

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

Test Report No. : OT-20D-RWD-063

Reception No. : 2012005224

Applicant : LG Innotek Co., Ltd.

Address : 26, Hanamsandan 5beon-ro Gwangsan-gu, Gwangju, 506-731, South Korea

Manufacturer : LG Innotek Co., Ltd.

Address : 26, Hanamsandan 5beon-ro Gwangsan-gu, Gwangju, 506-731, South Korea

Type of Equipment : BT(V4.2) + WLAN(802.11a/b/g/n/ac) 2x2 MIMO Module

FCC ID. : YZP-RBHPB216C1

Model Name : RBHP-B216C

Serial number : N/A

Total page of Report : 78 pages (including this page)

Date of Incoming : December 03, 2020

Date of issue : December 17, 2020

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.

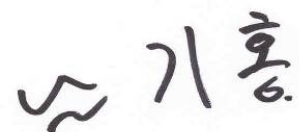
It is not a generally valid assessment of the features of the respective products of the mass-production.



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Revision History

Rev. No.	Issue Report No.	Issued Date	Revisions	Section Affected
0	OT-20D-RWD-063	December 17, 2020	Initial Issue	All

1. VERIFICATION OF COMPLIANCE

Applicant : LG Innotek Co., Ltd.

Address : 26, Hanamsandan 5beon-ro Gwangsan-gu, Gwangju, 506-731, South Korea

Contact Person : Jeong Inchang / Chief Research Engineer

Telephone No. : +82-10-2326-9972

FCC ID : YZP-RBHPB216C1

Model Name : RBHP-B216C

Brand Name : LG Innotek Co., Ltd.

Serial Number : N/A

Date : December 17, 2020

EQUIPMENT CLASS	DSS – PART 15 SPREAD SPECTRUM TRANSMITTER
E.U.T. DESCRIPTION	Modular Transmitter, BT(V4.2) + WLAN(802.11a/b/g/n/ac) 2x2 MIMO Module
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 KDB 558074 D01 15.247 Meas Guidance v05r02
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	N/A (See Note)
15.203	Antenna Requirement	Met requirement / PASS

Note: This test is not performed because the EUT is operated by DC Power.

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-20122/ C-14617/ G-10666/ T-11842

ISED (Innovation, Science and Economic Development Canada) – Registration No. Site# 3736A-3

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 LG Innotek Co., Ltd., Model RBHP-B216C (referred to as the EUT in this report) is a BT(V4.2) + WLAN(802.11a/b/g/n/ac) 2x2 MIMO Module. The product specification described herein was obtained from product data sheet or user's manual.

DEVICE TYPE	BT(V4.2) + WLAN(802.11a/b/g/n/ac) 2x2 MIMO Module	
OPERATING FREQUENCY	Bluetooth LE	2 402 MHz ~ 2 480 MHz
	Bluetooth	2 402 MHz ~ 2 480 MHz
	WLAN 2.4 GHz	2 412 MHz ~ 2 462 MHz (802.11b/g/n(HT20))
	5 150 MHz ~ 5 250 MHz Band	5 180 MHz ~ 5 240 MHz (802.11a/n(HT20)/ac(VHT20))
		5 190 MHz ~ 5 230 MHz (802.11n(HT40)/ac(VHT40))
		5 210 MHz (802.11ac(VHT80))
	5 250 MHz ~ 5 350 MHz Band	5 260 MHz ~ 5 320 MHz (802.11a/n(HT20)/ac(VHT20))
		5 270 MHz ~ 5 310 MHz (802.11n(HT40)/ac(VHT40))
		5 290 MHz (802.11ac(VHT80))
	5 470 MHz ~ 5 725 MHz Band	5 500 MHz ~ 5 700 MHz (802.11a/n(HT20)/ac(VHT20))
		5 510 MHz ~ 5 670 MHz (802.11n(HT40)/ac(VHT40))
		5 530 MHz (802.11ac(VHT80))
	5 725 MHz ~ 5 850 MHz Band	5 745 MHz ~ 5 825 MHz (802.11a/n(HT20)/ac(VHT20))
		5 755 MHz ~ 5 795 MHz (802.11n(HT40)/ac(VHT40))
		5 775 MHz (802.11ac(VHT80))
MODULATION TYPE	Bluetooth LE	GFSK for 1 Mbps
	Bluetooth	GFSK for 1 Mbps, $\pi/4$ -DQPSK for 2 Mbps, 8-DPSK for 3 Mbps
	WLAN 2.4 GHz	802.11b: DSSS Modulation(DBPSK/DQPSK/CCK) 802.11g/n(HT20): OFDM Modulation(BPSK/QPSK/16QAM/64QAM)
	WLAN 5 GHz	802.11a/n(HT20)/n(HT40)/ac(VHT80): OFDM Modulation(BPSK/QPSK/16QAM/64QAM)

