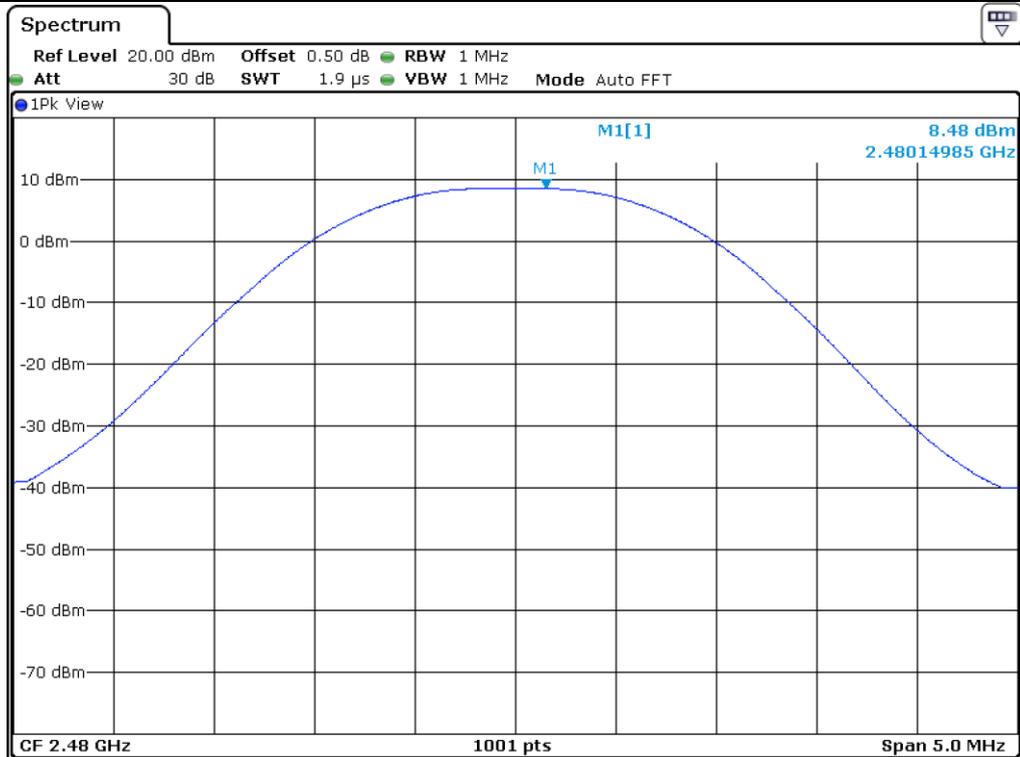


Tested by: Hyung-Kwon, Oh / Assistant Manager





Middle Channel



High Channel

11.5 Test data for 2 Mbps

-. Test Date : March 18, 2019

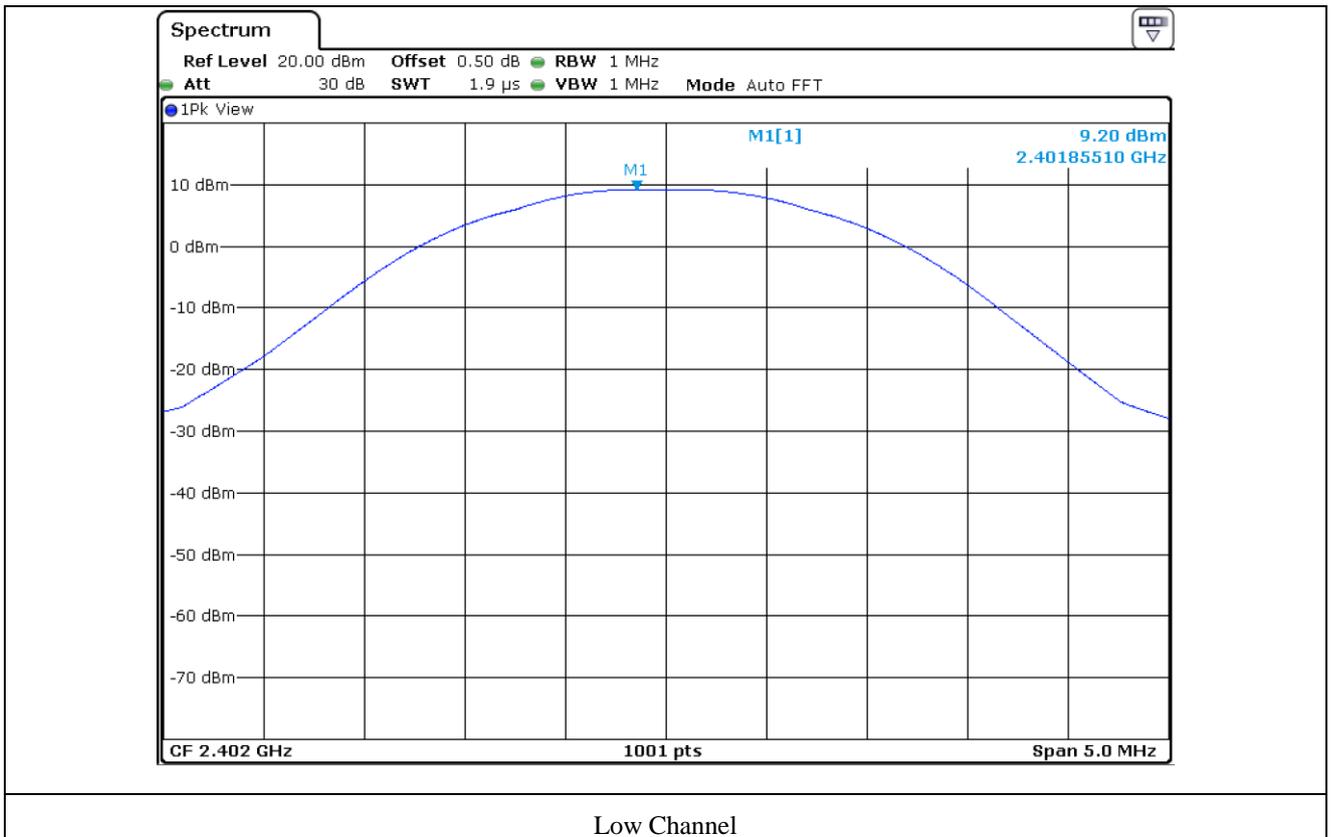
-. Test Result : Pass

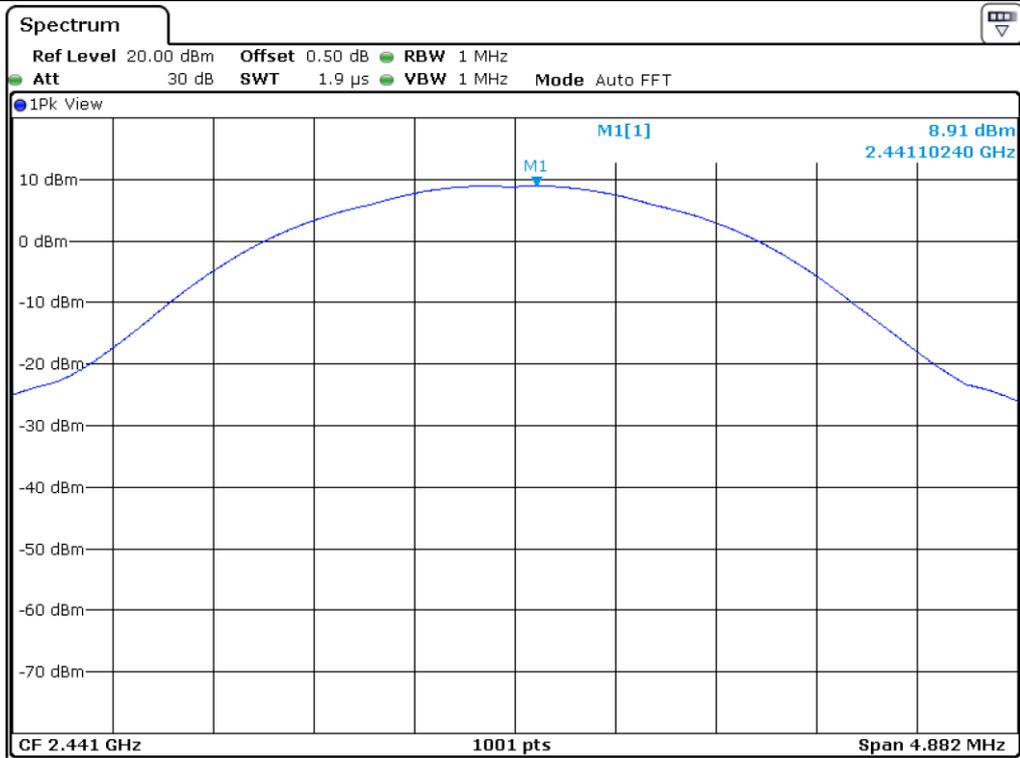
| CHANNEL | FREQUENCY (MHz) | MEASURED VLAUE (dBm) | LIMIT (dBm) | MARGIN (dB) |
|---------|-----------------|----------------------|-------------|-------------|
| LOW | 2 402.00 | 9.20 | 30.00 | 20.80 |
| MIDDLE | 2 441.00 | 8.91 | 30.00 | 21.09 |
| HIGH | 2 480.00 | 8.55 | 30.00 | 21.45 |

Remark. Margin = Limit – Measured Value (=Receiver Reading + Cable Loss)

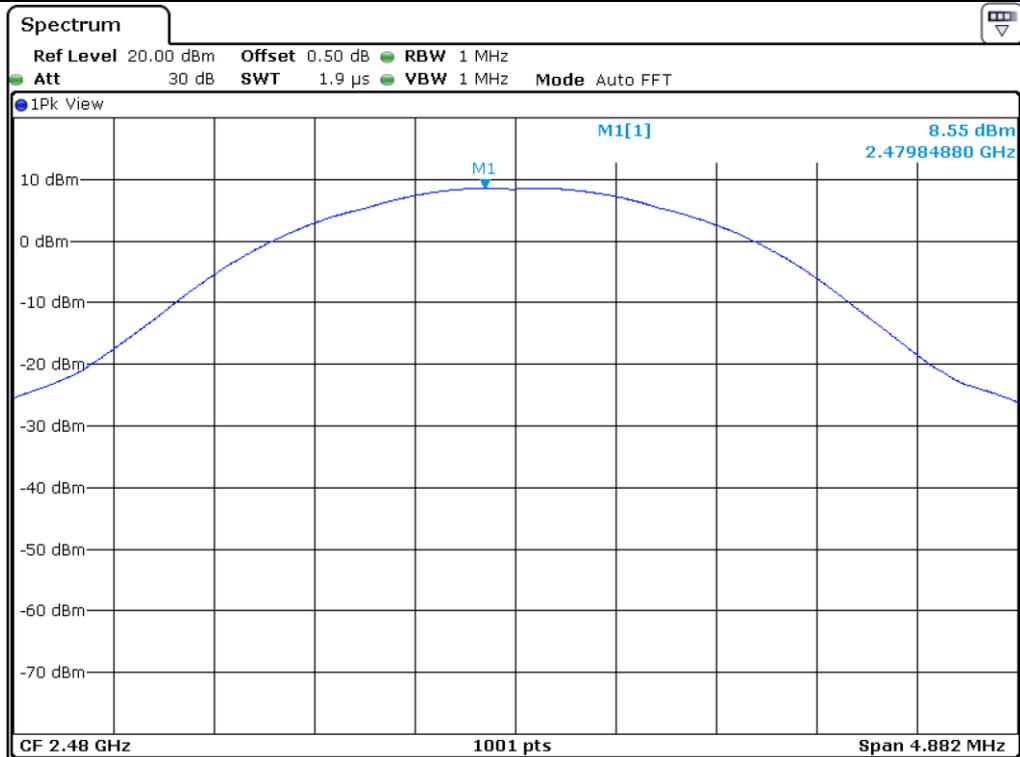


Tested by: Hyung-Kwon, Oh / Assistant Manager





Middle Channel



High Channel

11.6 Test data for 3 Mbps

- Test Date : March 18, 2019

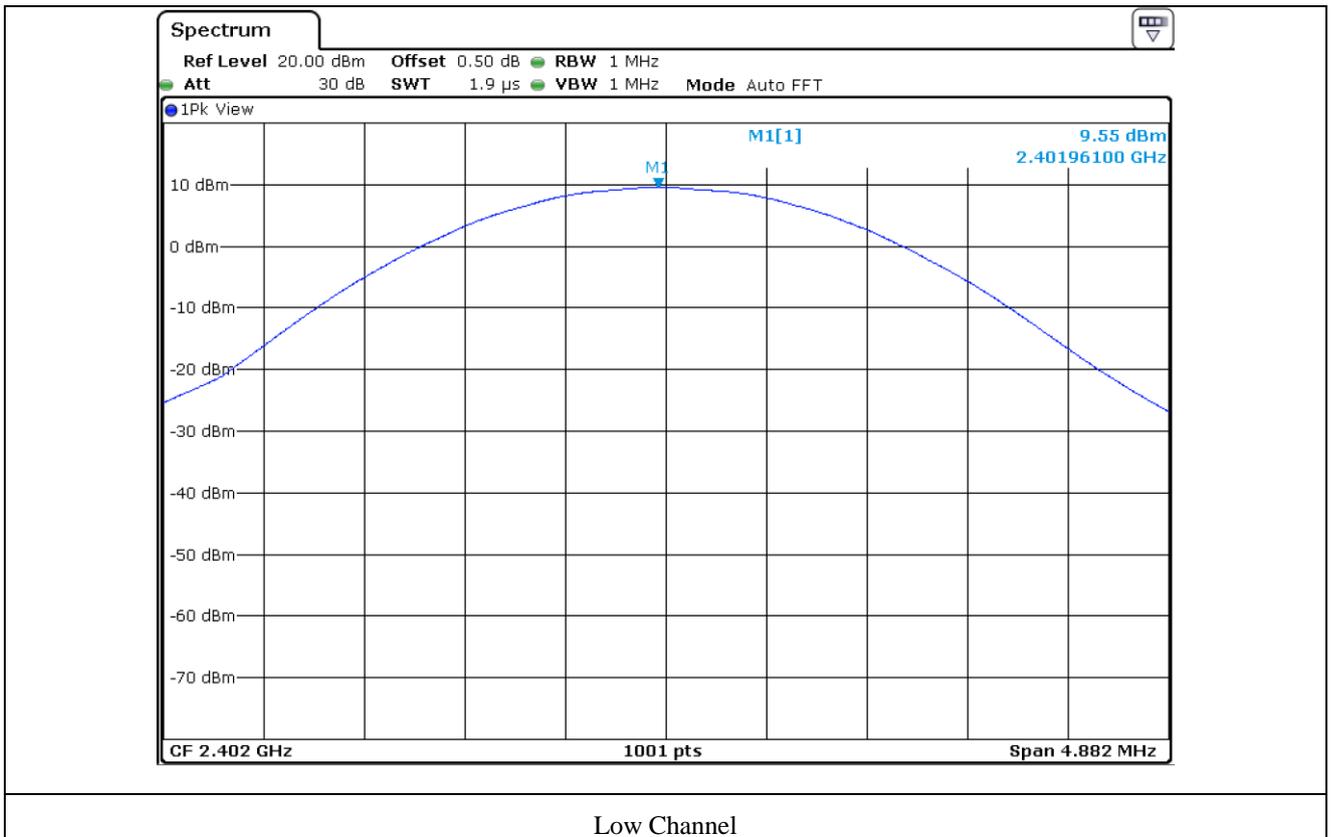
- Test Result : Pass

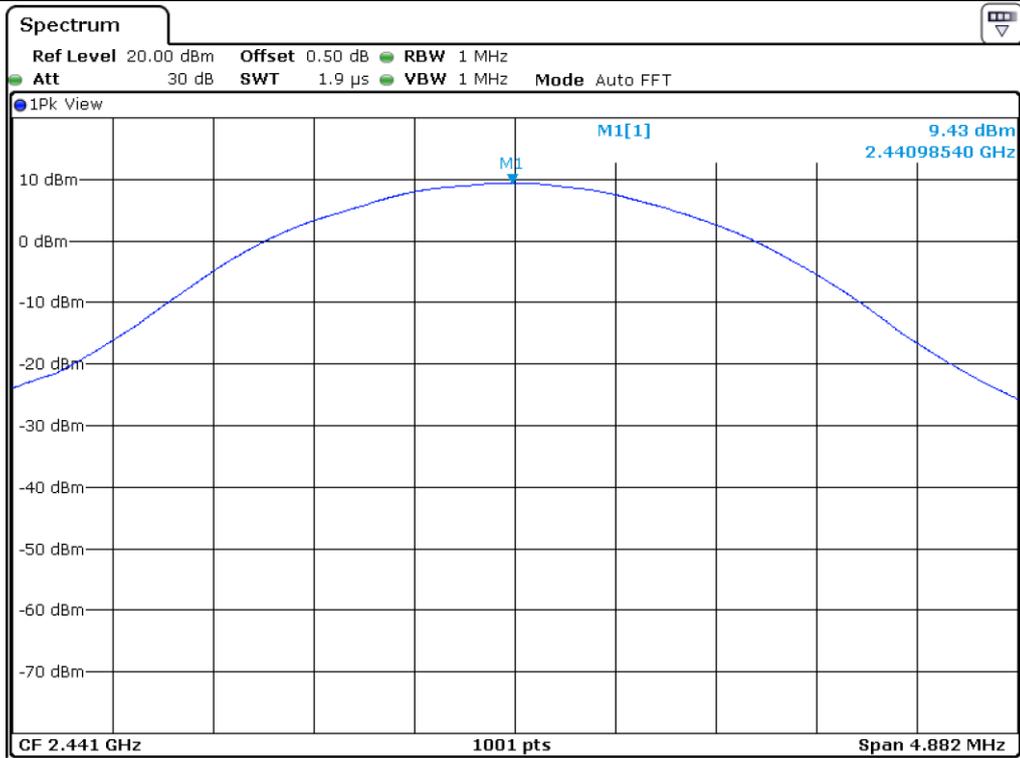
| CHANNEL | FREQUENCY (MHz) | MEASURED VLAUE (dBm) | LIMIT (dBm) | MARGIN (dB) |
|---------|-----------------|----------------------|-------------|-------------|
| LOW | 2 402.00 | 9.55 | 30.00 | 20.45 |
| MIDDLE | 2 441.00 | 9.43 | 30.00 | 20.57 |
| HIGH | 2 480.00 | 9.05 | 30.00 | 20.95 |

