

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

Test Report No. : W157R-D004

AGR No. : A154A-165

Applicant : LG Innotek Co., Ltd.

Address : 978-1, Jangduk-dong, Gwangsan-gu, Gwangju, 506-731 Korea

Manufacturer : LG Innotek Co., Ltd.

Address : 978-1, Jangduk-dong, Gwangsan-gu, Gwangju, 506-731 Korea

Type of Equipment : Wi-Fi module

FCC ID. : YZP-TWCMB202D

IC Certification No. : 7414C-TWCMB202D

Model Name : TWCM-B202D

Serial number : N/A

Total page of Report : 104 pages (including this page)

Date of Incoming : February 13, 2015

Date of issue : July 14, 2015

## SUMMARY

The equipment complies with the regulation; *FCC PART 15 SUBPART C Section 15.247 and IC RSS-Gen Issue 4 Nov 2014 and RSS-247 Issue 1 May 2015*

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.

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ONETECH Corp.

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ONETECH Corp.

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### Revision History

Issued Report No.	Issued Date	Revisions	Effect Section
W157R-D004	July 14, 2015	Initial Issue	All

## 1. VERIFICATION OF COMPLIANCE

Applicant : LG Innotek Co., Ltd.  
Address : 978-1, Jangduk-dong, Gwangsan-gu, Gwangju, 506-731 Korea  
Contact Person : Inchang, Jeong / Director  
Telephone No. : +82-62-950-0332  
FCC ID : YZP-TWCMB202D  
IC Certification No. : 7414C-TWCMB202D  
Model Name : TWCM-B202D  
Serial Number : N/A  
Date : July 14, 2015

EQUIPMENT CLASS	FCC : DSS – PART 15 SPREAD SPECTRUM TRANSMITTER IC : Low Power License-Exempt Radio-communication Device
E.U.T. DESCRIPTION	Modular Transmitter, Wi-Fi module
THIS REPORT CONCERNS	Original Grant
MEASUREMENT PROCEDURES	ANSI C63.10: 2013
TYPE OF EQUIPMENT TESTED	Pre-Production
KIND OF EQUIPMENT AUTHORIZATION REQUESTED	Certification, Modular Approval
EQUIPMENT WILL BE OPERATED UNDER FCC RULES PART(S)	FCC PART 15 SUBPART C Section 15.247, RSS-Gen Issue 4 Nov 2014, RSS-247 Issue 1 May 2015
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&IC 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) (2)	RSS-247, 5.2(1) Minimum 6 dB Bandwidth & 99 % Occupied Bandwidth	Met the Limit / PASS
15.247 (b) (3)	RSS-247, 5.4(4) Maximum Peak Conducted Output Power	Met the Limit / PASS
15.247 (d)	RSS-247, 5.5 100 kHz Bandwidth Outside the Frequency Band	Met the Limit / PASS
15.247 (d)	RSS-247, 5.5 Radiated Emission which fall in the Restricted Band	Met the Limit / PASS
15.247 (e)	RSS-247, 5.2(2) Peak Power Spectral Density	Met the Limit / PASS
15.209	RSS-247, 5.5 Radiated Emission Limits	Met the Limit / PASS
15.207	RSS-Gen, Section 7.2.4 Conducted Limits	Met the Limit / PASS
15.203	RSS-Gen, Section 7.1.2 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, IC RSS-Gen Issue 4 Nov 2014 and RSS-247 Issue 1 May 2015

### 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 301-14, Daessangnyeong-ri, Chowol-eup, Gwangju-si, Gyeonggi-do, 464-862 Korea.

-. Site Filing:

VCCI (Voluntary Control Council for Interference) – Registration No. R-4112/ C-4617/ G-666/ T-1842 IC (Industry Canada) – Registration No. Site# 3736-3

-. Site Accreditation:

KOLAS (Korea Laboratory Accreditation Scheme) - Accreditation No. 85

FCC (Federal Communications Commission) - Accreditation No. KR0013

RRA (Radio Research Agency) – Designation No. KR0013

### 3. GENERAL INFORMATION

#### 3.1 Product Description

The LG Innotek Co., Ltd., Model TWCM-B202D (referred to as the EUT in this report) is a Wi-Fi module. Product specification information described herein was obtained from product data sheet or user's manual.

DEVICE TYPE	Wi-Fi module		
OPERATING FREQUENCY	WLAN	2 412 MHz ~ 2 462 MHz (802.11b/g/n(HT20))	
		2 422 MHz ~ 2 452 MHz (802.11n(HT40))	
	Bluetooth	2 402 MHz ~ 2 480 MHz	
	Bluetooth LE	2 402 MHz ~ 2 480 MHz	
	5 150 MHz ~ 5 250 MHz Band	5 180 MHz ~ 5 240 MHz (802.11a/n(HT20)/ac(HT20))	
		5 190 MHz ~ 5 230 MHz (802.11n(HT40)/ac(HT40))	
		5 210 MHz (802.11n(HT80))	
	5 250 MHz ~ 5 350 MHz Band	5 260 MHz ~ 5 320 MHz (802.11a/n(HT20)/ac(HT20))	
		5 270 MHz ~ 5 310 MHz (802.11n(HT40)/ac(HT40))	
		5 290 MHz (802.11n(HT80))	
	5 470 MHz ~ 5 725 MHz Band	5 500 MHz ~ 5 700 MHz (802.11a/n(HT20)/ac(HT20))	
		5 510 MHz ~ 5 670 MHz (802.11n(HT40)/ac(HT40))	
		5 530 MHz (802.11n(HT80))	
	5 725 MHz ~ 5 850 MHz Band	5 745 MHz ~ 5 825 MHz (802.11a/n(HT20)/ac(HT20))	
		5 755 MHz ~ 5 795 MHz (802.11n(HT40)/ac(HT40))	
		5 775 MHz (802.11n(HT80))	
MAX. RF OUTPUT POWER	WLAN	Antenna 0	Wi-Fi 802.11b (13.85 dBm)
			Wi-Fi 802.11g (13.37 dBm)
			Wi-Fi 802.11n_20 MHz (11.32 dBm)
			Wi-Fi 802.11n_40 MHz (11.52 dBm)
		Antenna 1	Wi-Fi 802.11b (14.08 dBm)
			Wi-Fi 802.11g (13.75 dBm)
			Wi-Fi 802.11n_20 MHz (11.65 dBm)
			Wi-Fi 802.11n_40 MHz (11.86 dBm)
		Multiple transmit	Wi-Fi 802.11g (16.57 dBm)
			Wi-Fi 802.11n_20 MHz (14.50 dBm)
			Wi-Fi 802.11n_40 MHz (14.70 dBm)



MAX. RF OUTPUT POWER	Bluetooth	1 Mbps	4.13 dBm
		2 Mbps	5.21 dBm
		3 Mbps	5.86 dBm
	Bluetooth LE	6.39 dBm	
	Antenna 0	5 150 MHz ~ 5 250 MHz Band	Wi-Fi 802.11a (12.09 dBm) Wi-Fi 802.11n_20 MHz (12.11 dBm) Wi-Fi 802.11n_40 MHz (12.31 dBm) Wi-Fi 802.11ac_20 MHz (12.15 dBm) Wi-Fi 802.11ac_40 MHz (12.65 dBm) Wi-Fi 802.11ac_80 MHz (9.81 dBm)
			Wi-Fi 802.11a (13.44 dBm) Wi-Fi 802.11n_20 MHz (13.66 dBm) Wi-Fi 802.11n_40 MHz (13.50 dBm) Wi-Fi 802.11ac_20 MHz (13.35 dBm) Wi-Fi 802.11ac_40 MHz (13.82 dBm) Wi-Fi 802.11ac_80 MHz (9.74 dBm)
			Wi-Fi 802.11a (13.94 dBm) Wi-Fi 802.11n_20 MHz (13.73 dBm) Wi-Fi 802.11n_40 MHz (14.06 dBm) Wi-Fi 802.11ac_20 MHz (13.97 dBm) Wi-Fi 802.11ac_40 MHz (14.34 dBm) Wi-Fi 802.11ac_80 MHz (11.40 dBm)
			Wi-Fi 802.11a (12.90 dBm) Wi-Fi 802.11n_20 MHz (12.69 dBm) Wi-Fi 802.11n_40 MHz (13.09 dBm) Wi-Fi 802.11ac_20 MHz (12.74 dBm) Wi-Fi 802.11ac_40 MHz (13.24 dBm) Wi-Fi 802.11ac_80 MHz (10.32 dBm)
		5 470 MHz ~ 5 725 MHz Band	Wi-Fi 802.11a (13.94 dBm) Wi-Fi 802.11n_20 MHz (13.73 dBm) Wi-Fi 802.11n_40 MHz (14.06 dBm) Wi-Fi 802.11ac_20 MHz (13.97 dBm) Wi-Fi 802.11ac_40 MHz (14.34 dBm) Wi-Fi 802.11ac_80 MHz (11.40 dBm)
		5 725 MHz ~ 5 850 MHz Band	Wi-Fi 802.11a (12.90 dBm) Wi-Fi 802.11n_20 MHz (12.69 dBm) Wi-Fi 802.11n_40 MHz (13.09 dBm) Wi-Fi 802.11ac_20 MHz (12.74 dBm) Wi-Fi 802.11ac_40 MHz (13.24 dBm) Wi-Fi 802.11ac_80 MHz (10.32 dBm)
		5 150 MHz ~ 5 250 MHz Band	Wi-Fi 802.11a (12.09 dBm) Wi-Fi 802.11n_20 MHz (12.11 dBm) Wi-Fi 802.11n_40 MHz (12.31 dBm) Wi-Fi 802.11ac_20 MHz (12.15 dBm) Wi-Fi 802.11ac_40 MHz (12.65 dBm) Wi-Fi 802.11ac_80 MHz (9.81 dBm)
		5 250 MHz ~ 5 350 MHz Band	Wi-Fi 802.11a (13.44 dBm) Wi-Fi 802.11n_20 MHz (13.66 dBm) Wi-Fi 802.11n_40 MHz (13.50 dBm) Wi-Fi 802.11ac_20 MHz (13.35 dBm) Wi-Fi 802.11ac_40 MHz (13.82 dBm) Wi-Fi 802.11ac_80 MHz (9.74 dBm)

MAX. RF OUTPUT POWER	Antenna 1	5 150 MHz ~ 5 250 MHz Band	Wi-Fi 802.11a (13.15 dBm) Wi-Fi 802.11n_20 MHz (12.98 dBm) Wi-Fi 802.11n_40 MHz (13.08 dBm) Wi-Fi 802.11ac_20 MHz (12.83 dBm) Wi-Fi 802.11ac_40 MHz (13.37 dBm) Wi-Fi 802.11ac_80 MHz (10.82 dBm)
		5 250 MHz ~ 5 350 MHz Band	Wi-Fi 802.11a (12.07 dBm) Wi-Fi 802.11n_20 MHz (12.42 dBm) Wi-Fi 802.11n_40 MHz (12.26 dBm) Wi-Fi 802.11ac_20 MHz (12.14 dBm) Wi-Fi 802.11ac_40 MHz (12.73 dBm) Wi-Fi 802.11ac_80 MHz (10.59 dBm)
		5 470 MHz ~ 5 725 MHz Band	Wi-Fi 802.11a (13.60 dBm) Wi-Fi 802.11n_20 MHz (13.22 dBm) Wi-Fi 802.11n_40 MHz (13.44 dBm) Wi-Fi 802.11ac_20 MHz (13.34 dBm) Wi-Fi 802.11ac_40 MHz (13.79 dBm) Wi-Fi 802.11ac_80 MHz (10.59 dBm)
		5 725 MHz ~ 5 850 MHz Band	Wi-Fi 802.11a (13.72 dBm) Wi-Fi 802.11n_20 MHz (13.56 dBm) Wi-Fi 802.11n_40 MHz (13.69 dBm) Wi-Fi 802.11ac_20 MHz (13.54 dBm) Wi-Fi 802.11ac_40 MHz (14.22 dBm) Wi-Fi 802.11ac_80 MHz (11.30 dBm)

MAX. RF OUTPUT POWER	Multiple transmit	5 150 MHz ~ 5 250 MHz Band	Wi-Fi 802.11a (15.63 dBm) Wi-Fi 802.11n_20 MHz (15.52 dBm) Wi-Fi 802.11n_40 MHz (15.68 dBm) Wi-Fi 802.11ac_20 MHz (15.47 dBm) Wi-Fi 802.11ac_40 MHz (16.04 dBm) Wi-Fi 802.11ac_80 MHz (13.35 dBm)
		5 250 MHz ~ 5 350 MHz Band	Wi-Fi 802.11a (15.82 dBm) Wi-Fi 802.11n_20 MHz (16.09 dBm) Wi-Fi 802.11n_40 MHz (15.93 dBm) Wi-Fi 802.11ac_20 MHz (15.80 dBm) Wi-Fi 802.11ac_40 MHz (16.26 dBm) Wi-Fi 802.11ac_80 MHz (13.20 dBm)
		5 470 MHz ~ 5 725 MHz Band	Wi-Fi 802.11a (16.78 dBm) Wi-Fi 802.11n_20 MHz (16.49 dBm) Wi-Fi 802.11n_40 MHz (16.77 dBm) Wi-Fi 802.11ac_20 MHz (16.68 dBm) Wi-Fi 802.11ac_40 MHz (17.08 dBm) Wi-Fi 802.11ac_80 MHz (14.02 dBm)
		5 725 MHz ~ 5 850 MHz Band	Wi-Fi 802.11a (16.34 dBm) Wi-Fi 802.11n_20 MHz (16.16 dBm) Wi-Fi 802.11n_40 MHz (16.41 dBm) Wi-Fi 802.11ac_20 MHz (16.17 dBm) Wi-Fi 802.11ac_40 MHz (16.77 dBm) Wi-Fi 802.11ac_80 MHz (13.85 dBm)
MODULATION TYPE	WLAN 2.4 G	DSSS Modulation(DBPSK/DQPSK/CCK)	
	WLAN 5 G	OFDM Modulation(BPSK/QPSK/16QAM/64QAM)	
	Bluetooth	GFSK for 1 Mbps, DQPSK for 2 Mbps, 8-DPSK for 3 Mbps	
	Bluetooth LE	GFSK	
ANTENNA TYPE	WLAN : PIFA Antenna		
	Bluetooth / Bluetooth LE : PIFA Antenna		
ANTENNA GAIN	WLAN : 2.9 dBi		
	Bluetooth / Bluetooth LE : 0.42 dBi		
List of each Osc. or crystal Freq.(Freq. >= 1 MHz)	40 MHz		

**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	LG Innotek Co., Ltd.	N/A	N/A

### 5.2 Peripheral equipment

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

Model	Manufacturer	Description	Connected to
TWCM-B202D	LG Innotek Co., Ltd.	Wi-Fi module (EUT)	Notebook PC
LGR51	LG Electronics	Notebook PC	EUT

### 5.3 Mode of operation during the test

For the testing, software used to control the EUT for staying in continuous transmitting mode is programmed.

The worse case data rate for each modulation is determined 1 Mbps(Ant.0) / 1 Mbps(Ant.1) for IEEE 802.11b, 6 Mbps(Ant.0) / 6 Mbps(Ant.1) for IEEE 802.11g, 6.5 Mbps(Ant.0) / 6.5 Mbps(Ant.1) for HT20, 13 Mbps(Ant.0)/ 13 Mbps(Ant.1) for HT40.

## 5.4 Configuration of Test System

**Line Conducted Test:** The EUT was connected to USB and the power of USB was connected to Notebook PC. 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 open area test site.

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 and RSS-Gen Issue 4 November 2014 Section 8.3, 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 transmitter antenna of the EUT is WLAN PIFA antenna and Bluetooth/BLE PIFA antenna, 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)
Transmitting 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. BLUETOOTH

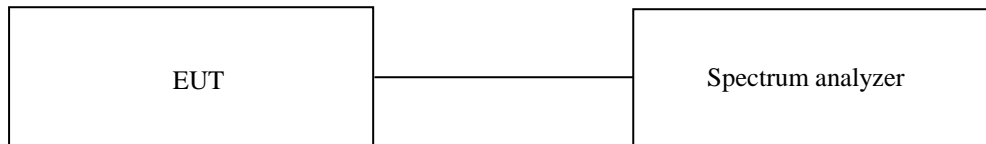
### 7.1 MINIMUM 20 dB BANDWIDTH & 99 % OCCUPIED BANDWIDTH

#### 7.1.1 Operating environment

Temperature : 21.4 °C  
Relative humidity : 45.1 % R.H.

#### 7.1.2 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.



#### 7.1.3 Test equipment used

Model Number	Manufacturer	Description	Serial Number	Last Cal. (Interval)
■ - FSV30	Rohde & Schwarz	Signal Analyzer	101372	Apr. 29, 2015(1Y)

All test equipment used is calibrated on a regular basis.



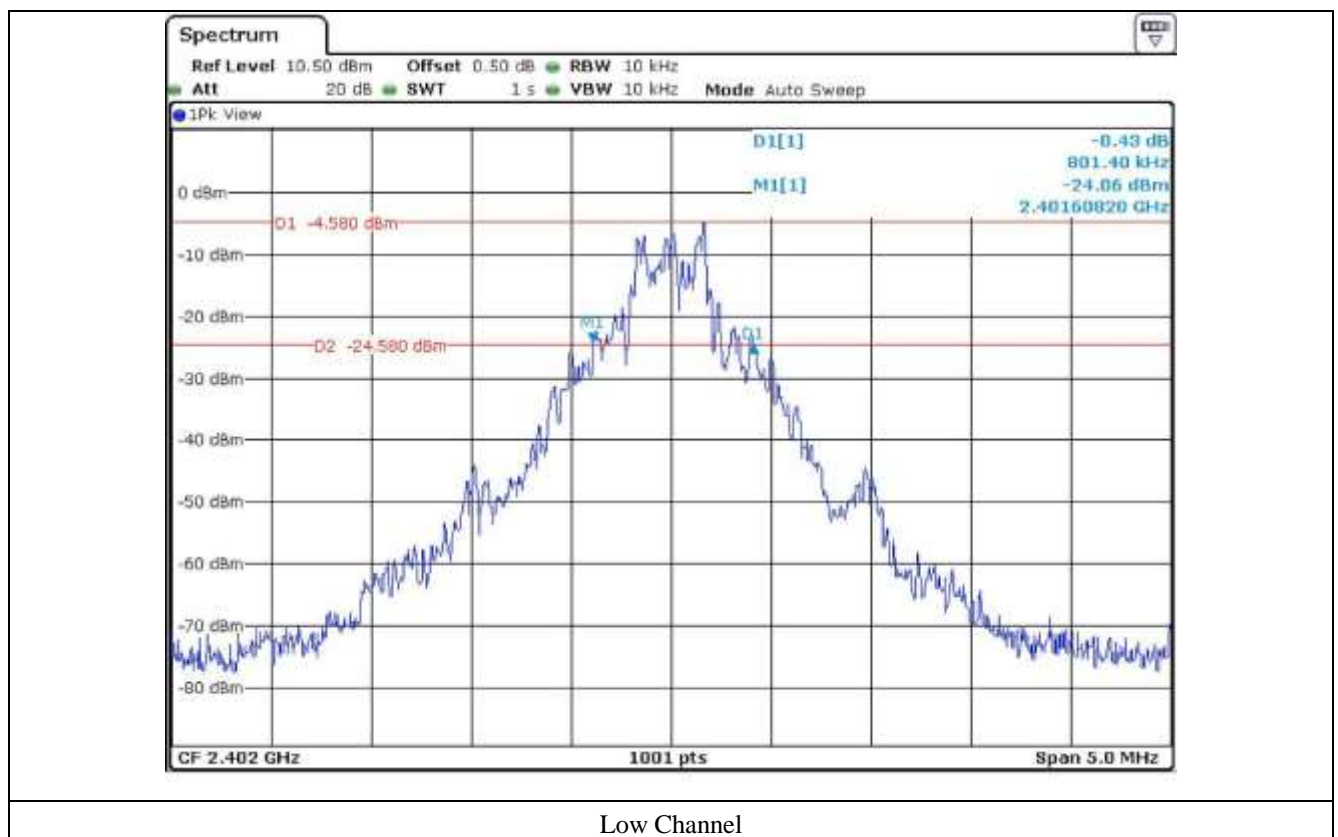
#### 7.1.4 Test data for 1 Mbps

-. Test Date : May 20, 2015

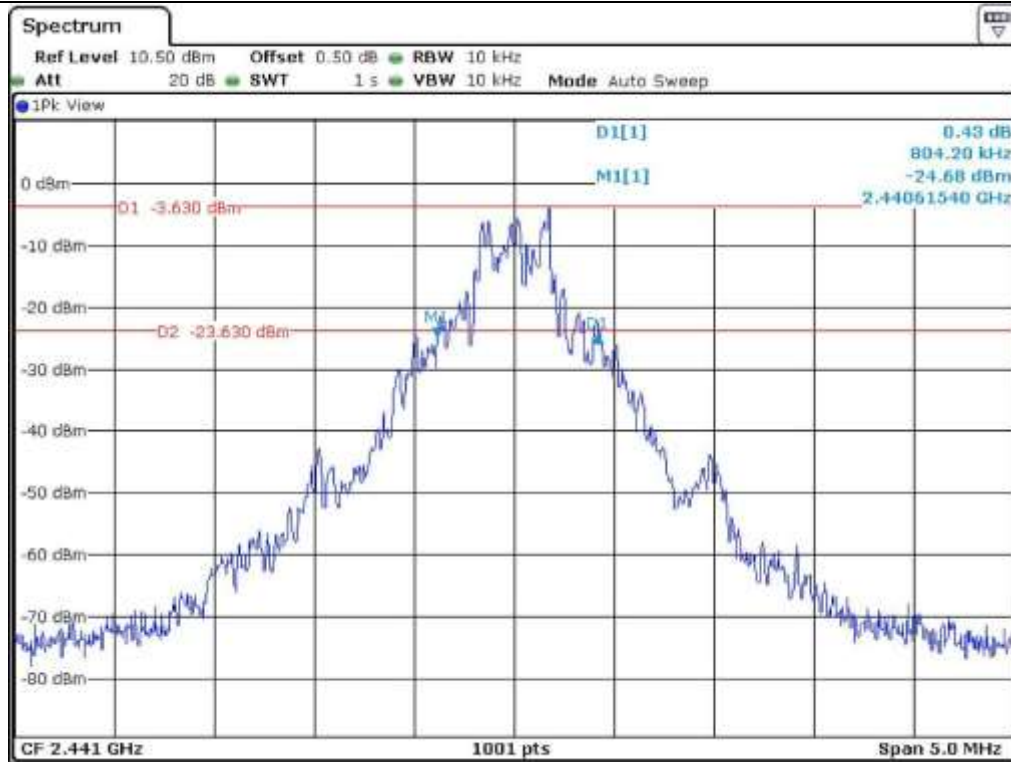
CHANNEL	FREQUENCY (MHz)	20 dB Bandwidth (kHz)	99 % Occupied Bandwidth(kHz)
Low	2 402	801.40	834.20
Middle	2 441	804.20	834.20
High	2 480	804.20	839.20



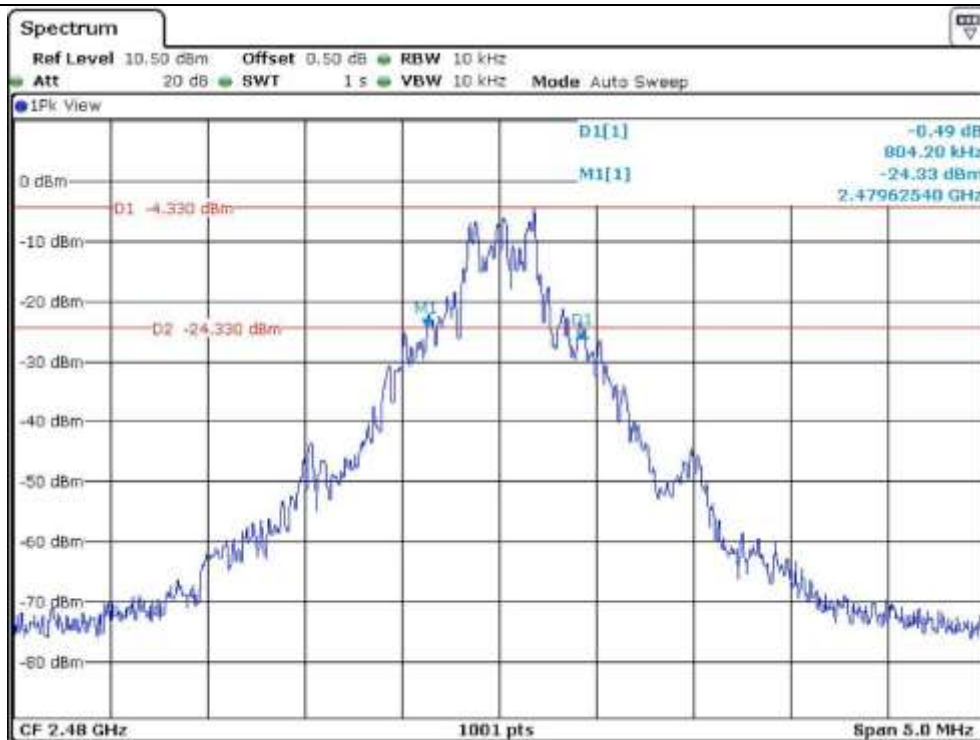
Tested by: Tae-Ho, Kim / Project Engineer



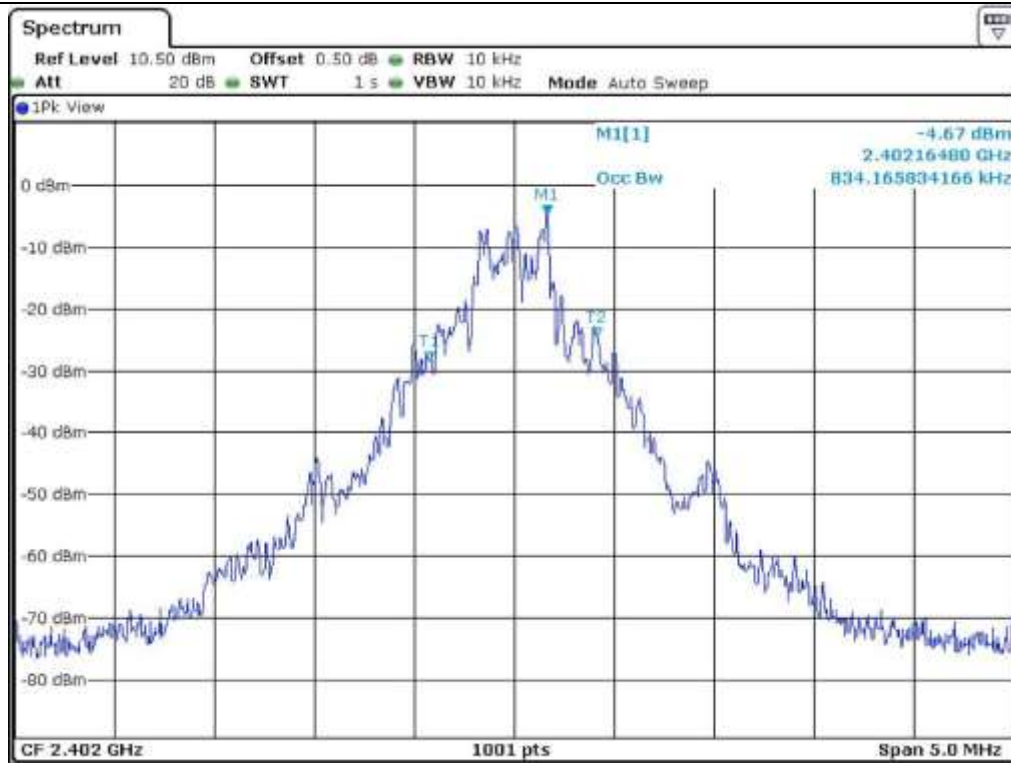
Low Channel



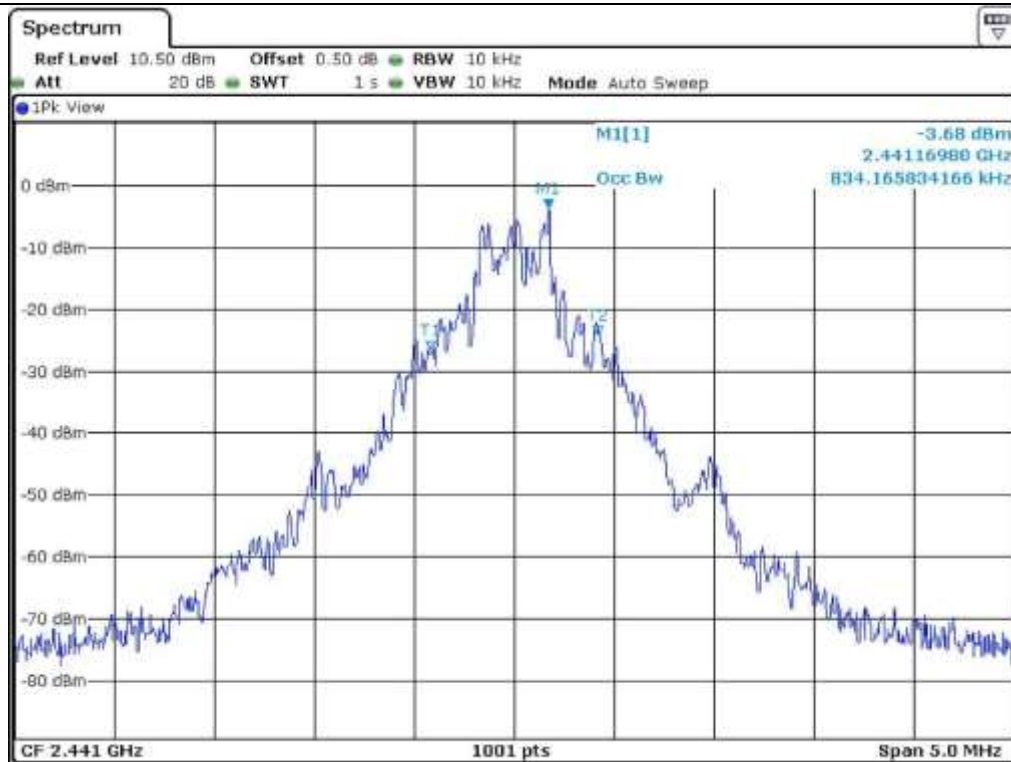
Middle Channel



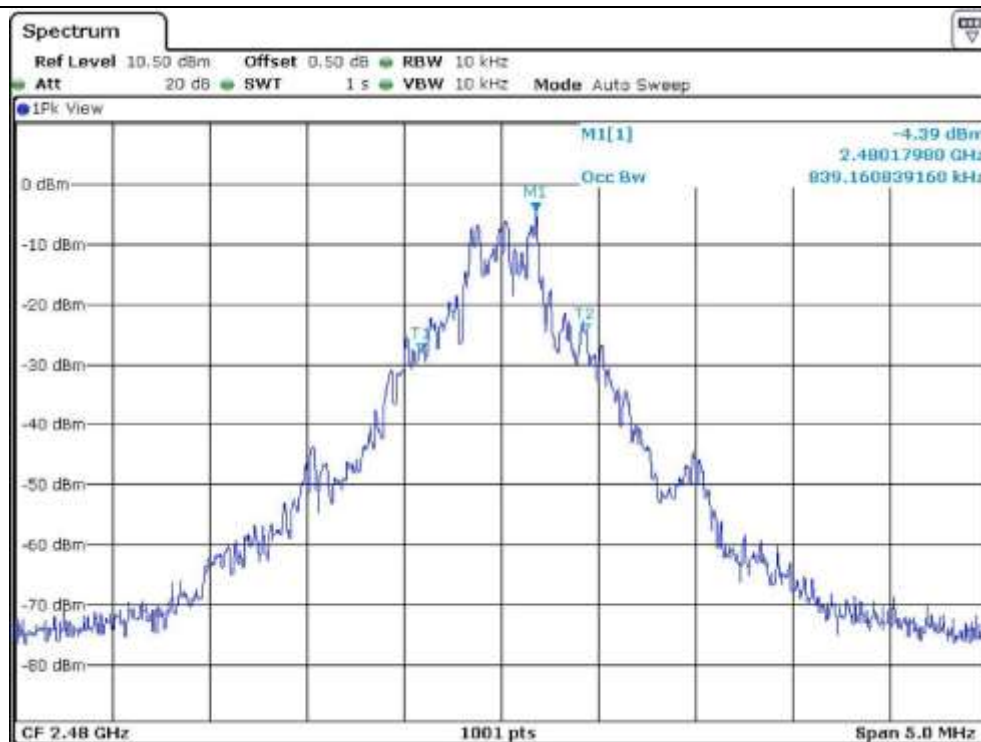
High Channel



Low Channel



Middle Channel



High Channel

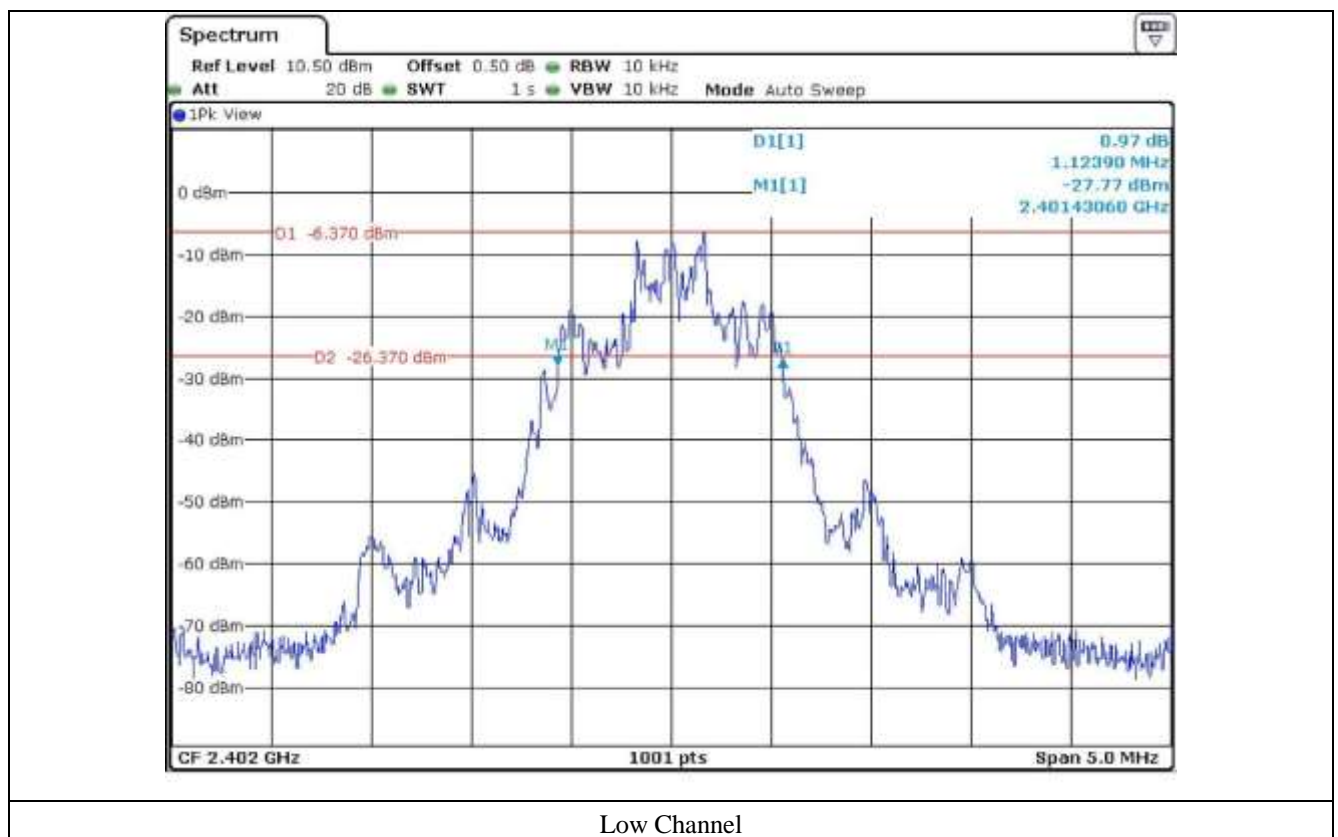
### 7.1.5 Test data for 2 Mbps

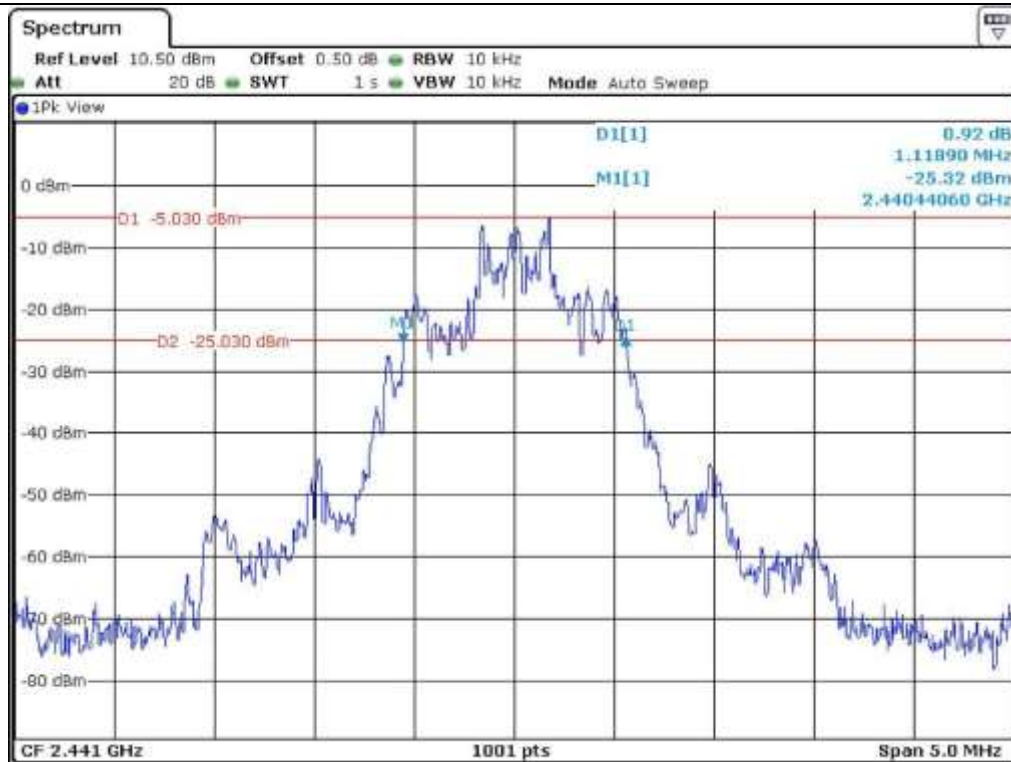
-. Test Date : May 20, 2015

CHANNEL	FREQUENCY (MHz)	20 dB Bandwidth (kHz)	99 % Occupied Bandwidth(kHz)
Low	2 402	1 123.90	1 073.90
Middle	2 441	1 118.90	1 073.90
High	2 480	1 118.90	1 068.90