RF OUTPUT POWER	Bluetooth LE	1 Mbps	5.44 dBm
	Bluetooth	1 Mbps	4.05 dBm
		2 Mbps	1.45 dBm
		3 Mbps	2.02 dBm
	WLAN 2.4 GHz	Wi-Fi 802.11b (16.40 dBm) Wi-Fi 802.11g (15.84 dBm) Wi-Fi 802.11n(HT20) (15.05 dBm)	
	5 150 MHz ~ 5 250 MHz Band	Antenna 0	Wi-Fi 802.11a (13.96 dBm) Wi-Fi 802.11n(HT20) (11.80 dBm) Wi-Fi 802.11n(HT40) (10.14 dBm) Wi-Fi 802.11ac(HT80) (12.61 dBm)
		Antenna 1	Wi-Fi 802.11a (13.92 dBm) Wi-Fi 802.11n(HT20) (10.62 dBm) Wi-Fi 802.11n(HT40) (10.54 dBm) Wi-Fi 802.11ac(HT80) (12.66 dBm)
		Multiple Antenna	Wi-Fi 802.11n(HT20) (14.24 dBm) Wi-Fi 802.11n(HT40) (13.29 dBm) Wi-Fi 802.11ac(HT80) (12.96 dBm)
		Antenna 0	Wi-Fi 802.11a (14.42 dBm) Wi-Fi 802.11n(HT20) (14.61 dBm) Wi-Fi 802.11n(HT40) (14.10 dBm) Wi-Fi 802.11ac(HT80) (12.51 dBm)
		Antenna 1	Wi-Fi 802.11a (14.41 dBm) Wi-Fi 802.11n(HT20) (14.54 dBm) Wi-Fi 802.11n(HT40) (13.56 dBm) Wi-Fi 802.11ac(HT80) (13.21 dBm)
		Multiple Antenna	Wi-Fi 802.11n(HT20) (17.59 dBm) Wi-Fi 802.11n(HT40) (16.85 dBm) Wi-Fi 802.11ac(HT80) (15.88 dBm)

RF OUTPUT POWER	5 470 MHz ~ 5 725 MHz Band	Antenna 0	Wi-Fi 802.11a (14.91 dBm) Wi-Fi 802.11n(HT20) (14.94 dBm) Wi-Fi 802.11n(HT40) (14.81 dBm) Wi-Fi 802.11ac(HT80) (12.99 dBm)
		Antenna 1	Wi-Fi 802.11a (14.62 dBm) Wi-Fi 802.11n(HT20) (14.97 dBm) Wi-Fi 802.11n(HT40) (14.32 dBm) Wi-Fi 802.11ac(HT80) (13.44dBm)
		Multiple Antenna	Wi-Fi 802.11n(HT20) (17.88 dBm) Wi-Fi 802.11n(HT40) (17.58 dBm) Wi-Fi 802.11ac(HT80) (16.23 dBm)
	5 725 MHz ~ 5 850 MHz Band	Antenna 0	Wi-Fi 802.11a (14.58 dBm) Wi-Fi 802.11n(HT20) (14.27 dBm) Wi-Fi 802.11n(HT40) (13.88 dBm) Wi-Fi 802.11ac(HT80) (12.80 dBm)
		Antenna 1	Wi-Fi 802.11a (14.74 dBm) Wi-Fi 802.11n(HT20) (14.84 dBm) Wi-Fi 802.11n(HT40) (14.69 dBm) Wi-Fi 802.11ac(HT80) (13.88 dBm)
		Multiple Antenna	Wi-Fi 802.11n(HT20) (17.57 dBm) Wi-Fi 802.11n(HT40) (17.31 dBm) Wi-Fi 802.11ac(HT80) (16.38 dBm)