Remark. Margin = Limit – Measured Value (=Receiver Reading + Cable Loss)

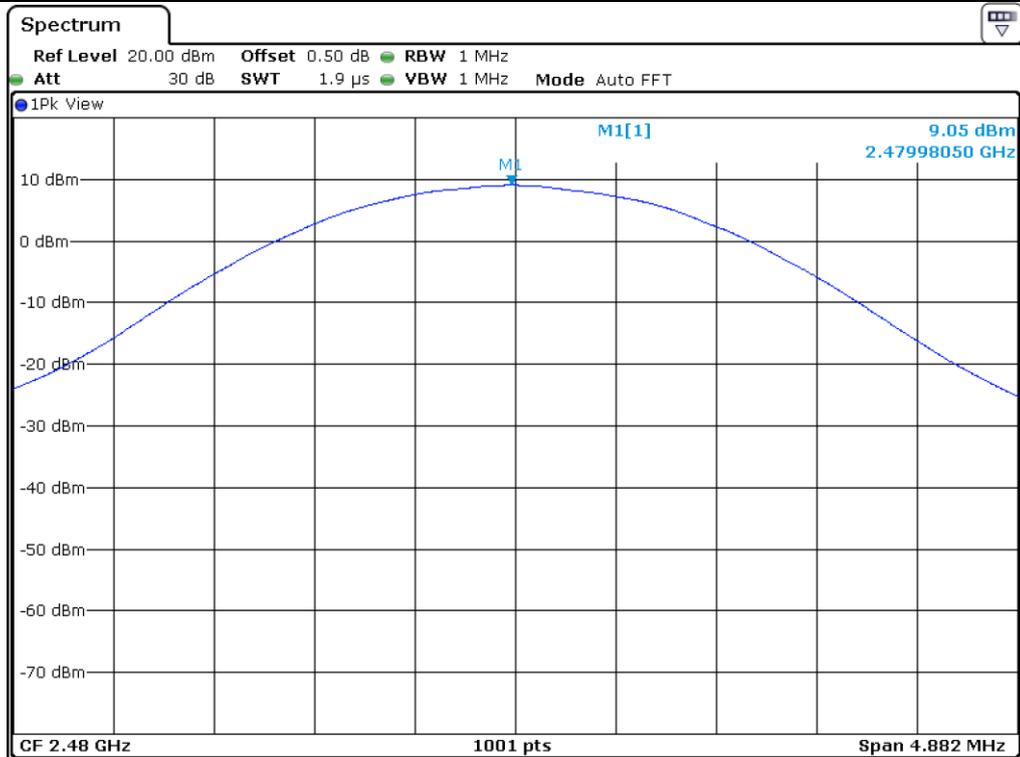


Tested by: Hyung-Kwon, Oh / Assistant Manager





Middle Channel



High Channel

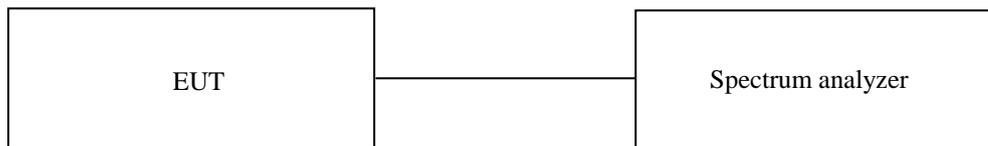
12. 100 kHz BANDWIDTH OUTSIDE THE FREQUENCY BAND

12.1 Operating environment

Temperature : 23 °C
 Relative humidity : 45 % R.H.

12.2 Test set-up for conducted measurement

The antenna output of the EUT was connected to the spectrum analyzer. The resolution and video bandwidth is set to 100 kHz, and peak detection was used.



12.3 Test set-up for radiated measurement

The radiated emissions measurements were performed on the 3 m semi anechoic chamber. The EUT was placed on turntable approximately 1.5 m above the ground plane.

The frequency spectrum from 30 MHz to 26.5 GHz was scanned and maximum emission levels at each frequency recorded. The system was rotated 360°, and the antenna was varied in the height between 1.0 m and 4.0 m in order to determine the maximum emission levels. This procedure was performed for horizontal and vertical polarization of the receiving antenna.

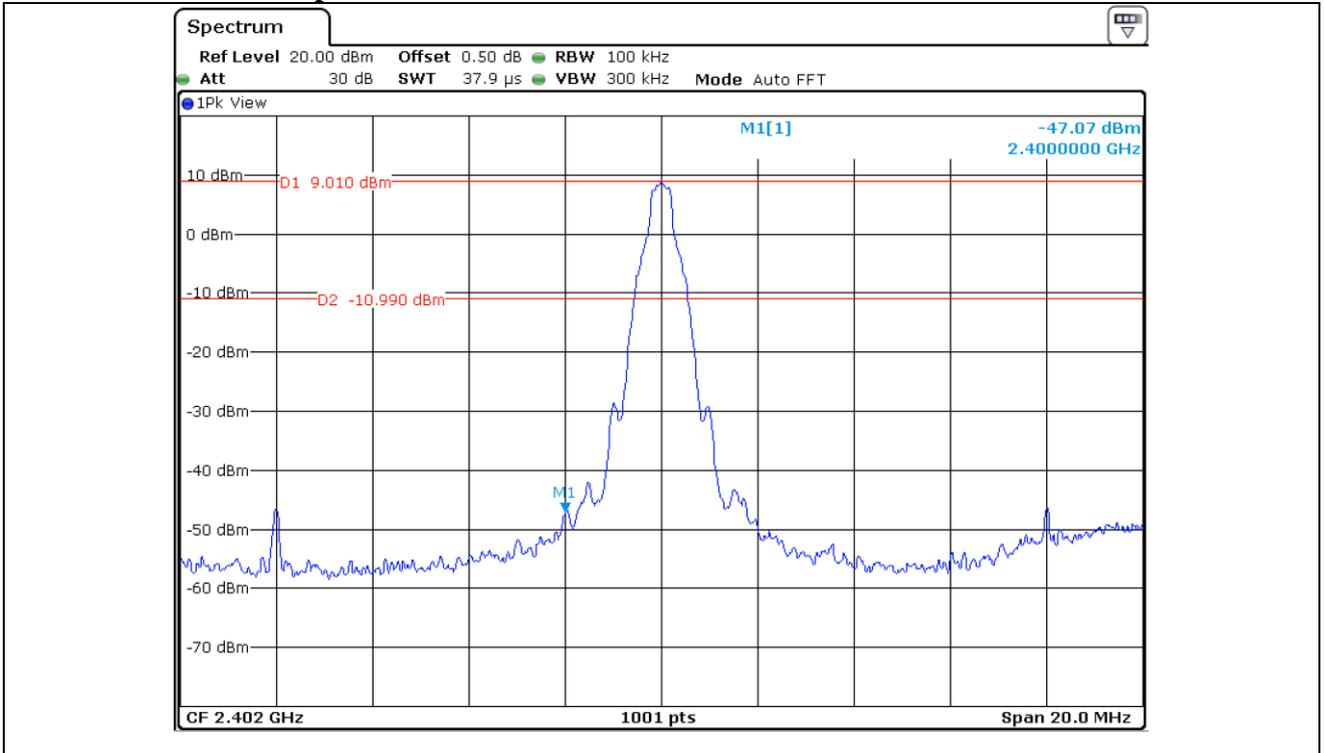
12.4 Test equipment used

| Model Number | Manufacturer | Description | Serial Number | Last Cal. |
|-----------------|-------------------|--------------------------|---------------|--------------------|
| ■ - FSV40 | Rohde & Schwarz | Signal Analyzer | 101009 | Mar. 11, 2019 (1Y) |
| ■ - ESU | Rohde & Schwarz | EMI Test Receiver | 100261 | Apr. 05, 2018 (1Y) |
| ■ - 310N | Sonoma Instrument | Pre-Amplifier | 312544 | Mar. 18, 2018 (1Y) |
| ■ - BBV 9718 B | Schwarzbeck | Amplifier | 009 | Mar. 20, 2018 (1Y) |
| ■ - SCU40A | Rohde & Schwarz | Signal Conditioning unit | 100436 | Mar. 11, 2019 (1Y) |
| ■ - DT3000-3t | Innco System | Turn Table | DT3000/093 | N/A |
| ■ - MA-4000XPET | Innco System | Antenna Master | MA4000/509 | N/A |
| ■ - VULB9163 | Schwarzbeck | TRILOG Broadband Antenna | 777 | Apr. 13, 2018 (2Y) |
| ■ - BBHA9120D | Schwarzbeck | Horn Antenna | BBHA9120D295 | Aug. 16, 2017 (2Y) |
| ■ - BBHA9170 | Schwarzbeck | Horn Antenna | BBHA9170179 | Jan. 16, 2019 (1Y) |

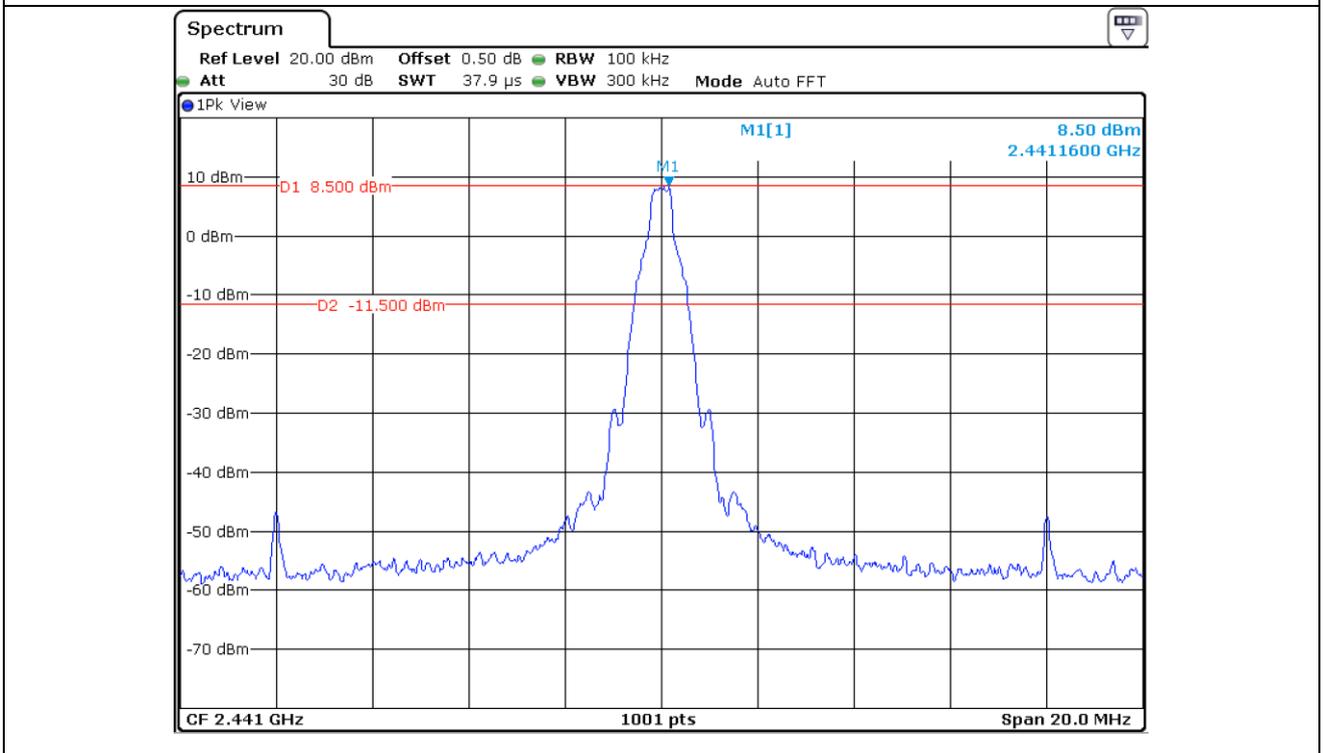
All test equipment used is calibrated on a regular basis.