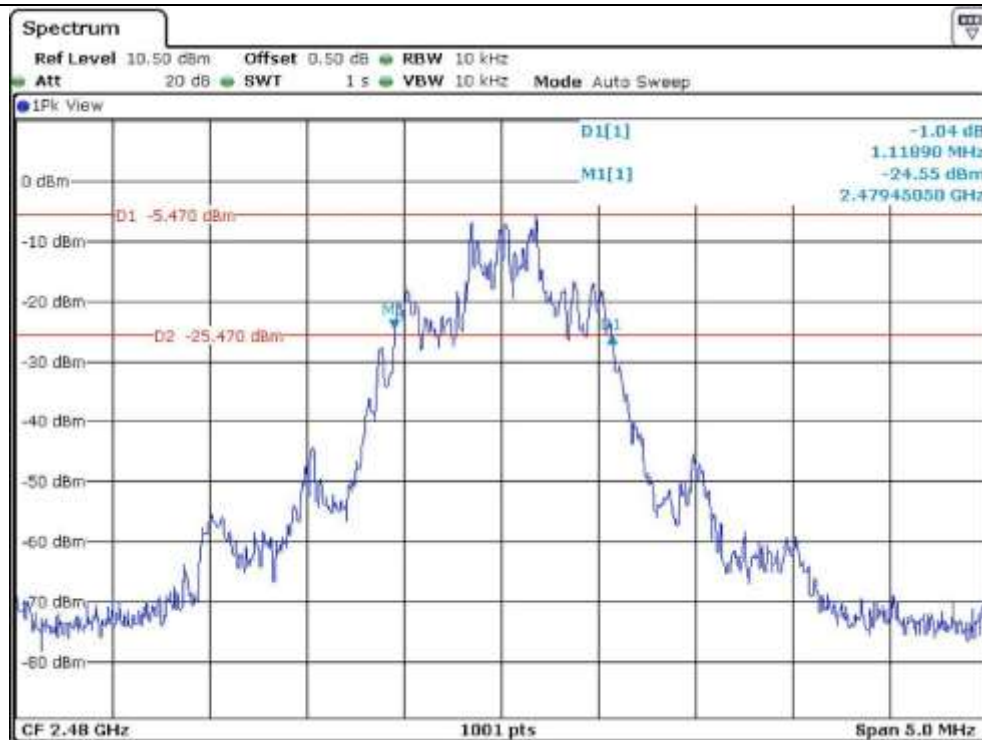


Tested by: Tae-Ho, Kim / Project Engineer



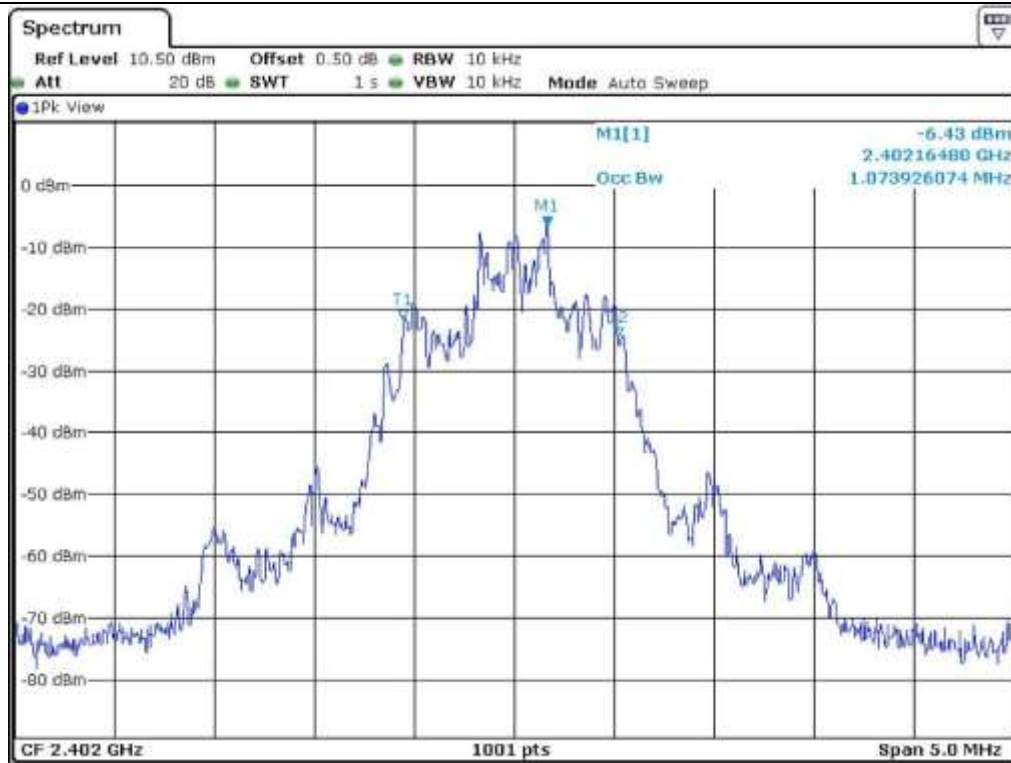


Middle Channel

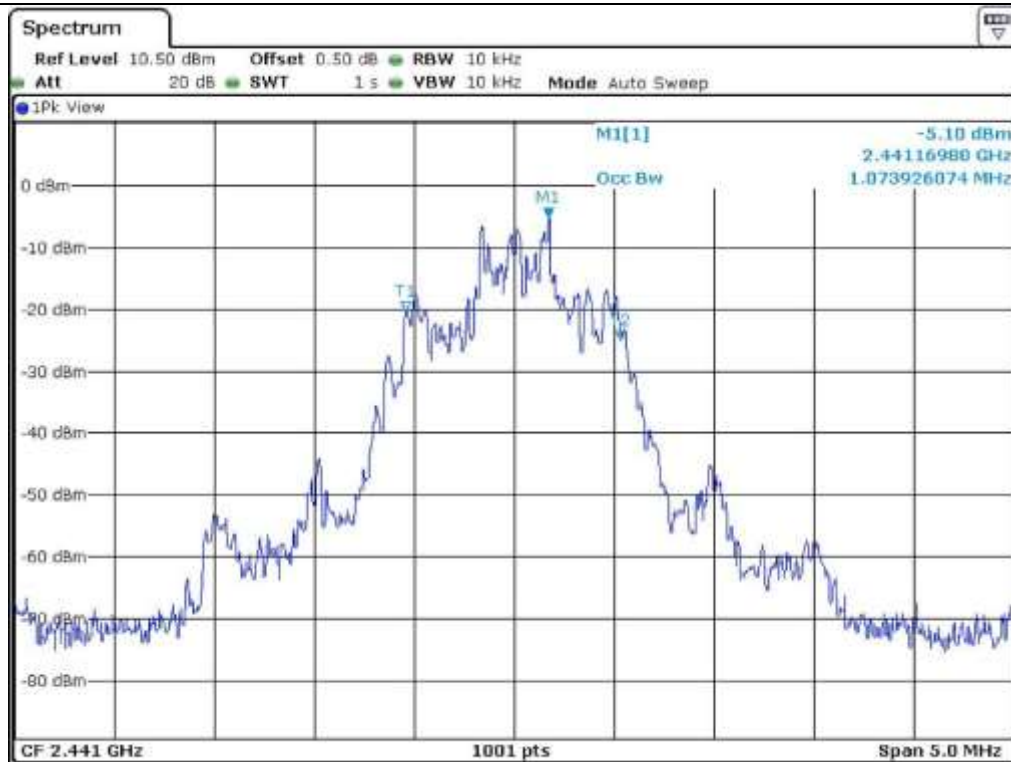


High Channel

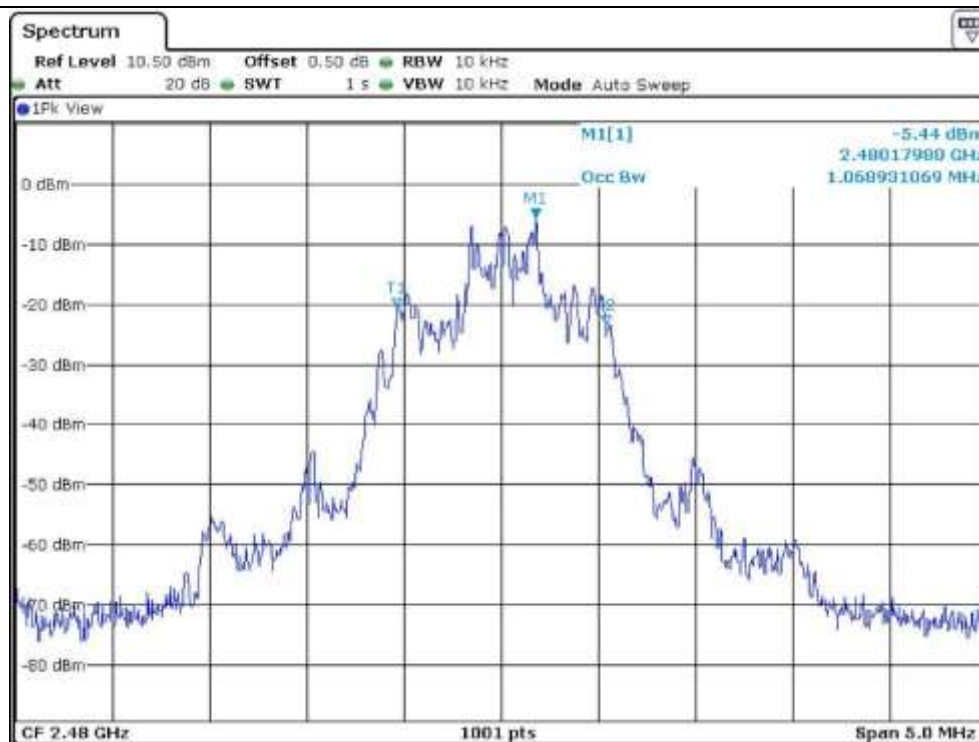




Low Channel



Middle Channel



High Channel



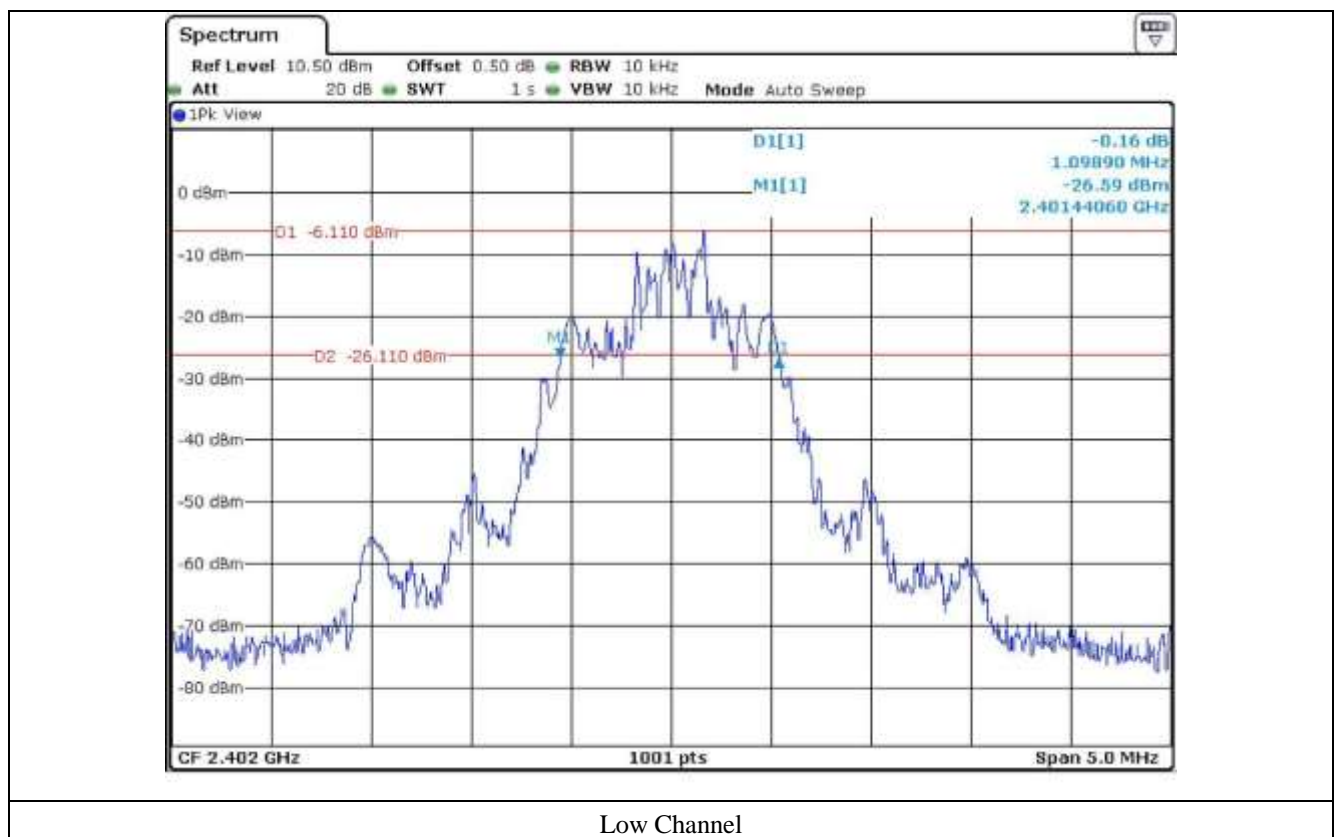
### 7.1.6 Test data for 3 Mbps

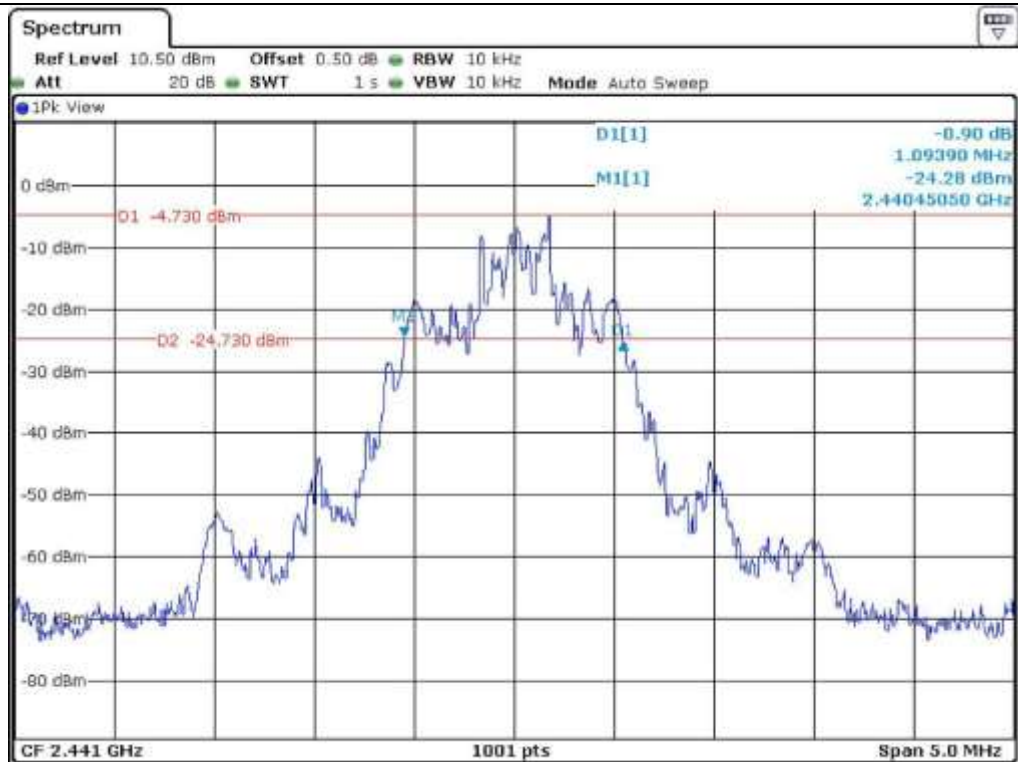
-. Test Date : May 20, 2015

CHANNEL	FREQUENCY (MHz)	20 dB Bandwidth (kHz)	99 % Occupied Bandwidth(kHz)
Low	2 402	1 098.90	1 063.90
Middle	2 441	1 093.90	1 063.90
High	2 480	1 098.90	1 063.90

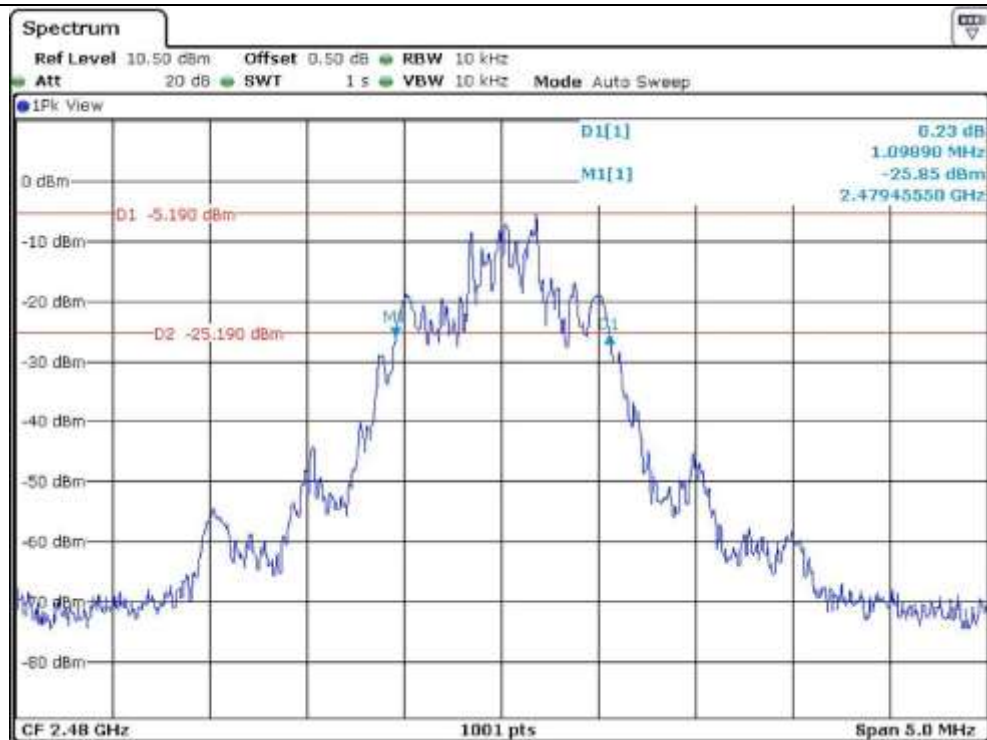


Tested by: Tae-Ho, Kim / Project Engineer





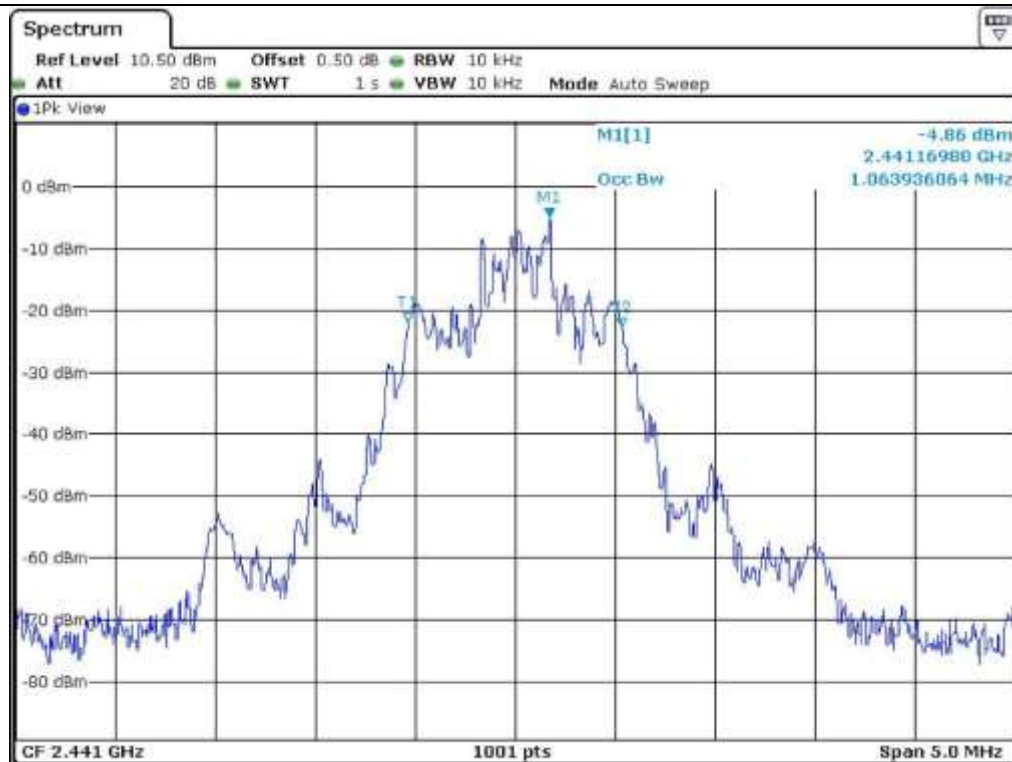
Middle Channel



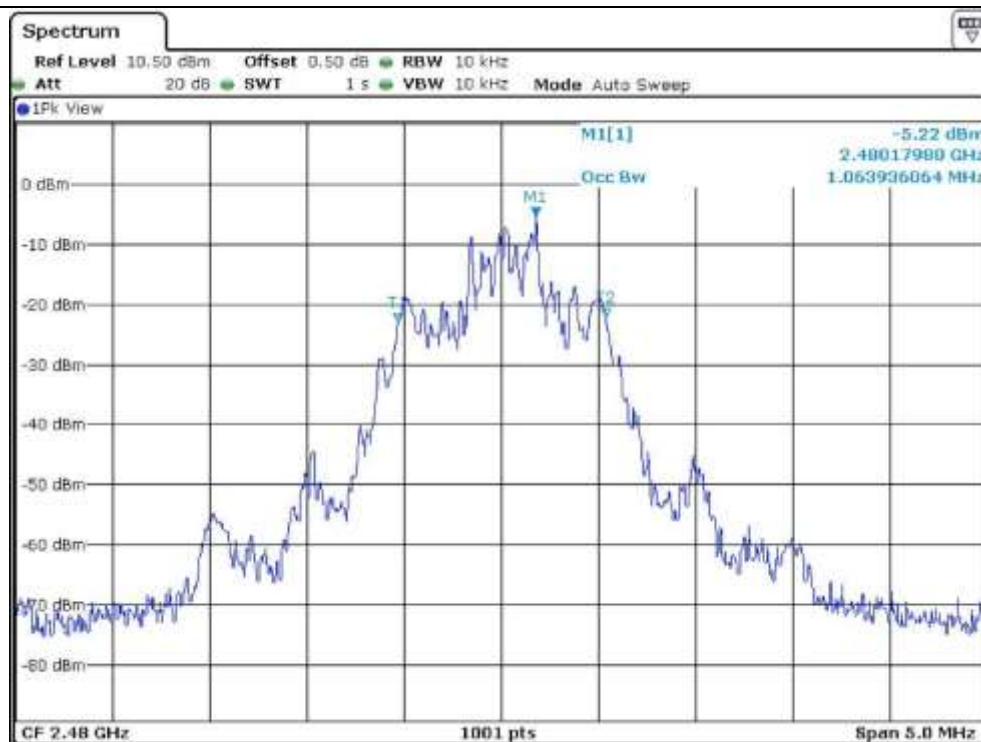
High Channel



Low Channel



Middle Channel



High Channel

## 7.2 HOPPING FREQUENCY SEPARATION

### 7.2.1 Operating environment

Temperature : 21.4 °C  
Relative humidity : 45.1 % R.H.

### 7.2.2 Test set-up

The antenna output of the EUT was connected to the spectrum analyzer. The frequency span is set to 10 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.



### 7.2.3 Test equipment used

	Model Number	Manufacturer	Description	Serial Number	Last Cal. (Interval)
■ -	FSV30	Rohde & Schwarz	Signal Analyzer	101372	Apr. 29, 2015(1Y)

All test equipment used is calibrated on a regular basis.

#### 7.2.4 Test data for 1 Mbps

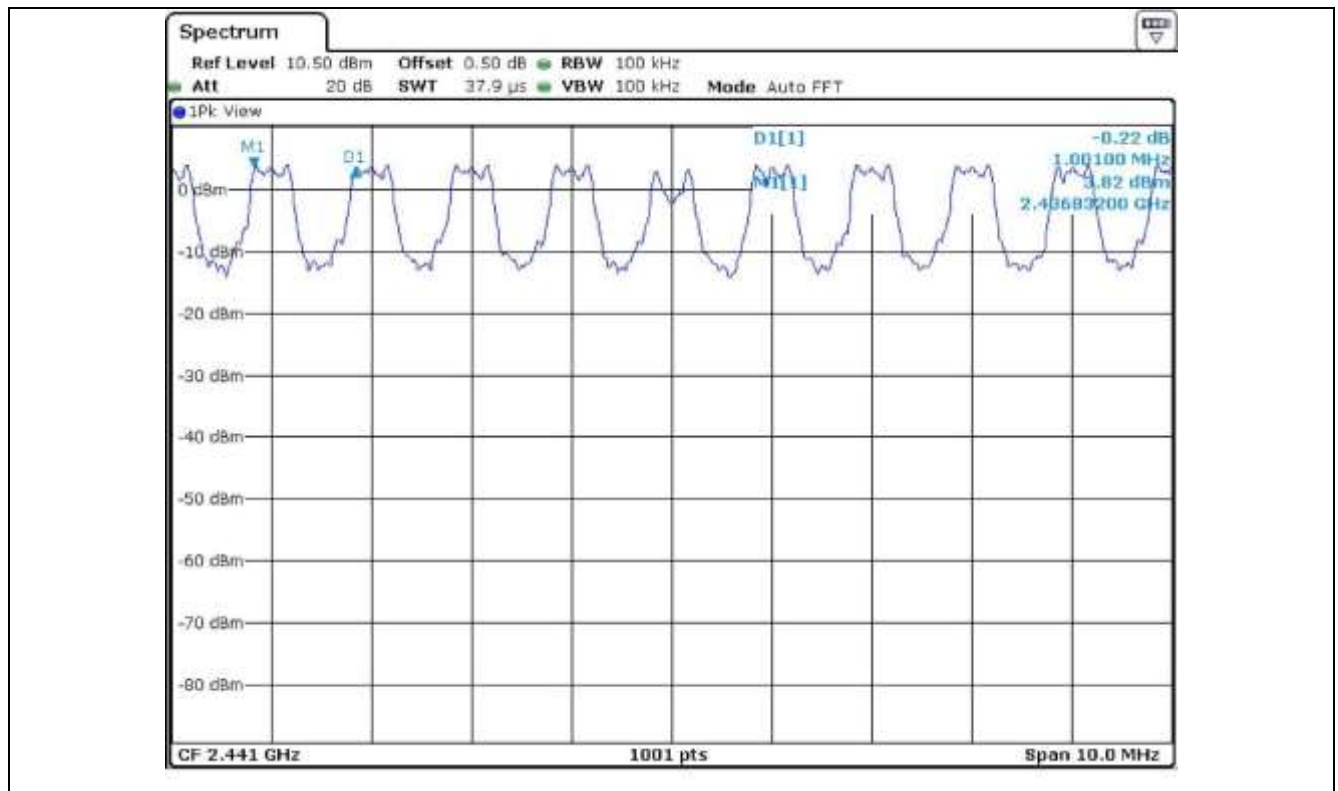
-. Test Date : May 20, 2015

-. Test Result : Pass

MEASURED VLAUE (kHz)	Two-third of 20 dB Bandwidth (kHz)	LIMIT
1 001.00	536.1	Separated by a minimum of 25 kHz



Tested by: Tae-Ho, Kim / Project Engineer



### 7.2.5 Test data for 2 Mbps

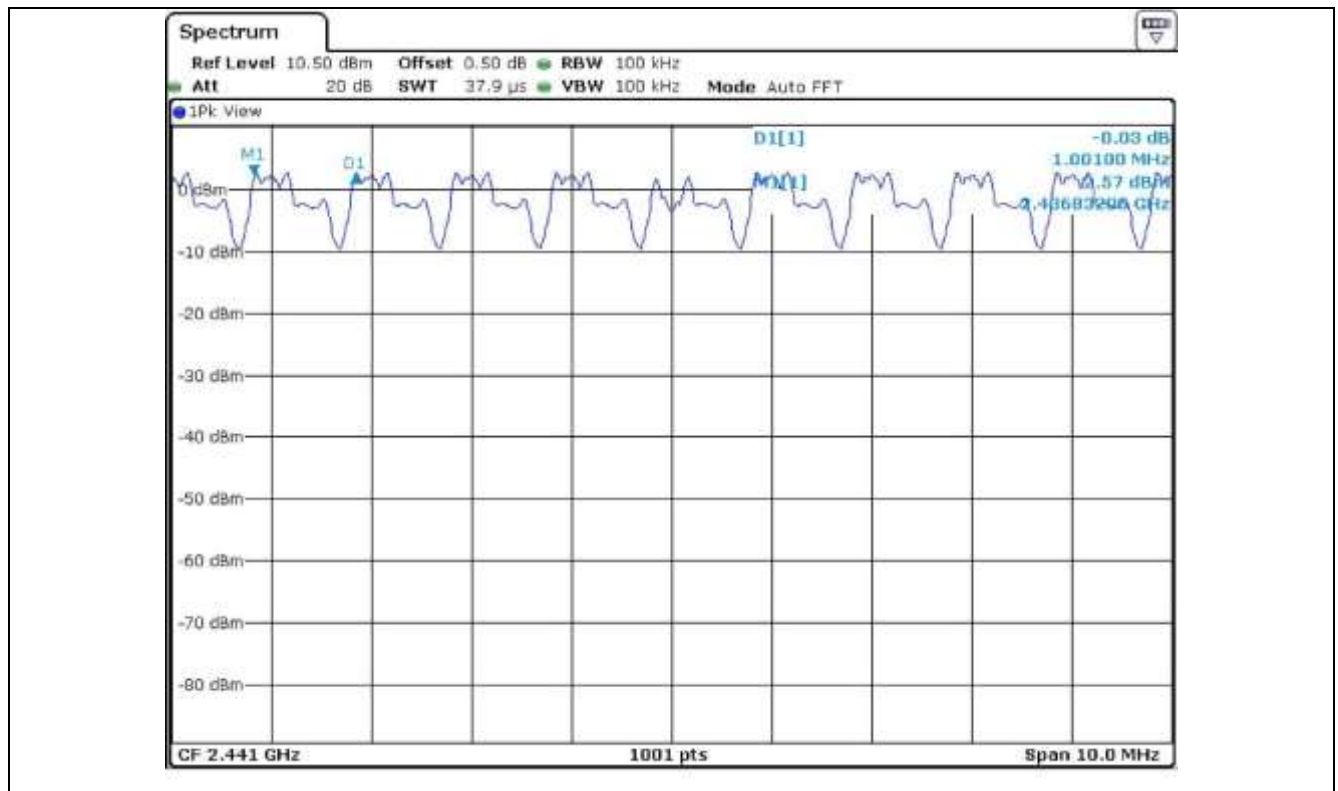
-. Test Date : May 20, 2015

-. Test Result : Pass

MEASURED VLAUE (kHz)	Two-third of 20 dB Bandwidth (kHz)	LIMIT
1 001.00	745.9	Separated by a minimum of 25 kHz



Tested by: Tae-Ho, Kim / Project Engineer



### 7.2.6 Test data for 3 Mbps

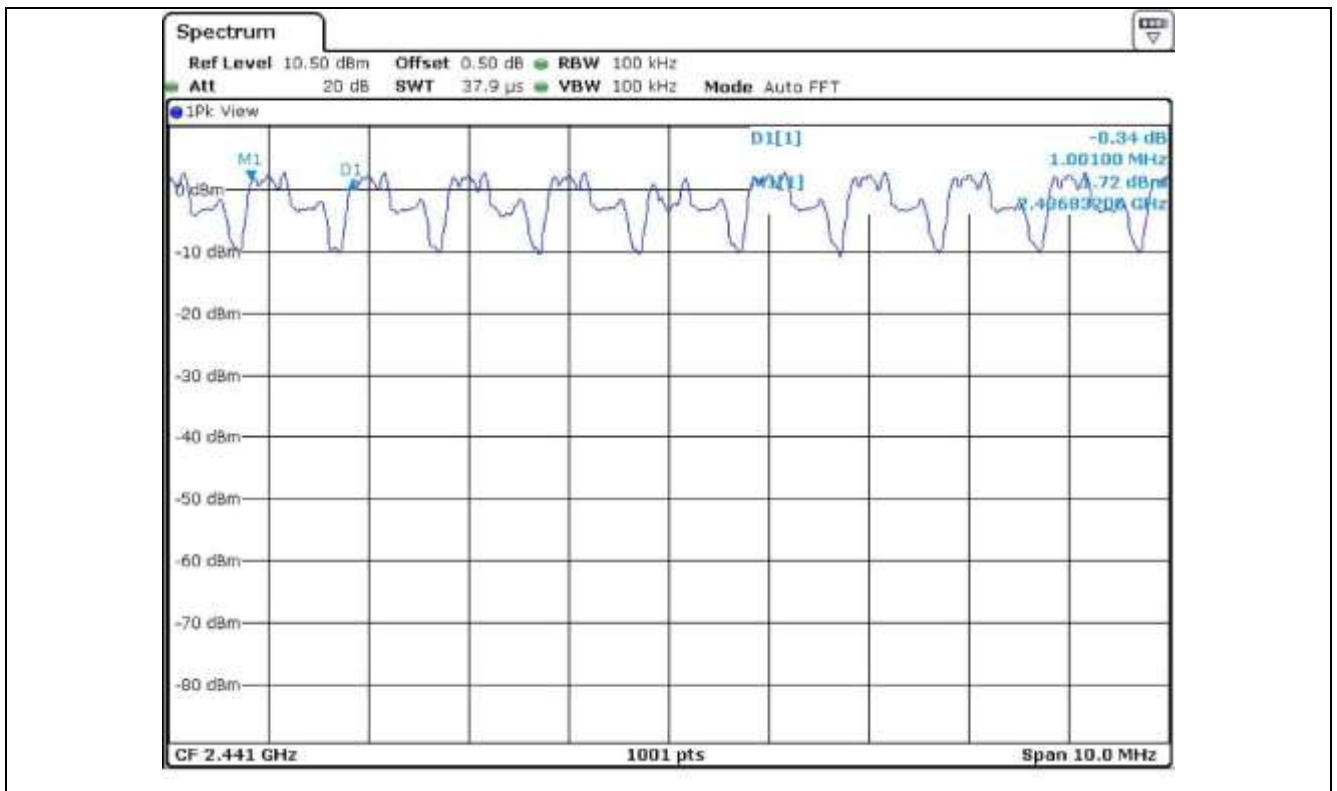
-. Test Date : May 20, 2015

-. Test Result : Pass

MEASURED VLAUE (kHz)	Two-third of 20 dB Bandwidth (kHz)	LIMIT
1 001.00	729.3	Separated by a minimum of 25 kHz



Tested by: Tae-Ho, Kim / Project Engineer





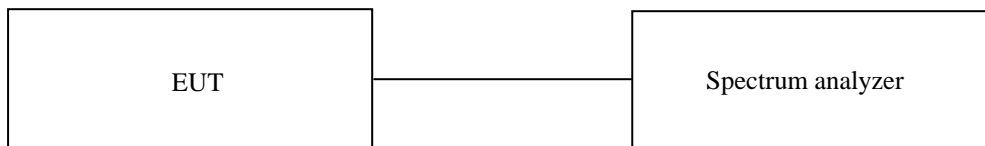
## 7.3 NUMBER OF HOPPING CHANNELS

### 7.3.1 Operating environment

Temperature : 21.4 °C  
Relative humidity : 45.1 % R.H.