ANTENNA TYPE	WLAN 2.4 GHz Band & WLAN 5 GHz Band		PCB Antenna
	Bluetooth & WLAN 5 GHz Band		PIFA antenna
ANTENNA GAIN	Bluetooth LE	2.20 dBi	
	Bluetooth	2.20 dBi	
	WLAN 2.4 GHz	4.80 dBi	
	5 150 MHz ~ 5 250 MHz Band	Antenna 0	5.40 dBi
		Antenna 1	5.70 dBi
		Multiple Antenna	8.56 dBi
	5 250 MHz ~ 5 350 MHz Band	Antenna 0	5.60 dBi
		Antenna 1	4.80 dBi
		Multiple Antenna	8.23 dBi
	5 470 MHz ~ 5 725 MHz Band	Antenna 0	5.70 dBi
		Antenna 1	5.30 dBi
		Multiple Antenna	8.51 dBi
	5 725 MHz ~ 5 850 MHz Band	Antenna 0	5.20 dBi
		Antenna 1	5.40 dBi
		Multiple Antenna	8.31 dBi
List of each Osc. or crystal Freq. (Freq. >= 1 MHz)		37.4 MHz	
DFS FUNCTION		Slave without radar detection	

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.	RBHA-B2168_RDK_Rev0.1	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
RBHP-B216C	LG Innotek Co., Ltd.	BT(V4.2) + WLAN(802.11a/b/g/n/ac) 2x2 MIMO Module (EUT)	Notebook PC
PP11L	DELL	Notebook PC	EUT
TC-3000C	TESCOM	Bluetooth Tester	EUT

5.3 Mode of operation during the test

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

For final testing, the EUT was set at 2 402 MHz, 2 441 MHz, and 2 480 MHz to get a maximum 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 report.

-. Channel List (Bluetooth)

Channel	Frequency[MHz]	Channel	Frequency[MHz]	Channel	Frequency[MHz]
0	2 402.00	27	2 429.00	54	2 456.00
1	2 403.00	28	2 430.00	55	2 457.00
2	2 404.00	29	2 431.00	56	2 458.00
3	2 405.00	30	2 432.00	57	2 459.00
4	2 406.00	31	2 433.00	58	2 460.00
5	2 407.00	32	2 434.00	59	2 461.00
6	2 408.00	33	2 435.00	60	2 462.00
7	2 409.00	34	2 436.00	61	2 463.00
8	2 410.00	35	2 437.00	62	2 464.00
9	2 411.00	36	2 438.00	63	2 465.00
10	2 412.00	37	2 439.00	64	2 466.00
11	2 413.00	38	2 440.00	65	2 467.00
12	2 414.00	39	2 441.00	66	2 468.00
13	2 415.00	40	2 442.00	67	2 469.00
14	2 416.00	41	2 443.00	68	2 470.00
15	2 417.00	42	2 444.00	69	2 471.00
16	2 418.00	43	2 445.00	70	2 472.00
17	2 419.00	44	2 446.00	71	2 473.00
18	2 420.00	45	2 447.00	72	2 474.00
19	2 421.00	46	2 448.00	73	2 475.00
20	2 422.00	47	2 449.00	74	2 476.00
21	2 423.00	48	2 450.00	75	2 477.00
22	2 424.00	49	2 451.00	76	2 478.00
23	2 425.00	50	2 452.00	77	2 479.00
24	2 426.00	51	2 453.00	78	2 480.00
25	2 427.00	52	2 454.00		
26	2 428.00	53	2 455.00		