12.5 Test data for conducted emission

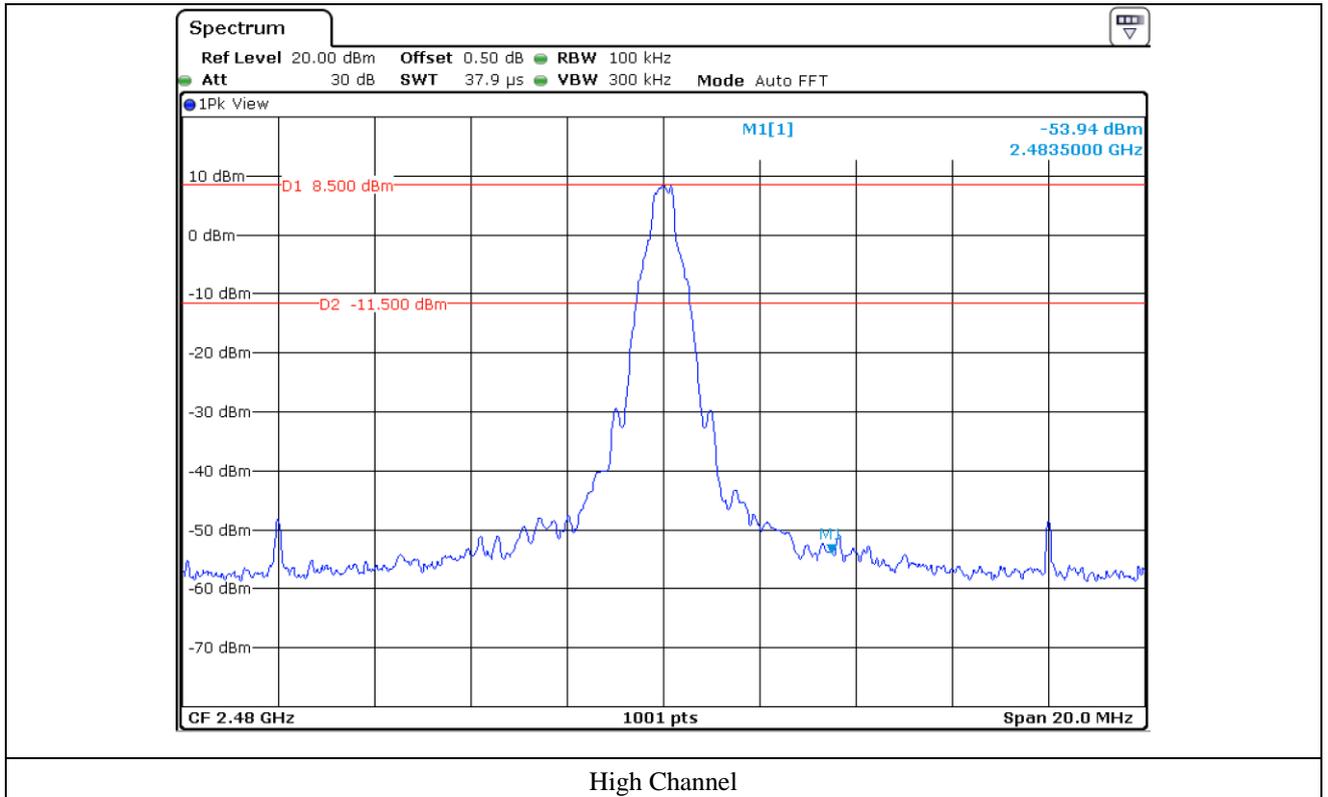
12.5.1 Test data for 1 Mbps

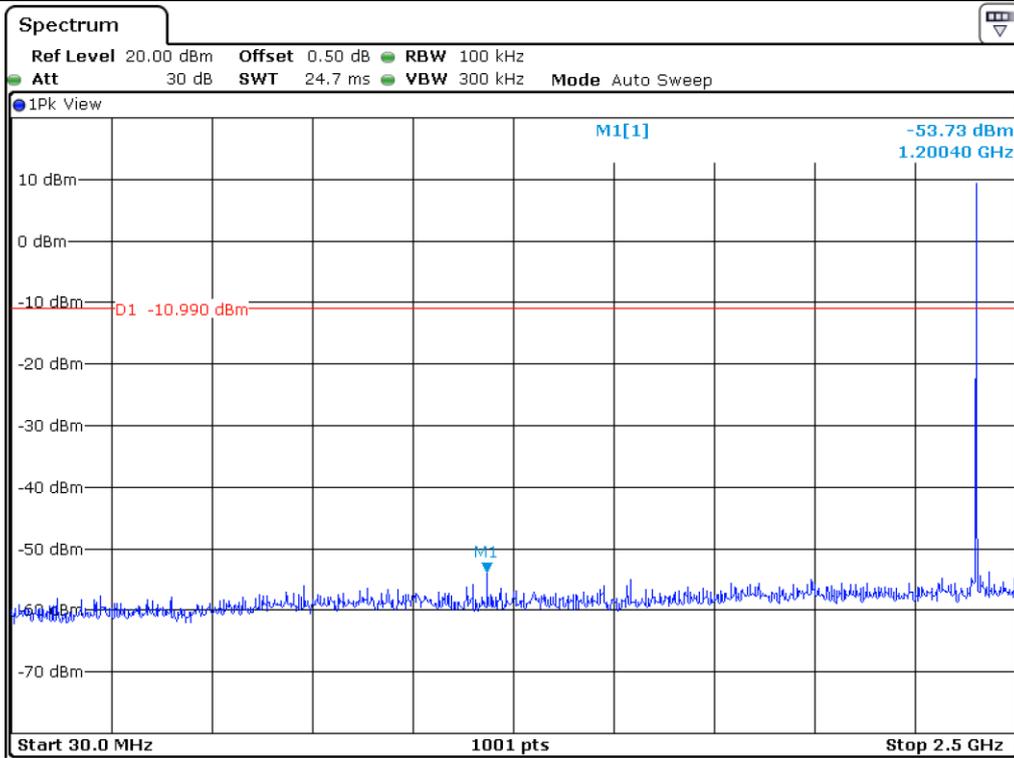


Low Channel

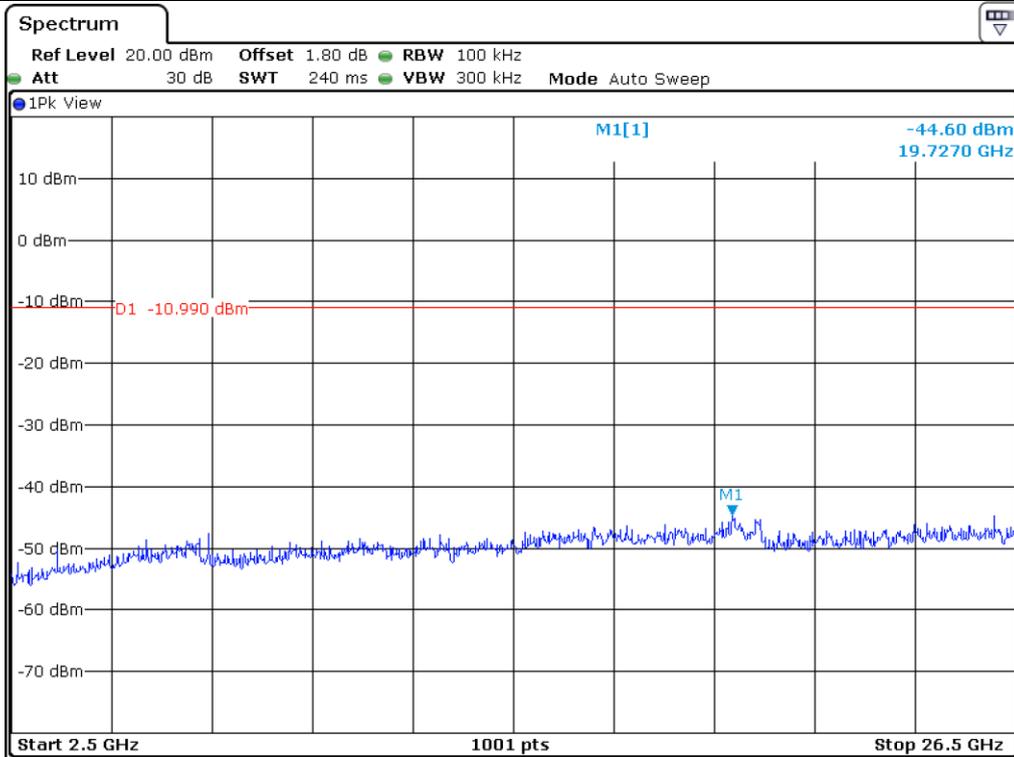


Middle Channel

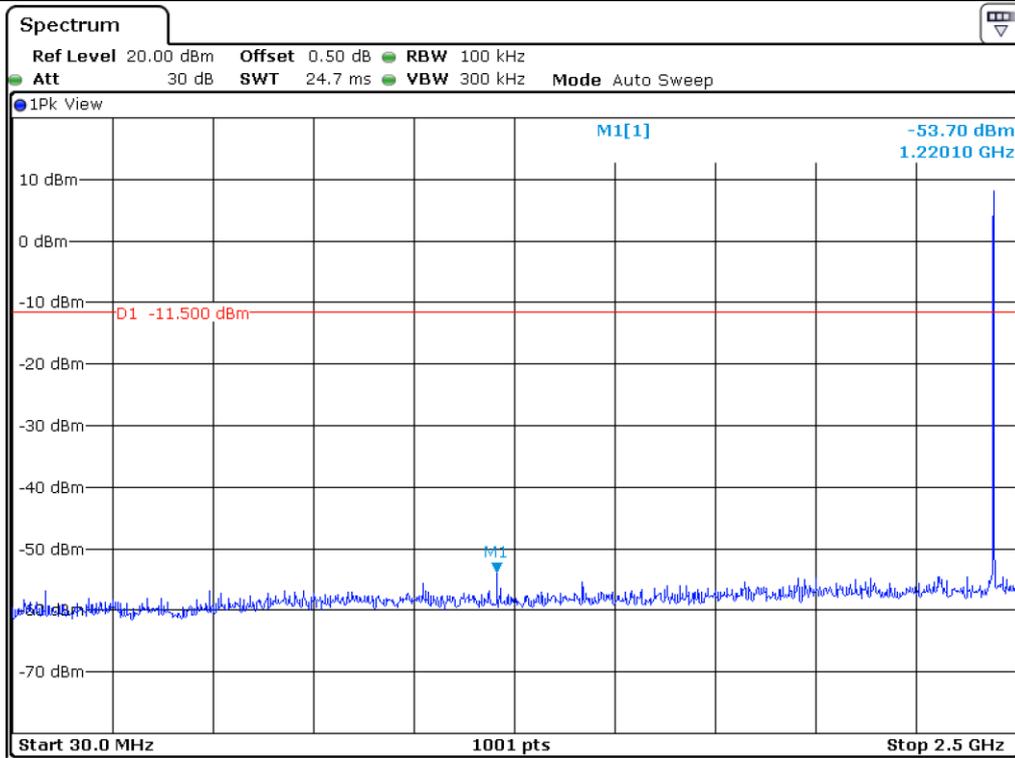




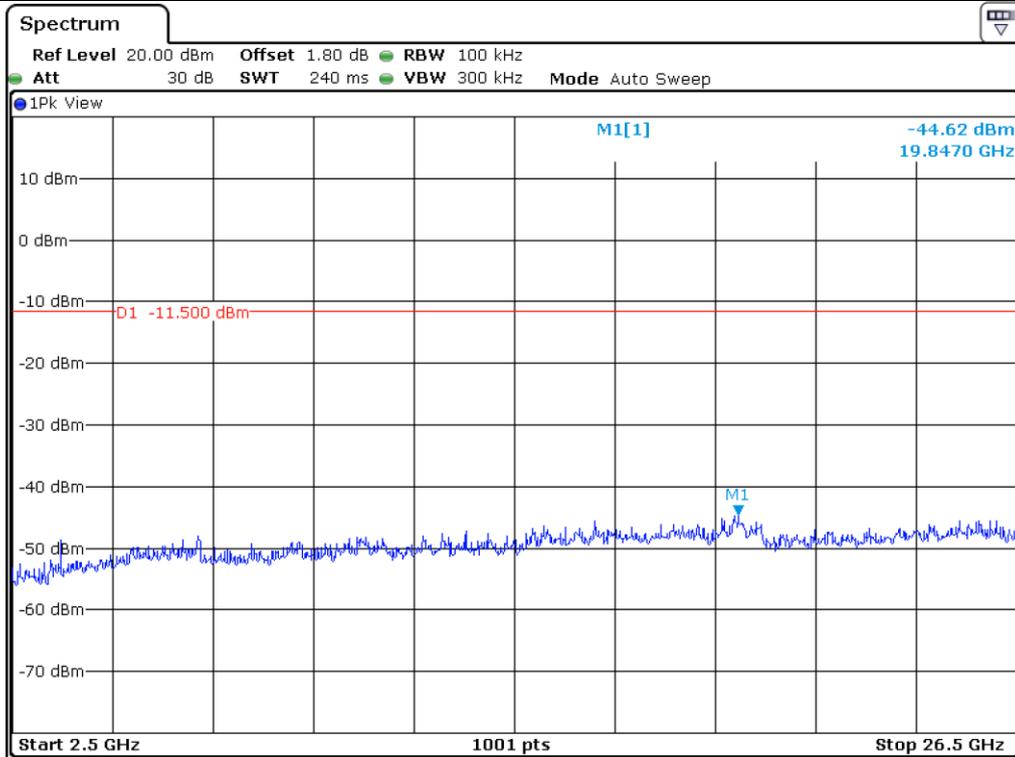
Low Channel



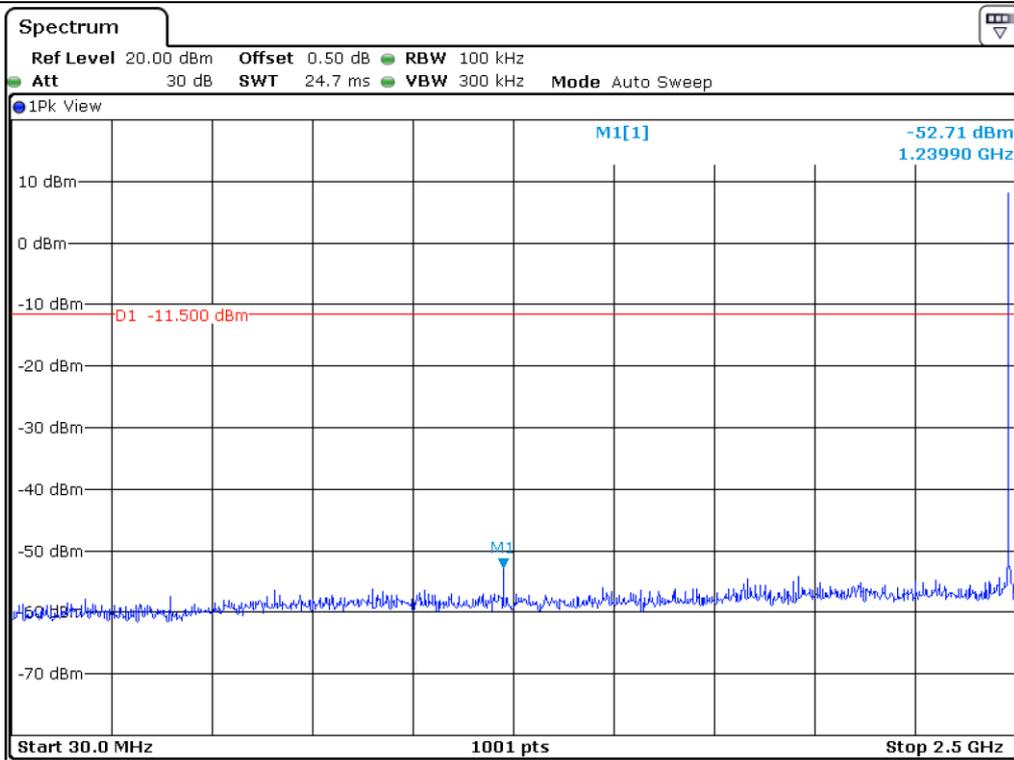
Low Channel



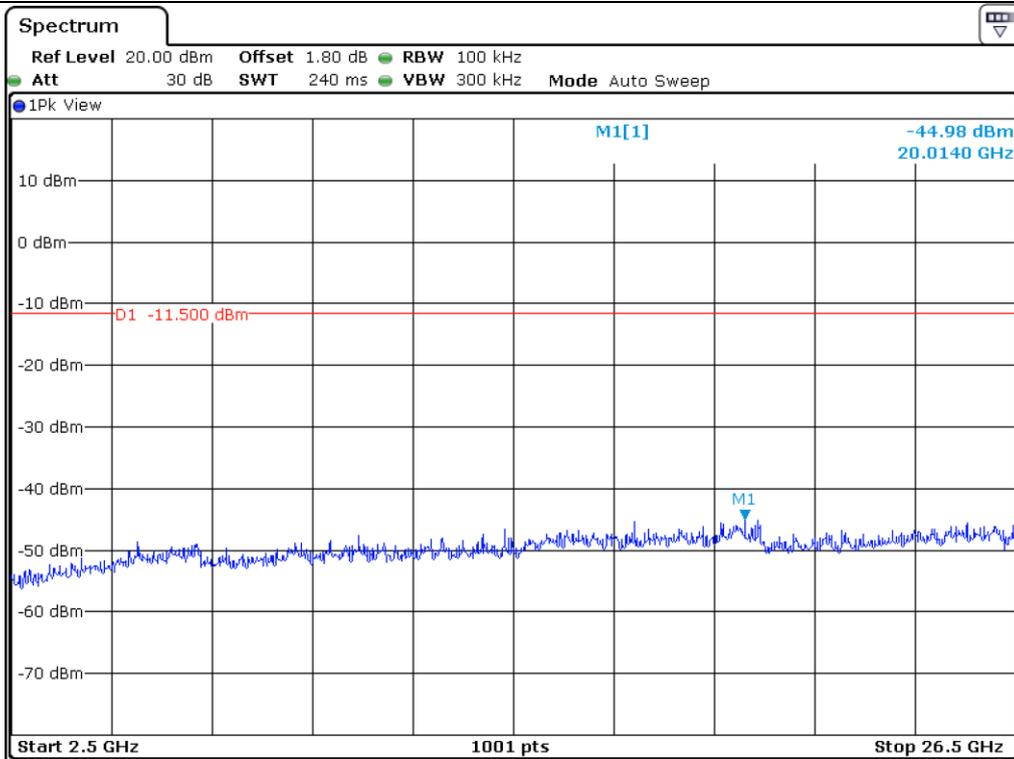
Middle Channel



Middle Channel

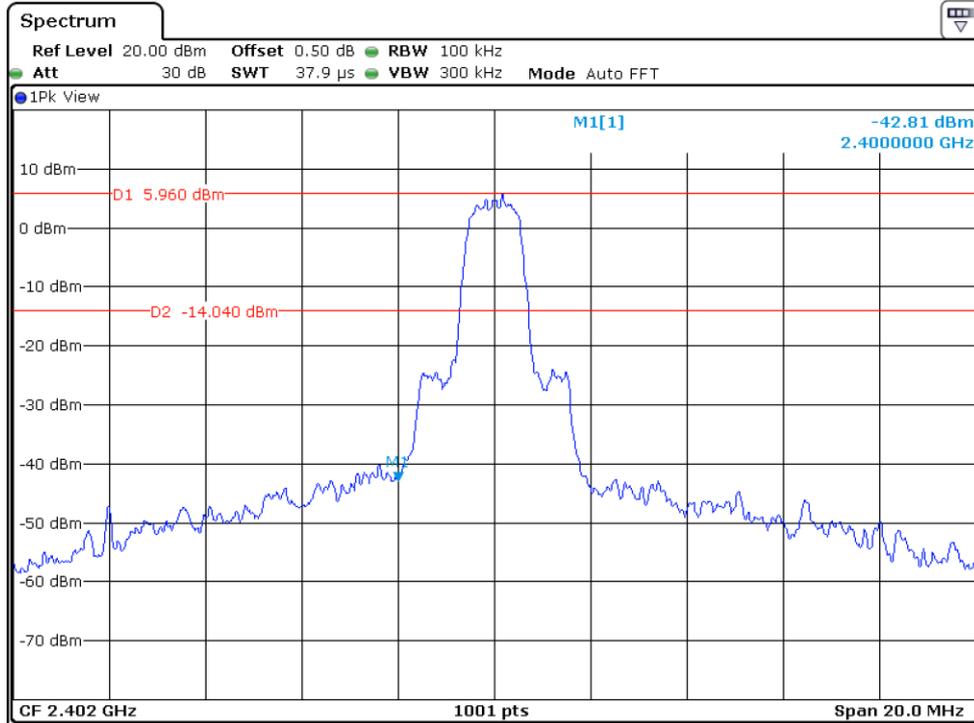


High Channel

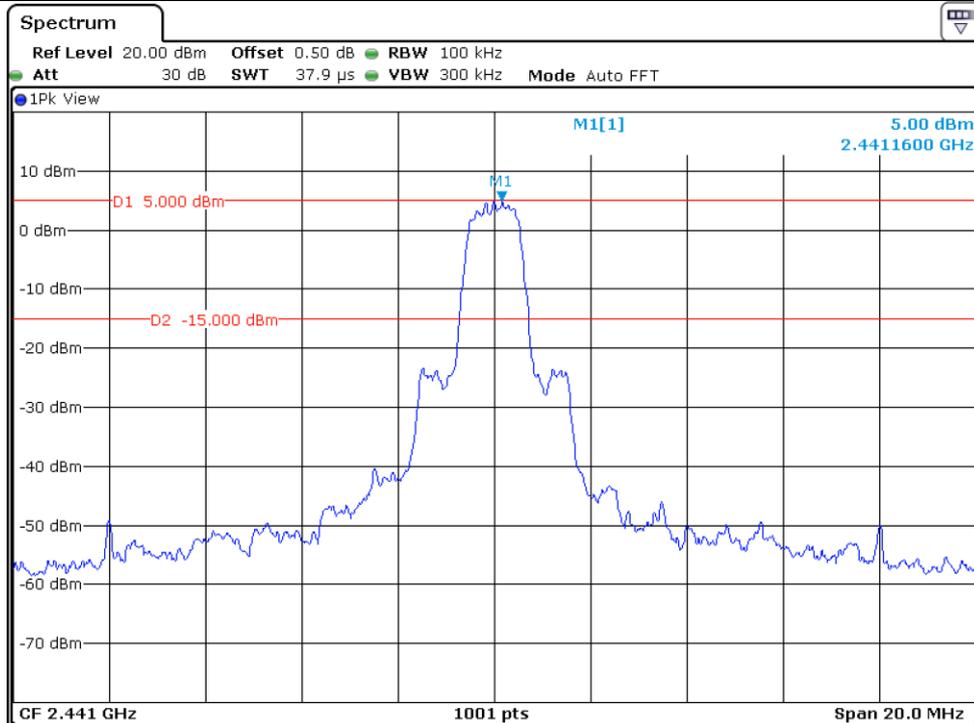


High Channel

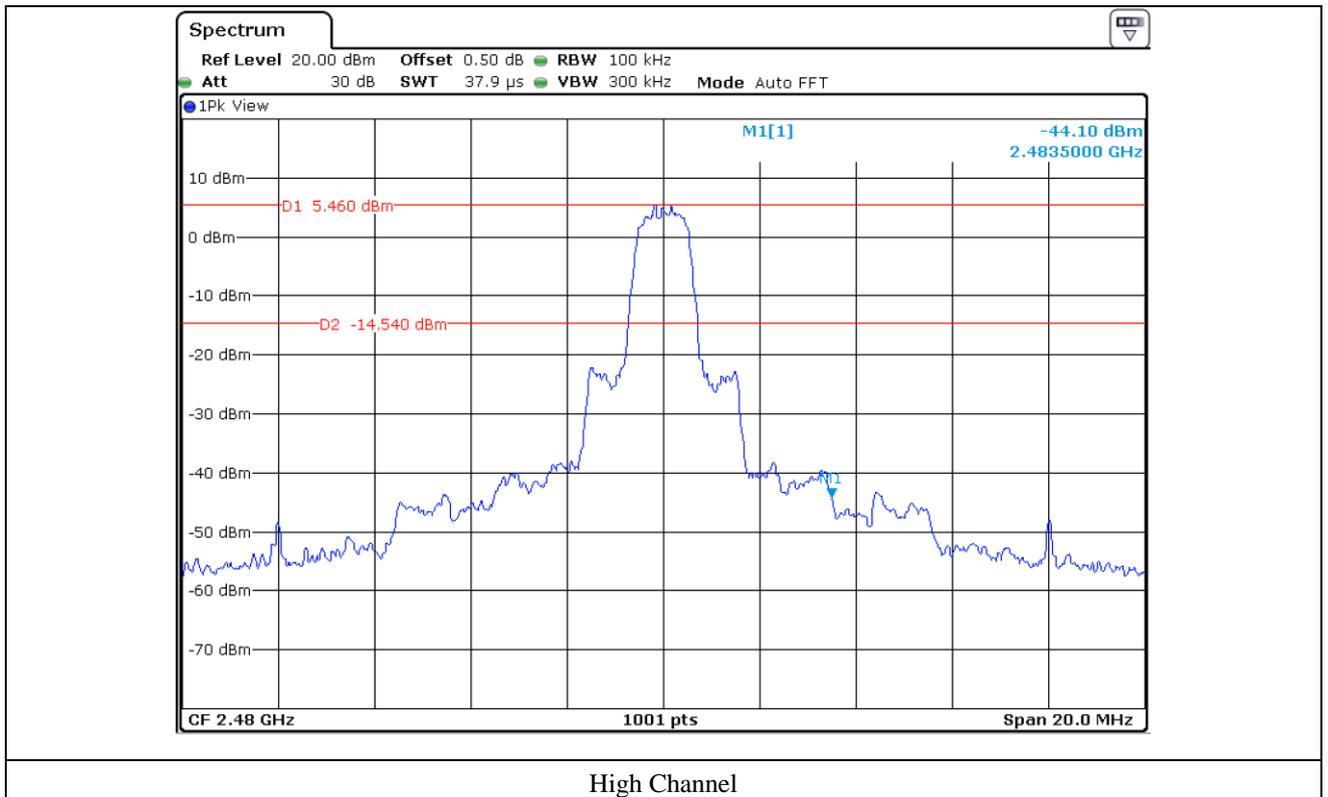
12.5.2 Test data for 2 Mbps

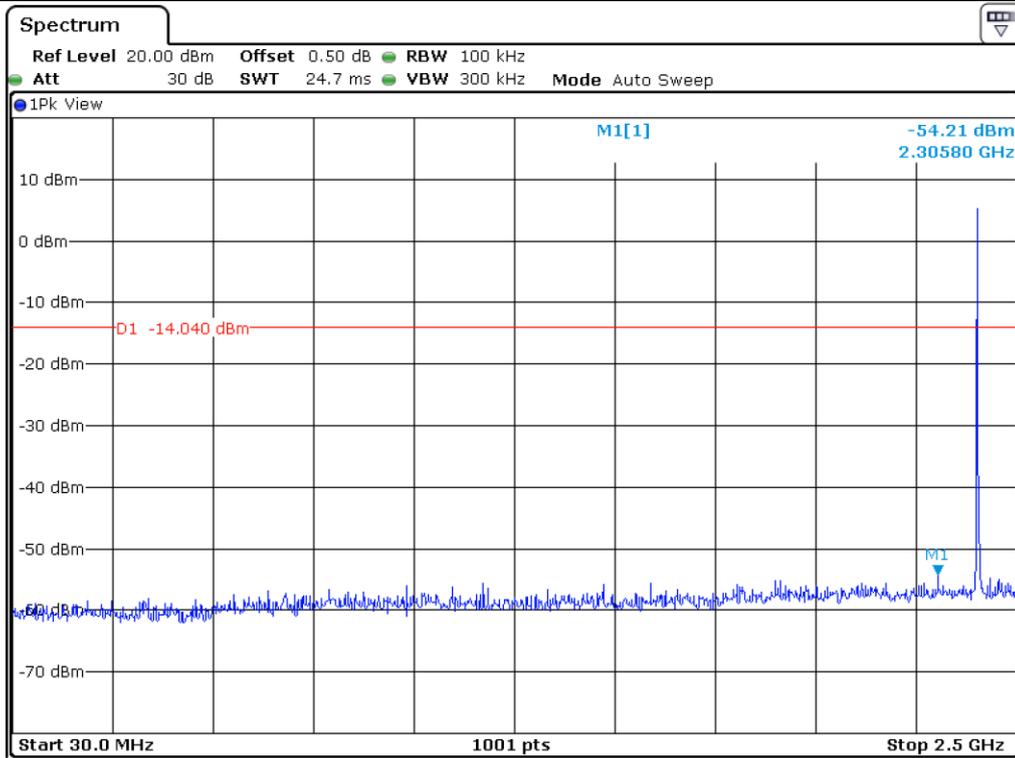


Low Channel

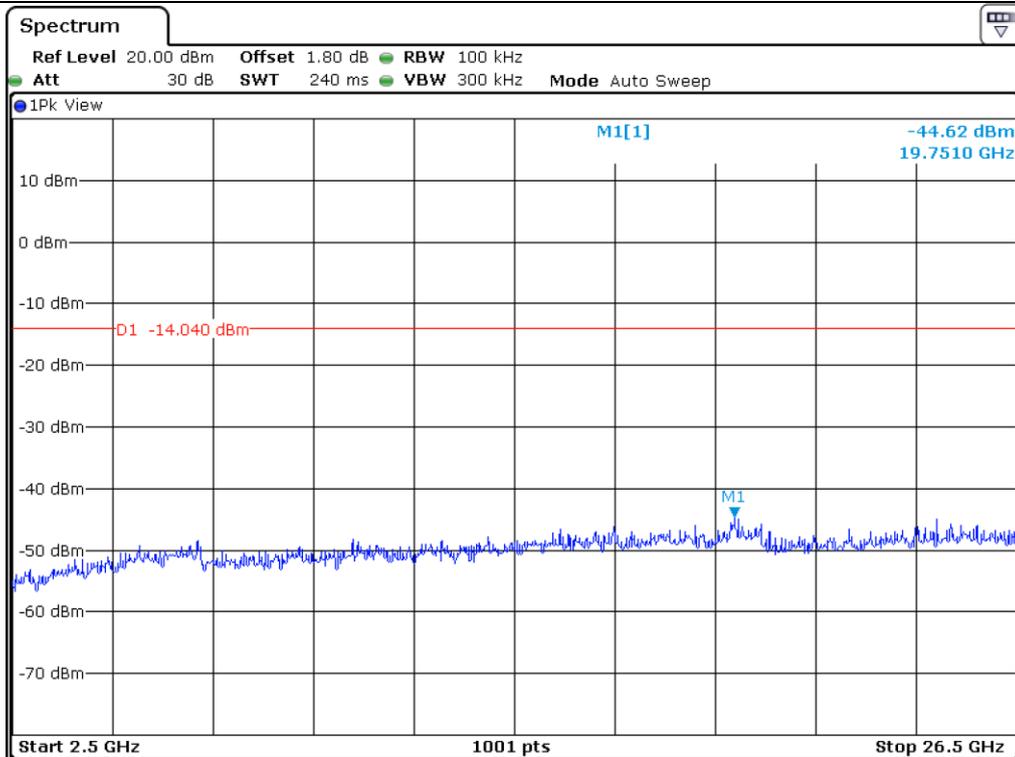


Middle Channel

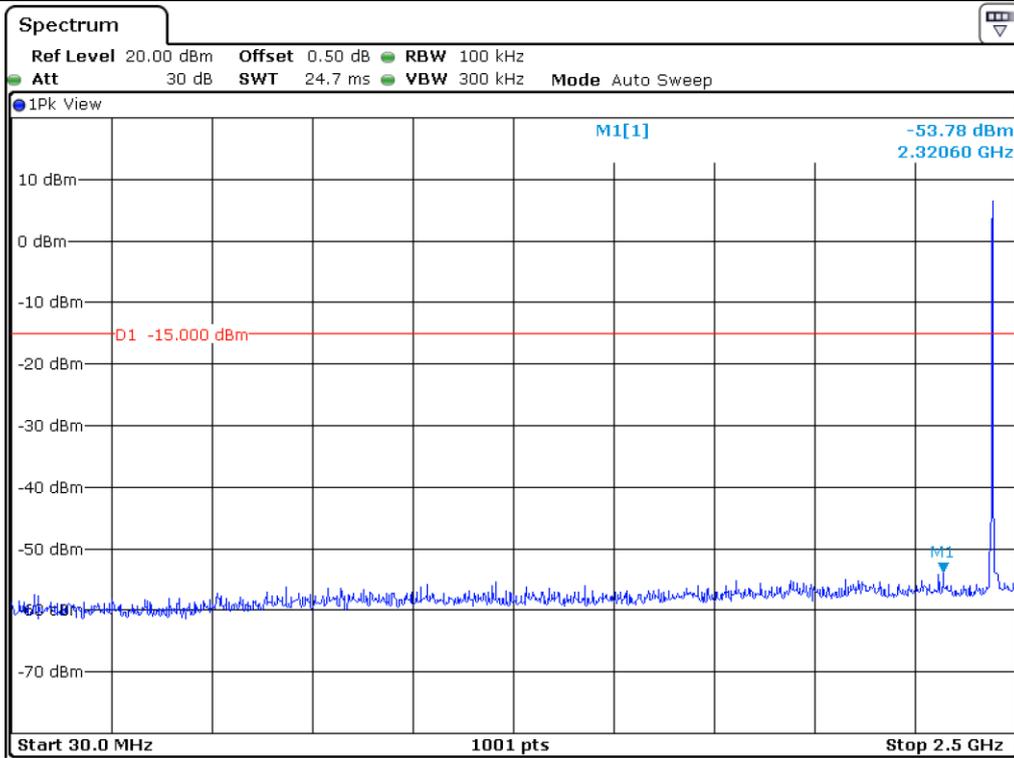




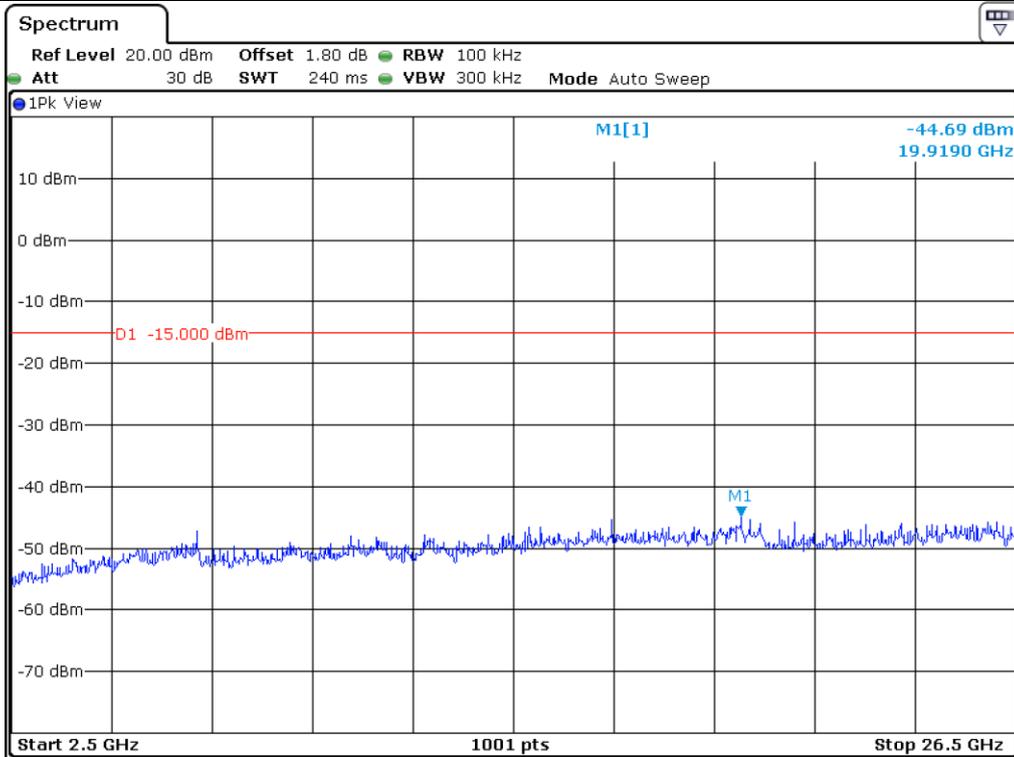
Low Channel



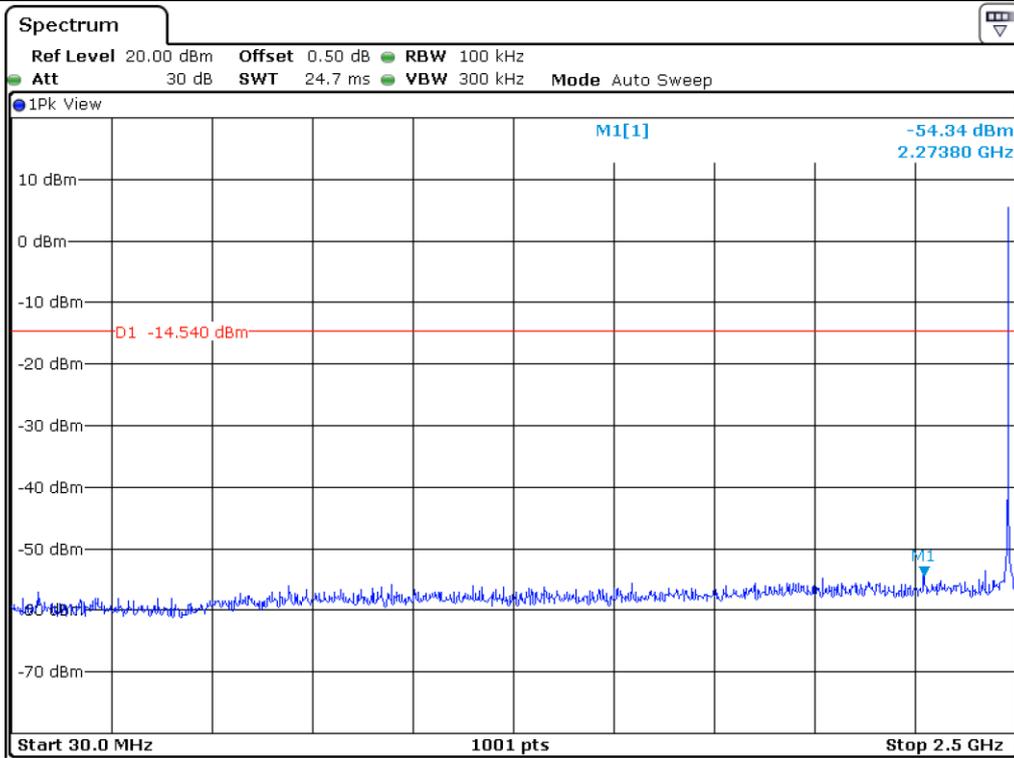
Low Channel



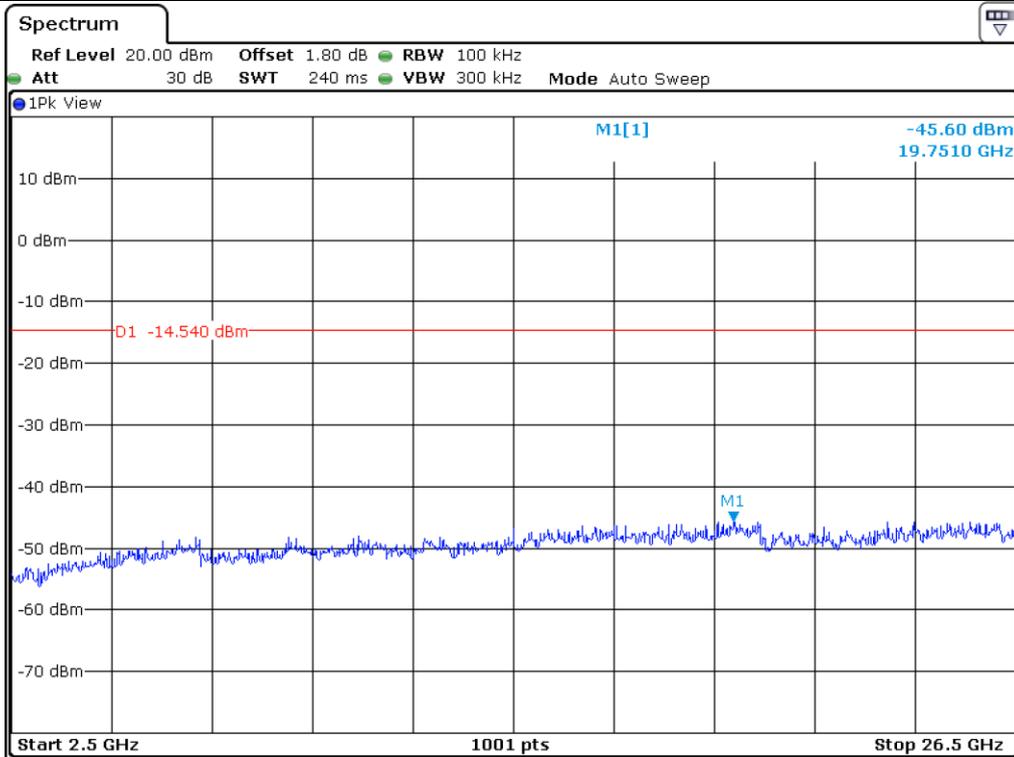
Middle Channel



Middle Channel

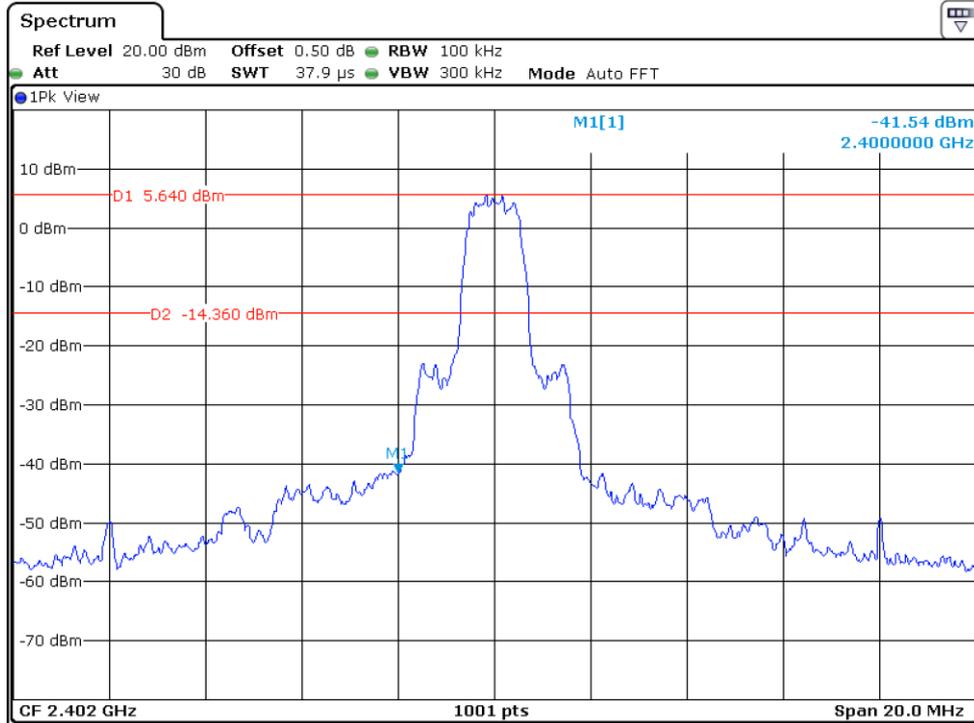


High Channel

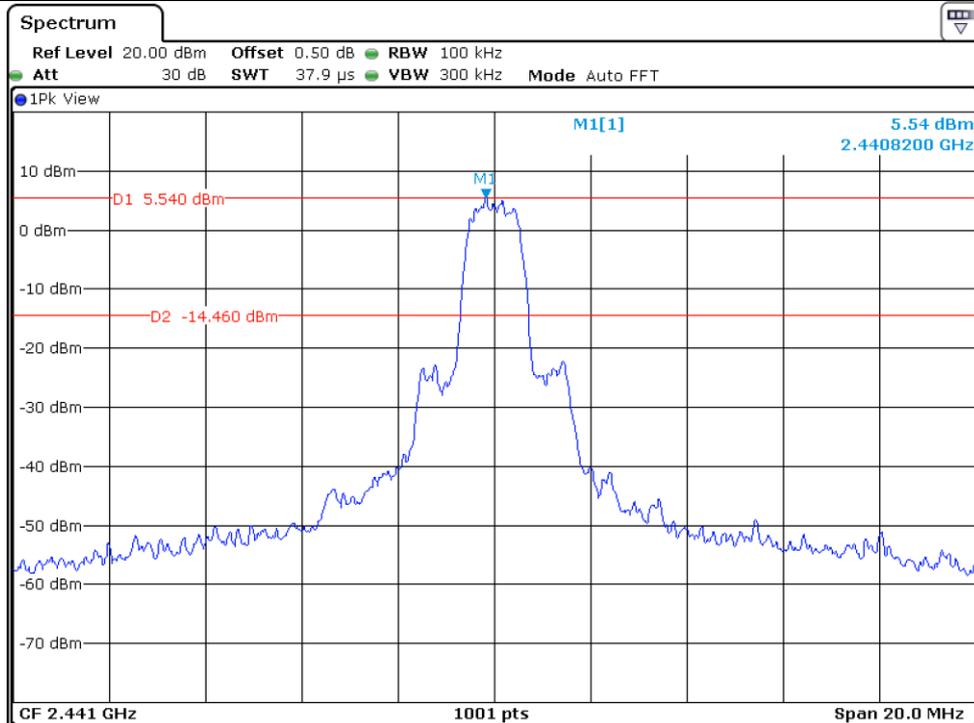


High Channel

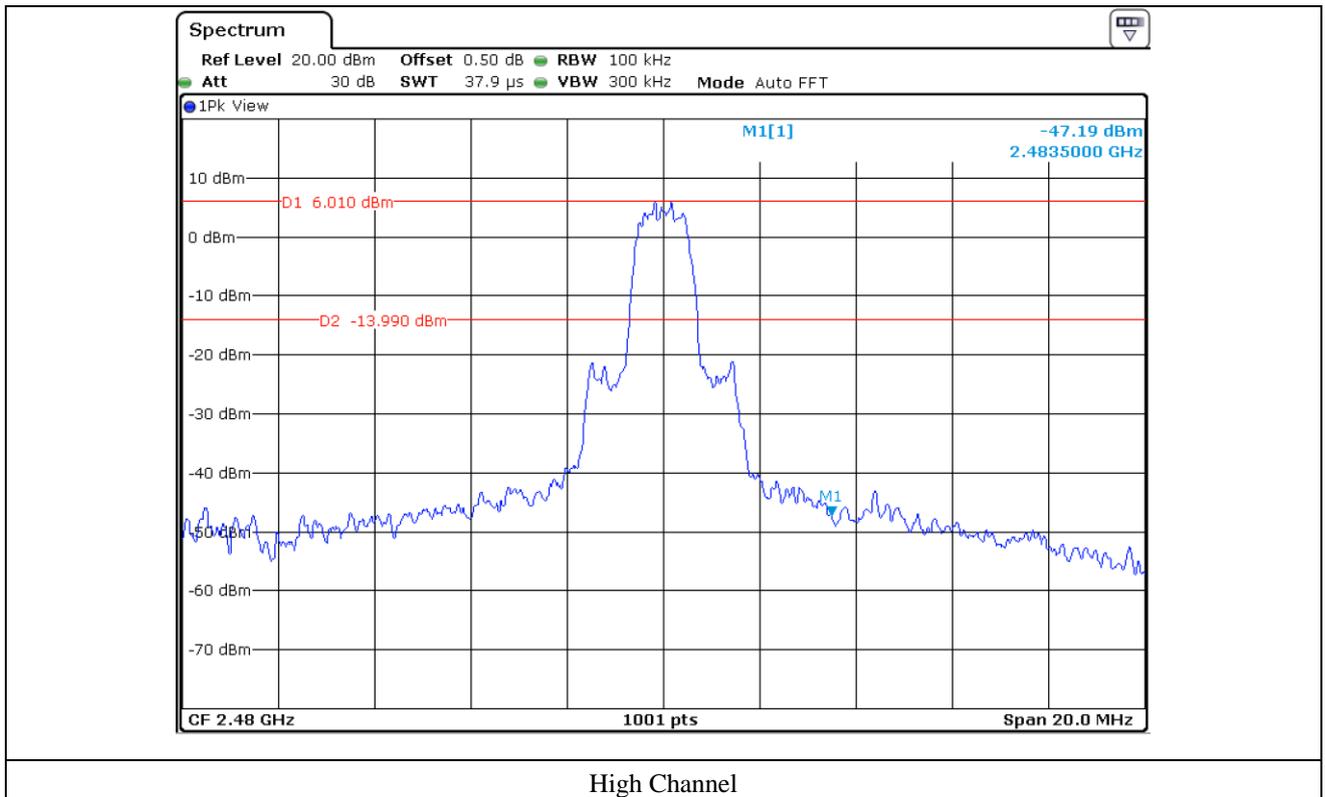
12.5.3 Test data for 3 Mbps

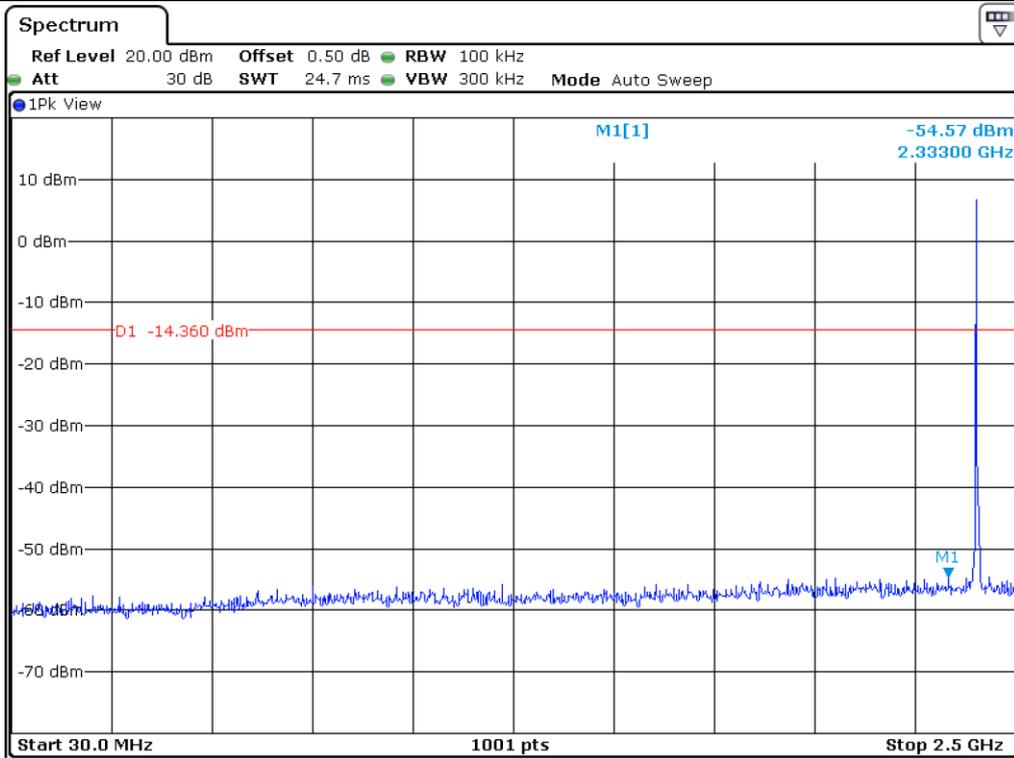


Low Channel

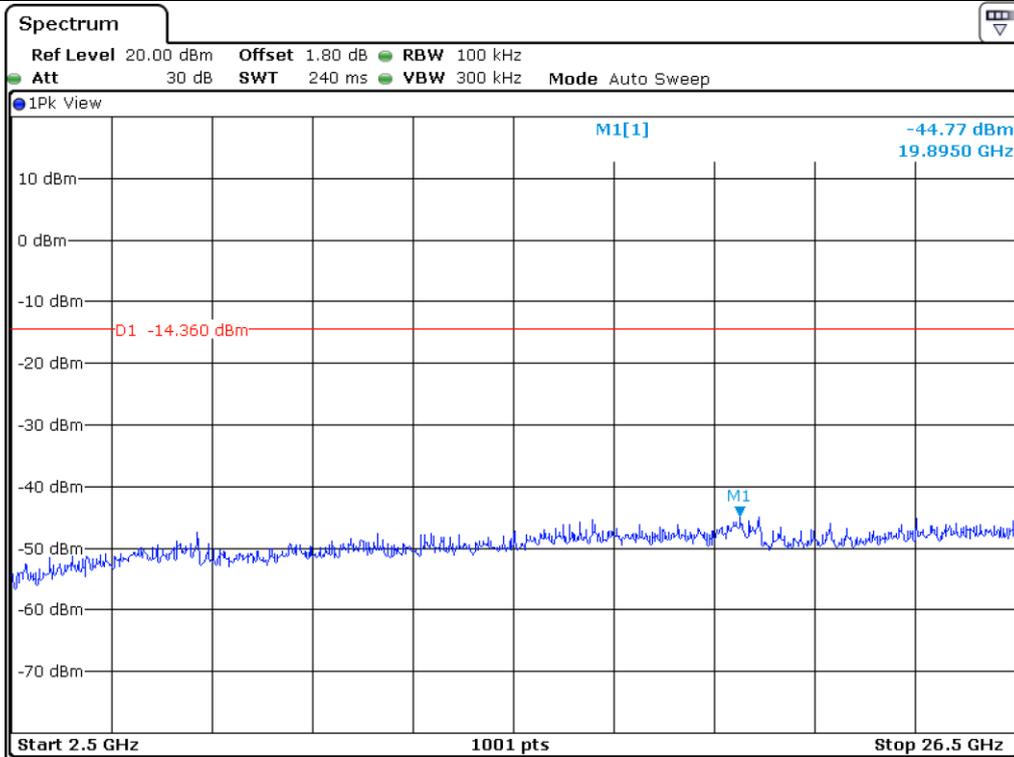


Middle Channel

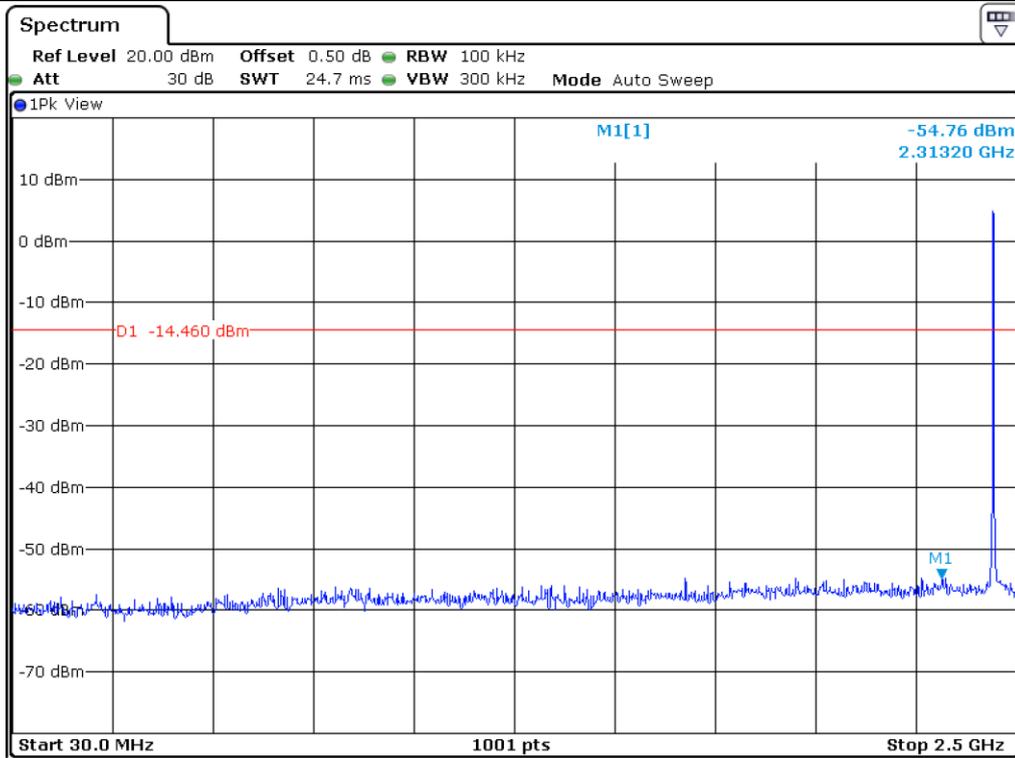




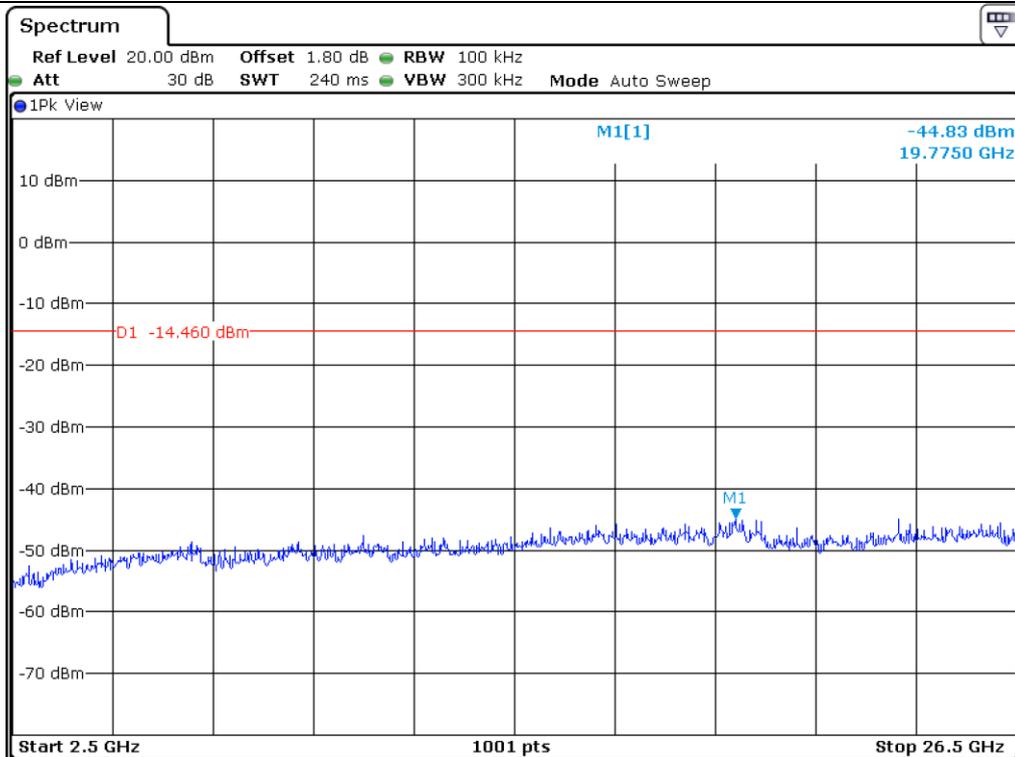
Low Channel



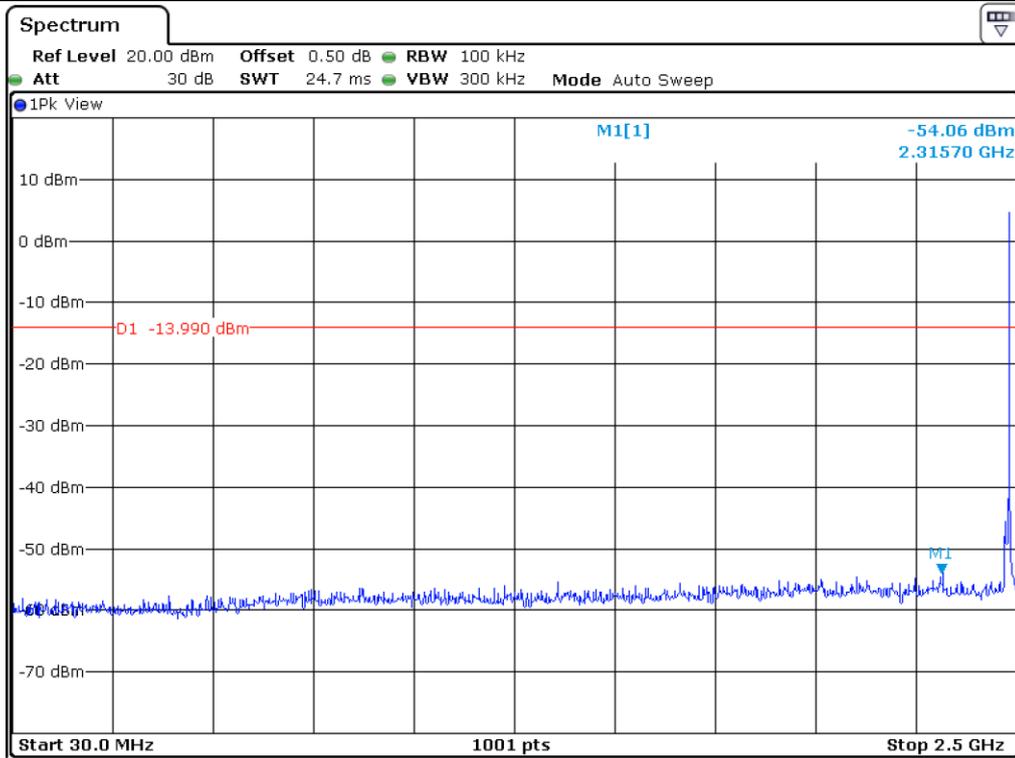
Low Channel



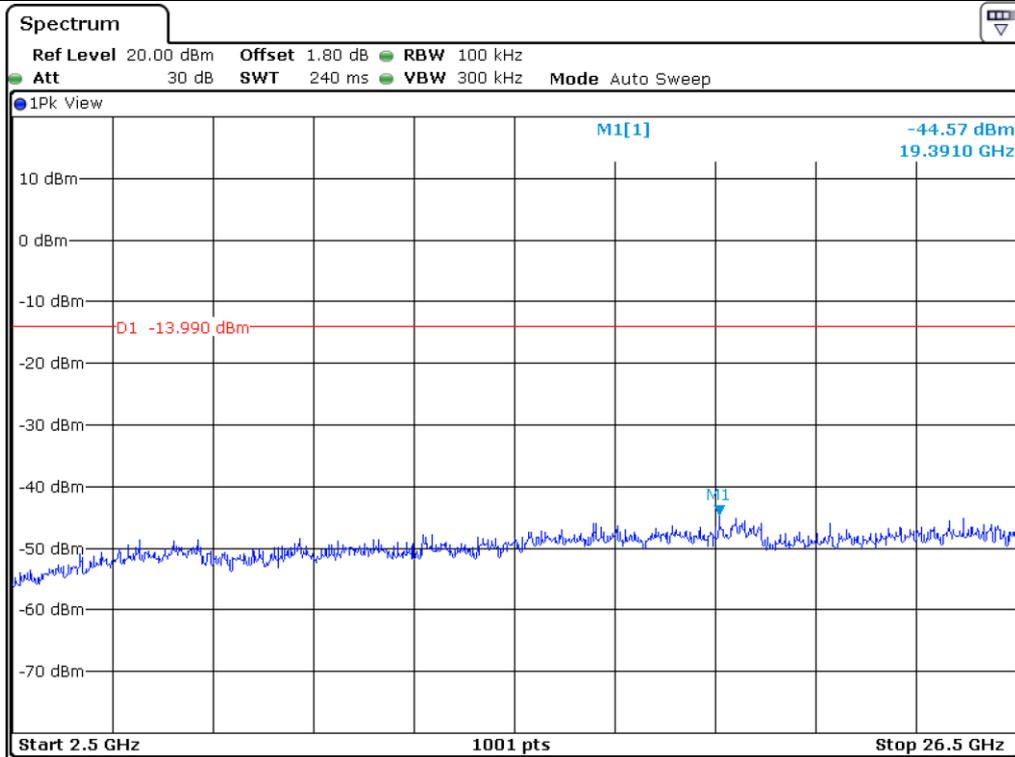
Middle Channel



Middle Channel



High Channel



High Channel

12.6 Test data for Transmitting mode radiated emission

12.6.1 Radiated Emission which fall in the Restricted Band

12.6.1.1 Test data for 1 Mbps

- Test Date : March 18, 2019
- Resolution bandwidth : 1 MHz and Peak Detector for Peak Mode
1 MHz and RMS Detector for Average Mode
- Video bandwidth : 3 MHz for Peak and Average Mode
- Measurement distance : 3 m
- Result : PASSED

| Frequency (MHz) | Reading (dBμV) | Detector Mode | Ant. Pol. (H/V) | Ant. Factor | Cable Loss | Amp Gain | Total (dBμV/m) | Limits (dBμV/m) | Margin (dB) |
|-----------------------------------|----------------|---------------|-----------------|-------------|------------|----------|----------------|-----------------|-------------|
| Test Data for Low Channel | | | | | | | | | |
| 2 319.151 | 47.44 | Peak | H | 26.91 | 9.17 | 34.76 | 48.76 | 74.00 | 25.24 |
| 2 345.604 | 35.40 | Average | H | 26.91 | 9.17 | 34.72 | 36.76 | 54.00 | 17.24 |
| 2 372.298 | 46.84 | Peak | V | 26.91 | 9.17 | 34.72 | 48.20 | 74.00 | 25.80 |
| 2 383.247 | 34.47 | Average | V | 26.91 | 9.17 | 34.72 | 35.83 | 54.00 | 18.17 |
| Test Data for High Channel | | | | | | | | | |
| 2 483.920 | 54.86 | Peak | H | 27.47 | 9.49 | 35.51 | 56.31 | 74.00 | 17.69 |
| 2 483.508 | 43.74 | Average | H | 27.47 | 9.49 | 35.51 | 45.19 | 54.00 | 8.81 |
| 2 499.283 | 51.18 | Peak | V | 27.47 | 9.49 | 35.52 | 52.62 | 74.00 | 21.38 |