### 7.3.2 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 1 MHz. The analyzer is set to peak hold and then complete pseudo-random hopping sequence of the transmitter is captured.



### 7.3.3 Test equipment used

	Model Number	Manufacturer	Description	Serial Number	Last Cal. (Interval)
■ -	FSV30	Rohde & Schwarz	Signal Analyzer	101372	Apr. 29, 2015(1Y)

All test equipment used is calibrated on a regular basis.

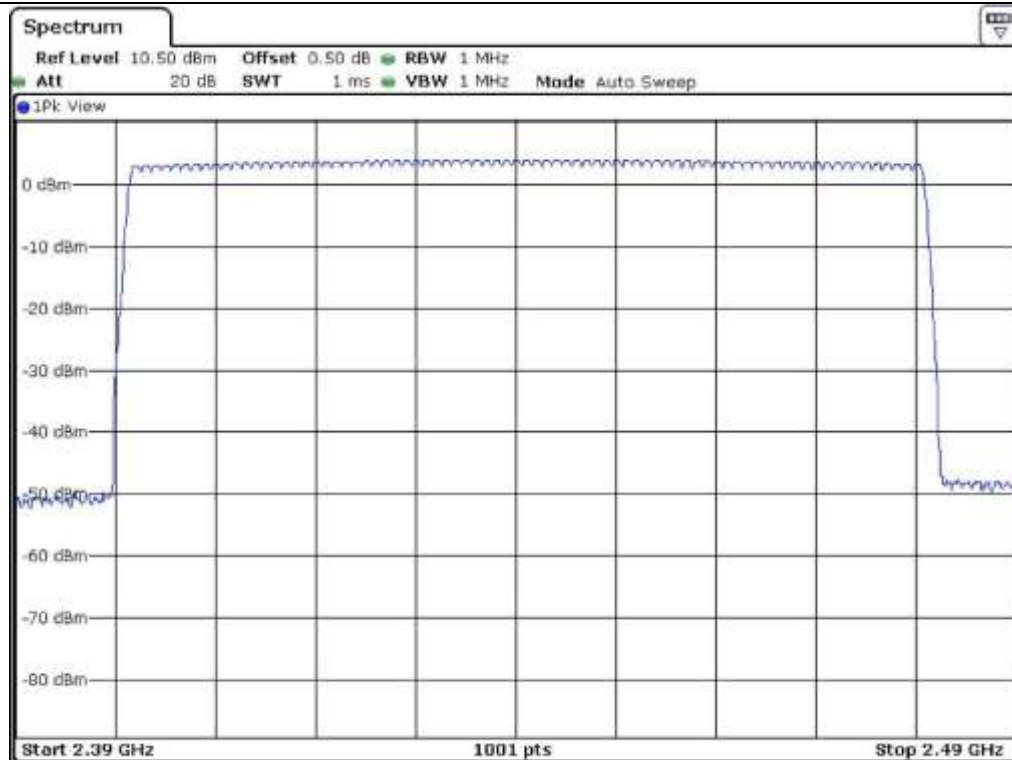
### 7.3.4 Test data for 1 Mbps

-. Test Date : May 20, 2015  
 -. Test Result : Pass

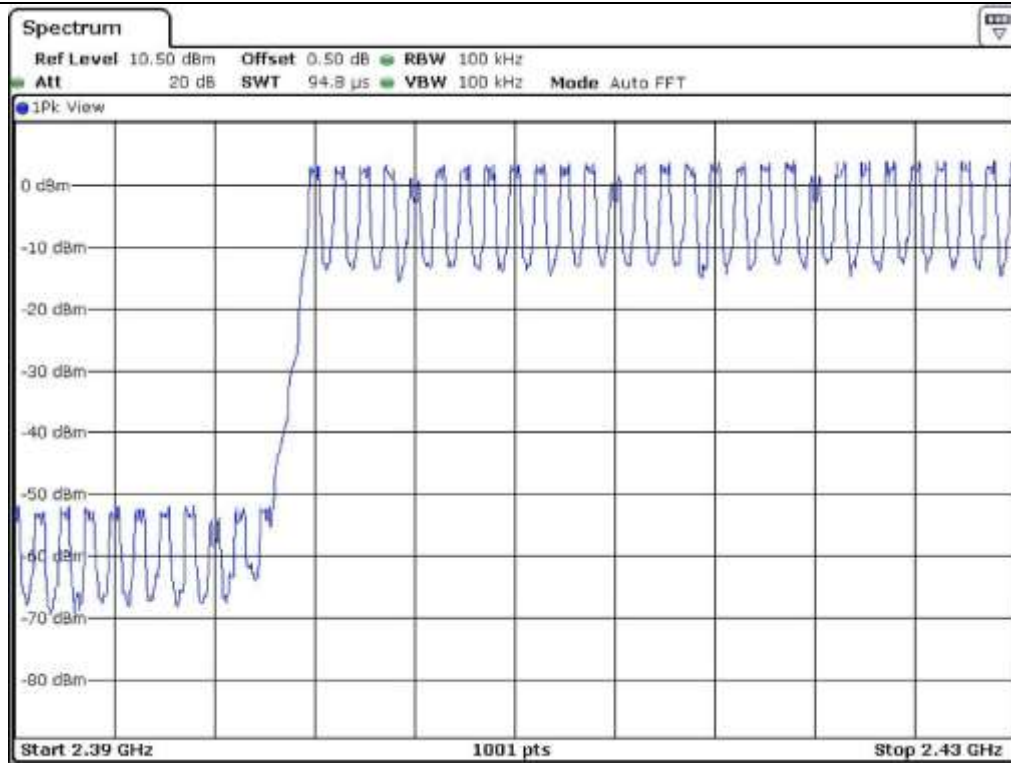
Data Transfer Rate	Measured value (Number)	Limit (Number)	Margin (Number)
1 Mbps	79	Minimum of 15	64



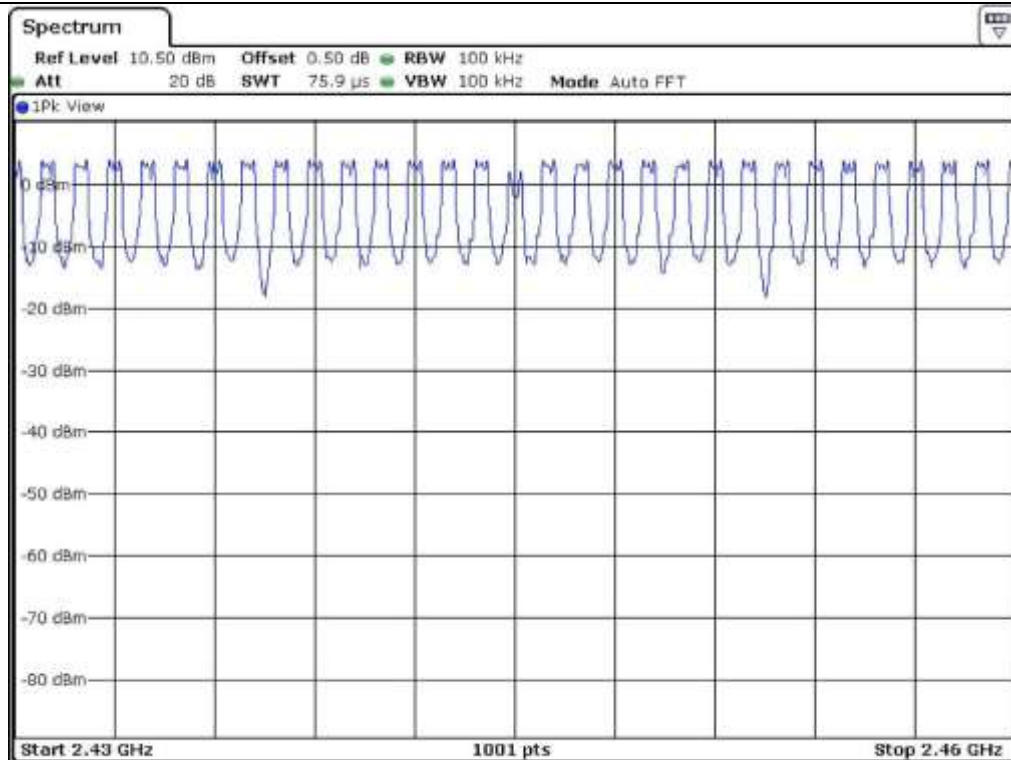
Tested by: Tae-Ho, Kim / Project Engineer



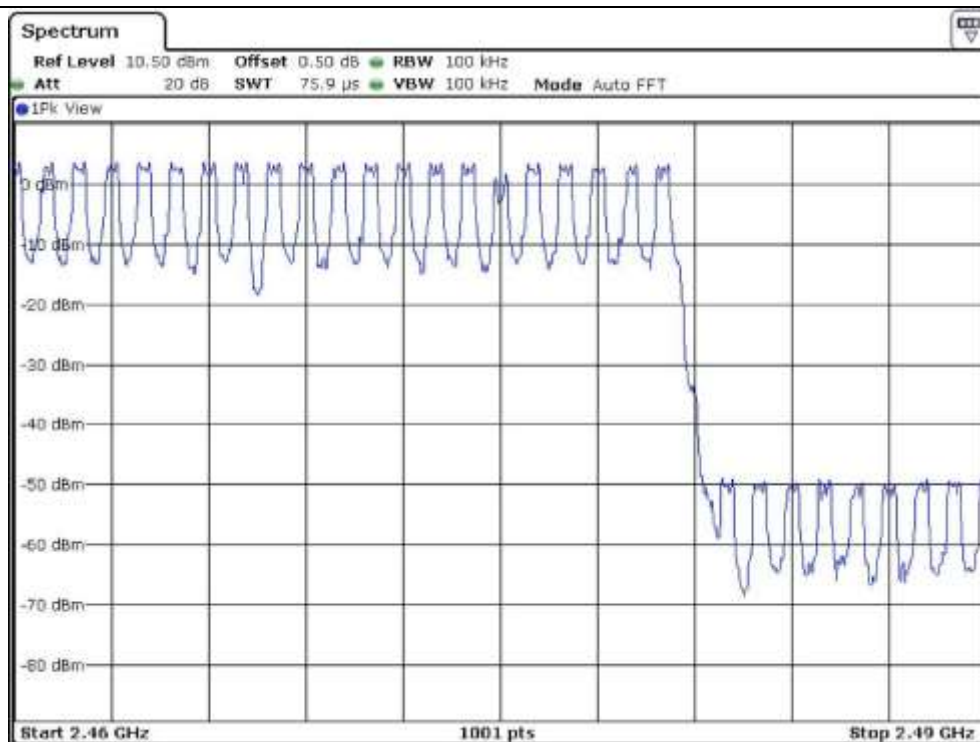
Total number of hopping channel:  $28+30+21 = 79$



Number of hopping channel: 28



Number of hopping channel: 30



Number of hopping channel: 21

### 7.3.5 Test data for 2 Mbps

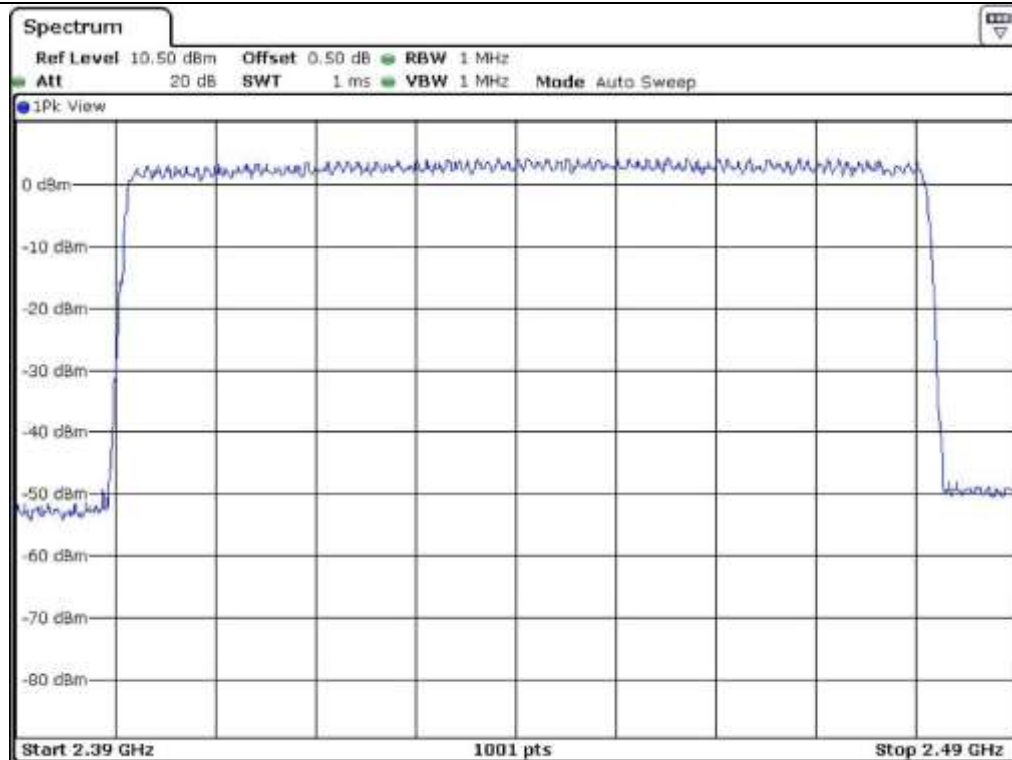
-. Test Date : May 20, 2015

-. Test Result : Pass

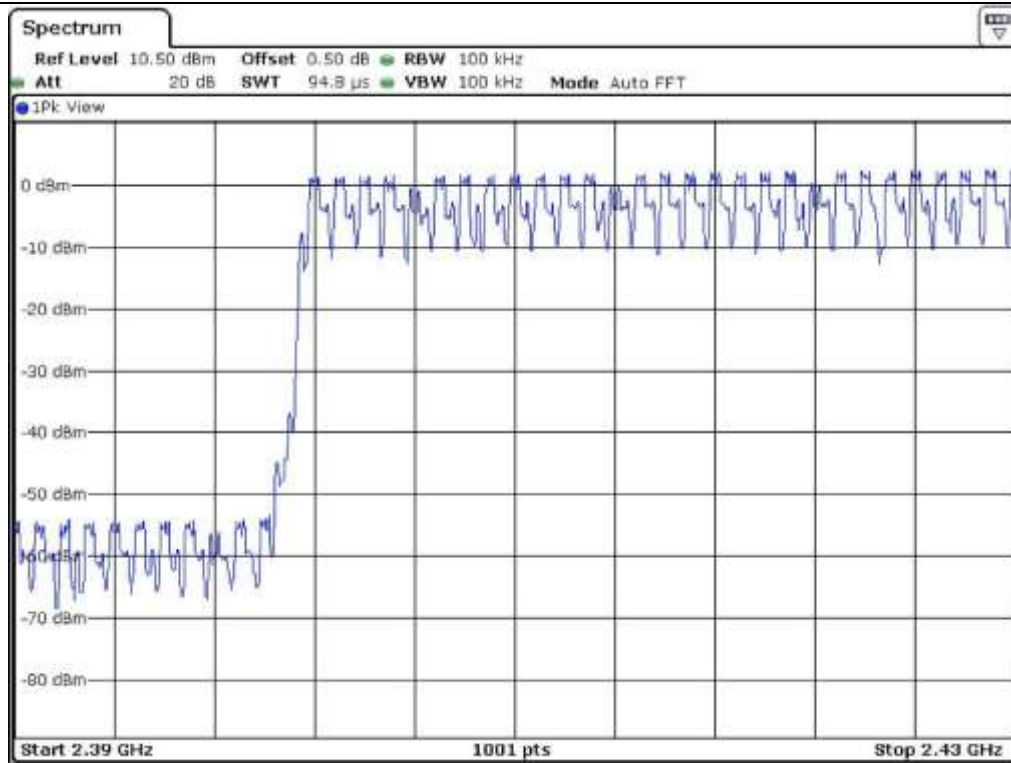
Data Transfer Rate	Measured value (Number)	Limit (Number)	Margin (Number)
2 Mbps	79	Minimum of 15	64



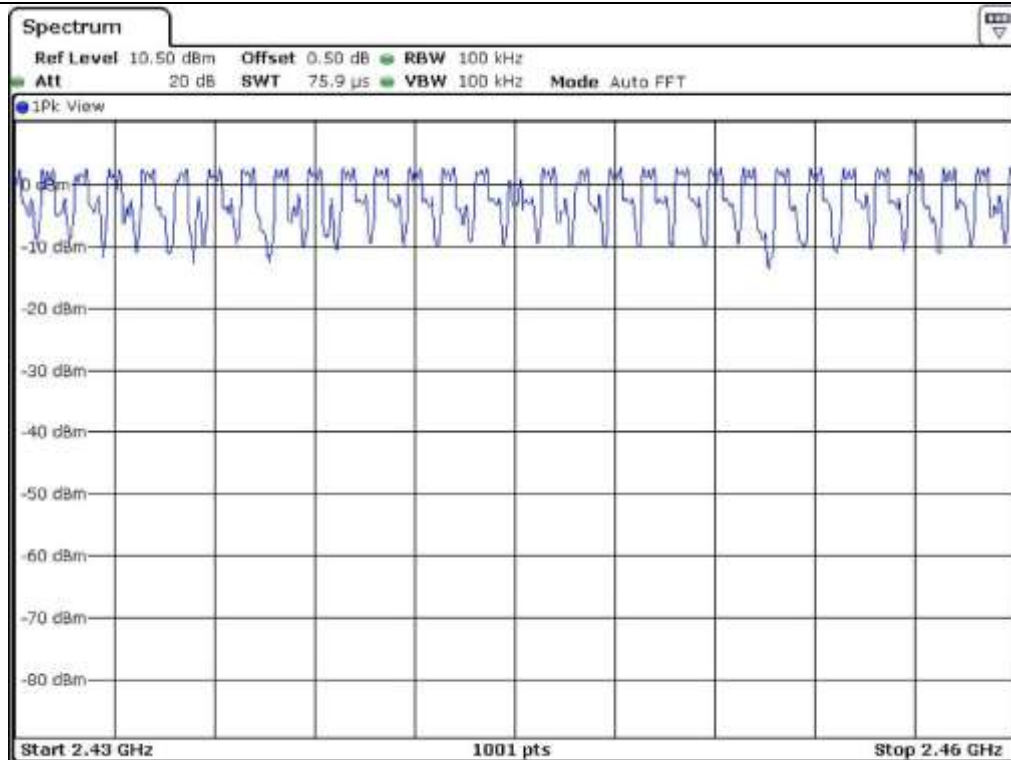
Tested by: Tae-Ho, Kim / Project Engineer



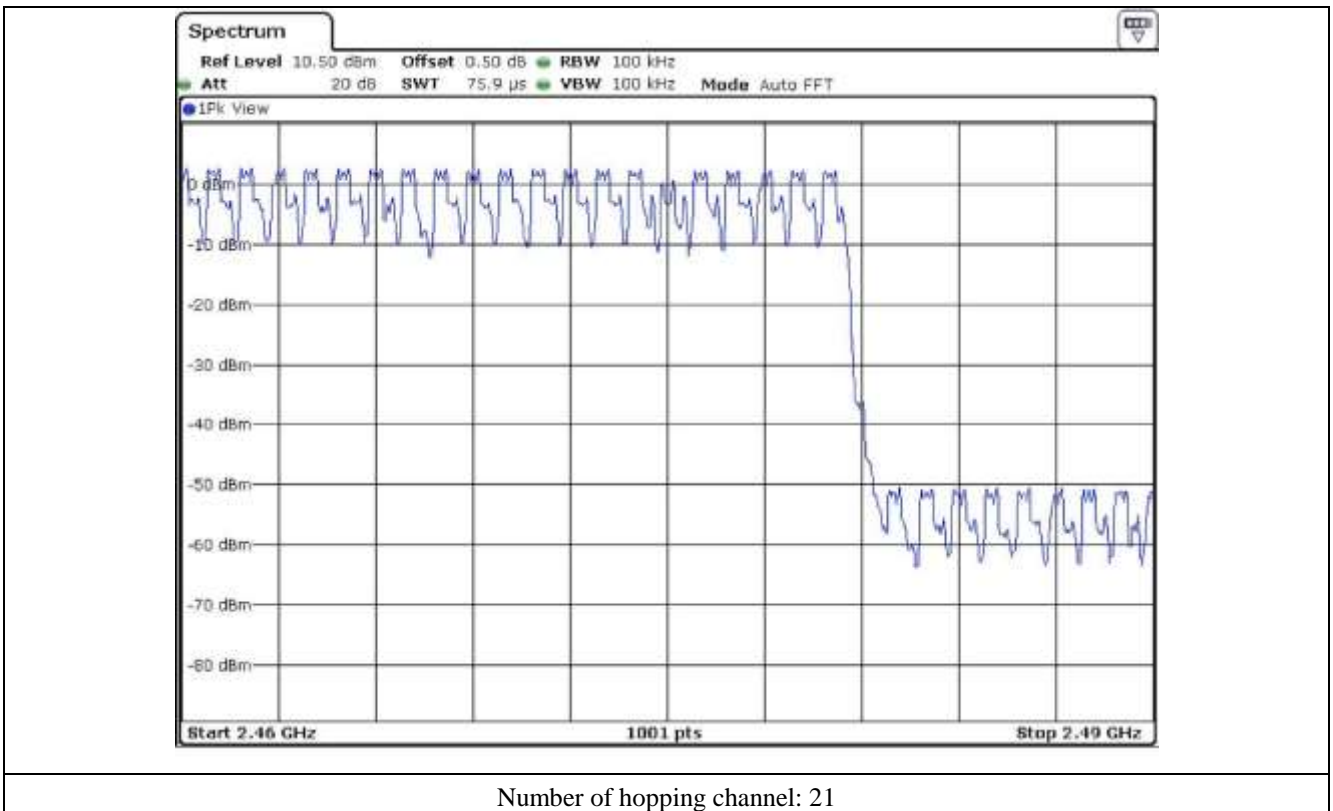
Total number of hopping channel:  $28+30+21 = 79$



Number of hopping channel: 28



Number of hopping channel: 30



### 7.3.6 Test data for 3 Mbps

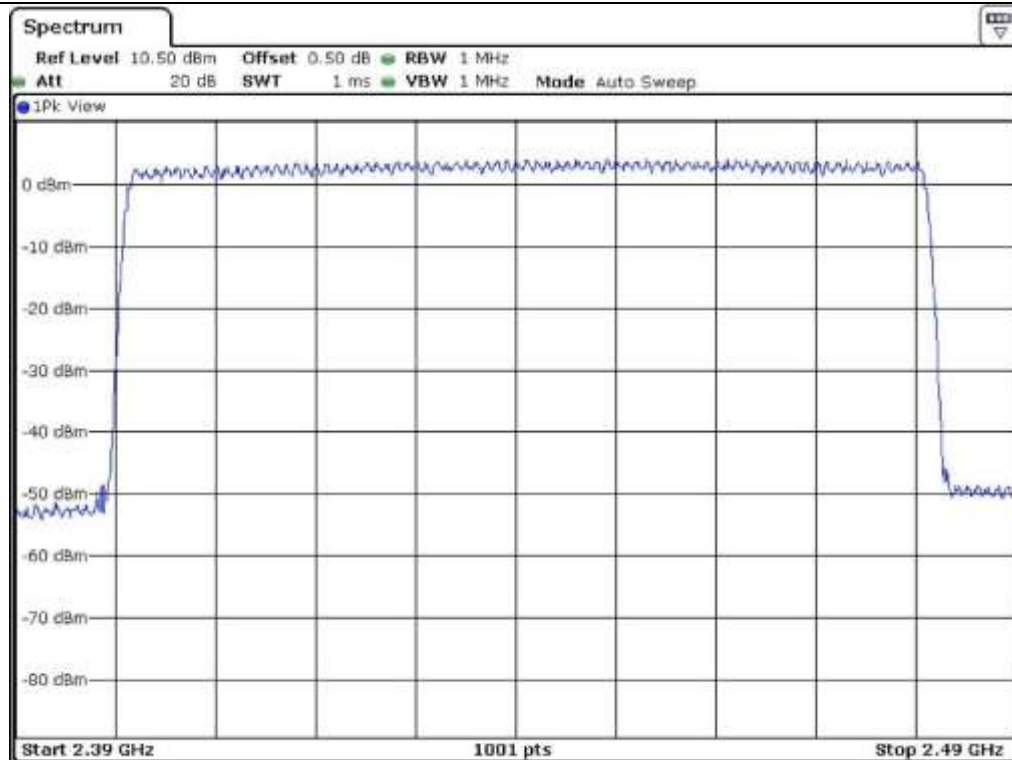
-. Test Date : May 20, 2015

-. Test Result : Pass

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

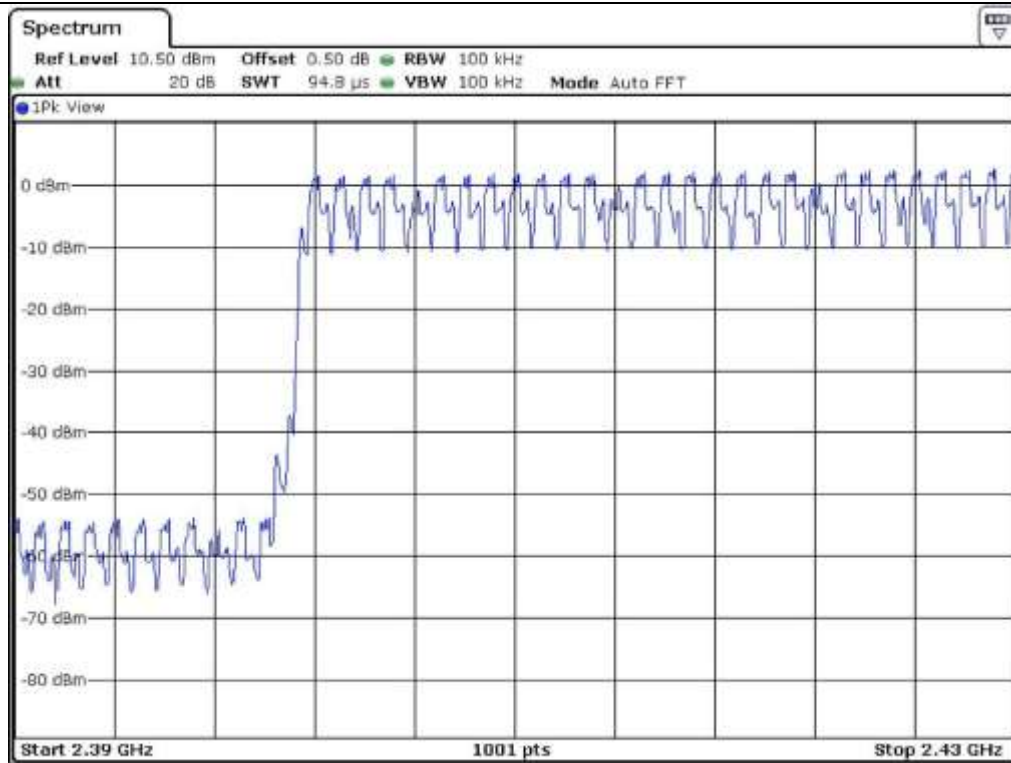


Tested by: Tae-Ho, Kim / Project Engineer

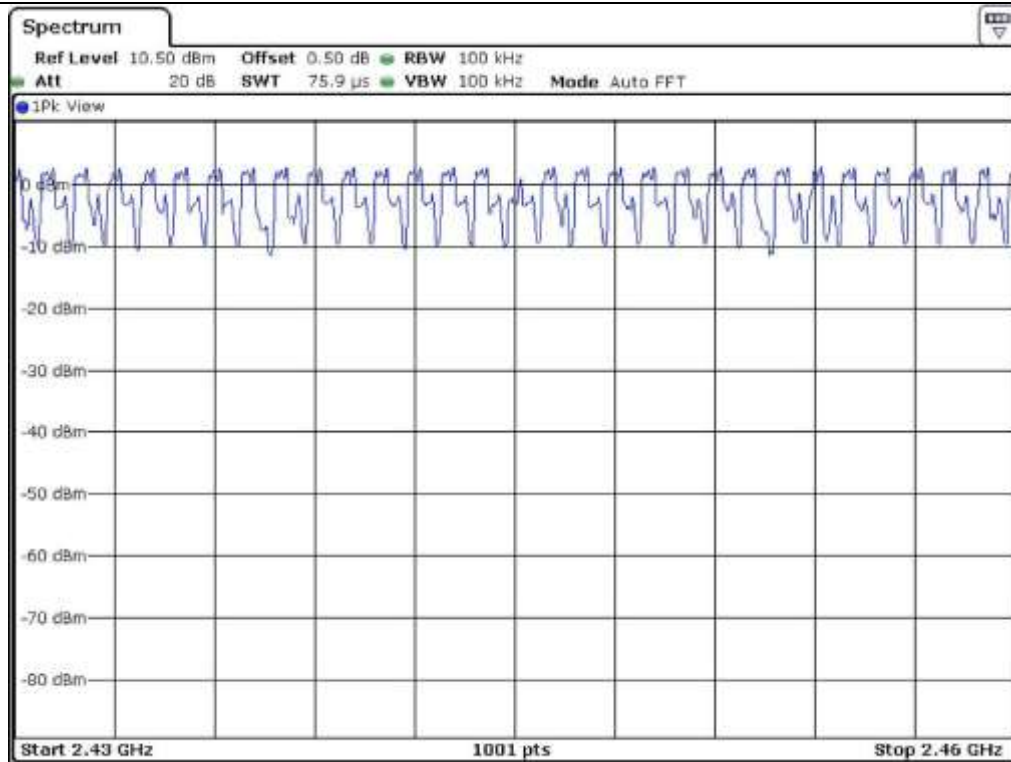


Total number of hopping channel:  $28+30+21 = 79$

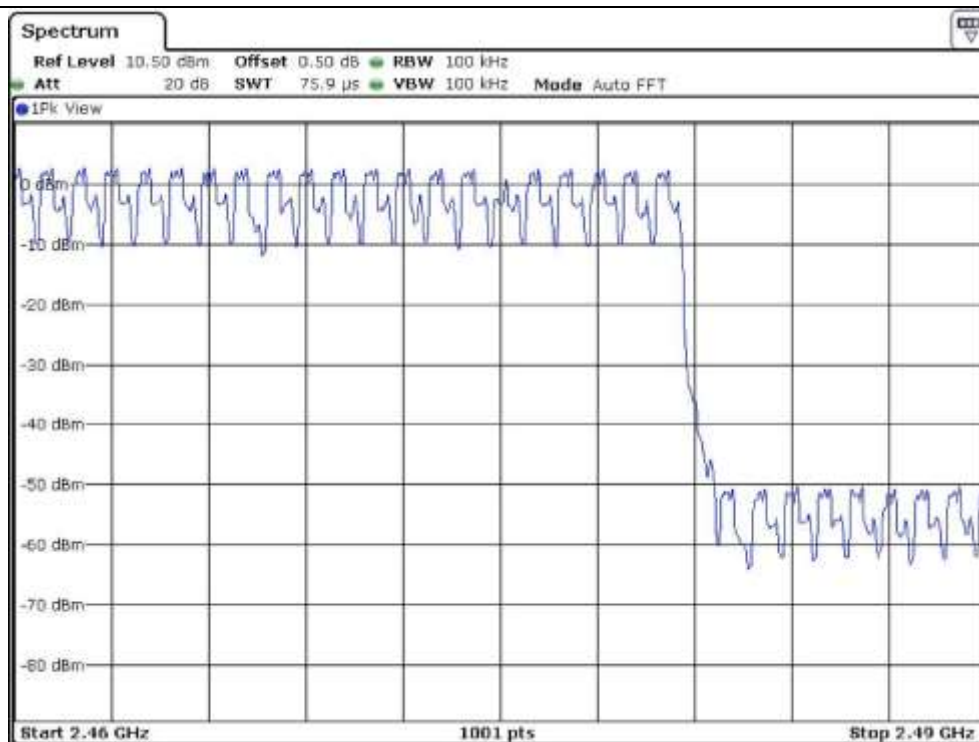




Number of hopping channel: 28



Number of hopping channel: 30



Number of hopping channel: 21

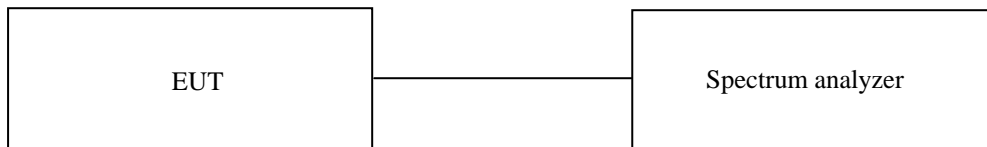
## 7.4 TIME OF OCCUPANCY

### 7.4.1 Operating environment

Temperature : 21.4 °C  
Relative humidity : 45.1 % R.H.