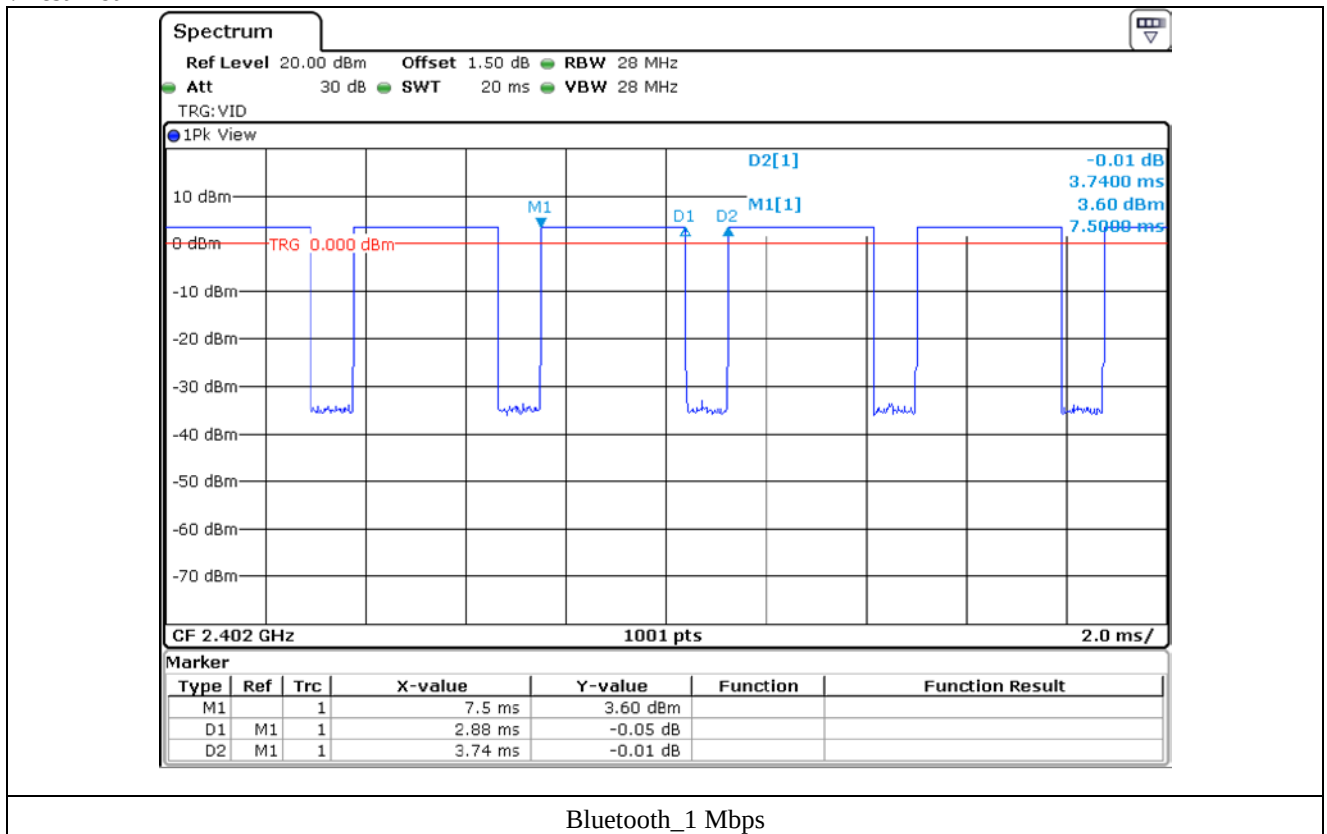
-. Duty Cycle

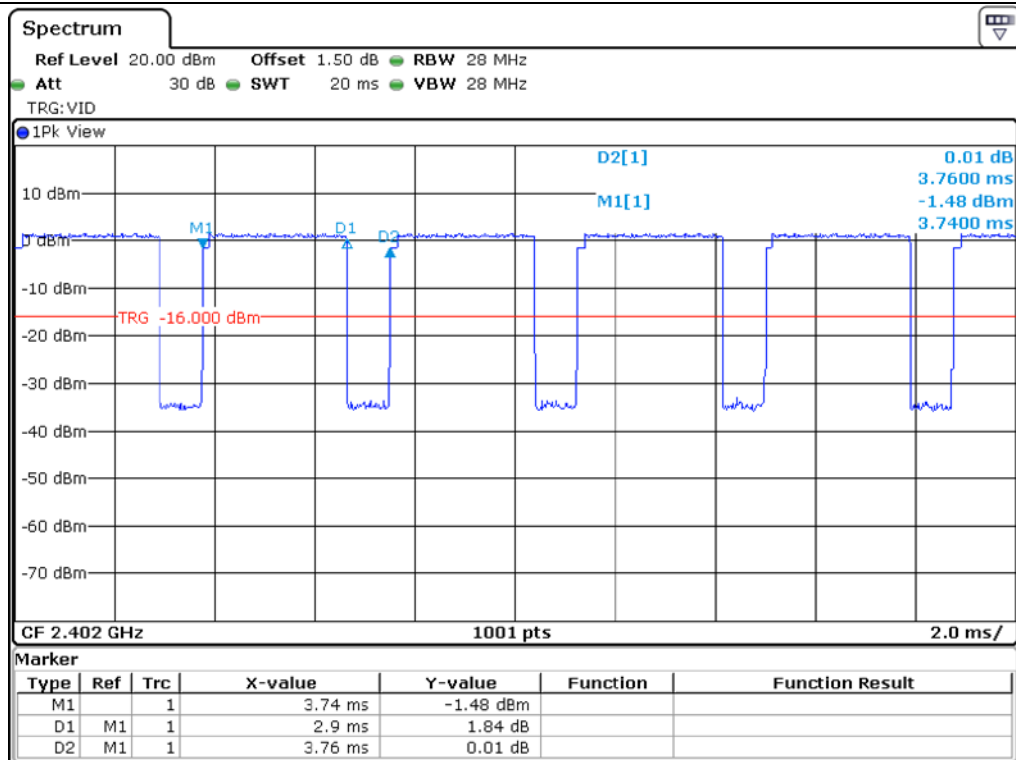
Mode	Tx On Time [ms]	Tx Off Time [ms]	Duty Cycle [%]	Correction Factor [dB]
Bluetooth [1 Mbps]	2.88	0.86	77.01	1.13