| 2 489.624 | 40.13 | Average | V | 27.47 | 9.49 | 35.51 | 41.58 | 54.00 | 12.42 |

Tabulated test data for Restricted Band

Remark: "H": Horizontal, "V": Vertical



Tested by: Hyung-Kwon, Oh / Assistant Manager

12.6.1.2 Test data for 2 Mbps

- Test Date : March 18, 2019
- Resolution bandwidth : 1 MHz and Peak Detector for Peak Mode
1 MHz and RMS Detector for Average Mode
- Video bandwidth : 3 MHz for Peak and Average Mode
- Measurement distance : 3 m
- Result : PASSED

| Frequency (MHz) | Reading (dBμV) | Detector Mode | Ant. Pol. (H/V) | Ant. Factor | Cable Loss | Amp Gain | Total (dBμV/m) | Limits (dBμV/m) | Margin (dB) |
|-----------------------------------|----------------|---------------|-----------------|-------------|------------|----------|----------------|-----------------|-------------|
| Test Data for Low Channel | | | | | | | | | |
| 2 359.830 | 44.74 | Peak | H | 26.91 | 9.17 | 34.76 | 46.06 | 74.00 | 27.94 |
| 2 346.723 | 33.29 | Average | H | 26.91 | 9.17 | 34.72 | 34.65 | 54.00 | 19.35 |
| 2 361.429 | 44.53 | Peak | V | 26.91 | 9.17 | 34.72 | 45.89 | 74.00 | 28.11 |
| 2 363.986 | 33.43 | Average | V | 26.91 | 9.17 | 34.72 | 34.79 | 54.00 | 19.21 |
| Test Data for High Channel | | | | | | | | | |
| 2 483.657 | 52.92 | Peak | H | 27.47 | 9.49 | 35.51 | 54.37 | 74.00 | 19.63 |
| 2 483.508 | 41.69 | Average | H | 27.47 | 9.49 | 35.51 | 43.14 | 54.00 | 10.86 |
| 2 483.854 | 49.59 | Peak | V | 27.47 | 9.49 | 35.52 | 51.03 | 74.00 | 22.97 |
| 2 483.508 | 38.05 | Average | V | 27.47 | 9.49 | 35.51 | 39.50 | 54.00 | 14.50 |

Tabulated test data for Restricted Band

Remark: "H": Horizontal, "V": Vertical



Tested by: Hyung-Kwon, Oh / Assistant Manager

12.6.1.3 Test data for 3 Mbps

- . Test Date : March 18, 2019
- . Resolution bandwidth : 1 MHz and Peak Detector for Peak Mode
1 MHz and RMS Detector for Average Mode
- . Video bandwidth : 3 MHz for Peak and Average Mode
- . Measurement distance : 3 m
- . Result : PASSED

| Frequency (MHz) | Reading (dBμV) | Detector Mode | Ant. Pol. (H/V) | Ant. Factor | Cable Loss | Amp Gain | Total (dBμV/m) | Limits (dBμV/m) | Margin (dB) |
|-----------------------------------|----------------|---------------|-----------------|-------------|------------|----------|----------------|-----------------|-------------|
| Test Data for Low Channel | | | | | | | | | |
| 2 387.163 | 44.28 | Peak | H | 26.91 | 9.17 | 34.76 | 45.60 | 74.00 | 28.40 |
| 2 333.057 | 33.27 | Average | H | 26.91 | 9.17 | 34.72 | 34.63 | 54.00 | 19.37 |
| 2 346.643 | 44.54 | Peak | V | 26.91 | 9.17 | 34.72 | 45.90 | 74.00 | 28.10 |
| 2 362.867 | 33.75 | Average | V | 26.91 | 9.17 | 34.72 | 35.11 | 54.00 | 18.89 |
| Test Data for High Channel | | | | | | | | | |
| 2 483.821 | 57.21 | Peak | H | 27.47 | 9.49 | 35.51 | 58.66 | 74.00 | 15.34 |
| 2 483.508 | 44.42 | Average | H | 27.47 | 9.49 | 35.51 | 45.87 | 54.00 | 8.13 |
| 2 483.838 | 53.39 | Peak | V | 27.47 | 9.49 | 35.52 | 54.83 | 74.00 | 19.17 |