### 7.4.2 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.



### 7.4.3 Test equipment used

Model Number	Manufacturer	Description	Serial Number	Last Cal. (Interval)
■ - FSV30	Rohde & Schwarz	Signal Analyzer	101372	Apr. 29, 2015(1Y)

All test equipment used is calibrated on a regular basis.

#### 7.4.4 Test data for 1 Mbps

-. Test Date : May 20, 2015

The system makes worst case 1 600 hops per second or 1 time slot has a length of 625  $\mu$ s 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	0.380	10.13	31.6	121.64	400	PASS
DH3	1.630	5.06	31.6	260.63	400	
DH5	2.890	3.38	31.6	308.68	400	

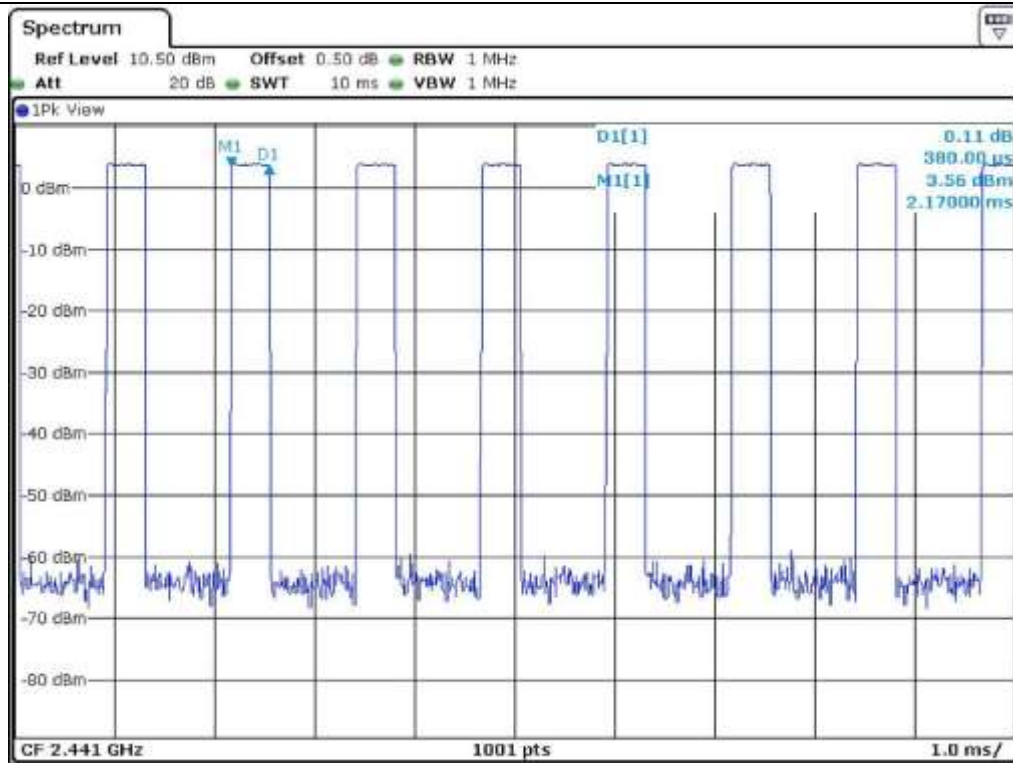
Total dwell time is calculated as following.

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

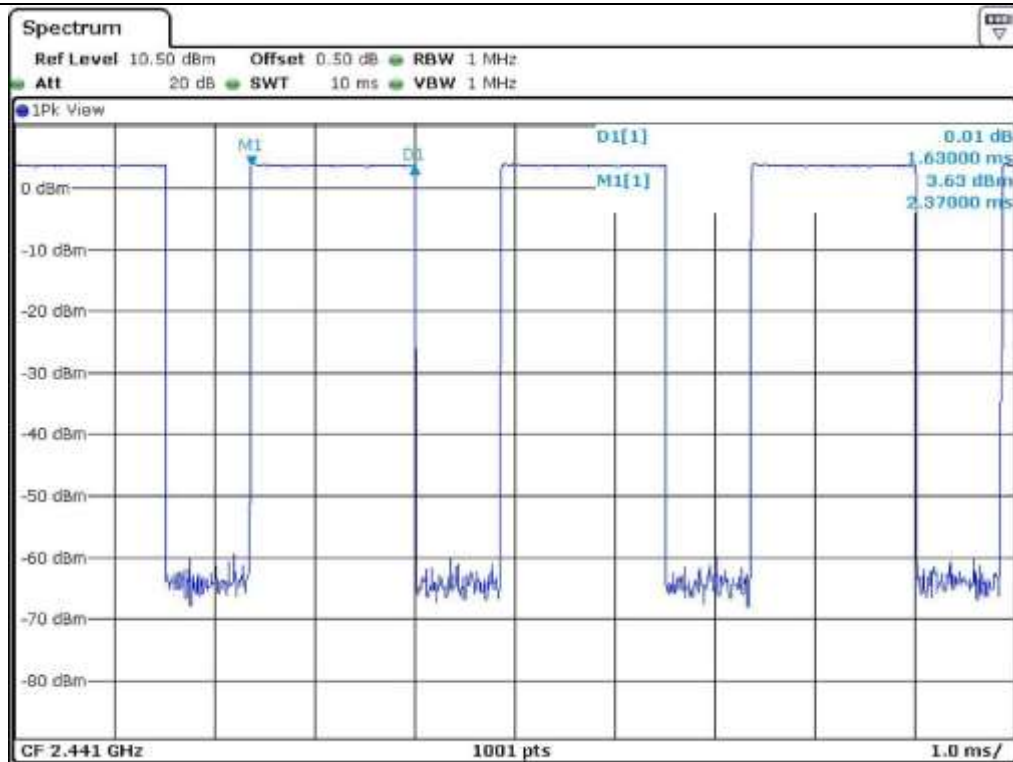
Remark: See next page for an overview sweep performed with peak detector.



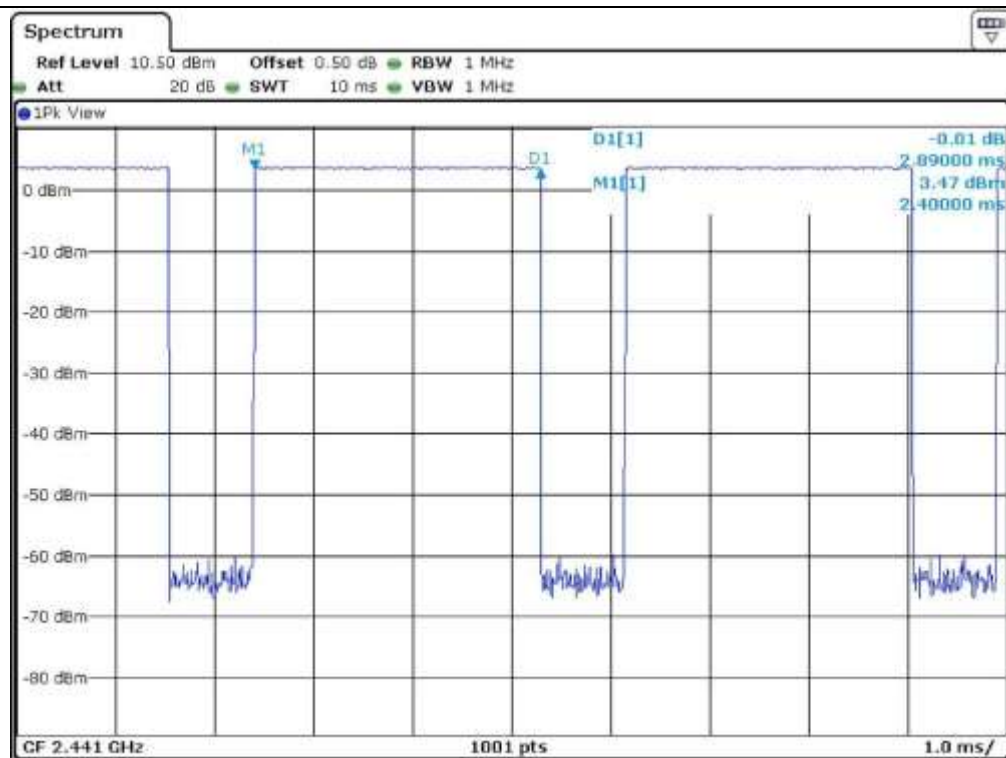
Tested by: Tae-Ho, Kim / Project Engineer



DH1



DH3



DH5

#### 7.4.5 Test data for 2 Mbps

-. Test Date : May 20, 2015

The system makes worst case 1 600 hops per second or 1 time slot has a length of 625  $\mu$ s 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	0.380	10.13	31.6	121.64	400	PASS
DH3	1.630	5.06	31.6	260.63	400	
DH5	2.890	3.38	31.6	308.68	400	

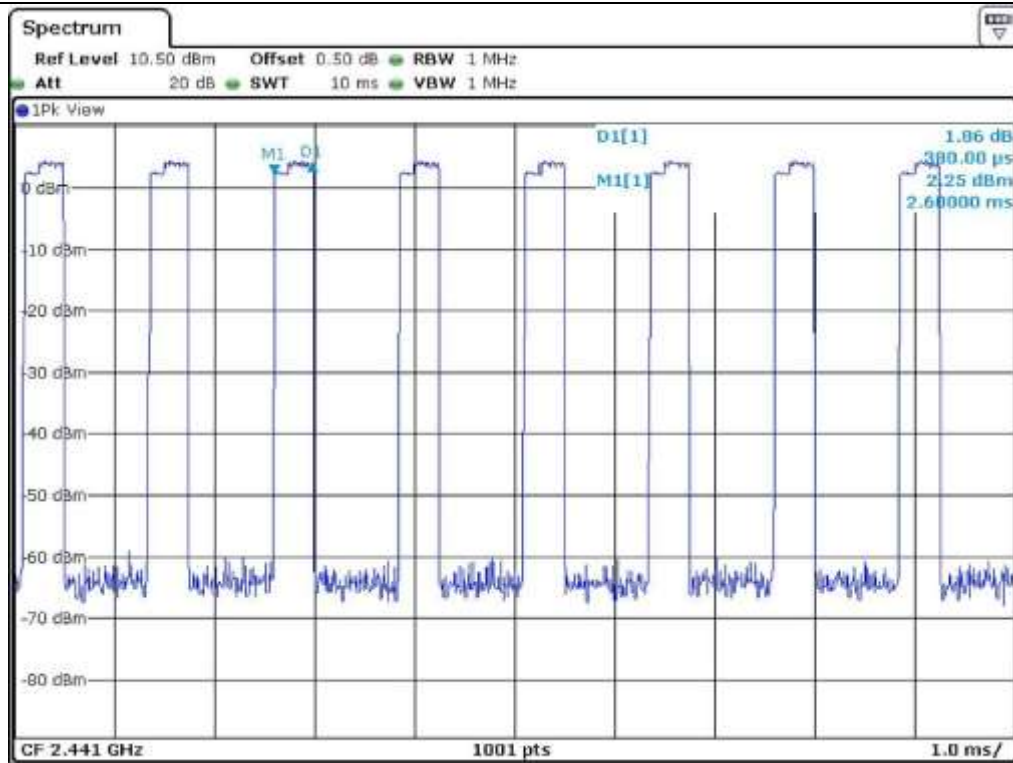
Total dwell time is calculated as following.

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

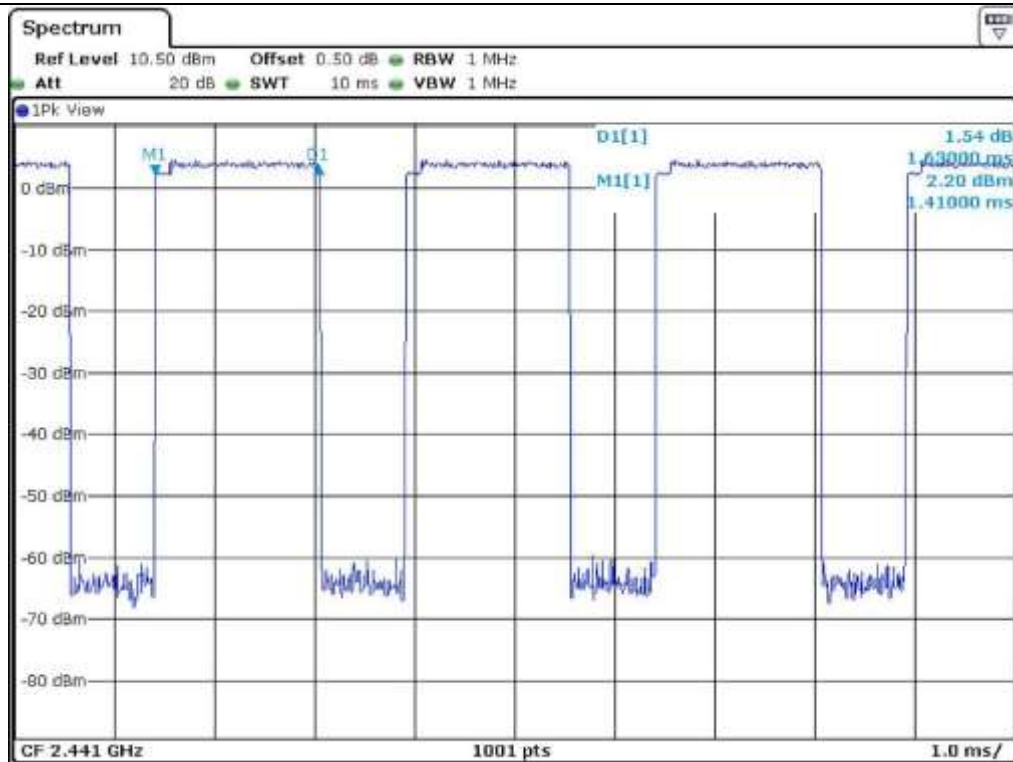
Remark: See next page for an overview sweep performed with peak detector.



Tested by: Tae-Ho, Kim / Project Engineer

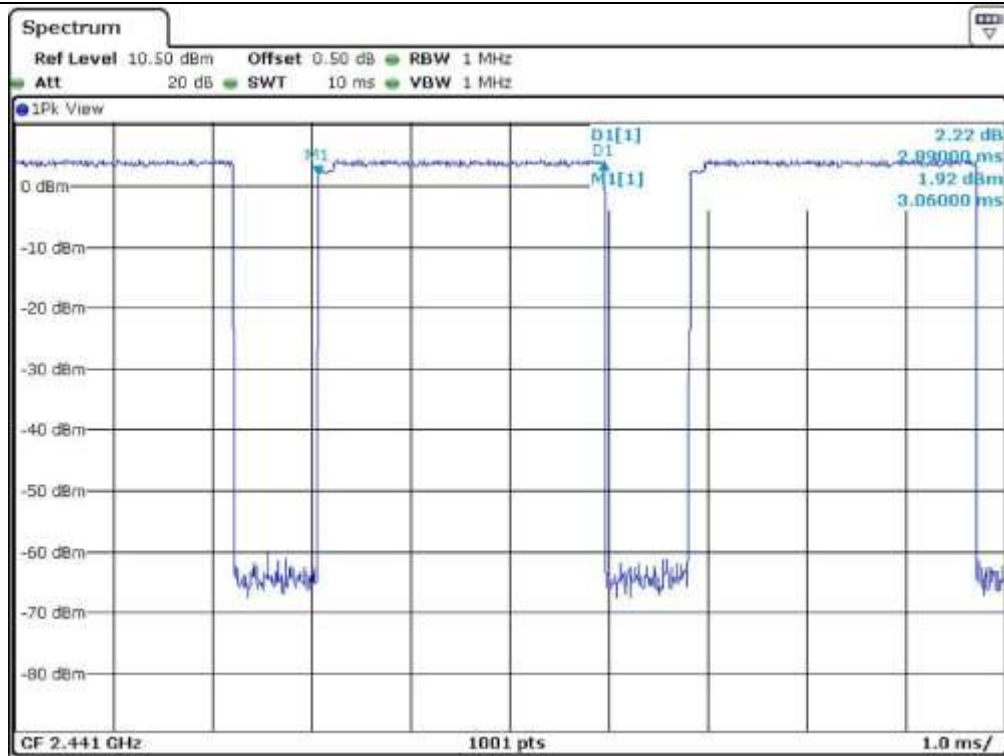


DH1



DH3





DH5

#### 7.4.6 Test data for 3 Mbps

-. Test Date : May 20, 2015

The system makes worst case 1 600 hops per second or 1 time slot has a length of 625  $\mu$ s 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	31.6	124.84	400	PASS
DH3	1.640	5.06	31.6	262.23	400	
DH5	2.890	3.38	31.6	308.68	400	

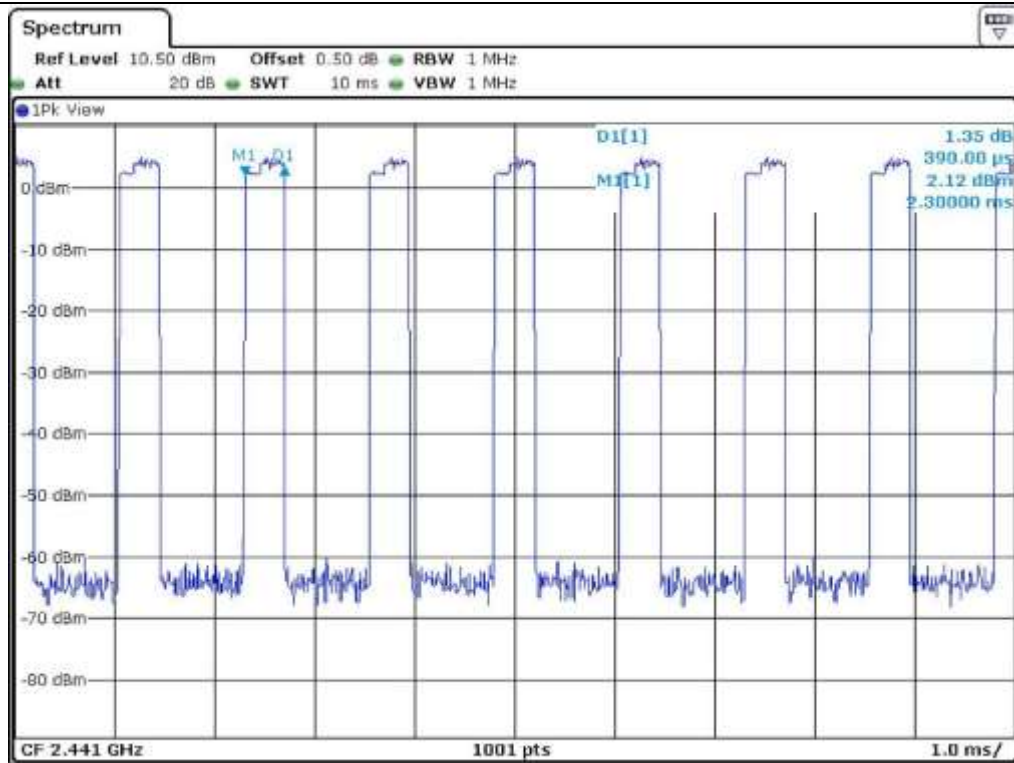
Total dwell time is calculated as following.

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

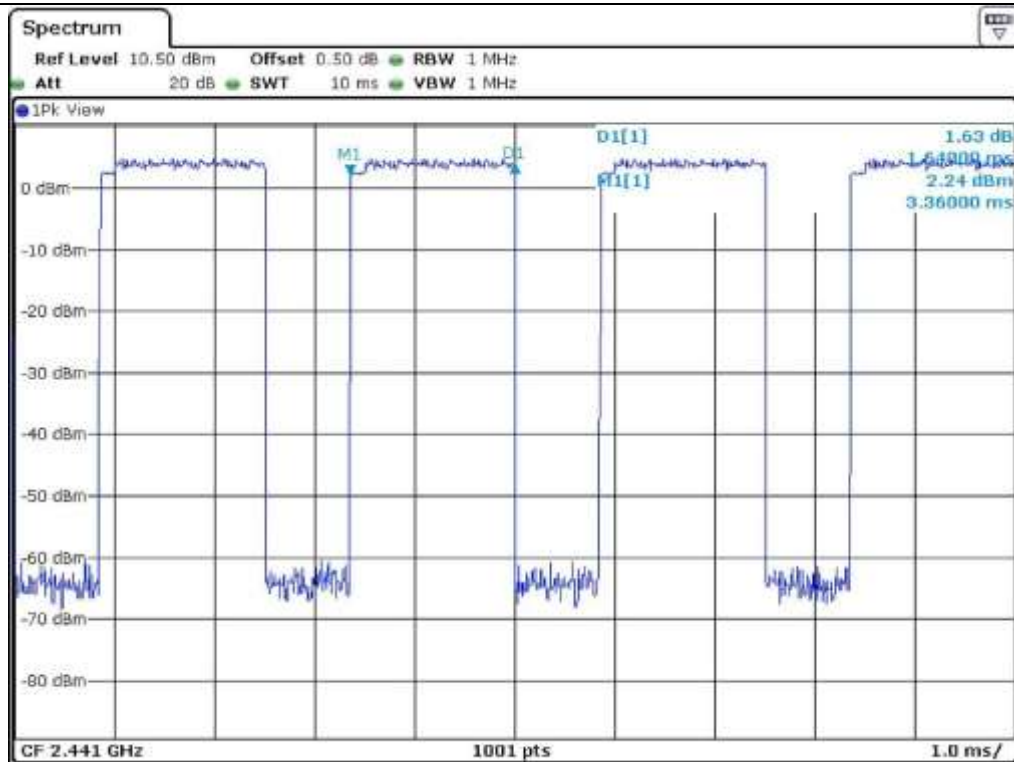
Remark: See next page for an overview sweep performed with peak detector.



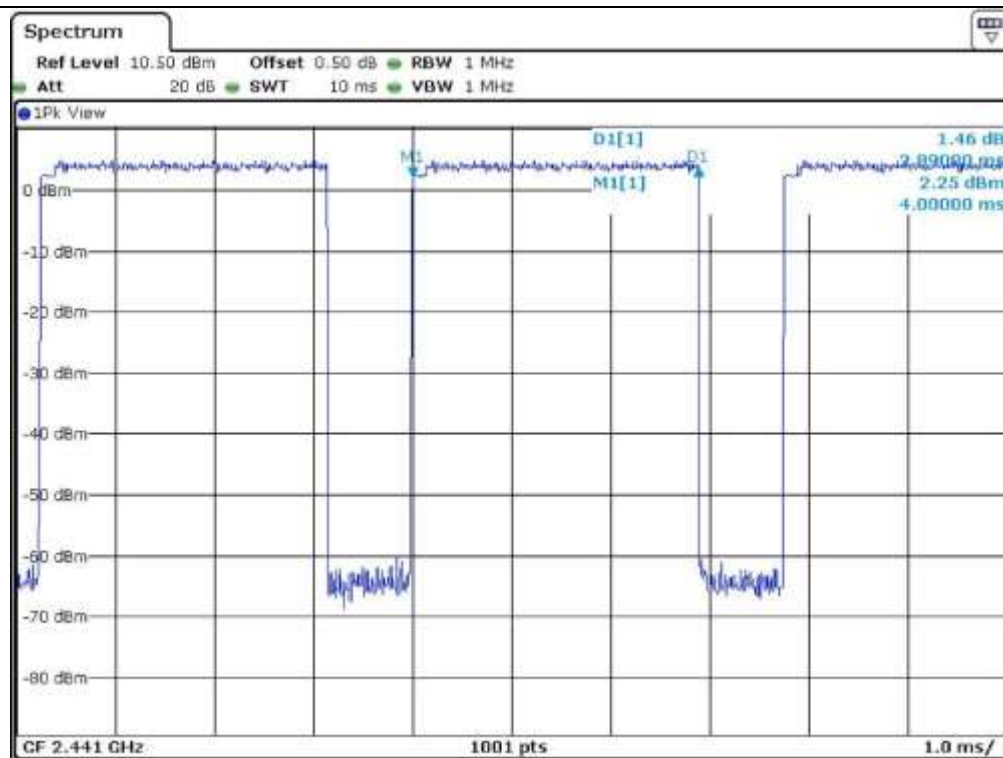
Tested by: Tae-Ho, Kim / Project Engineer



DH1



DH3



DH5

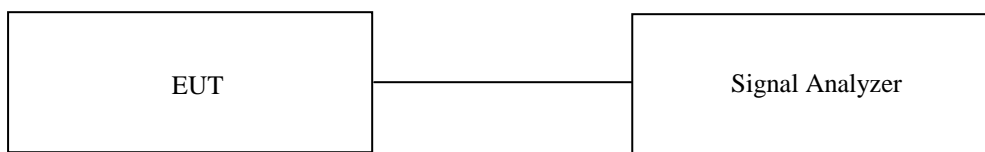
## 7.5 MAXIMUM PEAK OUTPUT POWER

### 7.5.1 Operating environment

Temperature : 21.4 °C  
Relative humidity : 45.1 % R.H

### 7.5.2 Test set-up

The maximum peak output power was measured with the spectrum analyzer connected to the antenna output of the EUT. The EUT was operating in transmit mode at the appropriate center frequency.



### 7.5.3 Test equipment used

Model Number	Manufacturer	Description	Serial Number	Last Cal. (Interval)
■ - FSV30	Rohde & Schwarz	Signal Analyzer	101372	Apr. 29, 2015(1Y)

All test equipment used is calibrated on a regular basis.

#### 7.5.4 Test data for 1 Mbps

-. Test Date : May 20, 2015

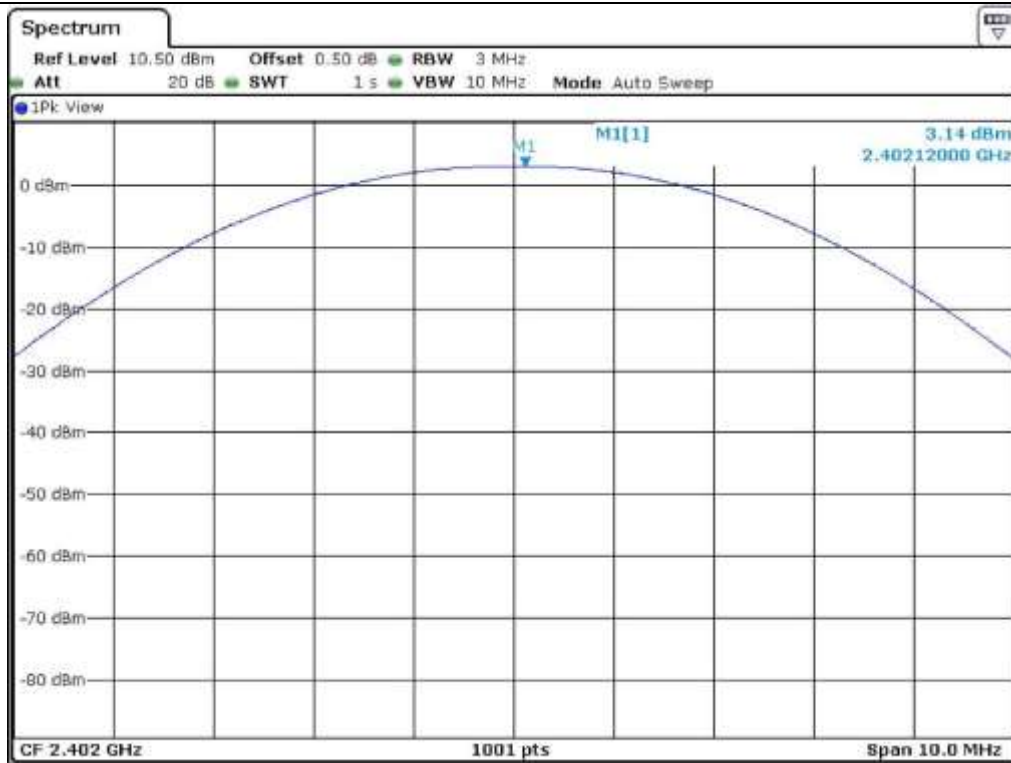
-. Test Result : Pass

CHANNEL	FREQUENCY (MHz)	MEASURED VLAUE (dBm)	LIMIT (dBm)	MARGIN (dB)
LOW	2 402	3.14	21	17.86
MIDDLE	2 441	4.13	21	16.87
HIGH	2 480	3.51	21	17.49

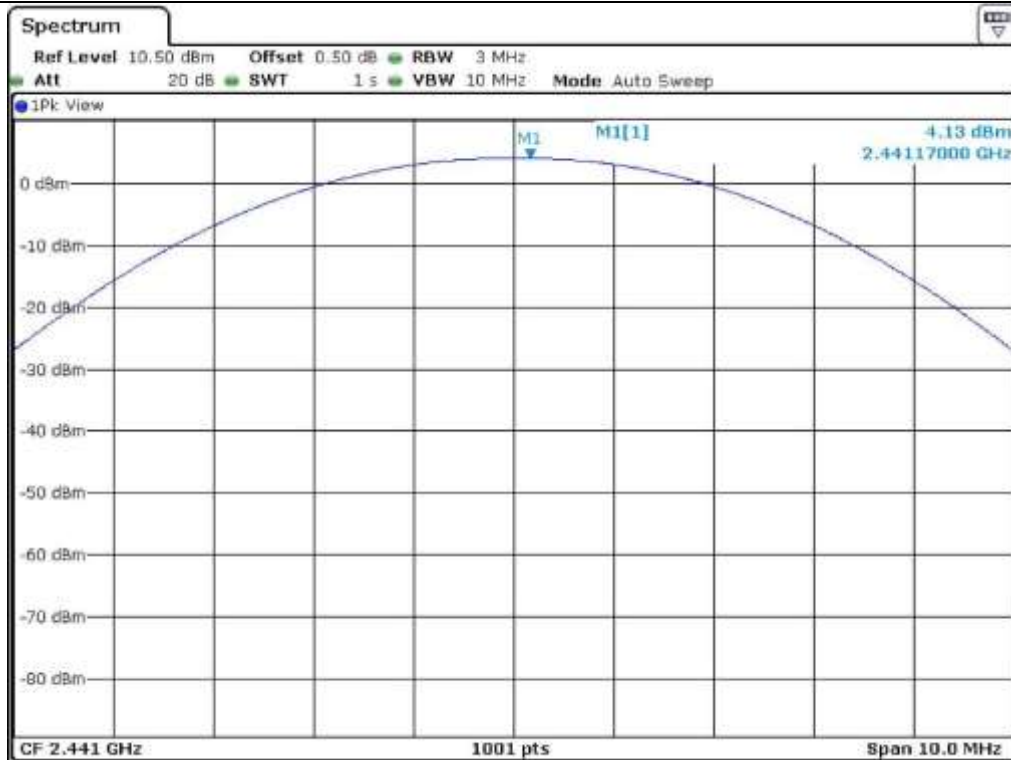
Remark. Margin = Limit – Measured Value (=Receiver Reading + Cable Loss)



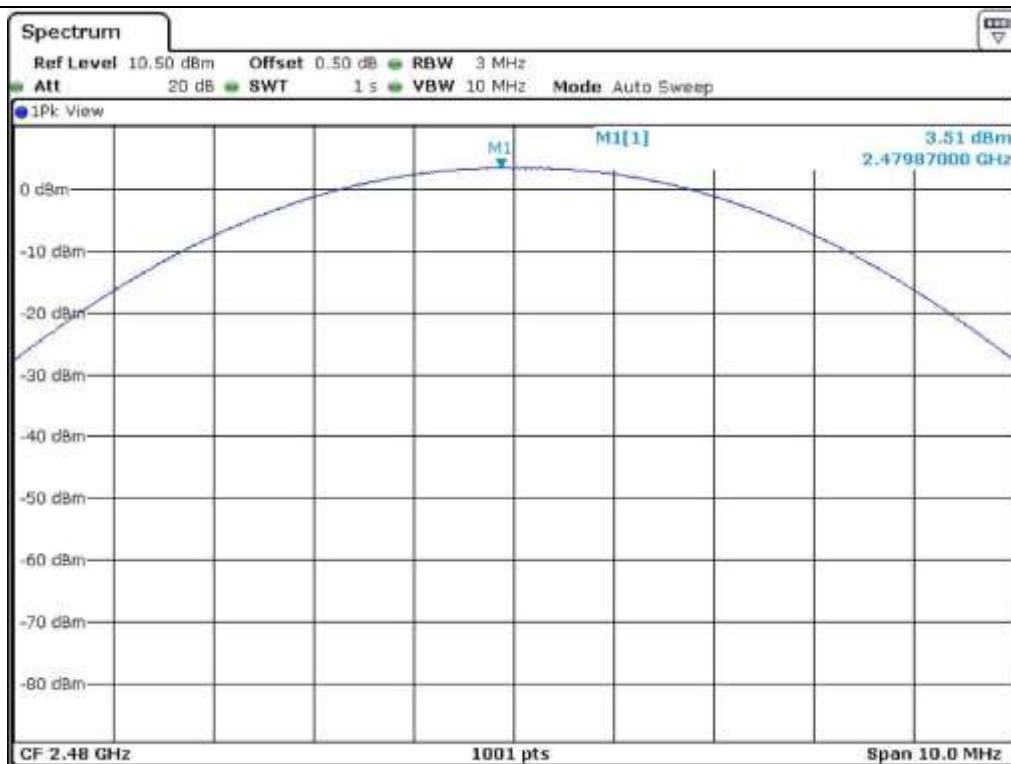
Tested by: Tae-Ho, Kim / Project Engineer