Bluetooth [2 Mbps]	2.90	0.86	77.13	1.13
Bluetooth [3 Mbps]	2.90	0.86	77.13	1.13

Note – Duty Cycle : (Tx On Time / (Tx On Time + Tx Off Time)) * 100

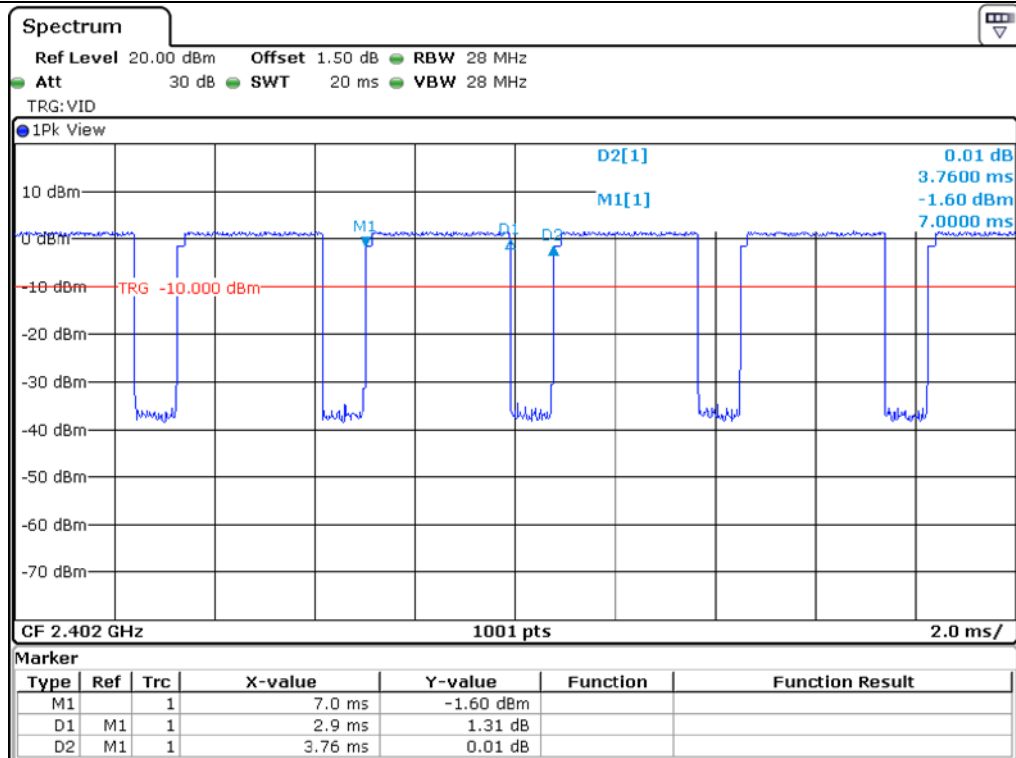
Correction Factor : 10 * Log(1 / (Duty Cycle / 100))