| 2 483.937 | 40.37 | Average | V | 27.47 | 9.49 | 35.51 | 41.82 | 54.00 | 12.18 |

Tabulated test data for Restricted Band

Remark: "H": Horizontal, "V": Vertical



Tested by: Hyung-Kwon, Oh / Assistant Manager

12.6.2 Spurious & Harmonic Radiated Emission above 1 GHz

12.6.2.1 Test data for 1 Mbps

- Test Date : March 18, 2019
- Resolution bandwidth : 1 MHz and Peak Detector for Peak Mode for the emissions fall in restricted band,
1 MHz and RMS Detector for Average Mode for the emissions fall in restricted band
100 kHz for Peak Mode for the emissions outside restricted band
- Video bandwidth : 3 MHz for Peak and Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m
- Result : PASSED

| Frequency (GHz) | Reading (dBμV) | Detector Mode | Ant. Pol. (H/V) | Ant. Factor | Cable Loss | Amp Gain | Total (dBμV/m) | Limits (dBμV/m) | Margin (dB) |
|-------------------------------------|----------------|---------------|-----------------|-------------|------------|----------|----------------|-----------------|-------------|
| Test Data for Low Channel | | | | | | | | | |
| 4 804.000 | 44.67 | Peak | H | 30.84 | 12.31 | 35.74 | 52.08 | 74.00 | 21.92 |
| | 34.65 | Average | H | | | | 34.65 | 54.00 | 19.35 |
| | 44.21 | Peak | V | | | | 44.21 | 74.00 | 29.79 |
| | 33.38 | Average | V | | | | 33.38 | 54.00 | 20.62 |
| Test Data for Middle Channel | | | | | | | | | |
| 4 882.000 | 45.33 | Peak | H | 30.01 | 12.43 | 35.80 | 51.97 | 74.00 | 22.03 |
| | 34.38 | Average | H | | | | 34.38 | 54.00 | 19.62 |
| | 43.98 | Peak | V | | | | 43.98 | 74.00 | 30.02 |
| | 34.27 | Average | V | | | | 34.27 | 54.00 | 19.73 |
| Test Data for High Channel | | | | | | | | | |
| 4 960.000 | 44.21 | Peak | H | 31.15 | 12.81 | 35.96 | 52.21 | 74.00 | 21.79 |
| | 34.65 | Average | H | | | | 34.65 | 54.00 | 19.35 |
| | 44.70 | Peak | V | | | | 44.70 | 74.00 | 29.30 |
| | 33.76 | Average | V | | | | 33.76 | 54.00 | 20.24 |

Tabulated test data for Restricted Band

Remark: "H": Horizontal, "V": Vertical, "*" Frequency fall in restricted band



Tested by: Hyung-Kwon, Oh / Assistant Manager

12.6.2.2 Test data for 2 Mbps

- Test Date : March 18, 2019
- Resolution bandwidth : 1 MHz and Peak Detector for Peak Mode for the emissions fall in restricted band,
1 MHz and RMS Detector for Average Mode for the emissions fall in restricted band
100 kHz for Peak Mode for the emissions outside restricted band
- Video bandwidth : 3 MHz for Peak and Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m
- Result : PASSED

| Frequency (GHz) | Reading (dBμV) | Detector Mode | Ant. Pol. (H/V) | Ant. Factor | Cable Loss | Amp Gain | Total (dBμV/m) | Limits (dBμV/m) | Margin (dB) |
|-------------------------------------|----------------|---------------|-----------------|-------------|------------|----------|----------------|-----------------|-------------|
| Test Data for Low Channel | | | | | | | | | |