Low Channel



Middle Channel



High Channel



### 7.5.5 Test data for 2 Mbps

-. Test Date : May 20, 2015

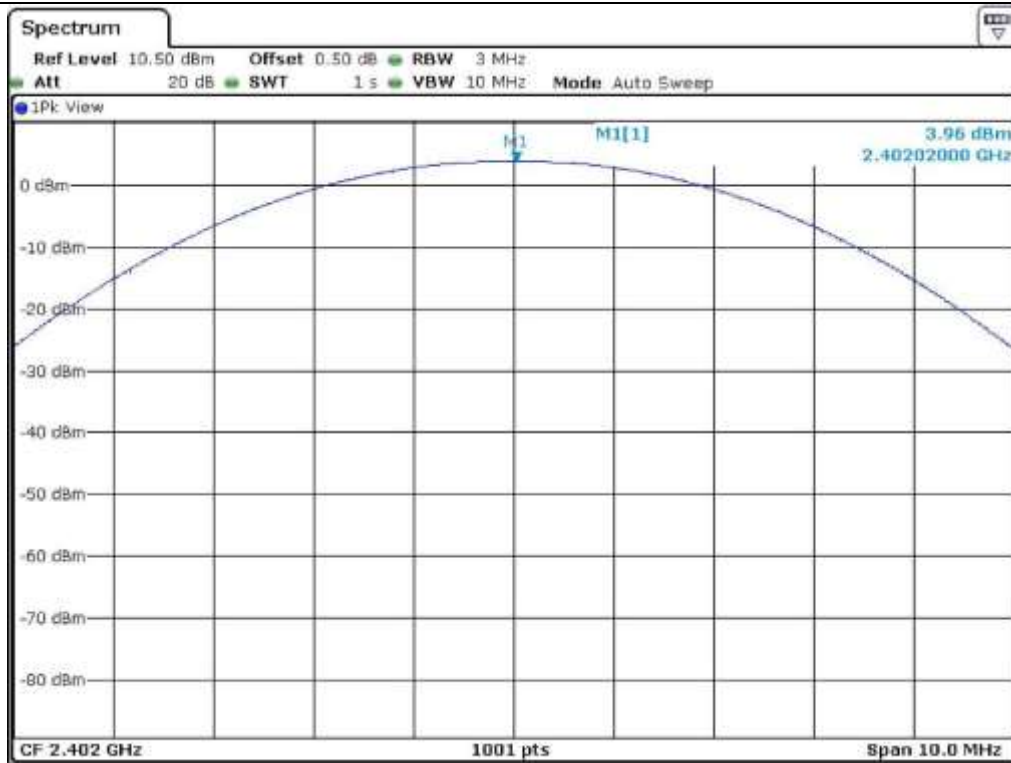
-. Test Result : Pass

CHANNEL	FREQUENCY (MHz)	MEASURED VLAUE (dBm)	LIMIT (dBm)	MARGIN (dB)
LOW	2 402	3.96	21	17.04
MIDDLE	2 441	5.21	21	15.79
HIGH	2 480	4.91	21	16.09

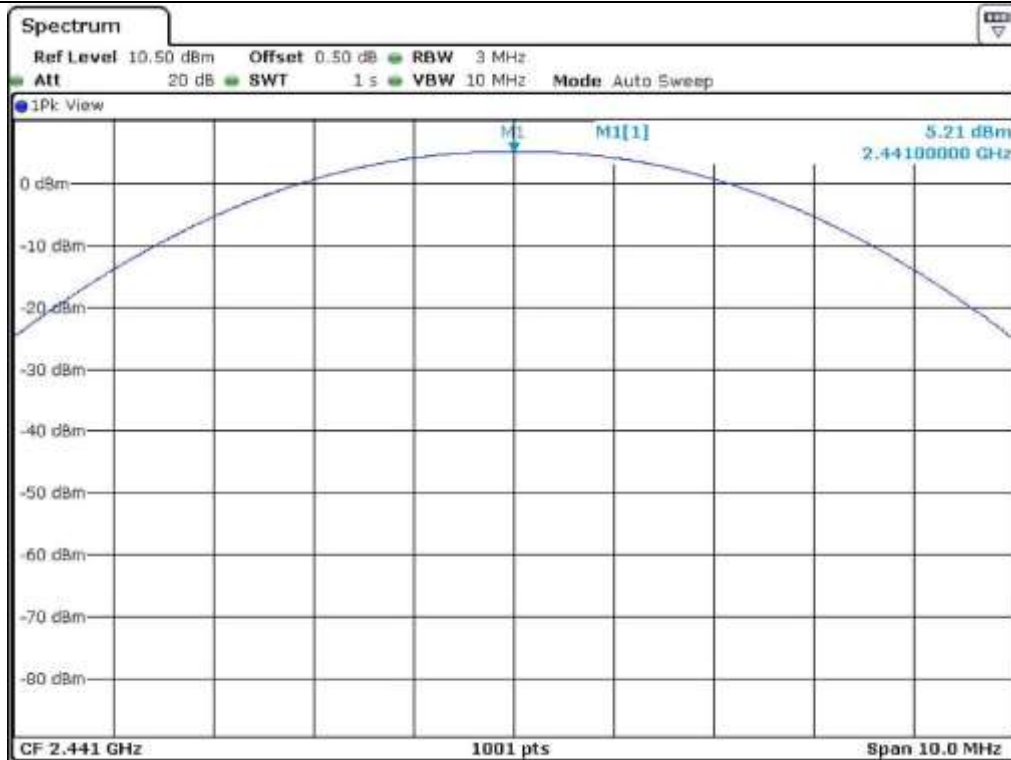
Remark. Margin = Limit – Measured Value (=Receiver Reading + Cable Loss)



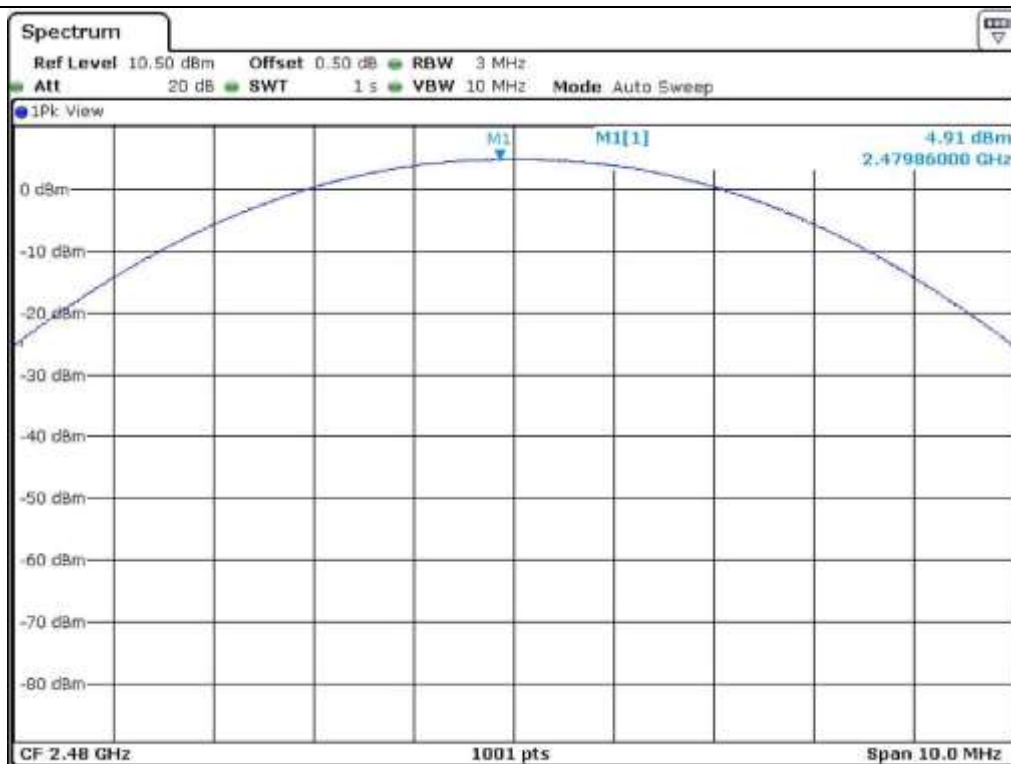
Tested by: Tae-Ho, Kim / Project Engineer



Low Channel



Middle Channel



High Channel

### 7.5.6 Test data for 3 Mbps

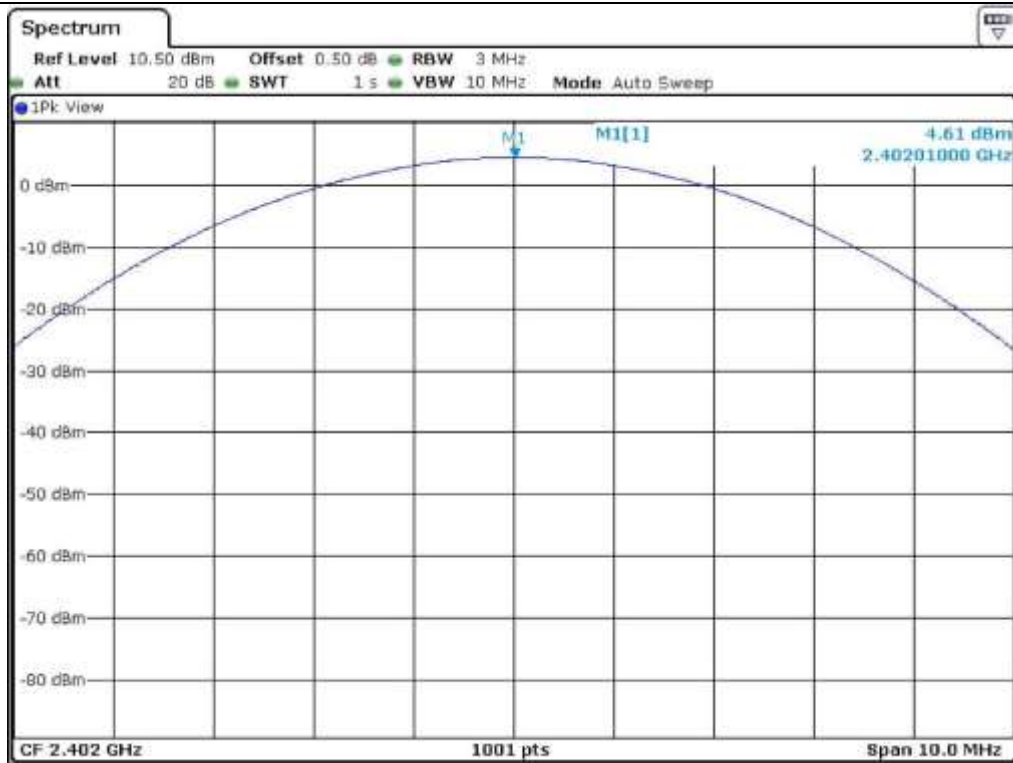
-. Test Date : May 20, 2015  
 -. Test Result : Pass

CHANNEL	FREQUENCY (MHz)	MEASURED VLAUE (dBm)	LIMIT (dBm)	MARGIN (dB)
LOW	2 402	4.61	21	16.39
MIDDLE	2 441	5.86	21	15.14
HIGH	2 480	5.59	21	15.41

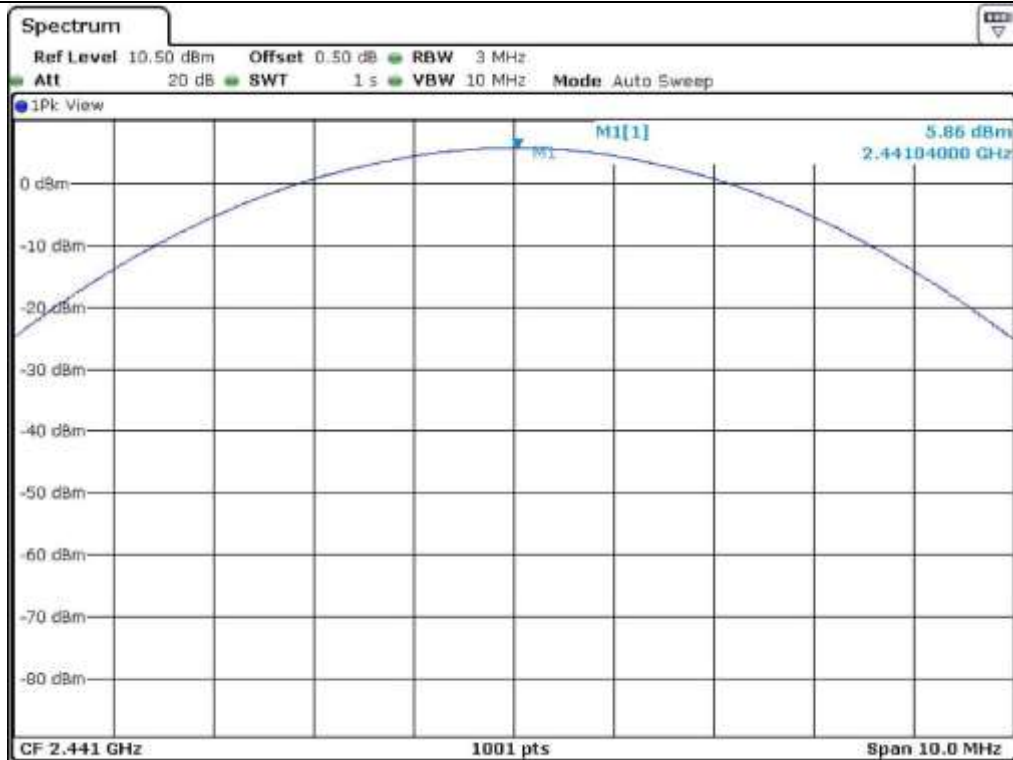
Remark. Margin = Limit – Measured Value (=Receiver Reading + Cable Loss)



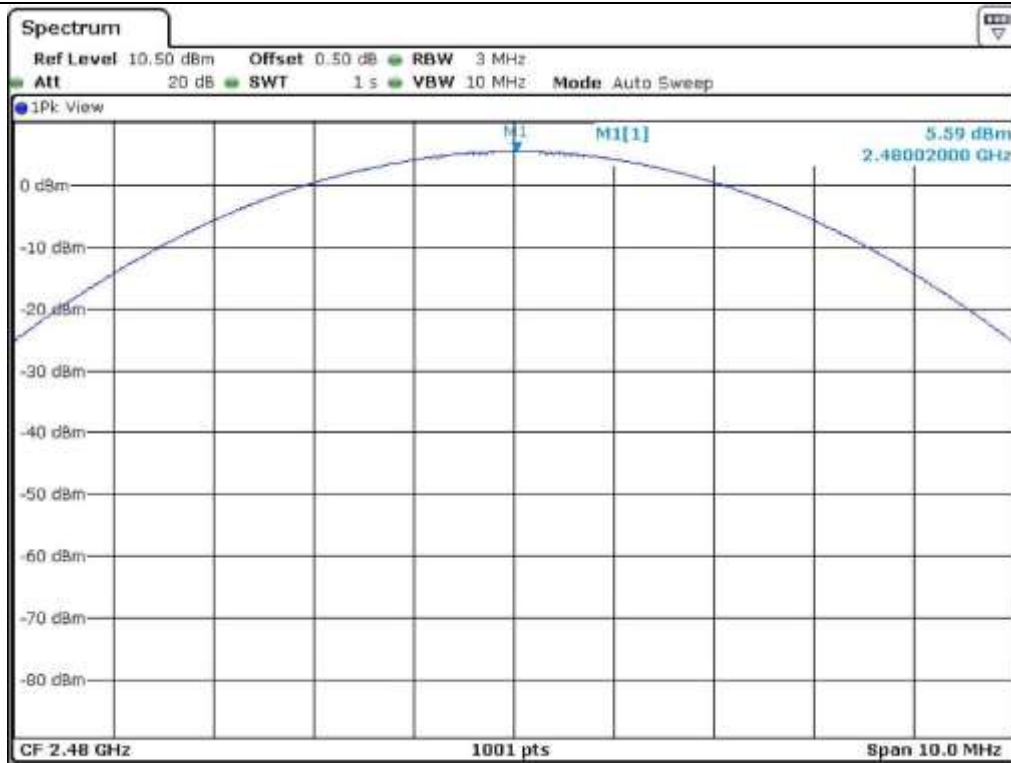
Tested by: Tae-Ho, Kim / Project Engineer



Low Channel



Middle Channel



High Channel

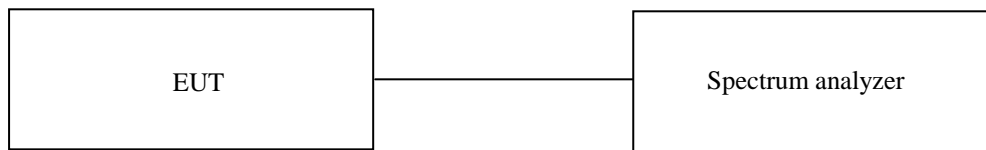
## 7.6 100 kHz BANDWIDTH OUTSIDE THE FREQUENCY BAND

### 7.6.1 Operating environment

Temperature : 21.4 °C  
Relative humidity : 45.1 % R.H

### 7.6.2 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.



### 7.6.3 Test set-up for radiated measurement

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 kHz 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 ms in order to determine the maximum emission levels. This procedure was performed for horizontal and vertical polarization of the receiving antenna.

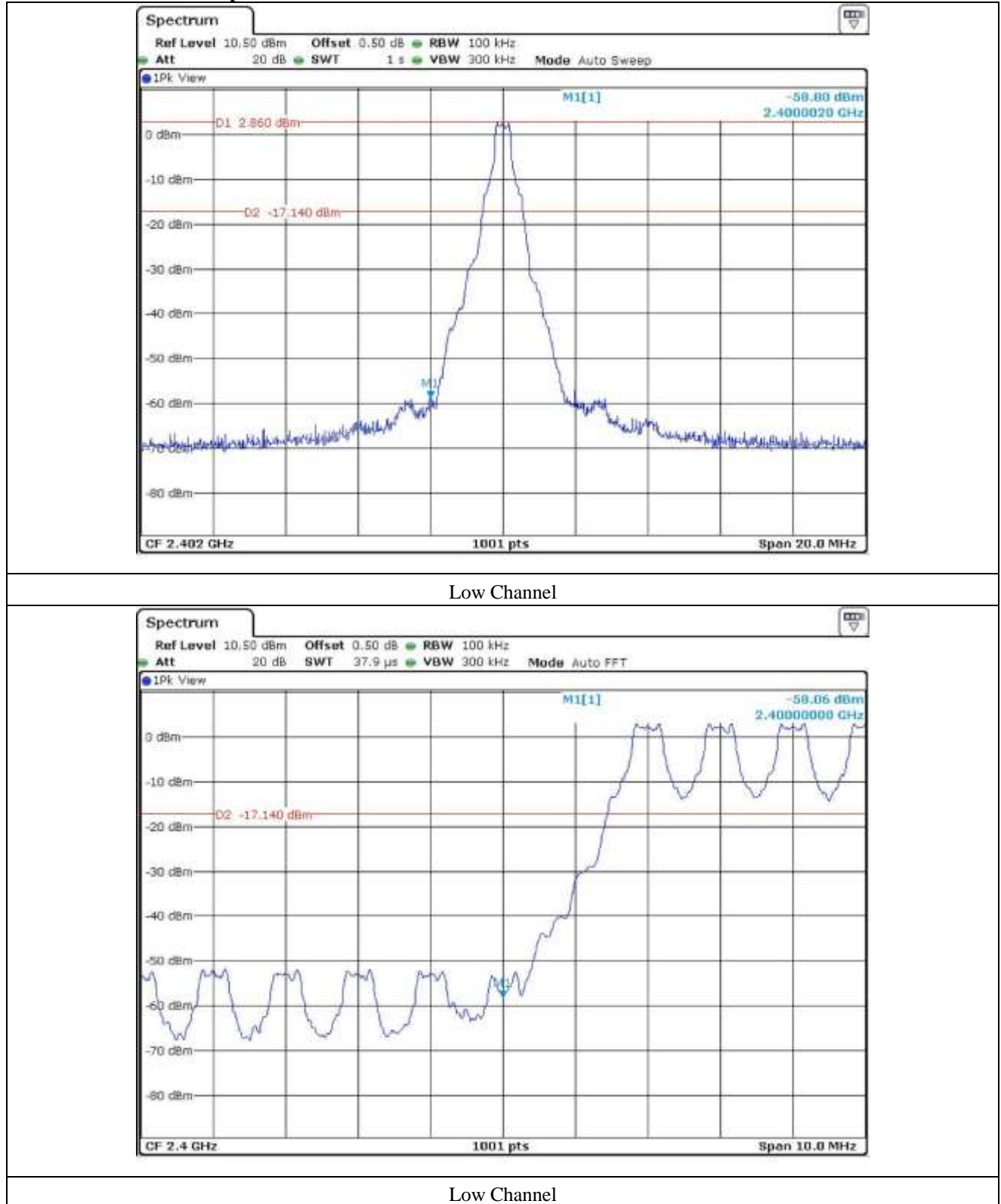
### 7.6.4 Test equipment used

	Model Number	Manufacturer	Description	Serial Number	Last Cal. (Interval)
■ -	FSV40	Rohde & Schwarz	Signal Analyzer	101009	Jul. 30, 2014 (1Y)
■ -	ESCI	Rohde & Schwarz	Test Receiver	101012	Nov. 03, 2014 (1Y)
■ -	310N	Sonoma Instrument	Pre-Amplifier	312544	Apr. 29, 2015 (1Y)
■ -	SCU-18	Rohde & Schwarz	Pre-Amplifier	10041	Nov. 25, 2014 (1Y)
■ -	DT3000	Innco System	Turn Table	930611	N/A
■ -	MA4000-EP	Innco System	Antenna Master	3320611	N/A
■ -	VULB9163	Schwarzbeck	TRILOG Broadband Antenna	9163-421	Jul. 10, 2014 (2Y)
■ -	BBHA9120D	Schwarzbeck	Horn Antenna	BBHA9120D295	Sep. 05, 2013 (2Y)
■ -	BBHA9170	Schwarzbeck	Horn Antenna	BBHA9170178	Apr. 30, 2015 (2Y)

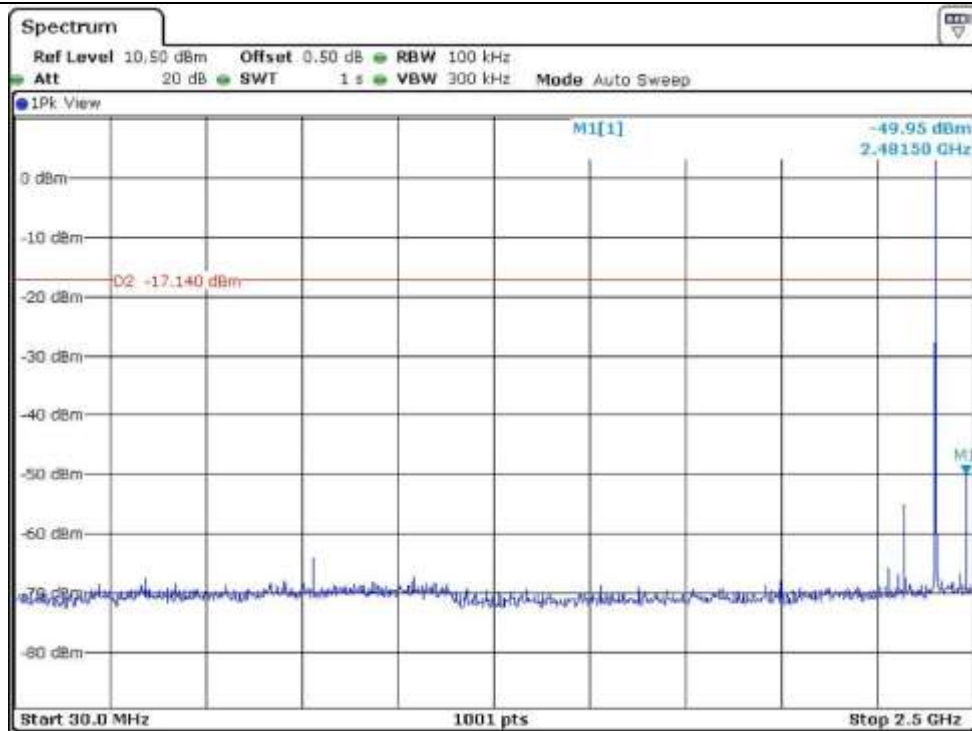
All test equipment used is calibrated on a regular basis.