-. Test Plot





Bluetooth_2 Mbps



Bluetooth_3 Mbps

5.4 Configuration of Test System

Line Conducted Test: It is not need to test this requirement, because the EUT shall be operated by DC Power.

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 transmitter antenna of the EUT is WLAN 2.4 GHz Band & WLAN 5 GHz Band is PCB antenna and Bluetooth & Bluetooth LE & WLAN 5 GHz Band is PIFA antenna.

It consists of the FAKRA Type RF cable between the EUT and the antenna, and the connector is molded so that it cannot be replaced 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)
It is not need to test this requirement, because the power of the EUT is supplied by DC Power.	

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

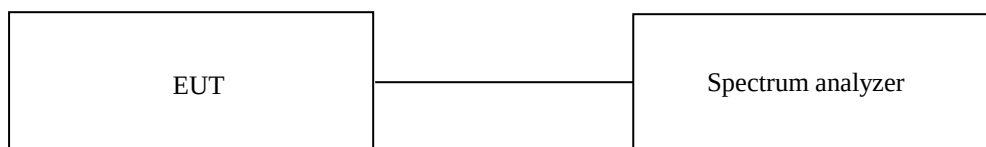
7. MINIMUM 20 dB BANDWIDTH

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 1 % to 5 % of the OBW, 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.