| 4 804.000 | 43.81 | Peak | H | 30.84 | 12.31 | 35.74 | 51.22 | 74.00 | 22.78 |
| | 35.01 | Average | H | | | | 42.42 | 54.00 | 11.58 |
| | 43.60 | Peak | V | | | | 51.01 | 74.00 | 22.99 |
| | 33.24 | Average | V | | | | 40.65 | 54.00 | 13.35 |
| Test Data for Middle Channel | | | | | | | | | |
| 4 882.000 | 46.31 | Peak | H | 30.01 | 12.43 | 35.80 | 52.95 | 74.00 | 21.05 |
| | 34.71 | Average | H | | | | 41.35 | 54.00 | 12.65 |
| | 44.46 | Peak | V | | | | 51.10 | 74.00 | 22.90 |
| | 33.81 | Average | V | | | | 40.45 | 54.00 | 13.55 |
| Test Data for High Channel | | | | | | | | | |
| 4 960.000 | 44.21 | Peak | H | 31.15 | 12.81 | 35.96 | 52.21 | 74.00 | 21.79 |
| | 35.29 | Average | H | | | | 43.29 | 54.00 | 10.71 |
| | 45.33 | Peak | V | | | | 53.33 | 74.00 | 20.67 |
| | 33.71 | Average | V | | | | 41.71 | 54.00 | 12.29 |

Tabulated test data for Restricted Band

Remark: "H": Horizontal, "V": Vertical, "*" Frequency fall in restricted band



Tested by: Hyung-Kwon, Oh / Assistant Manager

12.6.2.3 Test data for 3 Mbps

- Test Date : March 18, 2019
- Resolution bandwidth : 1 MHz and Peak Detector for Peak Mode for the emissions fall in restricted band,
1 MHz and RMS Detector for Average Mode for the emissions fall in restricted band
100 kHz for Peak Mode for the emissions outside restricted band
- Video bandwidth : 3 MHz for Peak and Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m
- Result : PASSED

| Frequency (GHz) | Reading (dBμV) | Detector Mode | Ant. Pol. (H/V) | Ant. Factor | Cable Loss | Amp Gain | Total (dBμV/m) | Limits (dBμV/m) | Margin (dB) |
|-------------------------------------|----------------|---------------|-----------------|-------------|------------|----------|----------------|-----------------|-------------|
| Test Data for Low Channel | | | | | | | | | |
| 4 804.000 | 45.55 | Peak | H | 30.84 | 12.31 | 35.74 | 52.96 | 74.00 | 21.04 |
| | 34.79 | Average | H | | | | 42.20 | 54.00 | 11.80 |
| | 44.67 | Peak | V | | | | 52.08 | 74.00 | 21.92 |
| | 33.84 | Average | V | | | | 41.25 | 54.00 | 12.75 |
| Test Data for Middle Channel | | | | | | | | | |
| 4 882.000 | 46.03 | Peak | H | 30.01 | 12.43 | 35.80 | 52.67 | 74.00 | 21.33 |
| | 33.64 | Average | H | | | | 40.28 | 54.00 | 13.72 |
| | 44.51 | Peak | V | | | | 51.15 | 74.00 | 22.85 |
| | 34.98 | Average | V | | | | 41.62 | 54.00 | 12.38 |
| Test Data for High Channel | | | | | | | | | |
| 4 960.000 | 44.16 | Peak | H | 31.15 | 12.81 | 35.96 | 52.16 | 74.00 | 21.84 |
| | 33.99 | Average | H | | | | 41.99 | 54.00 | 12.01 |
| | 43.80 | Peak | V | | | | 51.80 | 74.00 | 22.20 |
| | 33.25 | Average | V | | | | 41.25 | 54.00 | 12.75 |

Tabulated test data for Restricted Band

Remark: "H": Horizontal, "V": Vertical, "*" Frequency fall in restricted band



Tested by: Hyung-Kwon, Oh / Assistant Manager

13. RADIATED EMISSION TEST

13.1 Operating environment

Temperature : 25 °C
 Relative humidity : 46 % R.H.