## 7.6.5 Test data for conducted emission

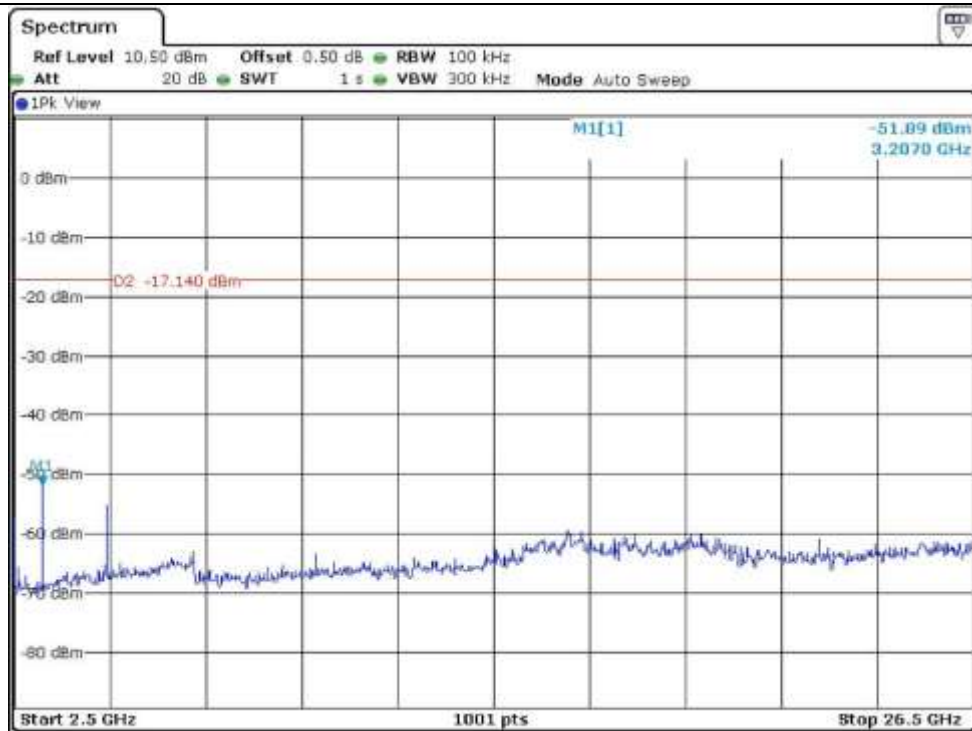
### 7.6.5.1 Test data for 1 Mbps



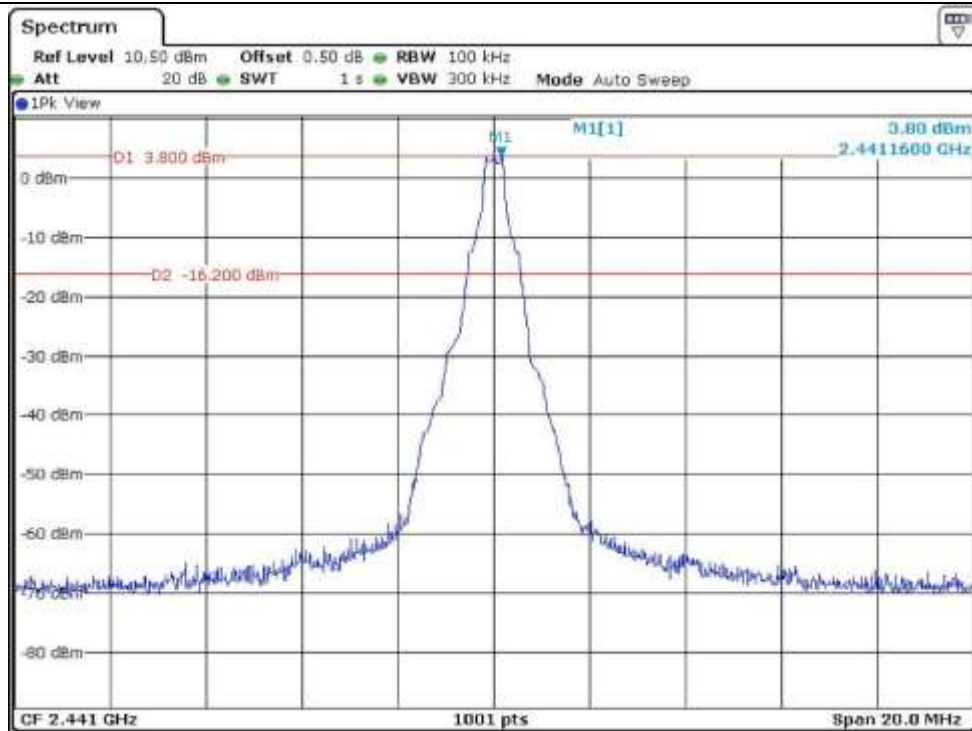




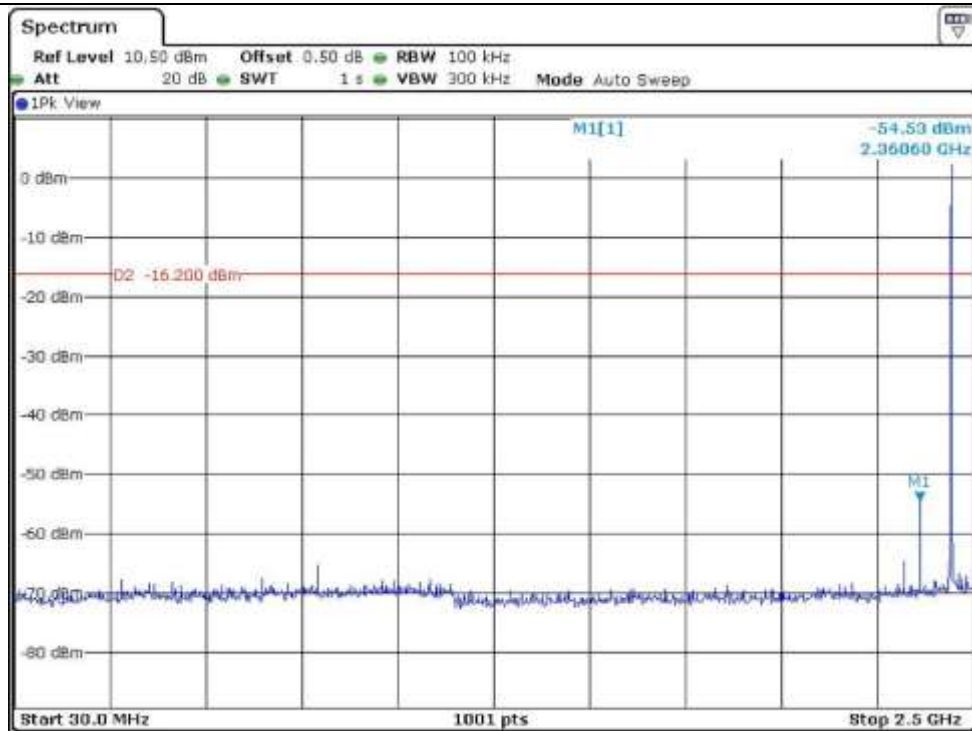
Low Channel



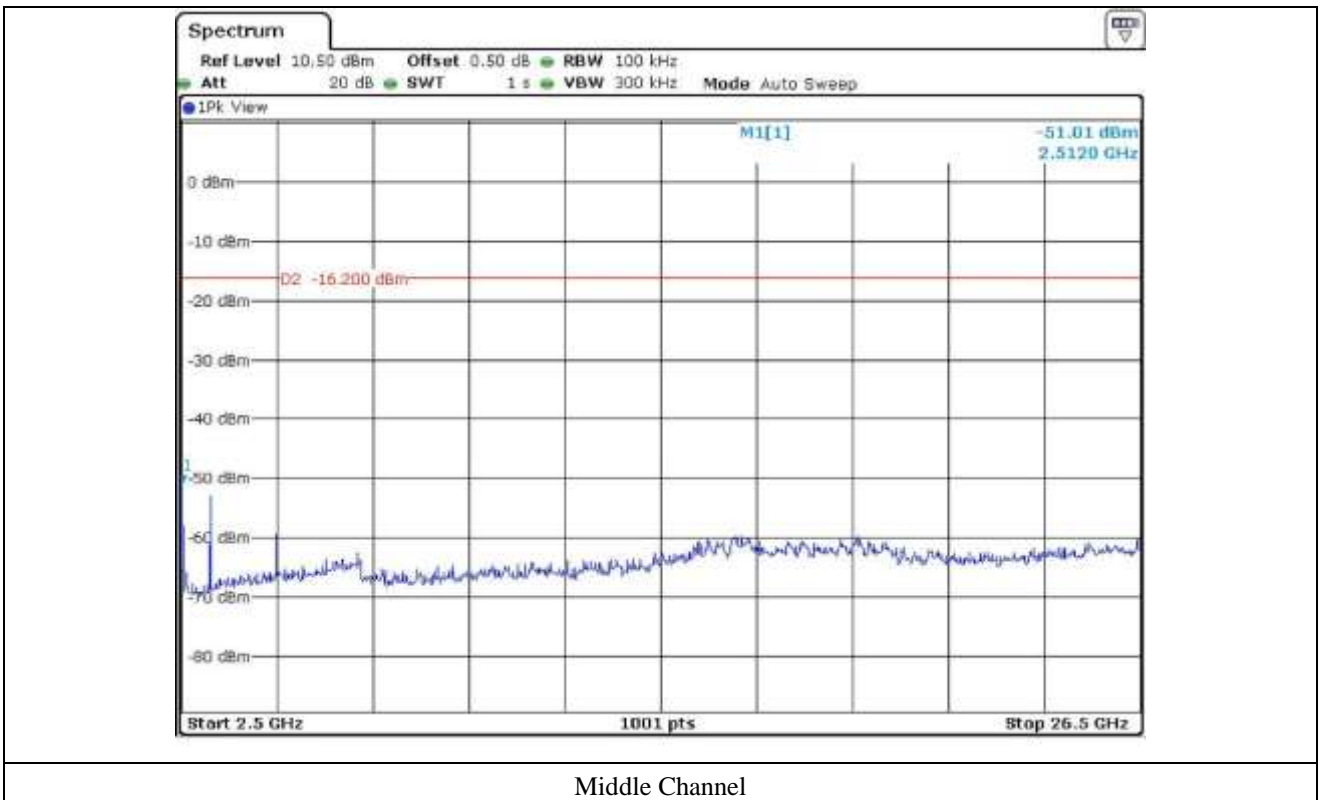
Low Channel

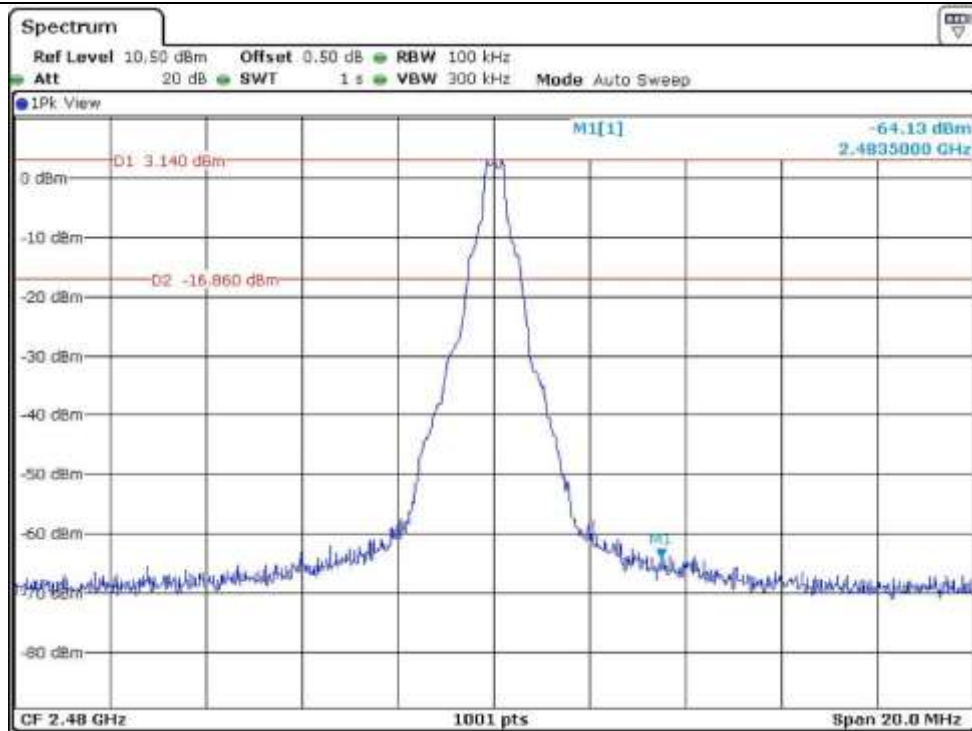


Middle Channel

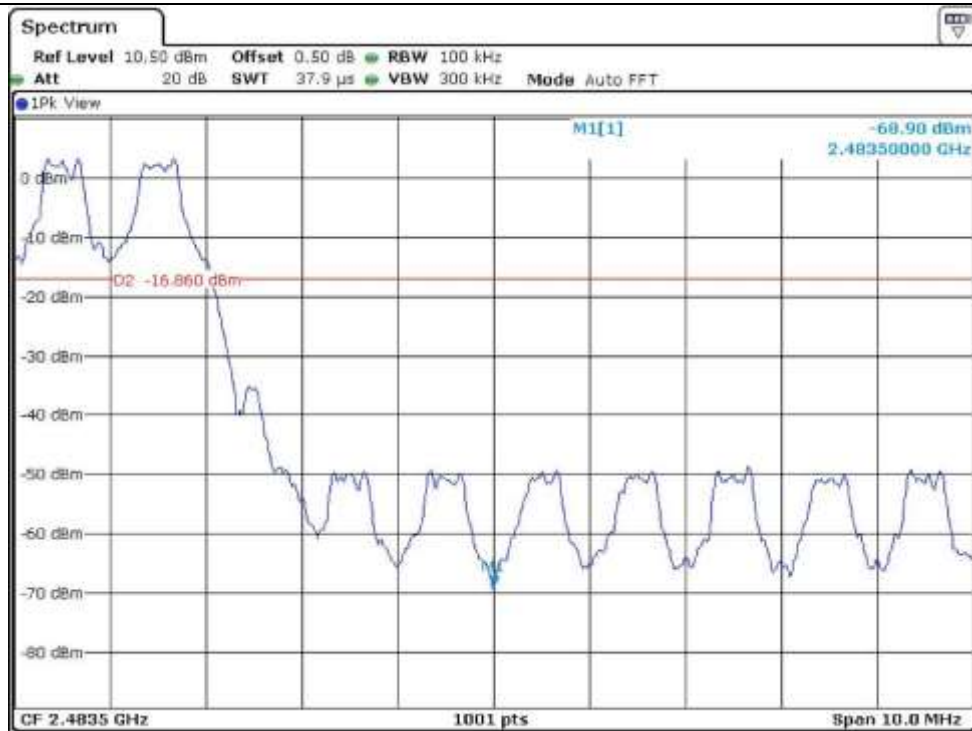


Middle Channel

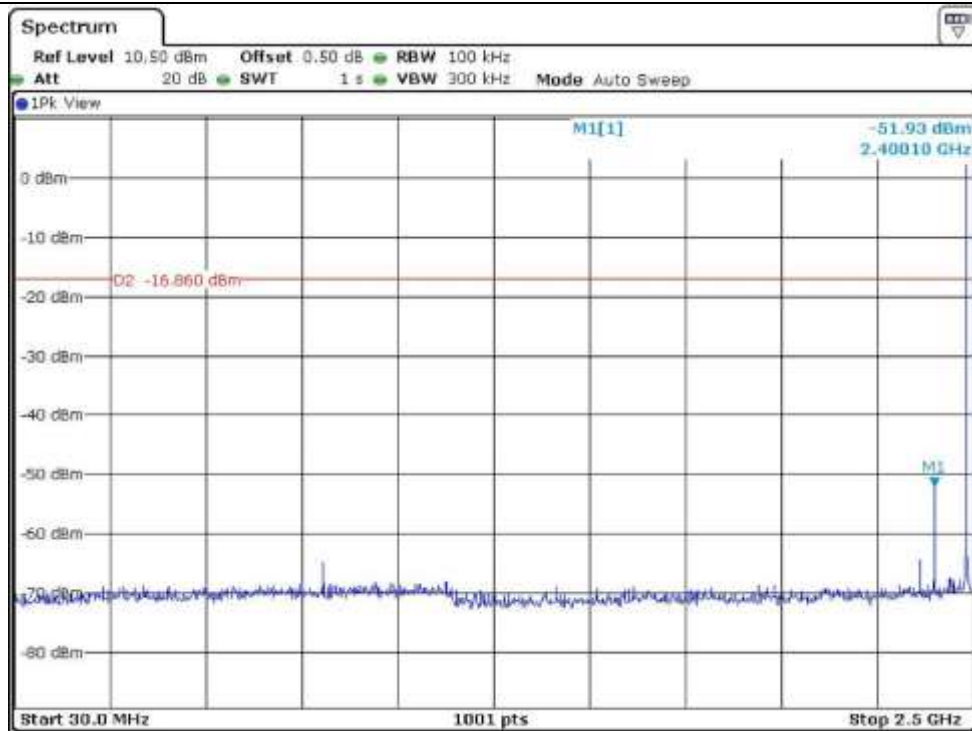




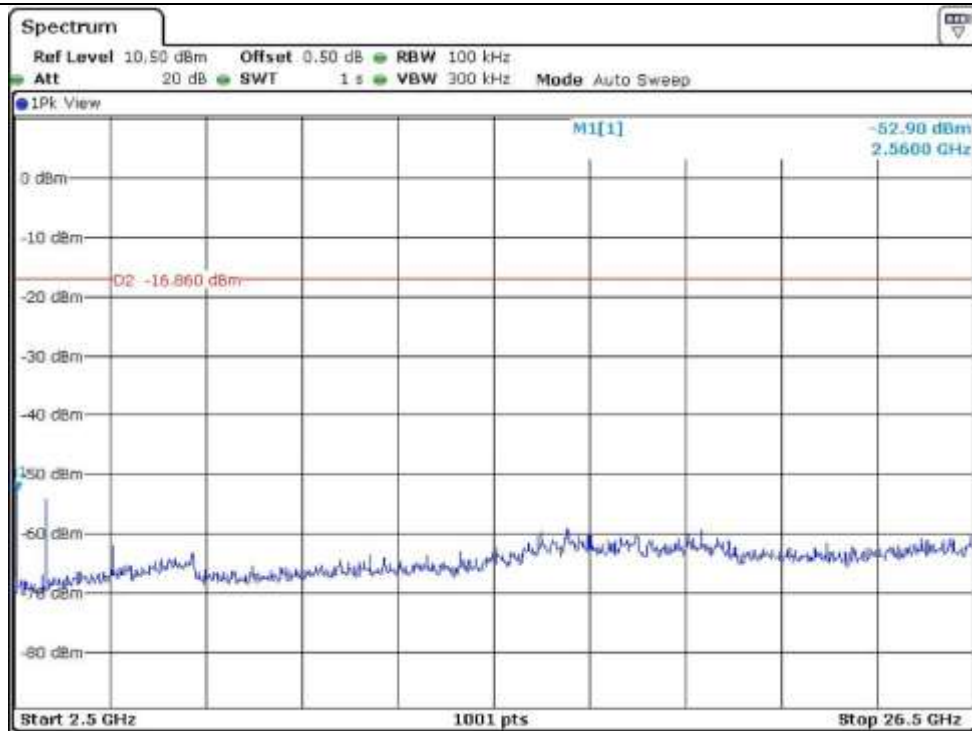
High Channel



High Channel

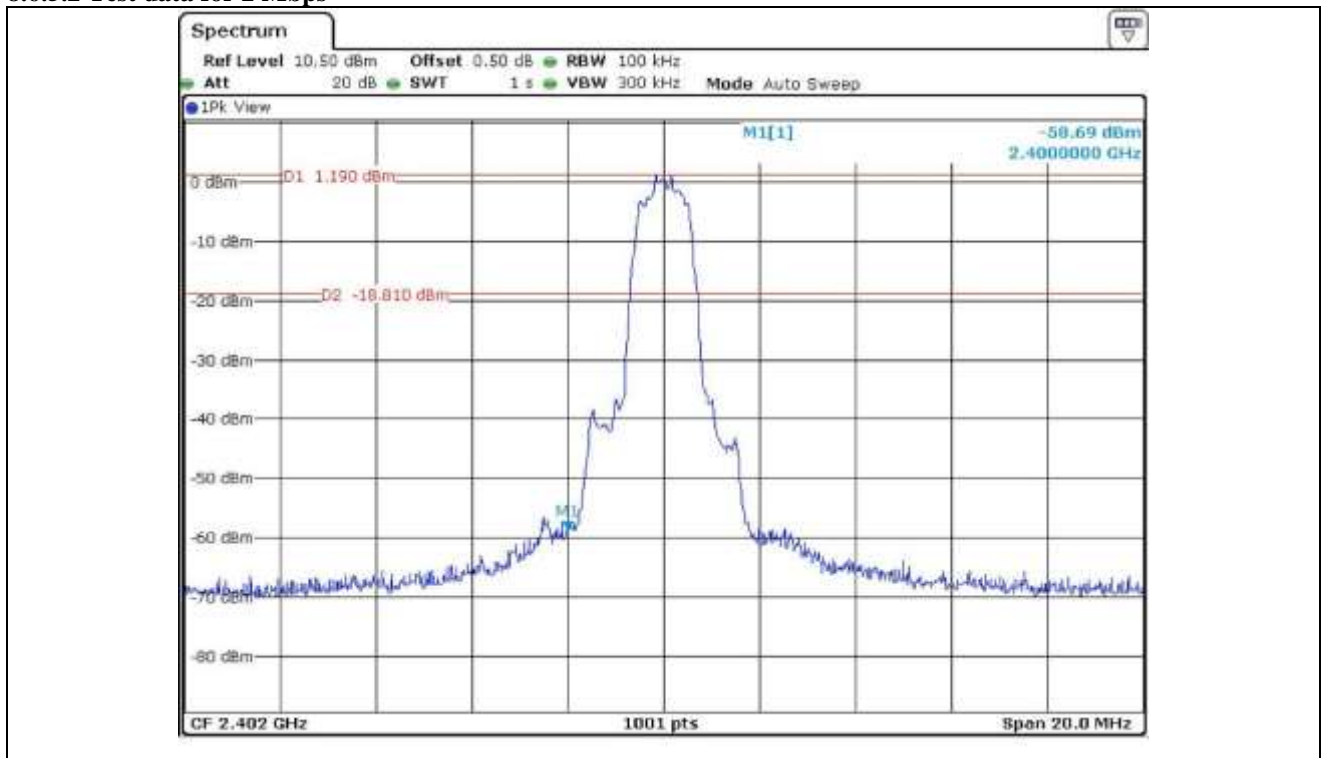


High Channel

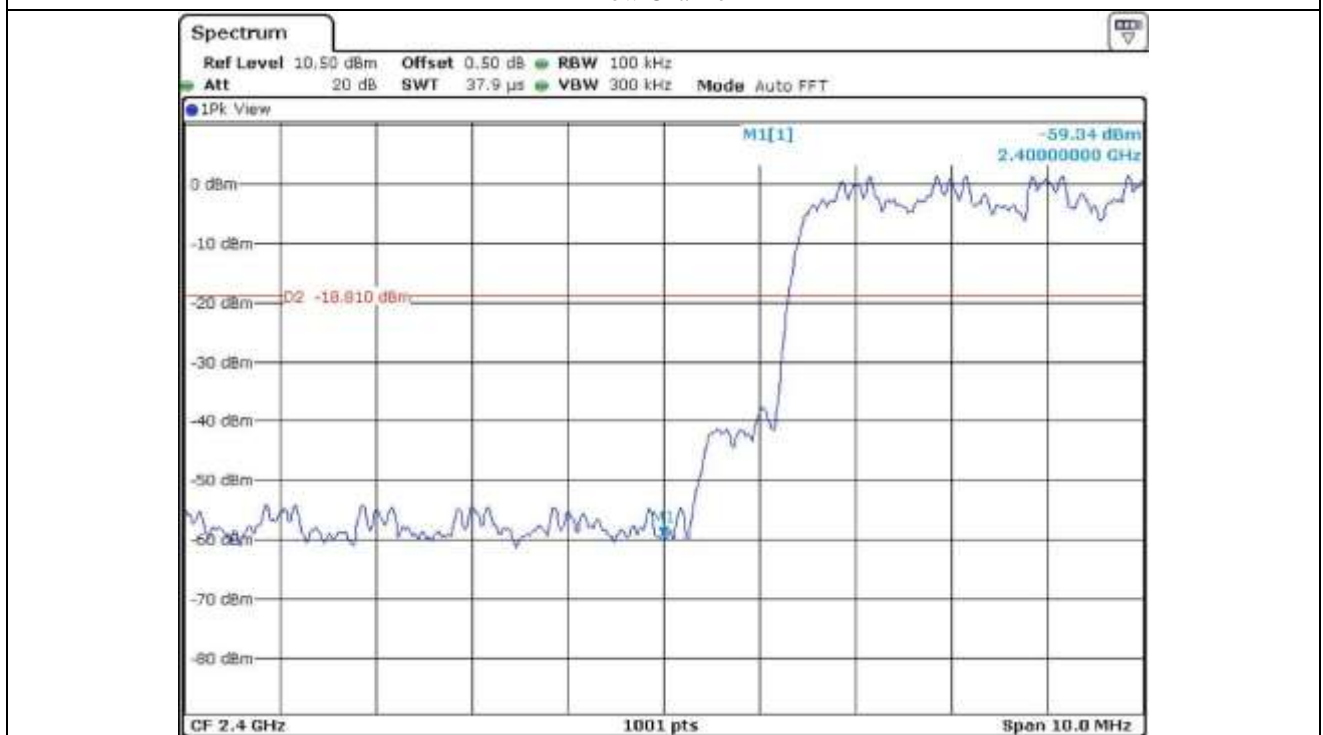


High Channel

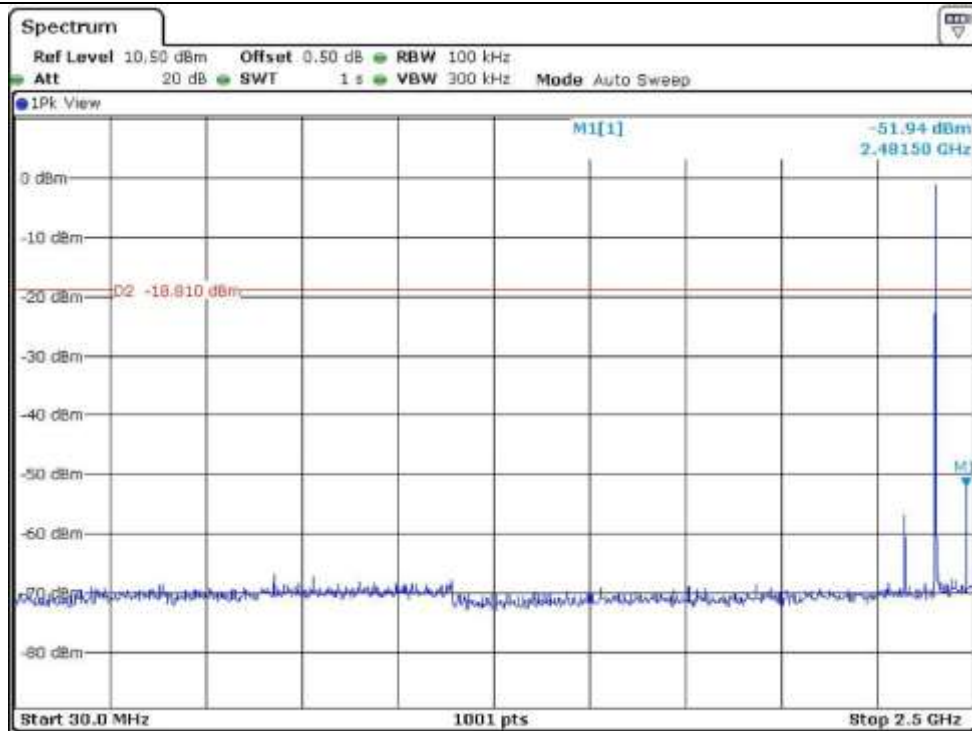
### 8.6.5.2 Test data for 2 Mbps



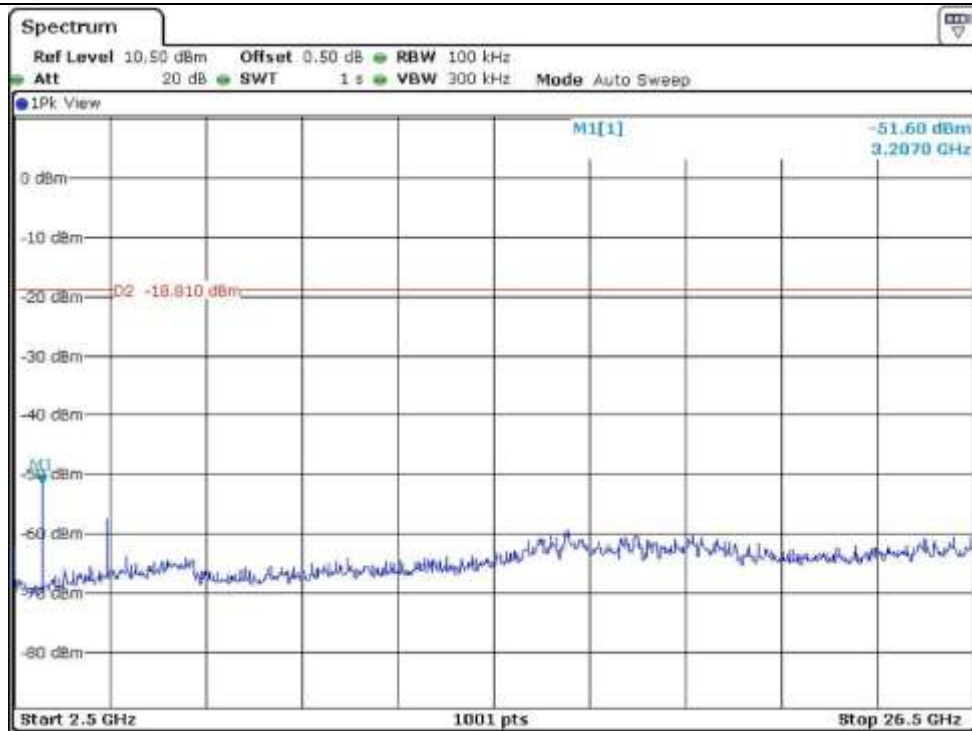
Low Channel



Low Channel

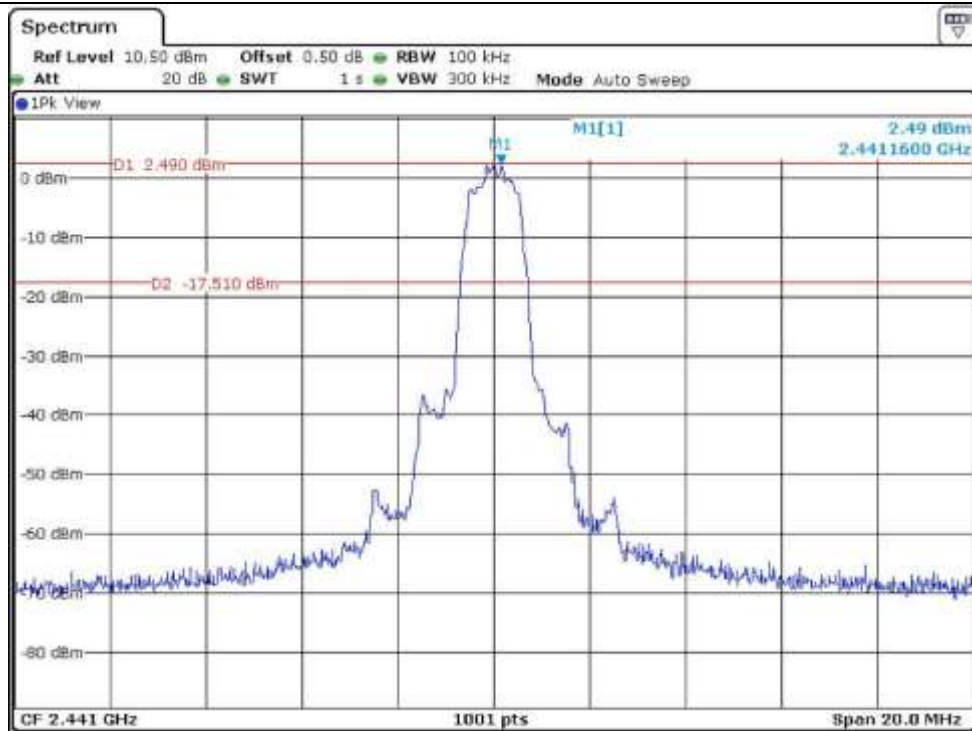


Low Channel

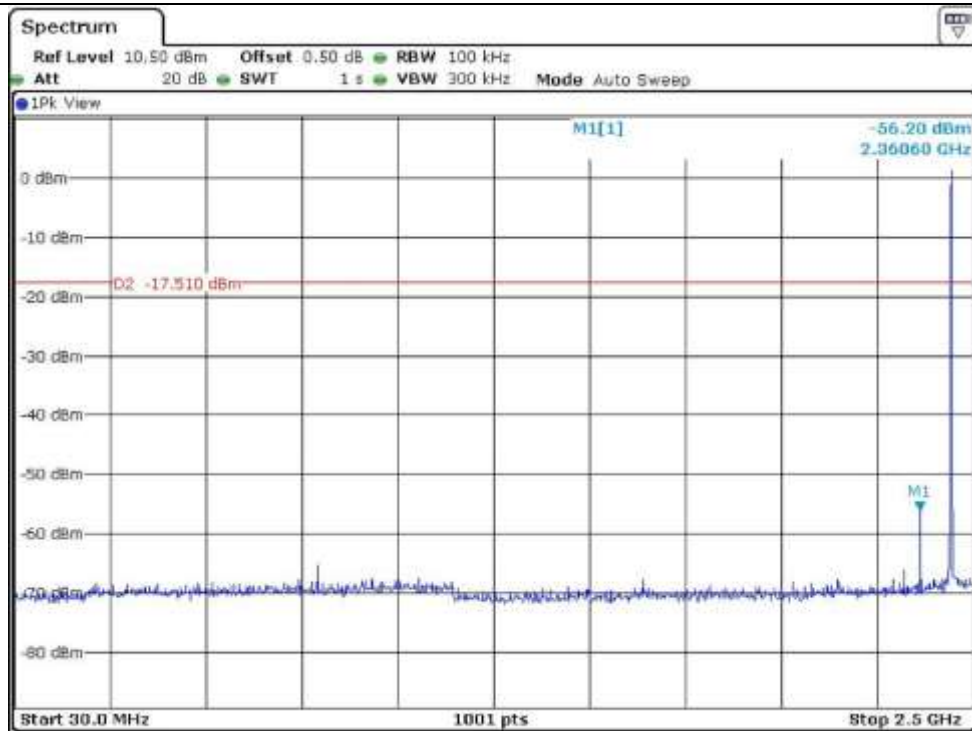


Low Channel



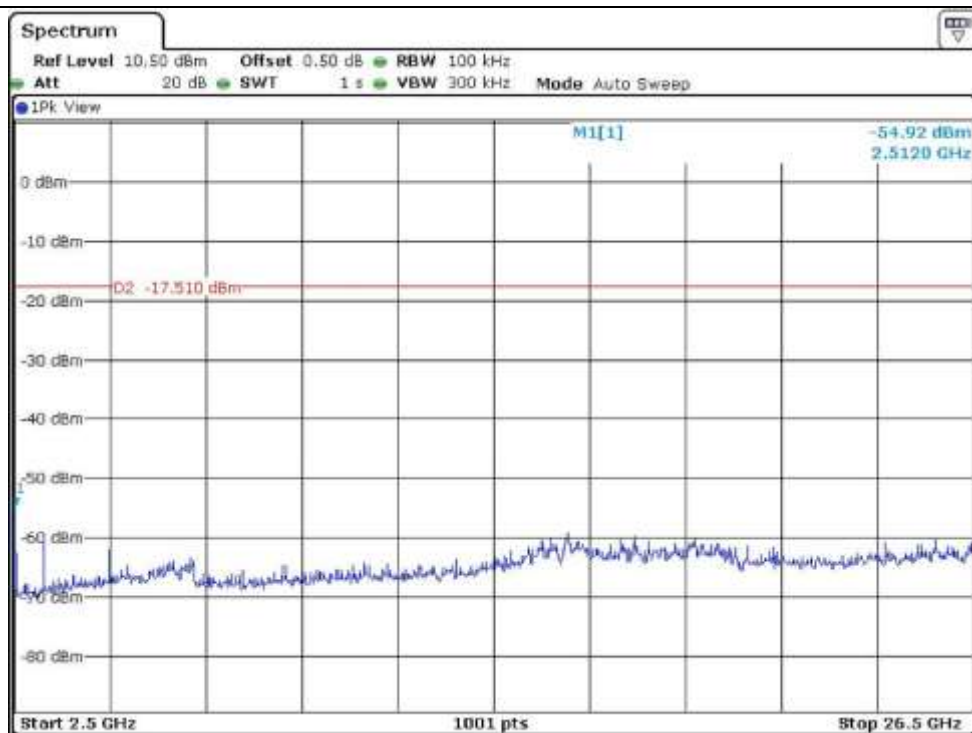


Middle Channel

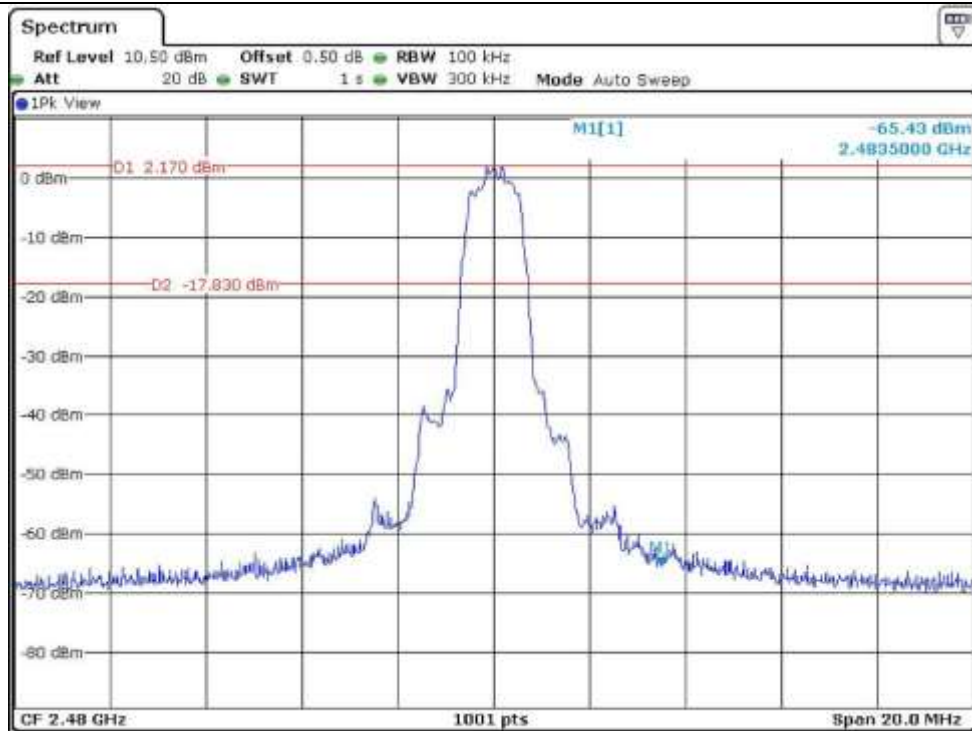


Middle Channel





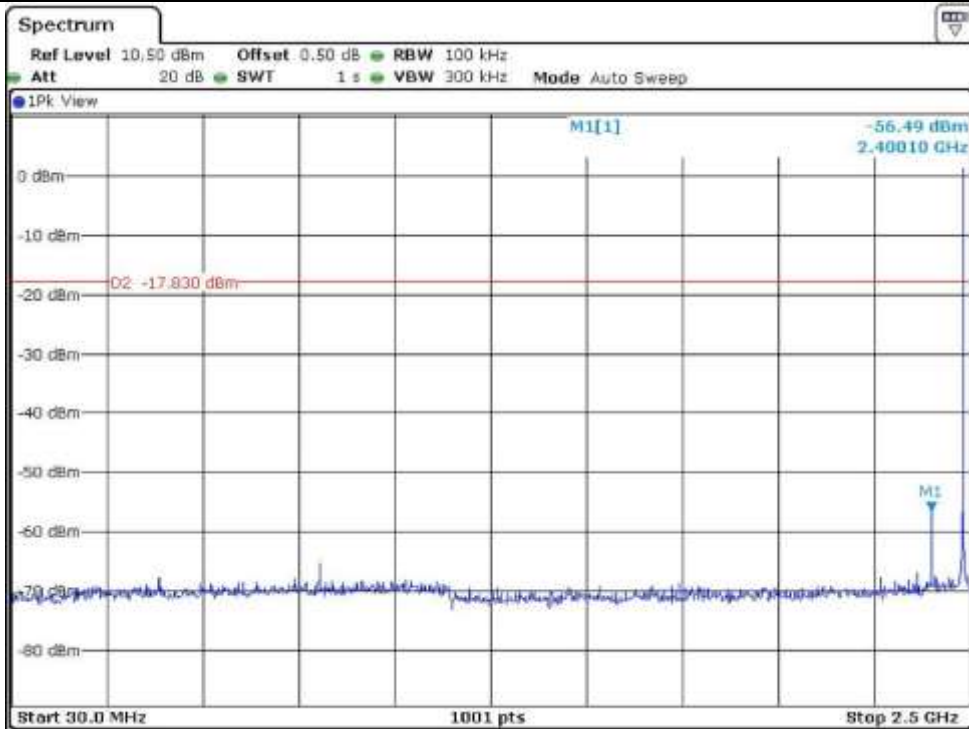
Middle Channel



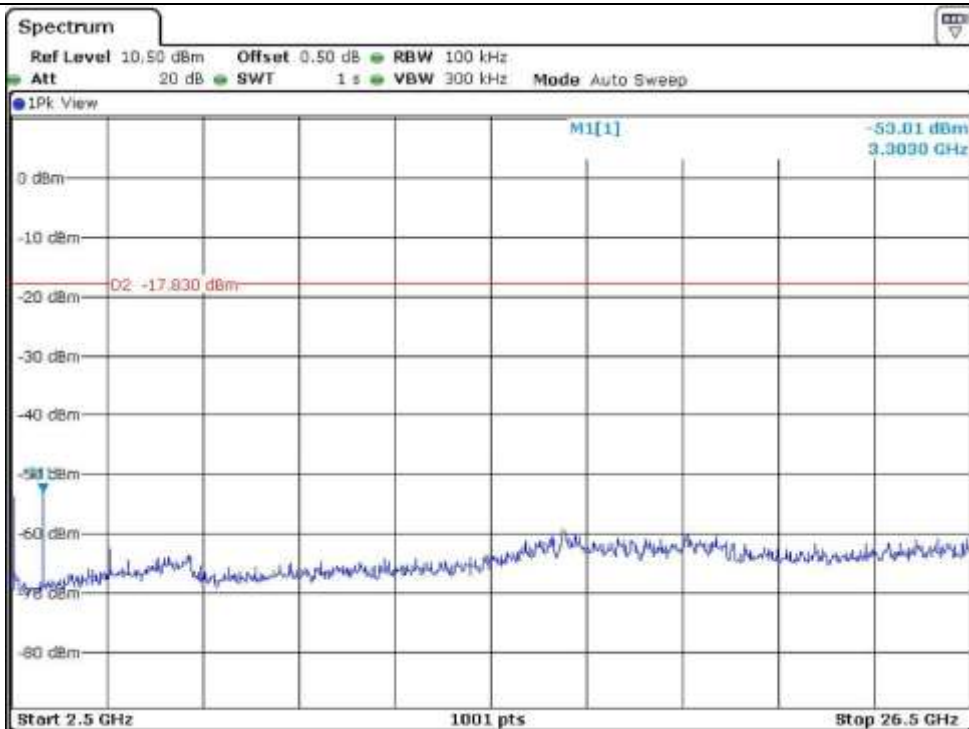
High Channel



High Channel

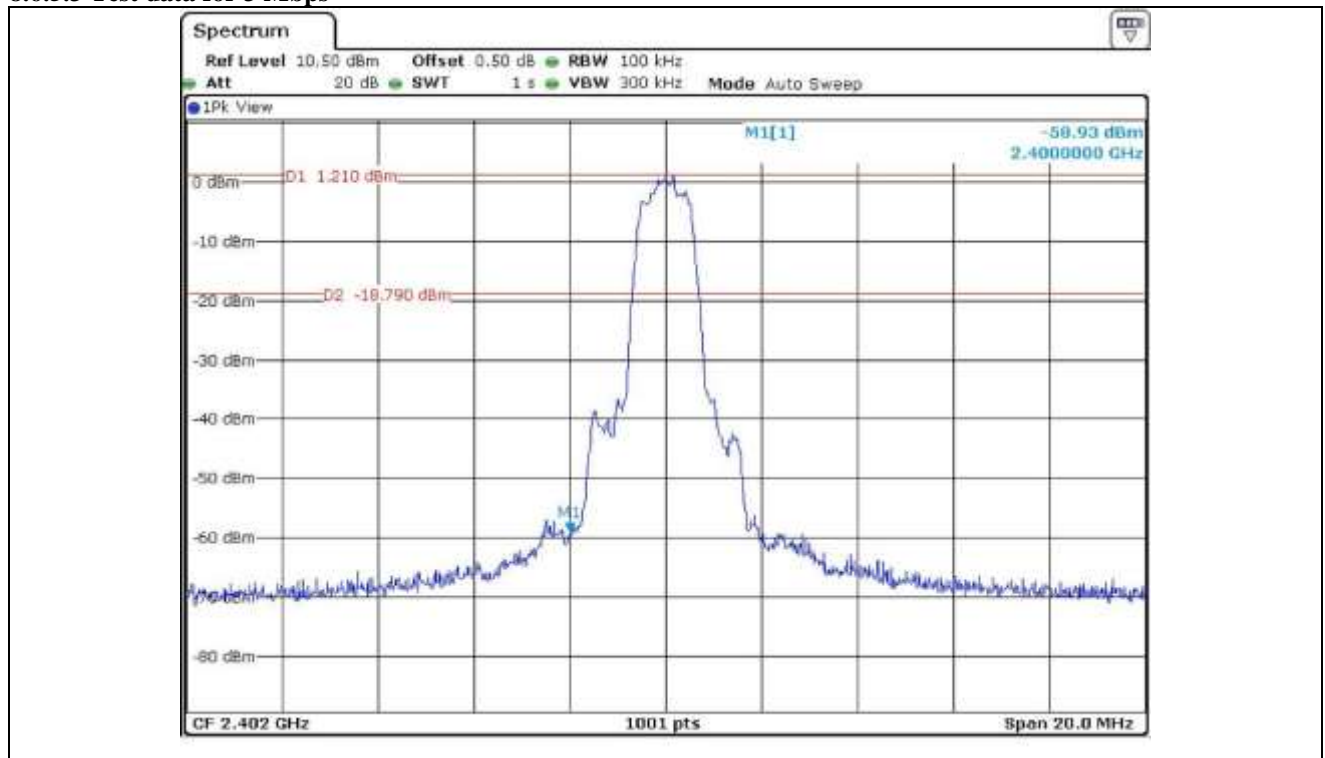


High Channel

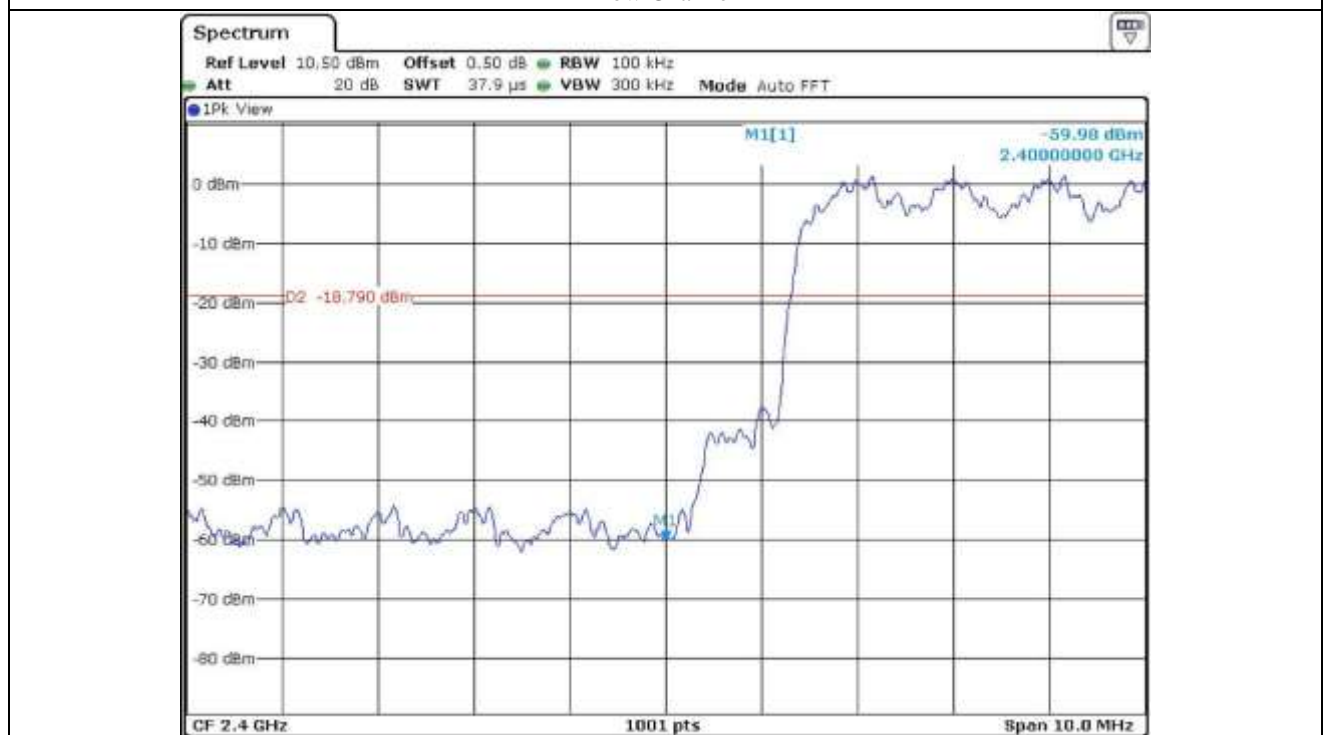


High Channel

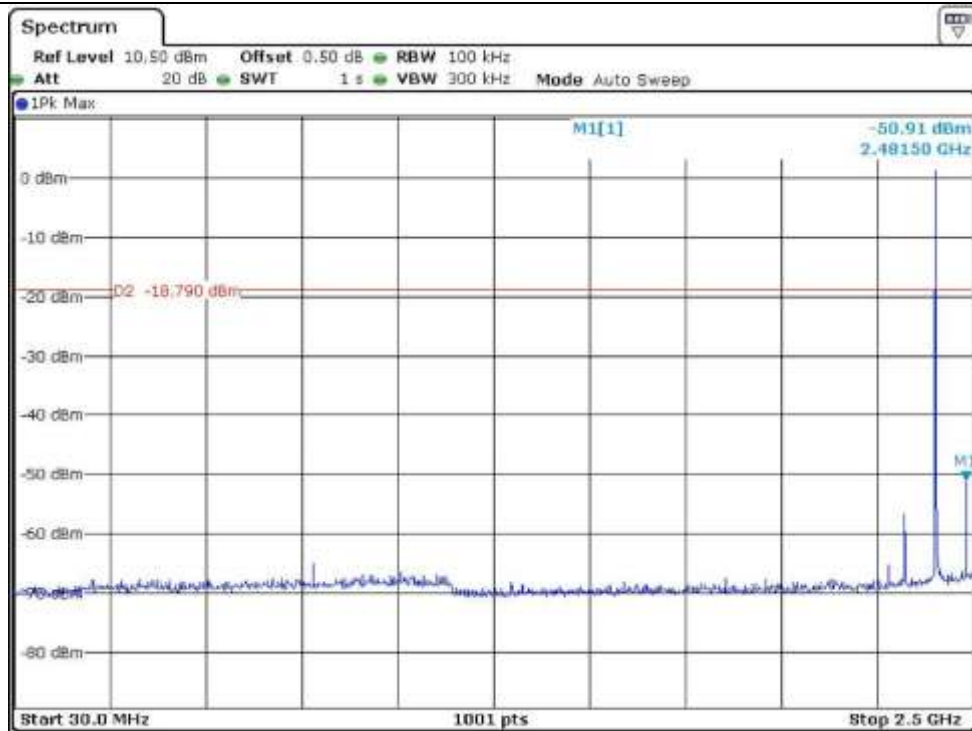
### 8.6.5.3 Test data for 3 Mbps



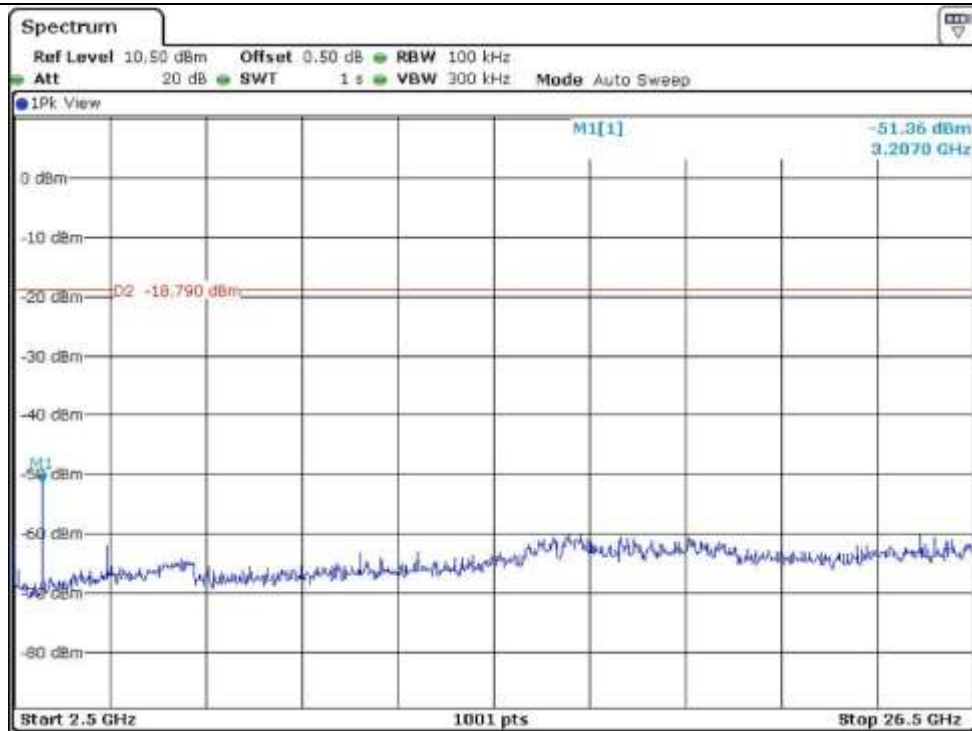
Low Channel



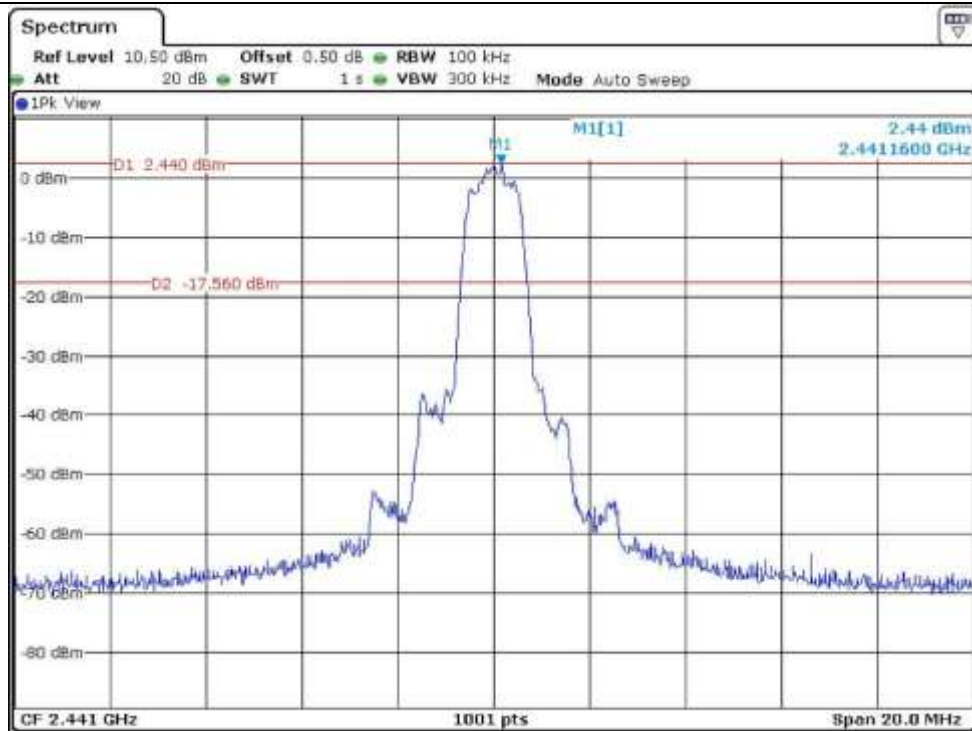
Low Channel



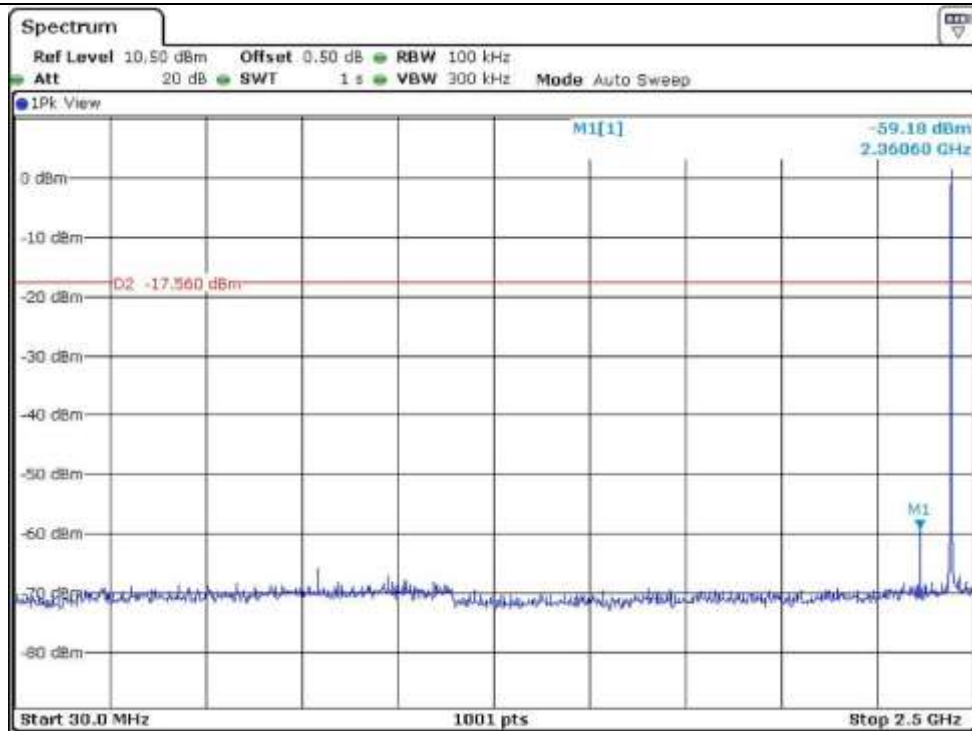
Low Channel



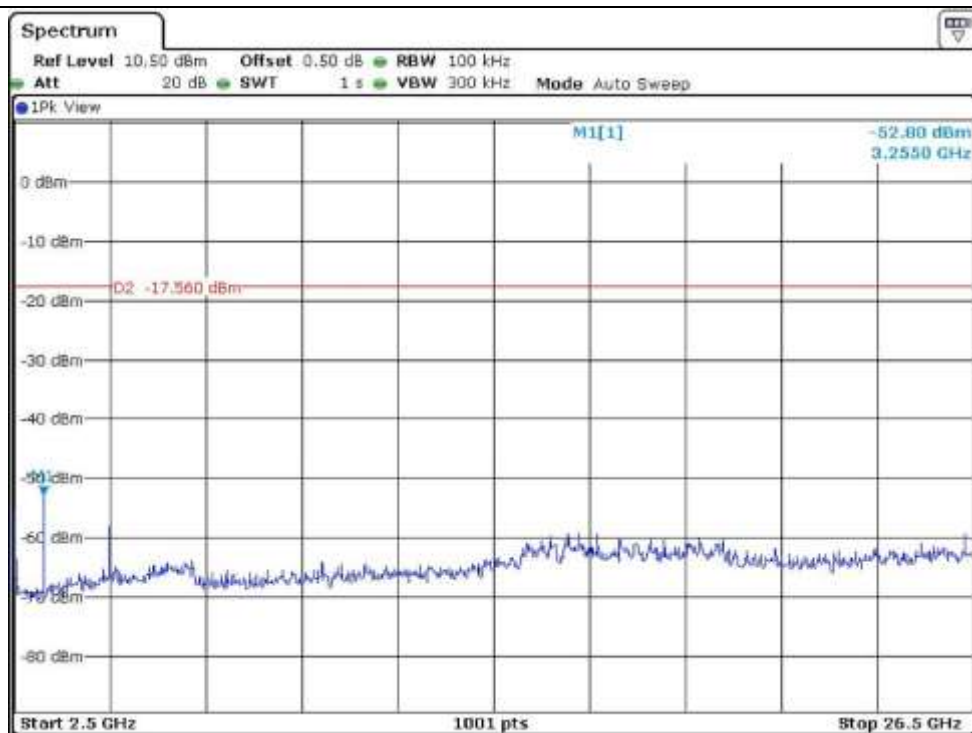
Low Channel



Middle Channel

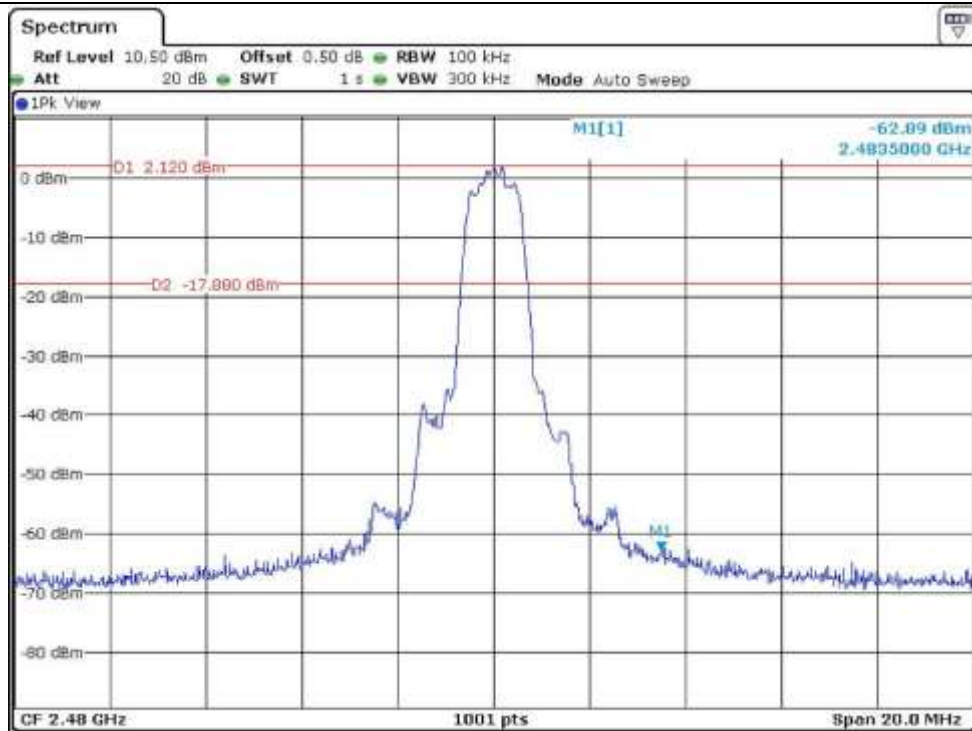


Middle Channel

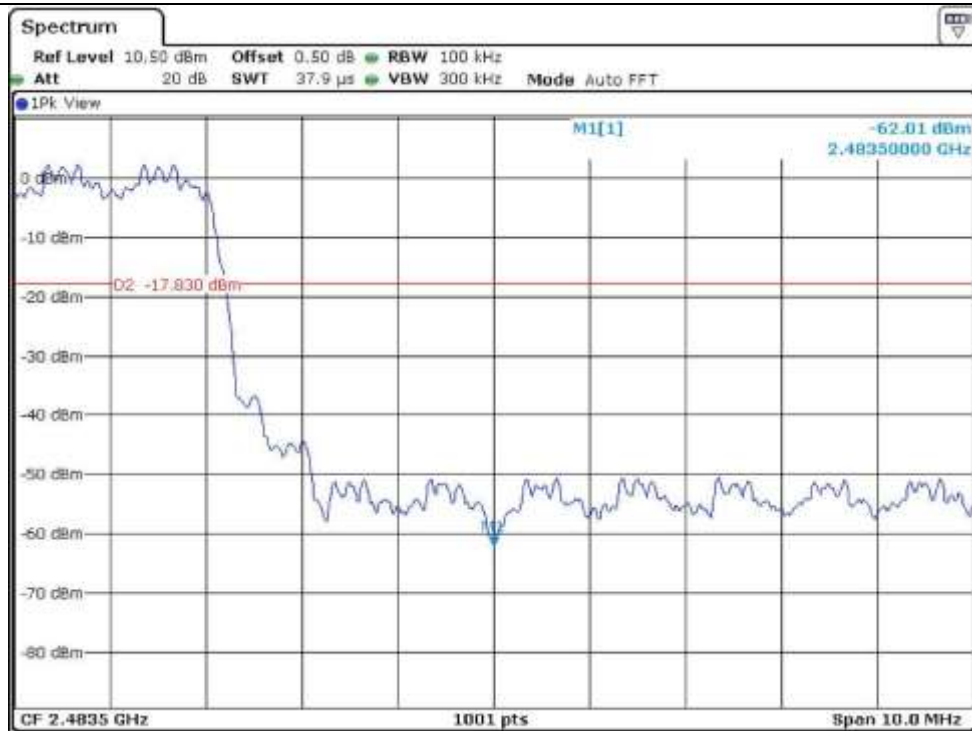


Middle Channel



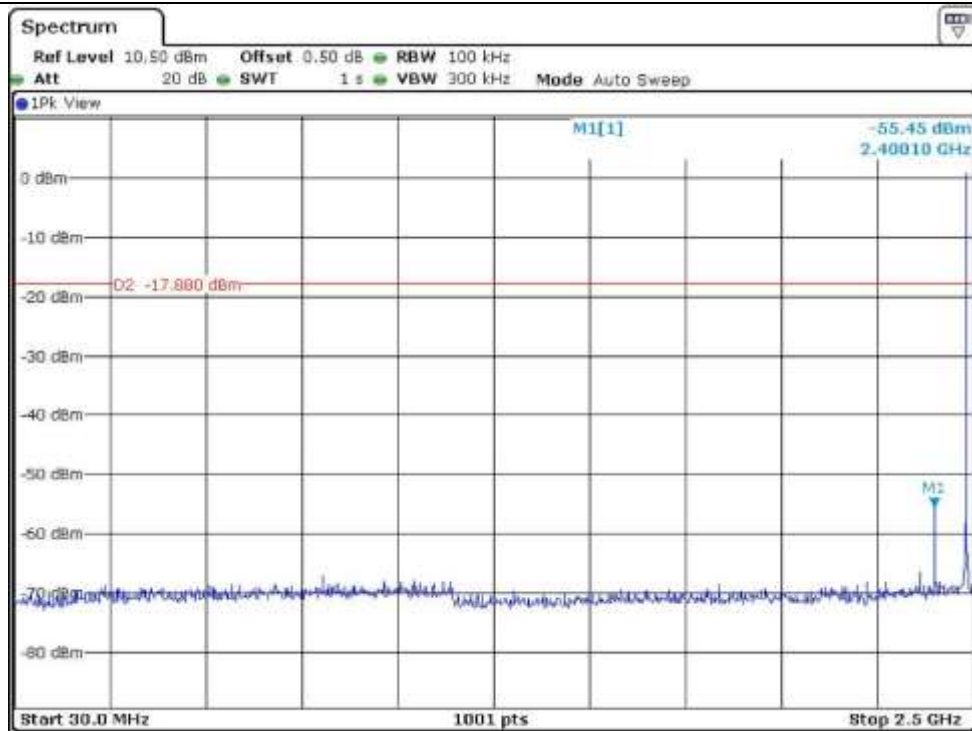


High Channel

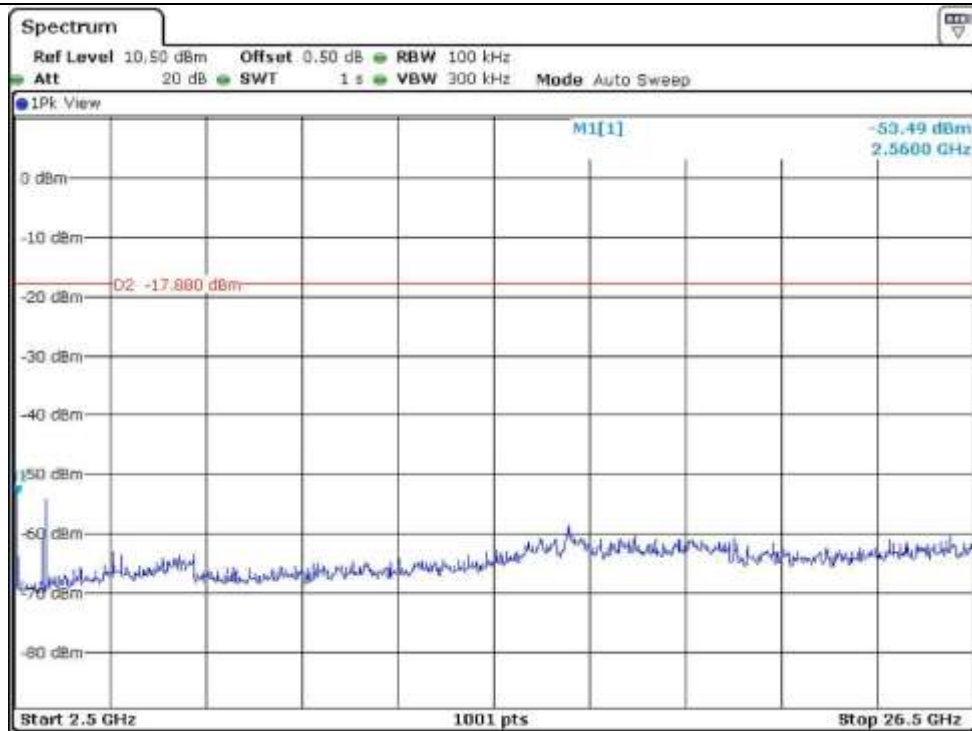


High Channel





High Channel



High Channel

## 7.6.6 Test data for Transmitting mode radiated emission

### 7.6.6.1 Radiated Emission which fall in the Restricted Band

#### 7.6.6.1.1 Test data for 1 Mbps

- Test Date : May 20, 2015
- Resolution bandwidth : 1 MHz for Peak and Average Mode
- Video bandwidth : 1 MHz for Peak Mode, 10 Hz for Average Mode
- Measurement distance : 3 m
- Operating Condition : Highest Output Power Transmitting Mode(Low Channel and High Channel)
- 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									
2 390.00	44.38	Peak	H	27.10	7.50	43.00	35.98	74.00	38.02
	34.51	Average	H				26.11	54.00	27.89
	44.41	Peak	V				36.01	74.00	37.99
	34.38	Average	V				25.98	54.00	28.02
Test Data for Low Channel									
2 400.00	48.97	Peak	H	27.10	7.50	43.00	40.57	74.00	33.43
	37.21	Average	H				28.81	54.00	25.19
	49.24	Peak	V				40.84	74.00	33.16
	37.33	Average	V				28.93	54.00	25.07
Test Data for High Channel									
2 483.50	44.53	Peak	H	27.10	7.50	43.00	36.13	74.00	37.87
	34.28	Average	H				25.88	54.00	28.12
	44.62	Peak	V				36.22	74.00	37.78
	34.33	Average	V				25.93	54.00	28.07

Tabulated test data for Restricted Band

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



Tested by: Tae-Ho, Kim / Project Engineer

### 7.6.6.1.2 Test data for 2 Mbps

- Test Date : May 20, 2015
- Resolution bandwidth : 1 MHz for Peak and Average Mode
- Video bandwidth : 1 MHz for Peak Mode, 10 Hz for Average Mode
- Measurement distance : 3 m
- Operating Condition : Highest Output Power Transmitting Mode(Low Channel and High Channel)
- 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									
2 390.00	44.25	Peak	H	27.10	7.50	43.00	35.85	74.00	38.15
	34.52	Average	H				26.12	54.00	27.88
	44.64	Peak	V				36.24	74.00	37.76
	34.62	Average	V				26.22	54.00	27.78
Test Data for Low Channel									
2 400.00	50.11	Peak	H	27.10	7.50	43.00	41.71	74.00	32.29
	38.68	Average	H				30.28	54.00	23.72
	49.51	Peak	V				41.11	74.00	32.89
	37.98	Average	V				29.58	54.00	24.42
Test Data for High Channel									
2 483.50	44.28	Peak	H	27.10	7.50	43.00	35.88	74.00	38.12
	34.54	Average	H				26.14	54.00	27.86
	44.84	Peak	V				36.44	74.00	37.56
	34.68	Average	V				26.28	54.00	27.72

Tabulated test data for Restricted Band

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



Tested by: Tae-Ho, Kim / Project Engineer

### 7.6.6.1.3 Test data for 3 Mbps

- Test Date : May 20, 2015
- Resolution bandwidth : 1 MHz for Peak and Average Mode
- Video bandwidth : 1 MHz for Peak Mode, 10 Hz for Average Mode
- Measurement distance : 3 m
- Operating Condition : Highest Output Power Transmitting Mode(Low Channel and High Channel)
- 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									
2 390.00	44.55	Peak	H	27.10	7.50	43.00	36.15	74.00	37.85
	34.58	Average	H				26.18	54.00	27.82
	44.47	Peak	V				36.07	74.00	37.93
	34.29	Average	V				25.89	54.00	28.11
Test Data for Low Channel									
2 400.00	50.07	Peak	H	27.10	7.50	43.00	41.67	74.00	32.33
	38.55	Average	H				30.15	54.00	23.85
	49.24	Peak	V				40.84	74.00	33.16
	37.25	Average	V				28.85	54.00	25.15
Test Data for High Channel									
2 483.50	44.63	Peak	H	27.10	7.50	43.00	36.23	74.00	37.77
	34.38	Average	H				25.98	54.00	28.02
	44.84	Peak	V				36.44	74.00	37.56