13.2 Test set-up

The radiated emissions measurements were on the 3 m semi anechoic chamber. The EUT and other support equipment were placed on a non-conductive turntable above the ground plane. The interconnecting cables from outside test site were inserted into ferrite clamps at the point where the cables reach the turntable.

The frequency spectrum from 30 MHz to 26.5 GHz was scanned and emission levels maximized at each frequency recorded. The system was rotated 360°, and the antenna was varied in height between 1.0 m and 4.0 m in order to determine the maximum emission levels. This procedure was performed for both horizontal and vertical polarization of the receiving antenna.

13.3 Test equipment used

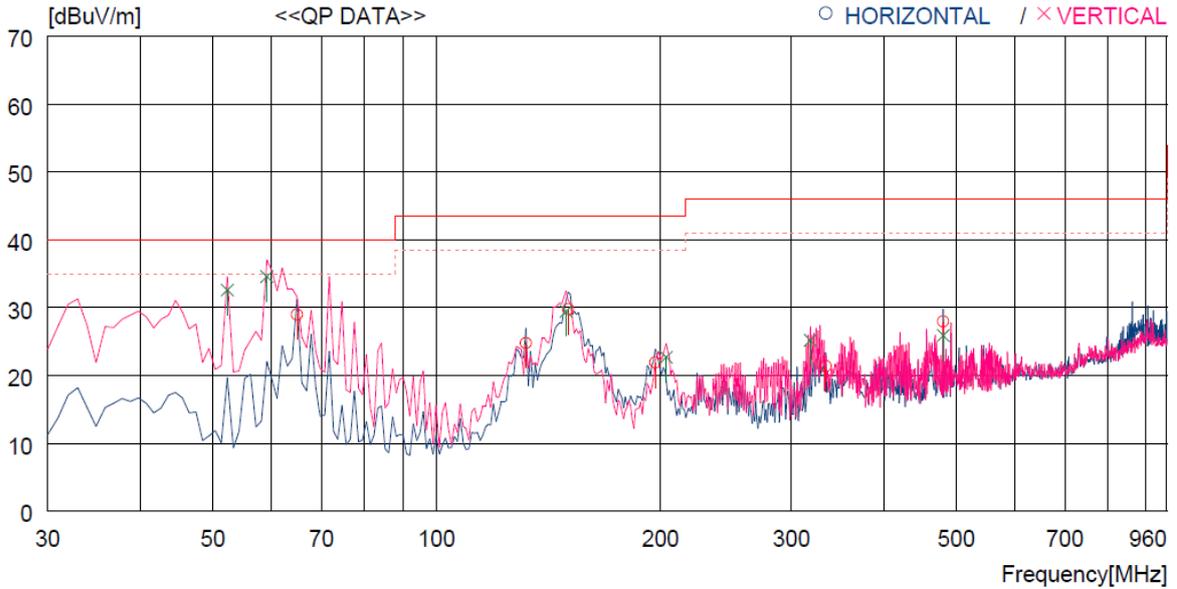
| Model Number | Manufacturer | Description | Serial Number | Last Cal. |
|-----------------|-------------------|--------------------------|---------------|--------------------|
| ■ - FSV40 | Rohde & Schwarz | Signal Analyzer | 101009 | Mar. 11, 2019 (1Y) |
| ■ - ESR | Rohde & Schwarz | EMI Test Receiver | 101470 | Oct. 22, 2018 (1Y) |
| ■ - 310N | Sonoma Instrument | Pre-Amplifier | 312544 | Mar. 18, 2019 (1Y) |
| ■ - BBV 9718 B | Schwarzbeck | Amplifier | 009 | Mar. 20, 2018 (1Y) |
| ■ SCU40A | Rohde & Schwarz | Signal Conditioning unit | 100436 | Mar. 11, 2019 (1Y) |
| ■ - DT3000-3t | Innco System | Turn Table | DT3000/093 | N/A |
| ■ - MA-4000XPET | Innco System | Antenna Master | MA4000/509 | N/A |
| ■ - VULB9163 | Schwarzbeck | TRILOG Broadband Antenna | 777 | Apr. 13, 2018 (2Y) |
| ■ - BBHA9120D | Schwarzbeck | Horn Antenna | BBHA9120D295 | Aug. 16, 2017 (2Y) |
| ■ - BBHA9170 | Schwarzbeck | Horn Antenna | BBHA9170179 | Jan. 16, 2019 (1Y) |

All test equipment used is calibrated on a regular basis.

13.4 Test data for Transmitting mode [BDR]

13.4.1 Test data for 30 MHz ~ 960 MHz

- Test Date : March 20, 2019
- Resolution bandwidth : 120 kHz
- Frequency range : 30 MHz ~ 960 MHz
- Measurement distance : 3 m



| No. | FREQ [MHz] | READING QP [dBuV] | ANT FACTOR [dB] | LOSS [dB] | GAIN [dB] | RESULT [dBuV/m] | LIMIT [dBuV/m] | MARGIN [dB] | ANTENNA [cm] | TABLE [DEG] |
|------------------------|---------------|-------------------------|-----------------------|--------------|--------------|--------------------|-------------------|----------------|-----------------|----------------|
| ----- Horizontal ----- | | | | | | | | | | |
| 1 | 64.920 | 48.7 | 11.5 | 1.9 | 33.1 | 29.0 | 40.0 | 11.0 | 300 | 122 |
| 2 | 131.850 | 46.5 | 8.6 | 2.7 | 33.0 | 24.8 | 43.5 | 18.7 | 300 | 359 |
| 3 | 150.280 | 52.1 | 7.7 | 2.9 | 32.9 | 29.8 | 43.5 | 13.7 | 300 | 162 |
| 4 | 196.840 | 41.3 | 10.5 | 3.3 | 33.2 | 21.9 | 43.5 | 21.6 | 300 | 187 |
| 5 | 333.610 | 36.0 | 14.3 | 4.2 | 33.1 | 21.4 | 46.0 | 24.6 | 300 | 327 |
| 6 | 480.081 | 39.4 | 16.8 | 5.1 | 33.3 | 28.0 | 46.0 | 18.0 | 100 | 226 |
| ----- Vertical ----- | | | | | | | | | | |
| 7 | 52.310 | 50.3 | 13.7 | 1.7 | 33.1 | 32.6 | 40.0 | 7.4 | 100 | 0 |
| 8 | 59.100 | 52.4 | 13.4 | 1.9 | 33.1 | 34.6 | 40.0 | 5.4 | 100 | 250 |
| 9 | 149.310 | 51.8 | 7.7 | 2.9 | 32.9 | 29.5 | 43.5 | 14.0 | 100 | 109 |
| 10 | 203.630 | 42.0 | 10.6 | 3.3 | 33.2 | 22.7 | 43.5 | 20.8 | 100 | 0 |
| 11 | 318.090 | 40.5 | 13.6 | 4.1 | 33.0 | 25.2 | 46.0 | 20.8 | 100 | 0 |
| 12 | 480.081 | 37.3 | 16.8 | 5.1 | 33.3 | 25.9 | 46.0 | 20.1 | 100 | 0 |

Tested by: Hyung-Kwon, Oh / Assistant Manager

13.4.2 Test data for Below 30 MHz

- Test Date : March 20, 2019
- Resolution bandwidth : 200 Hz (from 9 kHz to 0.15 MHz), 9 kHz (from 0.15 MHz to 30 MHz)
- Frequency range : 9 kHz ~ 30 MHz
- Measurement distance : 3 m

| Frequency (MHz) | Reading (dBμV) | Ant. Pol. (H/V) | Ant. Factor (dB/m) | Cable Loss | Amp Gain | Emission Level(dBμV/m) | Limits (dBμV/m) | Margin (dB) |
|---|----------------|-----------------|--------------------|------------|----------|------------------------|-----------------|-------------|
| It was not observed any emissions from the EUT. | | | | | | | | |

13.4.3 Test data for above 1 GHz

- Test Date : March 20, 2019
- Resolution bandwidth : 1 MHz for Peak and Average Mode
- Video bandwidth : 1 MHz for Peak Mode, 10 Hz for Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m

| Frequency (MHz) | Reading (dBμV) | Ant. Pol. (H/V) | Ant. Factor (dB/m) | Cable Loss | Amp Gain | Emission Level(dBμV/m) | Limits (dBμV/m) | Margin (dB) |
|---|----------------|-----------------|--------------------|------------|----------|------------------------|-----------------|-------------|
| It was not observed any emissions from the EUT. | | | | | | | | |

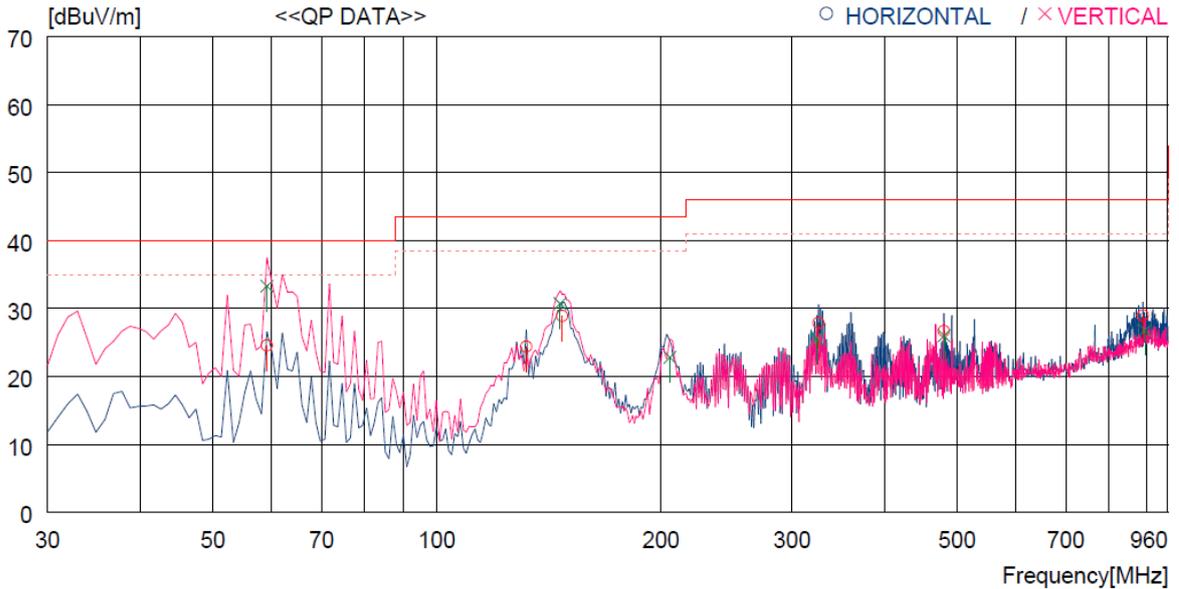


Tested by: Hyung-Kwon, Oh / Assistant Manager

13.5 Test data for Transmitting mode [EDR]

13.5.1 Test data for 30 MHz ~ 960 MHz

- Test Date : March 20, 2019
- Resolution bandwidth : 120 kHz
- Frequency range : 30 MHz ~ 960 MHz
- Measurement distance : 3 m



| No. | FREQ [MHz] | READING QP [dBuV] | ANT FACTOR [dB] | LOSS [dB] | GAIN [dB] | RESULT [dBuV/m] | LIMIT [dBuV/m] | MARGIN [dB] | ANTENNA [cm] | TABLE [DEG] |
|------------------------|---------------|-------------------------|-----------------------|--------------|--------------|--------------------|-------------------|----------------|-----------------|----------------|
| ----- Horizontal ----- | | | | | | | | | | |
| 1 | 59.100 | 42.4 | 13.4 | 1.9 | 33.1 | 24.6 | 40.0 | 15.4 | 400 | 0 |
| 2 | 131.850 | 46.1 | 8.6 | 2.7 | 33.0 | 24.4 | 43.5 | 19.1 | 300 | 359 |
| 3 | 147.370 | 51.1 | 7.8 | 2.9 | 32.9 | 28.9 | 43.5 | 14.6 | 400 | 0 |
| 4 | 325.850 | 42.9 | 13.9 | 4.2 | 33.1 | 27.9 | 46.0 | 18.1 | 300 | 359 |
| 5 | 480.081 | 38.1 | 16.8 | 5.1 | 33.3 | 26.7 | 46.0 | 19.3 | 200 | 0 |
| 6 | 888.439 | 33.1 | 21.7 | 6.9 | 32.7 | 29.0 | 46.0 | 17.0 | 100 | 359 |
| ----- Vertical ----- | | | | | | | | | | |
| 7 | 59.100 | 51.1 | 13.4 | 1.9 | 33.1 | 33.3 | 40.0 | 6.7 | 100 | 329 |
| 8 | 146.400 | 52.9 | 7.8 | 2.9 | 32.9 | 30.7 | 43.5 | 12.8 | 100 | 0 |
| 9 | 205.570 | 42.1 | 10.6 | 3.3 | 33.2 | 22.8 | 43.5 | 20.7 | 100 | 288 |
| 10 | 323.910 | 40.8 | 13.8 | 4.1 | 33.1 | 25.6 | 46.0 | 20.4 | 200 | 359 |
| 11 | 480.081 | 37.4 | 16.8 | 5.1 | 33.3 | 26.0 | 46.0 | 20.0 | 100 | 0 |
| 12 | 894.259 | 30.4 | 22.1 | 7.0 | 32.7 | 26.8 | 46.0 | 19.2 | 100 | 187 |

Tested by: Hyung-Kwon, Oh / Assistant Manager

13.5.2 Test data for Below 30 MHz

- Test Date : March 20, 2019
- Resolution bandwidth : 200 Hz (from 9 kHz to 0.15 MHz), 9 kHz (from 0.15 MHz to 30 MHz)
- Frequency range : 9 kHz ~ 30 MHz
- Measurement distance : 3 m

| Frequency (MHz) | Reading (dB μ V) | Ant. Pol. (H/V) | Ant. Factor (dB/m) | Cable Loss | Amp Gain | Emission Level(dB μ V/m) | Limits (dB μ V/m) | Margin (dB) |
|---|----------------------|-----------------|--------------------|------------|----------|------------------------------|-----------------------|-------------|
| It was not observed any emissions from the EUT. | | | | | | | | |

13.5.3 Test data for above 1 GHz

- Test Date : March 20, 2019
- Resolution bandwidth : 1 MHz for Peak and Average Mode
- Video bandwidth : 1 MHz for Peak Mode, 10 Hz for Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m

| Frequency (MHz) | Reading (dB μ V) | Ant. Pol. (H/V) | Ant. Factor (dB/m) | Cable Loss | Amp Gain | Emission Level(dB μ V/m) | Limits (dB μ V/m) | Margin (dB) |
|---|----------------------|-----------------|--------------------|------------|----------|------------------------------|-----------------------|-------------|
| It was not observed any emissions from the EUT. | | | | | | | | |