	34.56	Average	V				26.16	54.00	27.84

Tabulated test data for Restricted Band

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



Tested by: Tae-Ho, Kim / Project Engineer

## 7.6.6.2 Spurious & Harmonic Radiated Emission above 1 GHz

### 7.6.6.2.1 Test data for 1 Mbps

- . Test Date : May 20, 2015
- . Resolution bandwidth : 1 MHz for Peak and Average Mode for the emissions fall in restricted band,  
100 kHz for Peak Mode for the emissions outside restricted band
- . Video bandwidth : 1 MHz for Peak Mode, 10 Hz for Average Mode
- . Frequency range : 1 GHz ~ 26.5 GHz
- . Measurement distance : 3 m
- . Operating Condition : Highest Output Power Transmitting Mode
- . 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									
4 804.00	42.18	Peak	H	30.60	11.10	42.50	41.38	74.00	32.62
	34.28	Average	H				33.48	54.00	20.52
	42.31	Peak	V				41.51	74.00	32.49
	34.48	Average	V				33.68	54.00	20.32
Test Data for Middle Channel									
4 882.00	42.27	Peak	H	30.70	11.20	42.50	41.67	74.00	32.33
	34.39	Average	H				33.79	54.00	20.21
	42.33	Peak	V				41.73	74.00	32.27
	35.01	Average	V				34.41	54.00	19.59
Test Data for High Channel									
4 960.00	42.55	Peak	H	30.80	11.30	42.50	42.15	74.00	31.85
	34.40	Average	H				34.00	54.00	20.00
	42.32	Peak	V				41.92	74.00	32.08
	34.64	Average	V				34.24	54.00	19.76

Tabulated test data for Restricted Band

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



Tested by: Tae-Ho, Kim / Project Engineer

### 7.6.6.2.2 Test data for 2 Mbps

- Test Date : May 20, 2015
- Resolution bandwidth : 1 MHz for Peak and Average Mode for the emissions fall in restricted band,  
100 kHz for Peak Mode for the emissions outside restricted band
- Video bandwidth : 1 MHz for Peak Mode, 10 Hz for Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m
- Operating Condition : Highest Output Power Transmitting Mode
- 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									
4 804.00	42.64	Peak	H	30.60	11.10	42.50	41.84	74.00	32.16
	34.68	Average	H				33.88	54.00	20.12
	42.55	Peak	V				41.75	74.00	32.25
	34.51	Average	V				33.71	54.00	20.29
Test Data for Middle Channel									
4 882.00	43.05	Peak	H	30.70	11.20	42.50	42.45	74.00	31.55
	34.64	Average	H				34.04	54.00	19.96
	42.74	Peak	V				42.14	74.00	31.86
	34.51	Average	V				33.91	54.00	20.09
Test Data for High Channel									
4 960.00	43.55	Peak	H	30.80	11.30	42.50	43.15	74.00	30.85
	34.52	Average	H				34.12	54.00	19.88
	44.12	Peak	V				43.72	74.00	30.28
	34.58	Average	V				34.18	54.00	19.82

Tabulated test data for Restricted Band

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



Tested by: Tae-Ho, Kim / Project Engineer

### 7.6.6.2.3 Test data for 3 Mbps

- Test Date : May 20, 2015
- Resolution bandwidth : 1 MHz for Peak and Average Mode for the emissions fall in restricted band,  
100 kHz for Peak Mode for the emissions outside restricted band
- Video bandwidth : 1 MHz for Peak Mode, 10 Hz for Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m
- Operating Condition : Highest Output Power Transmitting Mode
- 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									
4 804.00	43.88	Peak	H	30.60	11.10	42.50	43.08	74.00	30.92
	34.62	Average	H				33.82	54.00	20.18
	43.58	Peak	V				42.78	74.00	31.22
	34.28	Average	V				33.48	54.00	20.52
Test Data for Middle Channel									
4 882.00	43.74	Peak	H	30.70	11.20	42.50	43.14	74.00	30.86
	34.50	Average	H				33.90	54.00	20.10
	43.28	Peak	V				42.68	74.00	31.32
	34.26	Average	V				33.66	54.00	20.34
Test Data for High Channel									
4 960.00	44.11	Peak	H	30.80	11.30	42.50	43.71	74.00	30.29
	34.58	Average	H				34.18	54.00	19.82
	43.84	Peak	V				43.44	74.00	30.56
	34.52	Average	V				34.12	54.00	19.88

Tabulated test data for Restricted Band

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



Tested by: Tae-Ho, Kim / Project Engineer

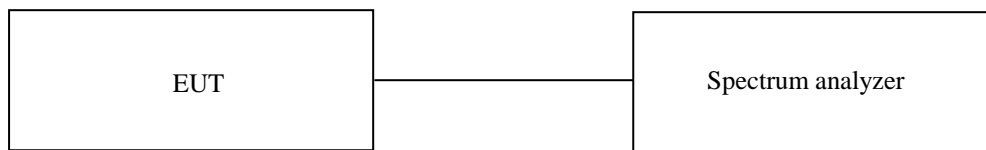
## 7.7 SPURIOUS EMISSION - RECEIVER

### 7.7.1 Operating environment

Temperature : 21.4 °C  
Relative humidity : 45 % R.H.

### 7.7.2 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.



### 7.7.3 Test set-up for radiated measurement

The radiated emissions measurements were on the 3 m, open-field test site. 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.

### 7.7.4 Test equipment used

	Model Number	Manufacturer	Description	Serial Number	Last Cal.(Interval)
■ -	FSV40	Rohde & Schwarz	Signal Analyzer	101009	Jul. 30, 2014 (1Y)
■ -	ESCI	Rohde & Schwarz	Test Receiver	101012	Nov. 03, 2014 (1Y)
■ -	310N	Sonoma Instrument	Pre-Amplifier	312544	Apr. 29, 2015 (1Y)
■ -	SCU-18	Rohde & Schwarz	Pre-Amplifier	10041	Nov. 25, 2014 (1Y)
■ -	DT3000	Innco System	Turn Table	930611	N/A
■ -	MA4000-EP	Innco System	Antenna Master	3320611	N/A
■ -	VULB9163	Schwarzbeck	TRILOG Broadband Antenna	9163-421	Jul. 10, 2014 (2Y)
■ -	BBHA9120D	Schwarzbeck	Horn Antenna	BBHA9120D295	Sep. 05, 2013 (2Y)
■ -	BBHA9170	Schwarzbeck	Horn Antenna	BBHA9170178	Apr. 30, 2015 (2Y)

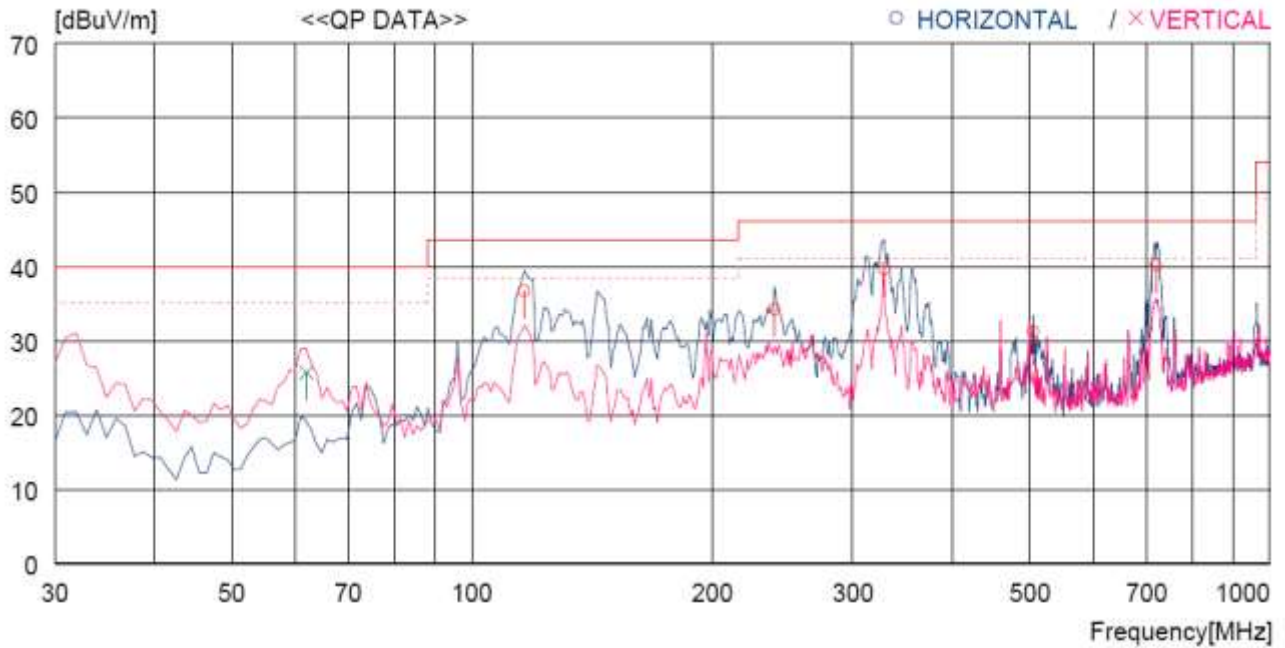
All test equipment used is calibrated on a regular basis.



## 7.7.5 Test data for 1 Mbps

### 7.7.5.1 Test data for 30 MHz ~ 1 000 MHz

- Test Date : May 20, 2015
- Resolution bandwidth : 120 kHz
- Frequency range : 30 MHz ~ 1 000 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	116.330	55.6	11.9	2.3	33.1	36.7	43.5	6.8	300	359
2	239.520	50.7	13.3	3.2	33.0	34.2	46.0	11.8	100	359
3	328.760	53.4	15.4	3.8	33.0	39.6	46.0	6.4	100	53
4	505.301	41.1	18.5	4.7	33.1	31.2	46.0	14.8	200	0
5	719.664	46.8	21.0	5.6	33.3	40.1	46.0	5.9	100	138
----- Vertical -----										
6	62.010	43.8	13.3	1.7	33.1	25.7	40.0	14.3	100	0

Tested by: Tae-Ho, Kim / Project Engineer

### 7.7.5.2 Test data for Below 30 MHz

- . Test Date : May 20, 2015
- . 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.								

### 7.7.5.3 Test data for above 1 GHz

- . Test Date : May 20, 2015
- . 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.								

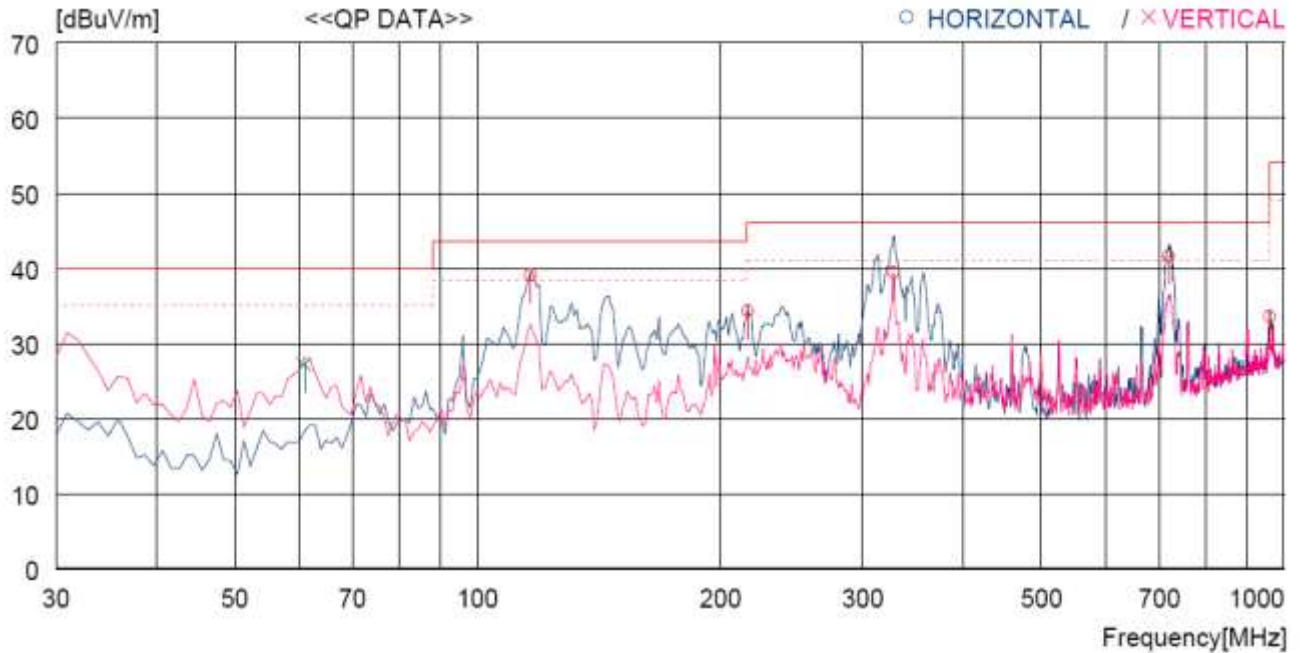


Tested by: Tae-Ho, Kim / Project Engineer

## 7.7.6 Test data for 2 Mbps

### 7.7.6.1 Test data for 30 MHz ~ 1 000 MHz

- Test Date : May 20, 2015
- Resolution bandwidth : 120 kHz
- Frequency range : 30 MHz ~ 1 000 MHz
- Measurement distance : 3 m



No.	FREQ	READING	ANT	LOSS	GAIN	RESULT	LIMIT	MARGIN	ANTENNA	TABLE
	[MHz]	QP	FACTOR	[dB]	[dB]	[dBuV/m]	[dBuV/m]	[dB]	[cm]	[DEG]
		[dBuV]	[dB]							
----- Horizontal -----										
1	116.330	58.3	10.6	3.3	33.1	39.1	43.5	4.4	200	165
2	216.240	52.0	11.3	3.9	32.9	34.3	46.0	11.7	100	359
3	327.790	53.3	14.2	4.8	32.9	39.4	46.0	6.6	100	359
4	719.664	47.5	19.9	7.4	33.2	41.6	46.0	4.4	100	131
5	959.247	34.3	22.5	8.7	31.9	33.6	46.0	12.4	100	12
----- Vertical -----										
6	61.040	45.2	12.9	2.2	33.1	27.2	40.0	12.8	100	116

Tested by: Tae-Ho, Kim / Project Engineer

### 7.7.6.2 Test data for Below 30 MHz

- . Test Date : May 20, 2015
- . 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.								

### 7.7.6.3 Test data for above 1 GHz

- . Test Date : May 20, 2015
- . 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.								

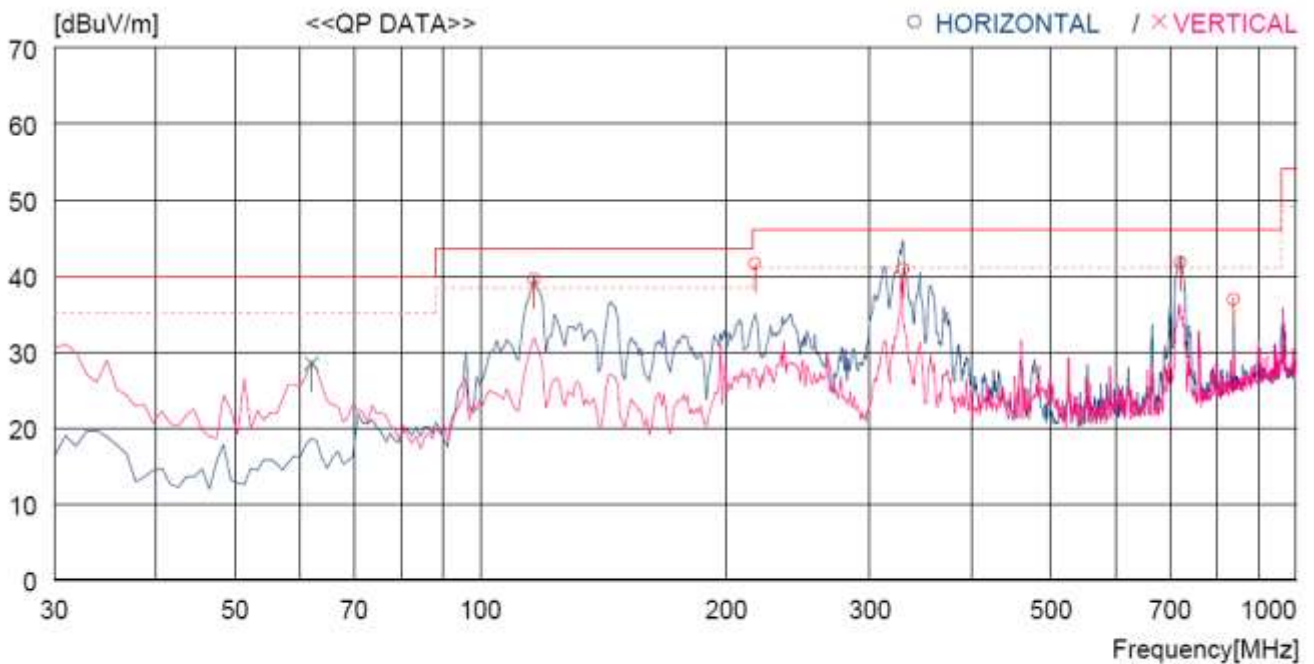


Tested by: Tae-Ho, Kim / Project Engineer

### 7.7.7 Test data for 3 Mbps

#### 7.7.7.1 Test data for 30 MHz ~ 1 000 MHz

- Test Date : May 20, 2015
- Resolution bandwidth : 120 kHz
- Frequency range : 30 MHz ~ 1 000 MHz
- Measurement distance : 3 m



No.	FREQ	READING	ANT	LOSS	GAIN	RESULT	LIMIT	MARGIN	ANTENNA	TABLE
	[MHz]	QP	FACTOR	[dB]	[dB]	[dBuV/m]	[dBuV/m]	[dB]	[cm]	[DEG]
----- Horizontal -----										
1	116.330	58.7	10.6	3.3	33.1	39.5	43.5	4.0	300	166
2	217.210	59.3	11.3	3.9	32.9	41.6	46.0	4.4	100	180
3	329.730	54.6	14.3	4.8	32.9	40.8	46.0	5.2	100	359
4	720.634	47.6	19.9	7.4	33.2	41.7	46.0	4.3	100	116
5	838.001	40.2	21.4	8.1	32.8	36.9	46.0	9.1	200	5
----- Vertical -----										
6	62.010	46.7	12.6	2.2	33.1	28.4	40.0	11.6	100	0

Tested by: Tae-Ho, Kim / Project Engineer

### 7.7.7.2 Test data for Below 30 MHz

- . Test Date : May 20, 2015
- . 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.								

### 7.7.7.3 Test data for above 1 GHz

- . Test Date : May 20, 2015
- . 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: Tae-Ho, Kim / Project Engineer

## 7.8 RADIATED EMISSION TEST

### 7.8.1 Operating environment

Temperature : 21.6 °C  
Relative humidity : 43.0 % R.H.

### 7.8.2 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.

### 7.8.3 Test equipment used

Model Number	Manufacturer	Description	Serial Number	Last Cal.(Interval)
■ - FSV40	Rohde & Schwarz	Signal Analyzer	101009	Jul. 30, 2014 (1Y)
■ - ESCI	Rohde & Schwarz	Test Receiver	101012	Nov. 03, 2014 (1Y)
■ - 310N	Sonoma Instrument	Pre-Amplifier	312544	Apr. 29, 2015 (1Y)
■ - SCU-18	Rohde & Schwarz	Pre-Amplifier	10041	Nov. 25, 2014 (1Y)
■ - DT3000	Innco System	Turn Table	930611	N/A
■ - MA4000-EP	Innco System	Antenna Master	3320611	N/A
■ - VULB9163	Schwarzbeck	TRILOG Broadband Antenna	9163-421	Jul. 10, 2014 (2Y)
■ - BBHA9120D	Schwarzbeck	Horn Antenna	BBHA9120D295	Sep. 05, 2013 (2Y)
■ - BBHA9170	Schwarzbeck	Horn Antenna	BBHA9170178	Apr. 30, 2015 (2Y)

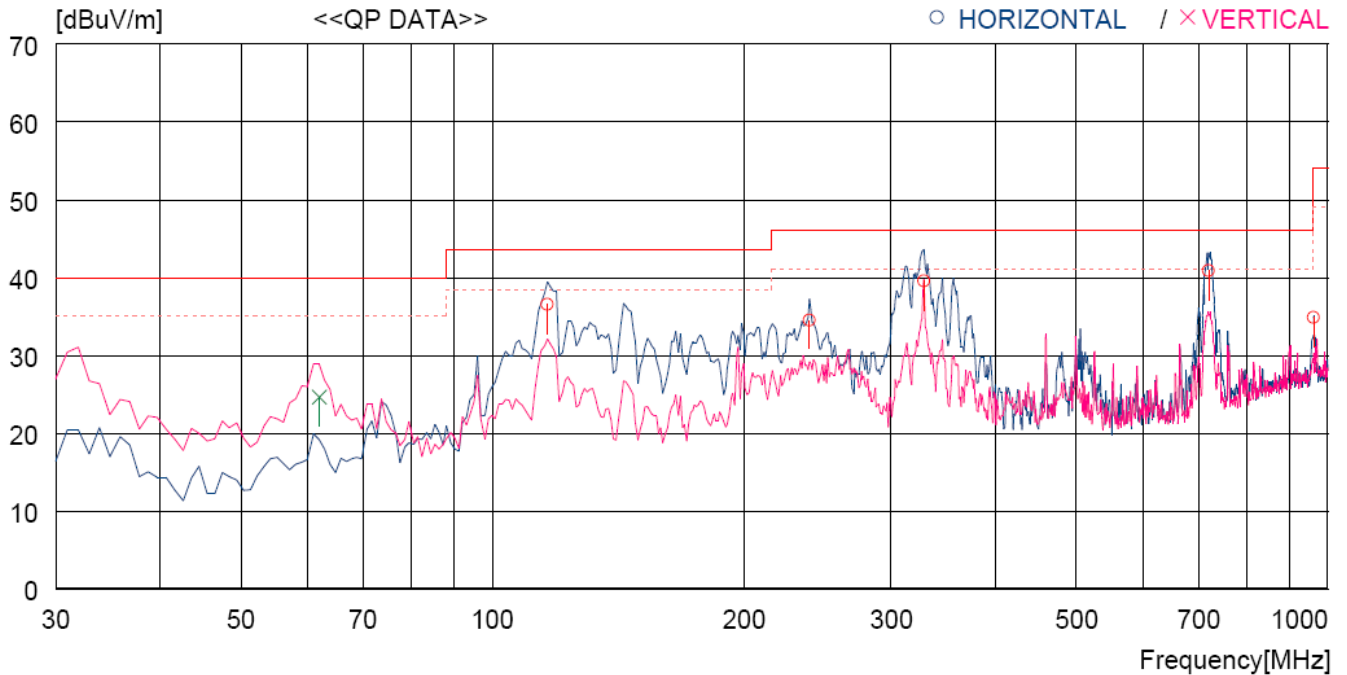
All test equipment used is calibrated on a regular basis.



## 7.8.5 Test data for 1 Mbps

### 7.8.5.1 Test data for 30 MHz ~ 1 000 MHz

- Test Date : May 20, 2015
- Resolution bandwidth : 120 kHz
- Frequency range : 30 MHz ~ 1 000 MHz
- Measurement distance : 3 m



No.	FREQ	READING	ANT	LOSS	GAIN	RESULT	LIMIT	MARGIN	ANTENNA	TABLE
	[MHz]	QP	FACTOR	[dB]	[dB]	[dBuV/m]	[dBuV/m]	[dB]	[cm]	[DEG]
----- Horizontal -----										
1	116.330	55.4	11.9	2.3	33.1	36.5	43.5	7.0	300	359
2	239.520	51.0	13.3	3.2	33.0	34.5	46.0	11.5	100	359
3	328.760	53.3	15.4	3.8	33.0	39.5	46.0	6.5	100	53
4	719.664	47.5	21.0	5.6	33.3	40.8	46.0	5.2	100	138
5	961.187	36.4	23.8	6.5	31.9	34.8	54.0	19.2	100	327
----- Vertical -----										
6	62.010	42.7	13.3	1.7	33.1	24.6	40.0	15.4	100	0

Tested by: Tae-Ho, Kim / Project Engineer



### 7.8.5.2 Test data for Below 30 MHz

- . Test Date : May 20, 2015
- . 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.								

### 7.8.5.3 Test data for above 1 GHz

- . Test Date : May 20, 2015
- . 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.								

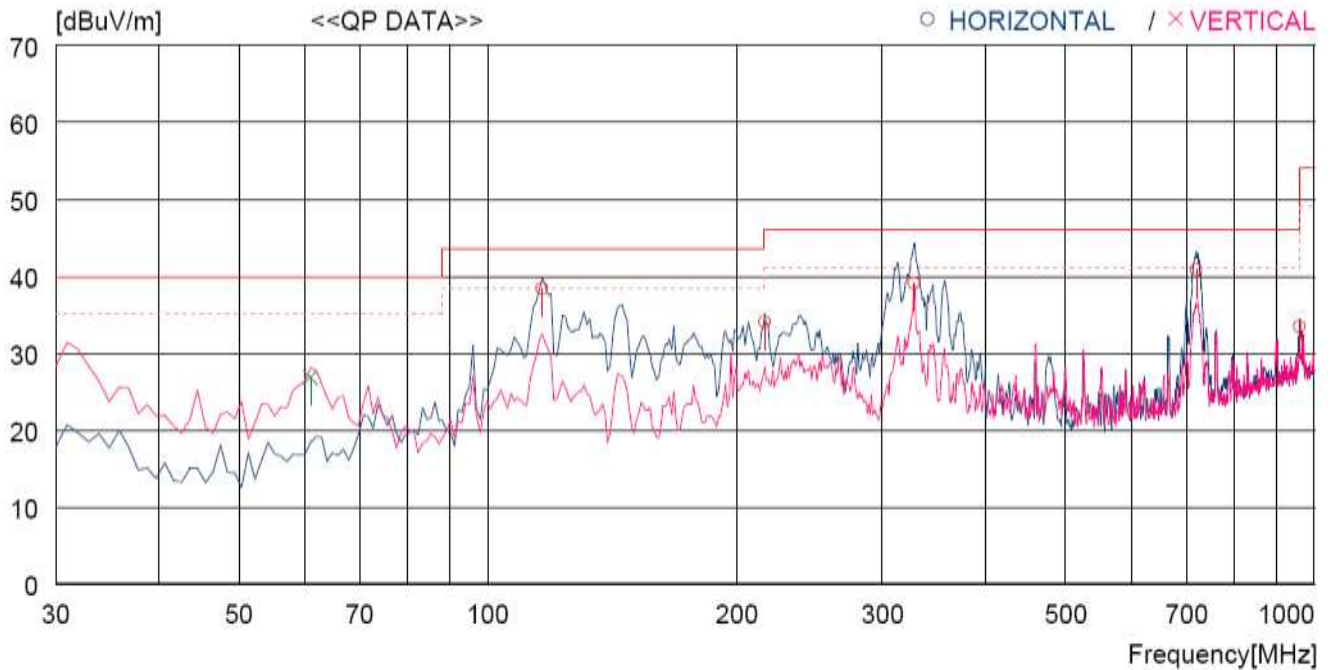


Tested by: Tae-Ho, Kim / Project Engineer

## 7.8.6 Test data for 2 Mbps

### 7.8.6.1 Test data for 30 MHz ~ 1 000 MHz

- Test Date : May 20, 2015
- Resolution bandwidth : 120 kHz
- Frequency range : 30 MHz ~ 1 000 MHz
- Measurement distance : 3 m



No.	FREQ	READING	ANT	LOSS	GAIN	RESULT	LIMIT	MARGIN	ANTENNA	TABLE
	[MHz]	[dBuV]	FACTOR	[dB]	[dB]	[dBuV/m]	[dBuV/m]	[dB]	[cm]	[DEG]
----- Horizontal -----										
1	116.330	57.6	10.6	3.3	33.1	38.4	43.5	5.1	200	165
2	216.240	51.7	11.3	3.9	32.9	34.0	46.0	12.0	100	359
3	327.790	53.0	14.2	4.8	32.9	39.1	46.0	6.9	100	359
4	719.664	46.7	19.9	7.4	33.2	40.8	46.0	5.2	100	131
5	959.247	34.1	22.5	8.7	31.9	33.4	46.0	12.6	100	12
----- Vertical -----										
6	61.040	44.8	12.9	2.2	33.1	26.8	40.0	13.2	100	116

Tested by: Tae-Ho, Kim / Project Engineer

### 7.8.6.2 Test data for Below 30 MHz

- . Test Date : May 20, 2015
- . 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.								

### 7.8.6.3 Test data for above 1 GHz

- . Test Date : May 20, 2015
- . 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.								

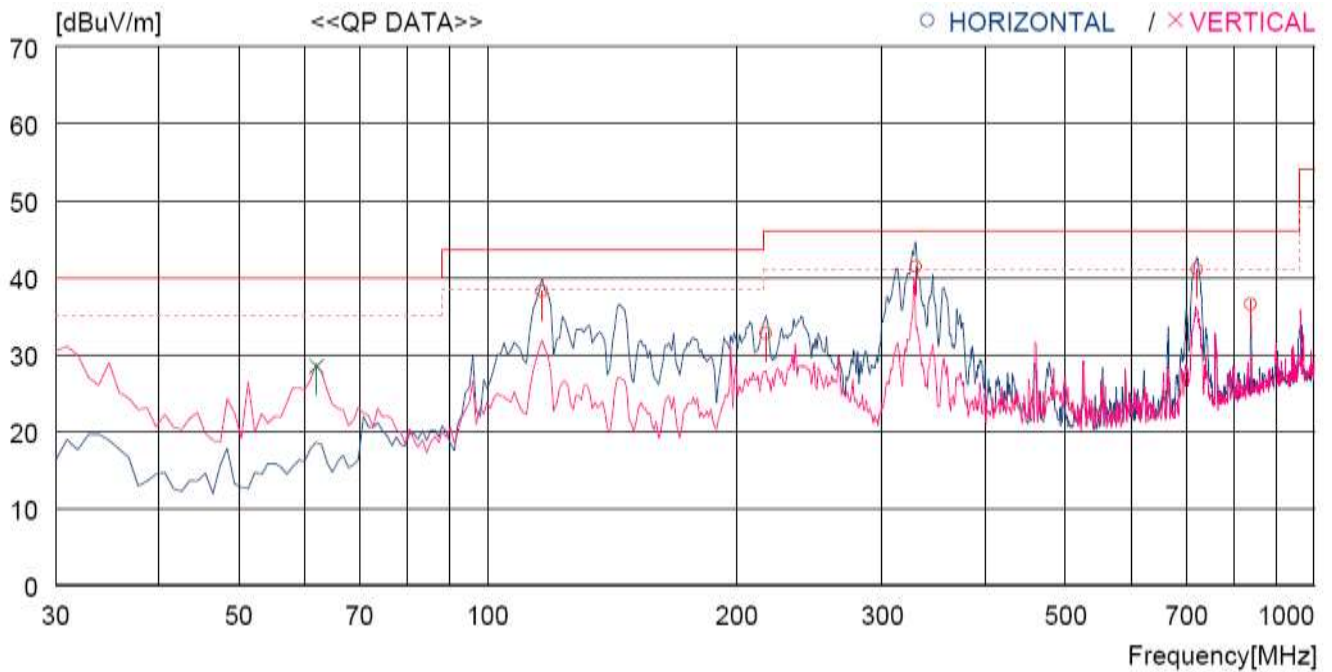


Tested by: Tae-Ho, Kim / Project Engineer

### 7.8.7 Test data for 3 Mbps

#### 7.8.7.1 Test data for 30 MHz ~ 1 000 MHz

- Test Date : May 20, 2015
- Resolution bandwidth : 120 kHz
- Frequency range : 30 MHz ~ 1 000 MHz
- Measurement distance : 3 m



No.	FREQ	READING	ANT	LOSS	GAIN	RESULT	LIMIT	MARGIN	ANTENNA	TABLE
	[MHz]	QP	FACTOR	[dB]	[dB]	[dBuV/m]	[dBuV/m]	[dB]	[cm]	[DEG]
----- Horizontal -----										
1	116.330	57.4	10.6	3.3	33.1	38.2	43.5	5.3	300	166
2	217.210	50.4	11.3	3.9	32.9	32.7	46.0	13.3	100	180
3	329.730	55.2	14.3	4.8	32.9	41.4	46.0	4.6	100	359
4	720.634	46.9	19.9	7.4	33.2	41.0	46.0	5.0	100	116
5	838.001	39.8	21.4	8.1	32.8	36.5	46.0	9.5	200	5
----- Vertical -----										
6	62.010	46.7	12.6	2.2	33.1	28.4	40.0	11.6	100	0

Tested by: Tae-Ho, Kim / Project Engineer

### 7.8.7.2 Test data for Below 30 MHz

- Test Date : May 20, 2015
- 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.								

### 7.8.7.3 Test data for above 1 GHz

- Test Date : May 20, 2015
- 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: Tae-Ho, Kim / Project Engineer

## 7.9 CONDUCTED EMISSION TEST

### 7.9.1 Operating environment

Temperature : 21.4 °C  
Relative humidity : 45.1 % R.H.

### 7.9.2 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  $\Omega$  / 50  $\mu$ H + 5  $\Omega$  Artificial Mains Network (AMN). The ground plane was electrically bonded to the reference ground system and all power lines were filtered from ambient.

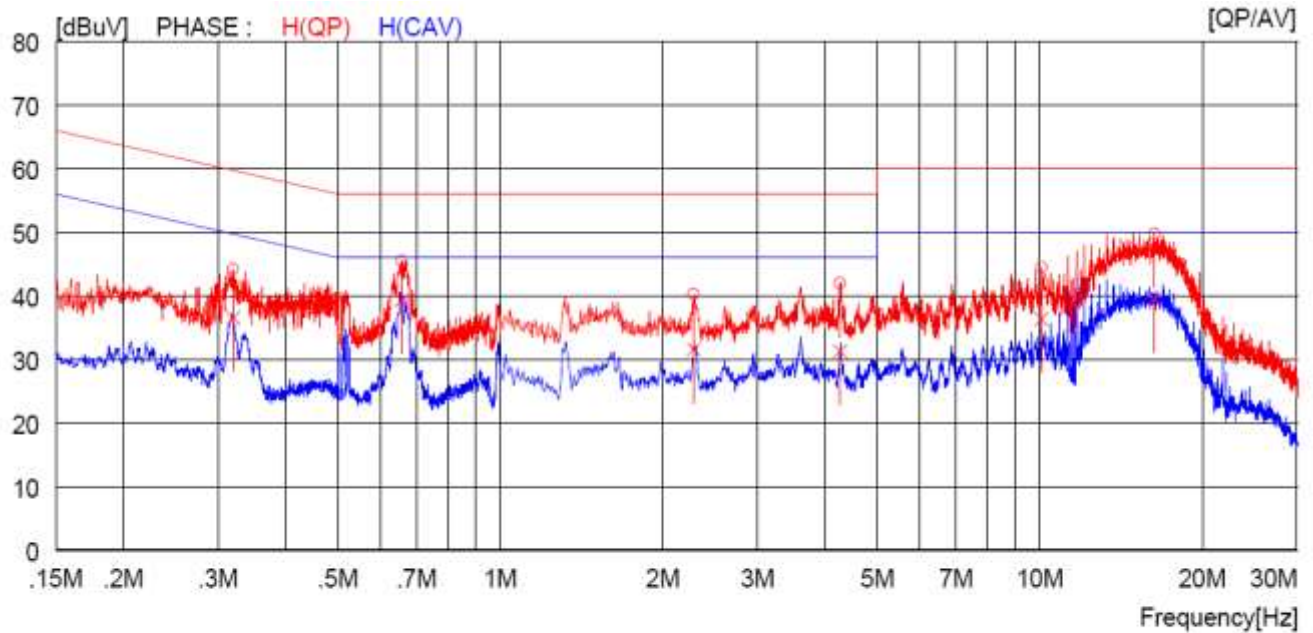
### 7.9.3 Test equipment used

	Model Number	Manufacturer	Description	Serial Number	Last Cal. (Interval)
■ -	ESPI	Rohde & Schwarz	EMI Test Receiver	101278	Nov. 03, 2014 (1Y)
□ -	ESHS10	Rohde & Schwarz	EMI Test Receiver	834467/007	Apr. 29, 2015 (1Y)
□	NSLK8128	Schwarzbeck	AMN	8128-216	Apr. 06, 2015 (1Y)
■ -	NSLK8126	Schwarzbeck	AMN	8126-404	Apr. 29, 2015 (1Y)
□ -	3825/2	EMCO	AMN	9109-1869	Apr. 29, 2015 (1Y)
■ --	3825/2	EMCO	AMN	9109-1867	Apr. 29, 2015 (1Y)

All test equipment used is calibrated on a regular basis.

#### 7.9.4 Test data

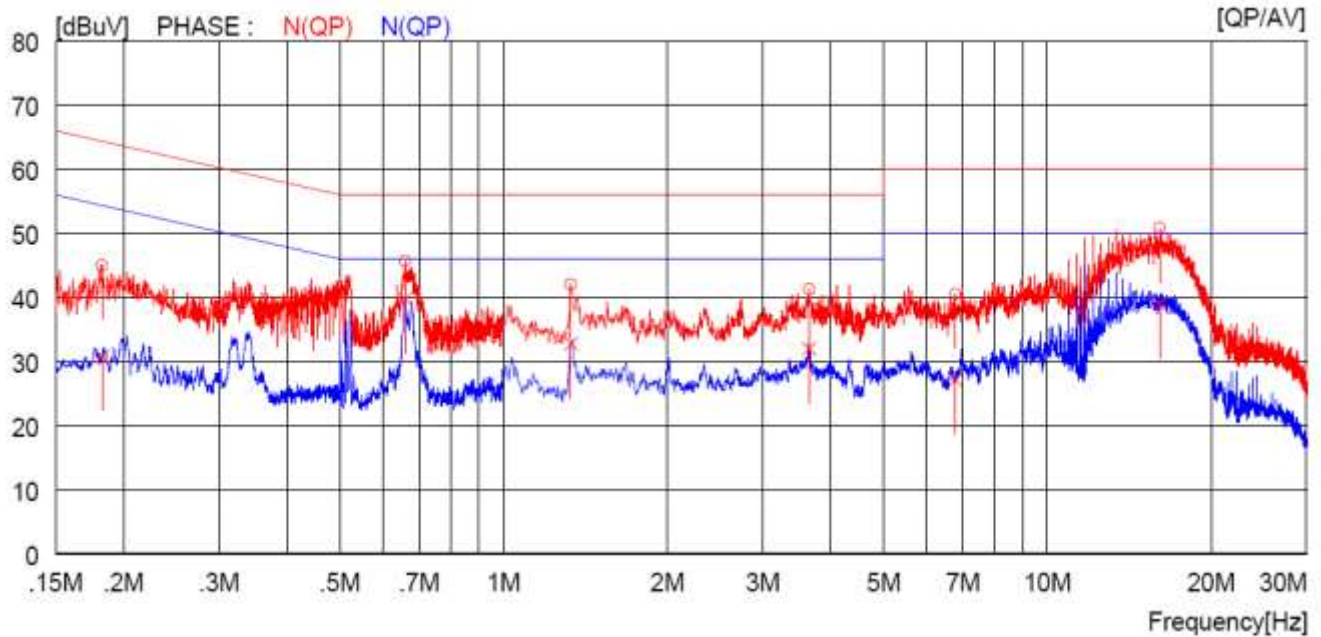
- Test Date : May 20, 2015
- Resolution bandwidth : 9 kHz
- Frequency range : 0.15 MHz ~ 30 MHz
- Tested Line : HOT LINE



NO	FREQ		READING		C.FACTOR		RESULT		LIMIT		MARGIN		PHASE
	QP	AV	QP	AV	QP	AV	QP	AV	QP	AV	QP	AV	
	[MHz]	[dBuV]	[dBuV]	[dB]	[dBuV]	[dBuV]	[dBuV]	[dBuV]	[dBuV]	[dBuV]	[dBuV]	[dBuV]	
1	0.32000	34.1	----	10.0	44.1	----	59.7	----	15.6	----	H(QP)		
2	0.65700	35.4	----	10.1	45.5	----	56.0	----	10.5	----	H(QP)		
3	2.28400	30.1	----	10.1	40.2	----	56.0	----	15.8	----	H(QP)		
4	4.26400	31.8	----	10.1	41.9	----	56.0	----	14.1	----	H(QP)		
5	10.08000	34.2	----	10.3	44.5	----	60.0	----	15.5	----	H(QP)		
6	16.32000	39.0	----	10.7	49.7	----	60.0	----	10.3	----	H(QP)		
7	0.32000	----	26.5	10.0	----	36.5	----	49.7	----	13.2	H(CAV)		
8	0.65700	----	29.2	10.1	----	39.3	----	46.0	----	6.7	H(CAV)		
9	2.28400	----	21.5	10.1	----	31.6	----	46.0	----	14.4	H(CAV)		
10	4.26400	----	21.2	10.1	----	31.3	----	46.0	----	14.7	H(CAV)		
11	10.08000	----	26.0	10.3	----	36.3	----	50.0	----	13.7	H(CAV)		
12	16.32000	----	28.8	10.7	----	39.5	----	50.0	----	10.5	H(CAV)		



-. Tested Line : NEUTRAL LINE



NO	FREQ		READING		C.FACTOR		RESULT		LIMIT		MARGIN		PHASE
	QP	AV	QP	AV	QP	AV	QP	AV	QP	AV	QP	AV	
	[MHz]	[dBuV]	[dBuV]	[dB]	[dBuV]	[dBuV]	[dBuV]	[dBuV]	[dBuV]	[dBuV]	[dBuV]	[dBuV]	
1	0.18300	35.0	----	10.0			45.0	----	64.3	----	19.3	----	N(QP)
2	0.66000	35.6	----	10.1			45.7	----	56.0	----	10.3	----	N(QP)
3	1.33200	31.9	----	10.1			42.0	----	56.0	----	14.0	----	N(QP)
4	3.65200	31.1	----	10.1			41.2	----	56.0	----	14.8	----	N(QP)
5	6.78000	30.3	----	10.2			40.5	----	60.0	----	19.5	----	N(QP)
6	16.12000	40.2	----	10.6			50.8	----	60.0	----	9.2	----	N(QP)
7	0.18300	----	20.8	10.0			----	30.8	----	54.3	----	23.5	N(CAV)
8	0.66000	----	29.7	10.1			----	39.8	----	46.0	----	6.2	N(CAV)
9	1.33200	----	22.7	10.1			----	32.8	----	46.0	----	13.2	N(CAV)
10	3.65200	----	21.9	10.1			----	32.0	----	46.0	----	14.0	N(CAV)
11	6.78000	----	16.9	10.2			----	27.1	----	50.0	----	22.9	N(CAV)
12	16.12000	----	28.4	10.6			----	39.0	----	50.0	----	11.0	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: Tae-Ho, Kim / Project Engineer