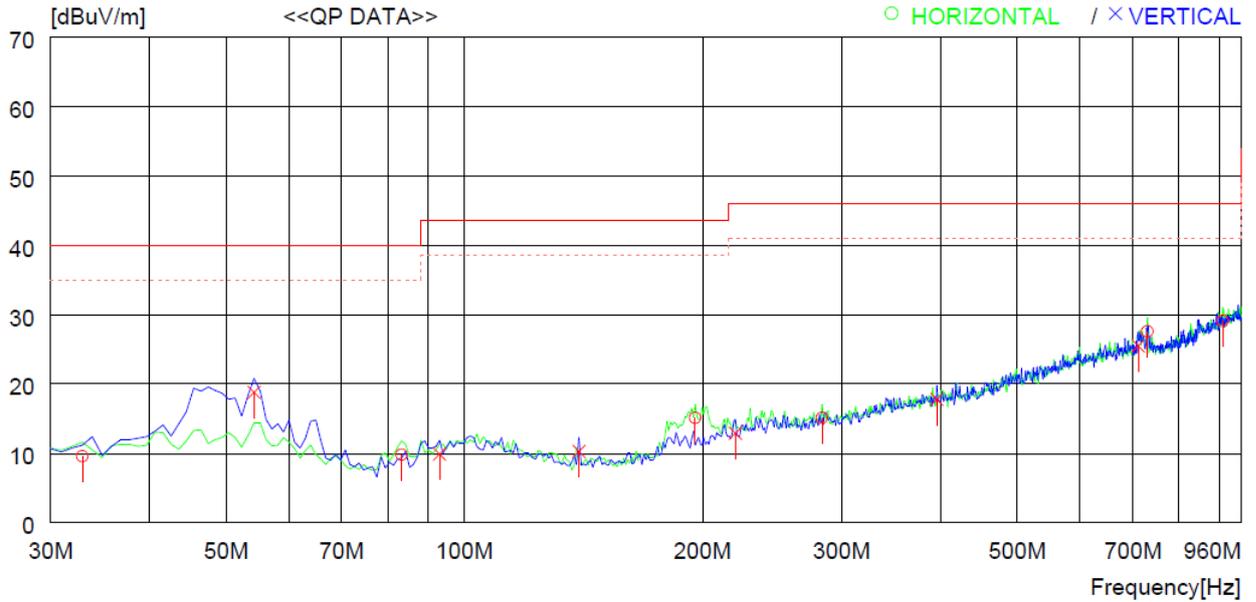


Tested by: Hyung-Kwon, Oh / Assistant Manager

13.6 Test data for Charging mode

13.6.1 Test data for 30 MHz ~ 960 MHz

- Test Date : March 20, 2019
- Resolution bandwidth : 120 kHz
- Frequency range : 30 MHz ~ 960 MHz
- Measurement distance : 3 m



| No. | FREQ [MHz] | READING QP [dBuV] | ANT FACTOR [dB] | LOSS [dB] | GAIN [dB] | RESULT [dBuV/m] | LIMIT [dBuV/m] | MARGIN [dB] | ANTENNA [cm] | TABLE [DEG] |
|------------------------|---------------|-------------------------|-----------------------|--------------|--------------|--------------------|-------------------|----------------|-----------------|----------------|
| ----- Horizontal ----- | | | | | | | | | | |
| 1 | 32.910 | 28.4 | 12.9 | 1.4 | 33.1 | 9.6 | 40.0 | 30.4 | 200 | 278 |
| 2 | 83.350 | 31.9 | 8.8 | 2.1 | 33.0 | 9.8 | 40.0 | 30.2 | 300 | 82 |
| 3 | 195.870 | 34.0 | 10.8 | 3.3 | 33.0 | 15.1 | 43.5 | 28.4 | 200 | 359 |
| 4 | 283.170 | 31.0 | 13.2 | 3.9 | 33.0 | 15.1 | 46.0 | 30.9 | 100 | 232 |
| 5 | 730.334 | 34.1 | 20.4 | 6.3 | 33.2 | 27.6 | 46.0 | 18.4 | 100 | 0 |
| 6 | 908.809 | 31.5 | 22.8 | 7.1 | 32.3 | 29.1 | 46.0 | 16.9 | 100 | 0 |
| ----- Vertical ----- | | | | | | | | | | |
| 7 | 54.250 | 36.4 | 13.7 | 1.8 | 33.1 | 18.8 | 40.0 | 21.2 | 300 | 359 |
| 8 | 93.050 | 29.1 | 11.6 | 2.2 | 33.0 | 9.9 | 43.5 | 33.6 | 200 | 0 |
| 9 | 139.610 | 32.2 | 8.4 | 2.7 | 33.0 | 10.3 | 43.5 | 33.2 | 100 | 280 |
| 10 | 220.120 | 30.9 | 11.5 | 3.4 | 32.9 | 12.9 | 46.0 | 33.1 | 400 | 124 |
| 11 | 395.690 | 30.5 | 15.8 | 4.6 | 33.1 | 17.8 | 46.0 | 28.2 | 300 | 359 |
| 12 | 710.935 | 32.4 | 20.2 | 6.2 | 33.3 | 25.5 | 46.0 | 20.5 | 200 | 282 |

Tested by: Hyung-Kwon, Oh / Assistant Manager

13.6.2 Test data for Below 30 MHz

- Test Date : March 20, 2019
- Resolution bandwidth : 200 Hz (from 9 kHz to 0.15 MHz), 9 kHz (from 0.15 MHz to 30 MHz)
- Frequency range : 9 kHz ~ 30 MHz
- Measurement distance : 3 m

| Frequency (MHz) | Reading (dBμV) | Ant. Pol. (H/V) | Ant. Factor (dB/m) | Cable Loss | Amp Gain | Emission Level(dBμV/m) | Limits (dBμV/m) | Margin (dB) |
|---|----------------|-----------------|--------------------|------------|----------|------------------------|-----------------|-------------|
| It was not observed any emissions from the EUT. | | | | | | | | |

13.6.3 Test data for above 1 GHz

- Test Date : March 20, 2019
- Resolution bandwidth : 1 MHz for Peak and Average Mode
- Video bandwidth : 1 MHz for Peak Mode, 10 Hz for Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m

| Frequency (MHz) | Reading (dBμV) | Ant. Pol. (H/V) | Ant. Factor (dB/m) | Cable Loss | Amp Gain | Emission Level(dBμV/m) | Limits (dBμV/m) | Margin (dB) |
|---|----------------|-----------------|--------------------|------------|----------|------------------------|-----------------|-------------|
| It was not observed any emissions from the EUT. | | | | | | | | |



Tested by: Hyung-Kwon, Oh / Assistant Manager

14. CONDUCTED EMISSION TEST

14.1 Operating environment

Temperature : 25 °C
 Relative humidity : 46 % R.H.

14.2 Test set-up

The EUT was placed on a wooden table, 0.8 m height above the floor. Power was fed to the EUT through a 50 Ω / 50 μH + 5 Ω Artificial Mains Network (AMN). The ground plane was electrically bonded to the reference ground system and all power lines were filtered from ambient.

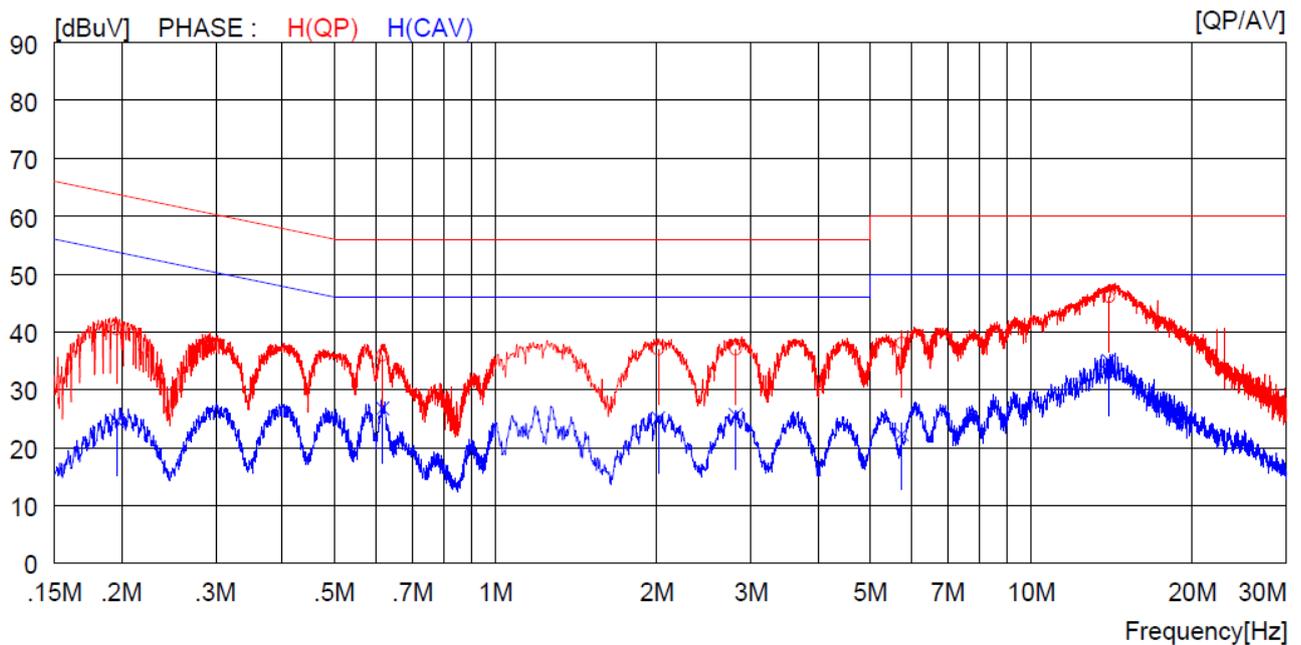
14.3 Test equipment used

| | Model Number | Manufacturer | Description | Serial Number | Last Cal. (Interval) |
|-----|--------------|-----------------|---------------|---------------|----------------------|
| ■ - | ESCI | Rohde & Schwarz | Test Receiver | 101012 | Oct. 22, 2018 (1Y) |
| ■ - | NSLK8128 | SCHWARZ BECK | LISN | 8128-216 | Mar. 20, 2018 (1Y) |
| □ - | NNLK8121 | SCHWARZ BECK | LISN | 804 | Oct. 22, 2018 (1Y) |
| ■ - | ESH3Z2 | Rohde & Schwarz | Pulse Limiter | 100655 | Mar. 20, 2018 (1Y) |

All test equipment used is calibrated on a regular basis.

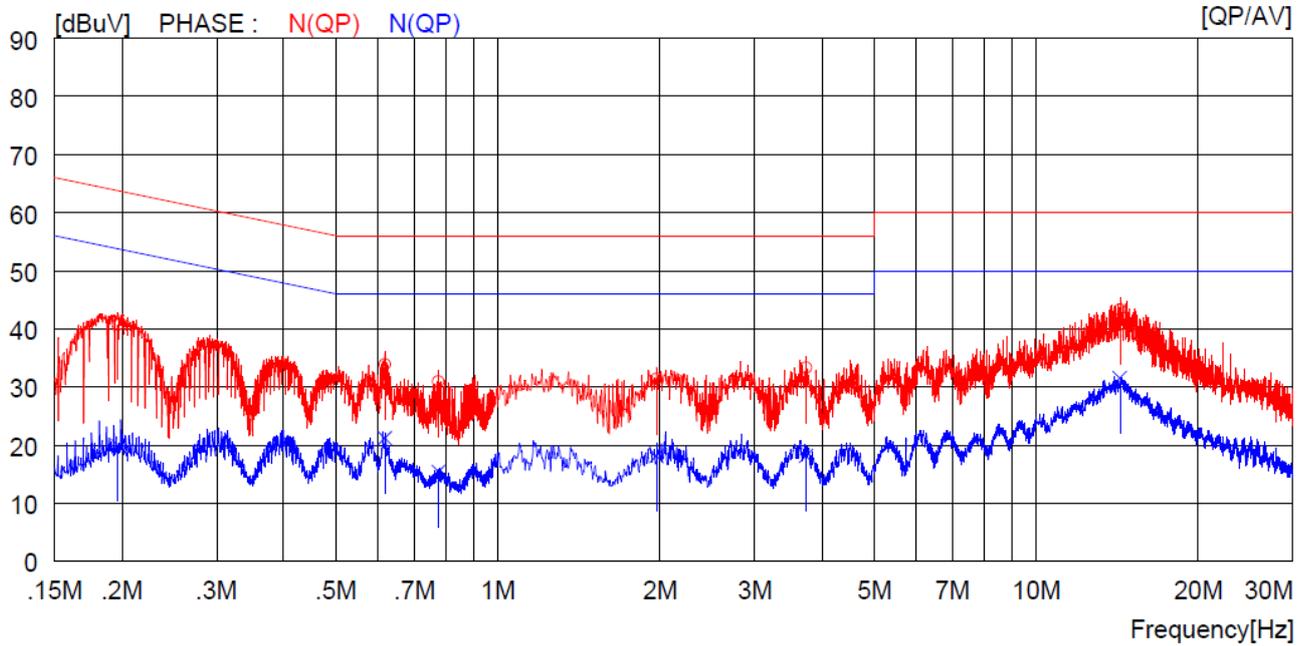
14.4 Test data for Charging Mode

- Test Date : March 20, 2019
- Resolution bandwidth : 9 kHz
- Frequency range : 0.15 MHz ~ 30 MHz
- Tested Line : HOT LINE



| NO | FREQ [MHz] | READING | | C. FACTOR [dB] | RESULT | | LIMIT | | MARGIN | | PHASE |
|----|---------------|--------------|--------------|-------------------|--------------|--------------|--------------|--------------|--------------|--------------|---------|
| | | QP [dBuV] | AV [dBuV] | | QP [dBuV] | AV [dBuV] | QP [dBuV] | AV [dBuV] | QP [dBuV] | AV [dBuV] | |
| 1 | 0.19600 | 30.6 | ---- | 9.9 | 40.5 | ---- | 63.8 | ---- | 23.3 | ---- | H (QP) |
| 2 | 0.61500 | 26.0 | ---- | 9.9 | 35.9 | ---- | 56.0 | ---- | 20.1 | ---- | H (QP) |
| 3 | 2.01200 | 26.9 | ---- | 10.0 | 36.9 | ---- | 56.0 | ---- | 19.1 | ---- | H (QP) |
| 4 | 2.80800 | 27.0 | ---- | 10.0 | 37.0 | ---- | 56.0 | ---- | 19.0 | ---- | H (QP) |
| 5 | 5.73500 | 28.0 | ---- | 10.1 | 38.1 | ---- | 60.0 | ---- | 21.9 | ---- | H (QP) |
| 6 | 13.98000 | 35.9 | ---- | 10.2 | 46.1 | ---- | 60.0 | ---- | 13.9 | ---- | H (QP) |
| 7 | 0.19600 | ---- | 14.8 | 9.9 | ---- | 24.7 | ---- | 53.8 | ---- | 29.1 | H (CAV) |
| 8 | 0.61500 | ---- | 16.9 | 9.9 | ---- | 26.8 | ---- | 46.0 | ---- | 19.2 | H (CAV) |
| 9 | 2.01200 | ---- | 15.1 | 10.0 | ---- | 25.1 | ---- | 46.0 | ---- | 20.9 | H (CAV) |
| 10 | 2.80800 | ---- | 15.6 | 10.0 | ---- | 25.6 | ---- | 46.0 | ---- | 20.4 | H (CAV) |
| 11 | 5.73500 | ---- | 12.2 | 10.1 | ---- | 22.3 | ---- | 50.0 | ---- | 27.7 | H (CAV) |
| 12 | 13.98000 | ---- | 24.8 | 10.2 | ---- | 35.0 | ---- | 50.0 | ---- | 15.0 | H (CAV) |

-. Tested Line : NEUTRAL LINE



| NO | FREQ [MHz] | READING | | C. FACTOR [dB] | RESULT | | LIMIT | | MARGIN | | PHASE |
|----|---------------|--------------|--------------|-------------------|--------------|--------------|--------------|--------------|--------------|--------------|---------|
| | | QP [dBuV] | AV [dBuV] | | QP [dBuV] | AV [dBuV] | QP [dBuV] | AV [dBuV] | QP [dBuV] | AV [dBuV] | |
| 1 | 0.19700 | 30.8 | ---- | 9.9 | 40.7 | ---- | 63.7 | ---- | 23.0 | ---- | N (QP) |
| 2 | 0.61600 | 24.0 | ---- | 9.9 | 33.9 | ---- | 56.0 | ---- | 22.1 | ---- | N (QP) |
| 3 | 0.77500 | 21.0 | ---- | 9.9 | 30.9 | ---- | 56.0 | ---- | 25.1 | ---- | N (QP) |
| 4 | 1.97200 | 21.4 | ---- | 10.0 | 31.4 | ---- | 56.0 | ---- | 24.6 | ---- | N (QP) |
| 5 | 3.73600 | 23.2 | ---- | 10.1 | 33.3 | ---- | 56.0 | ---- | 22.7 | ---- | N (QP) |
| 6 | 14.31000 | 33.1 | ---- | 10.2 | 43.3 | ---- | 60.0 | ---- | 16.7 | ---- | N (QP) |
| 7 | 0.19700 | ---- | 9.9 | 9.9 | ---- | 19.8 | ---- | 53.7 | ---- | 33.9 | N (CAV) |
| 8 | 0.61600 | ---- | 11.3 | 9.9 | ---- | 21.2 | ---- | 46.0 | ---- | 24.8 | N (CAV) |
| 9 | 0.77500 | ---- | 5.5 | 9.9 | ---- | 15.4 | ---- | 46.0 | ---- | 30.6 | N (CAV) |
| 10 | 1.97200 | ---- | 8.1 | 10.0 | ---- | 18.1 | ---- | 46.0 | ---- | 27.9 | N (CAV) |
| 11 | 3.73600 | ---- | 8.0 | 10.1 | ---- | 18.1 | ---- | 46.0 | ---- | 27.9 | N (CAV) |
| 12 | 14.31000 | ---- | 21.3 | 10.2 | ---- | 31.5 | ---- | 50.0 | ---- | 18.5 | N (CAV) |

Remark: Margin (dB) = Limit – Level (Result)

The emission level in above table is included the transducer factor that means insertion loss (LISN), cable loss and attenuator.

Tested by: Hyung-Kwon, Oh / Assistant Manager