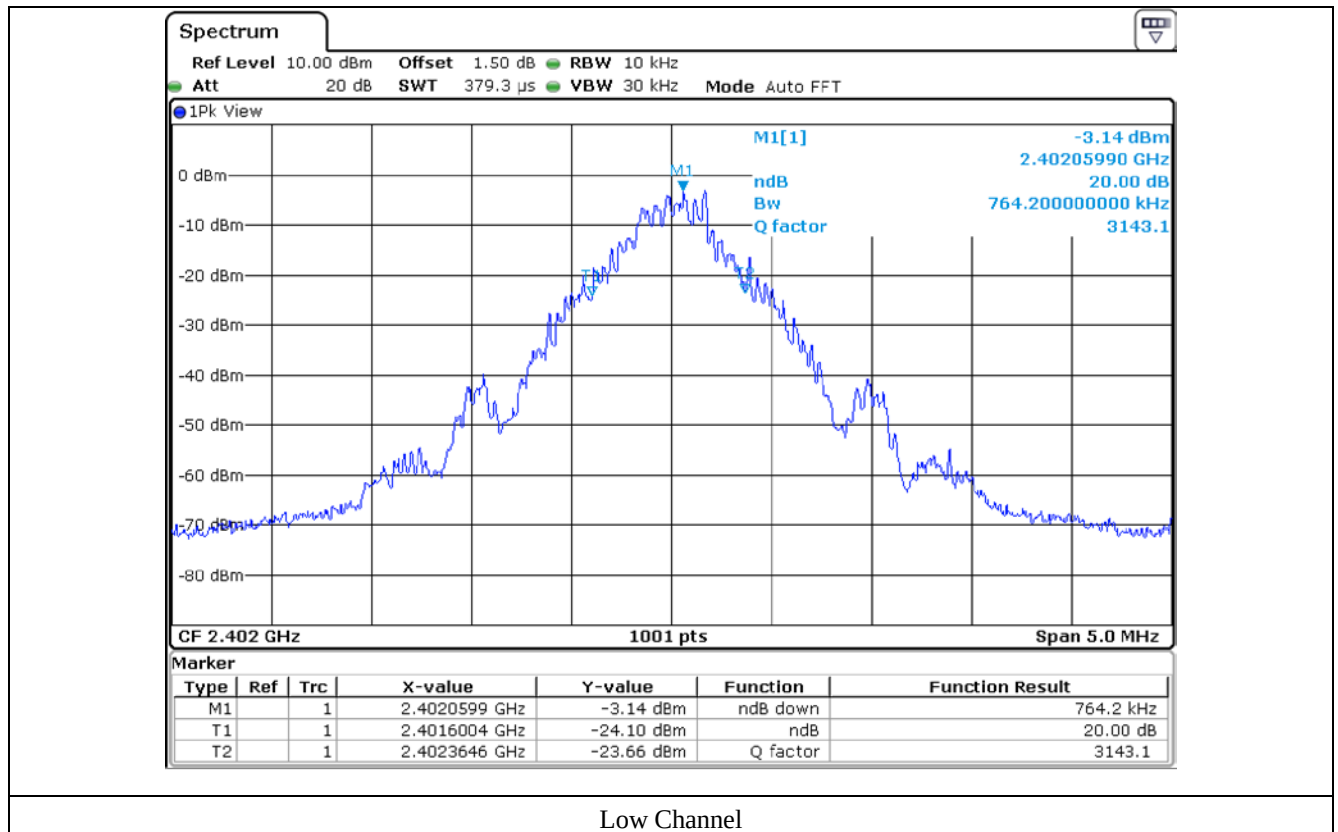


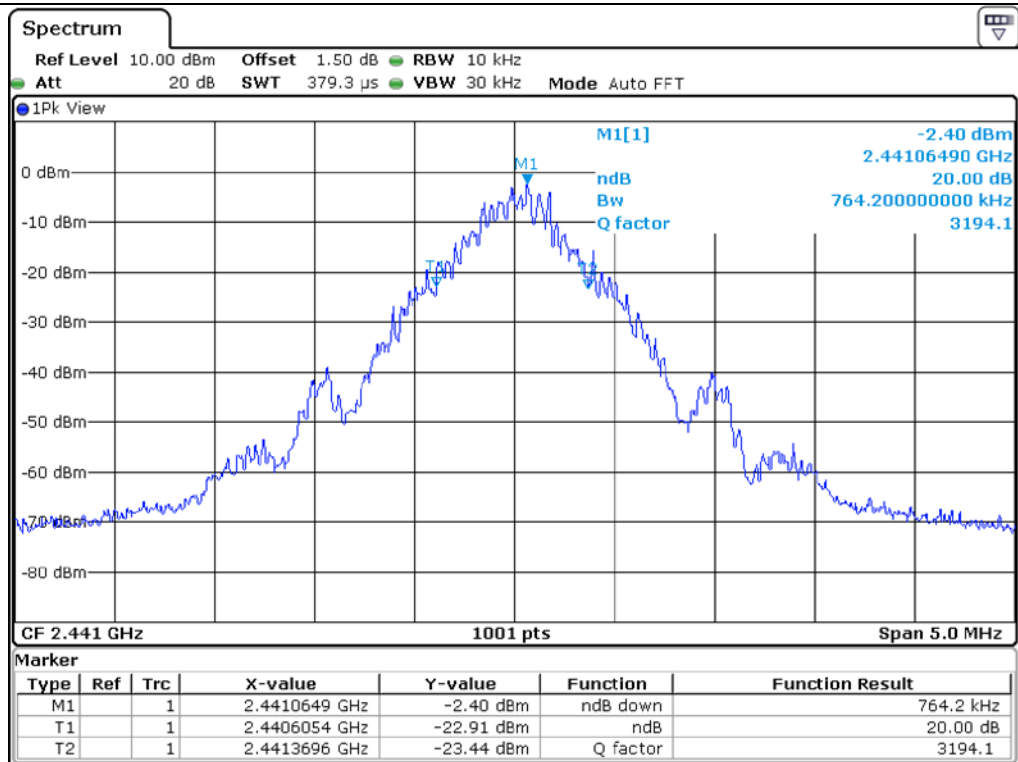
7.3 Test Date

December 03, 2020 ~ December 09, 2020

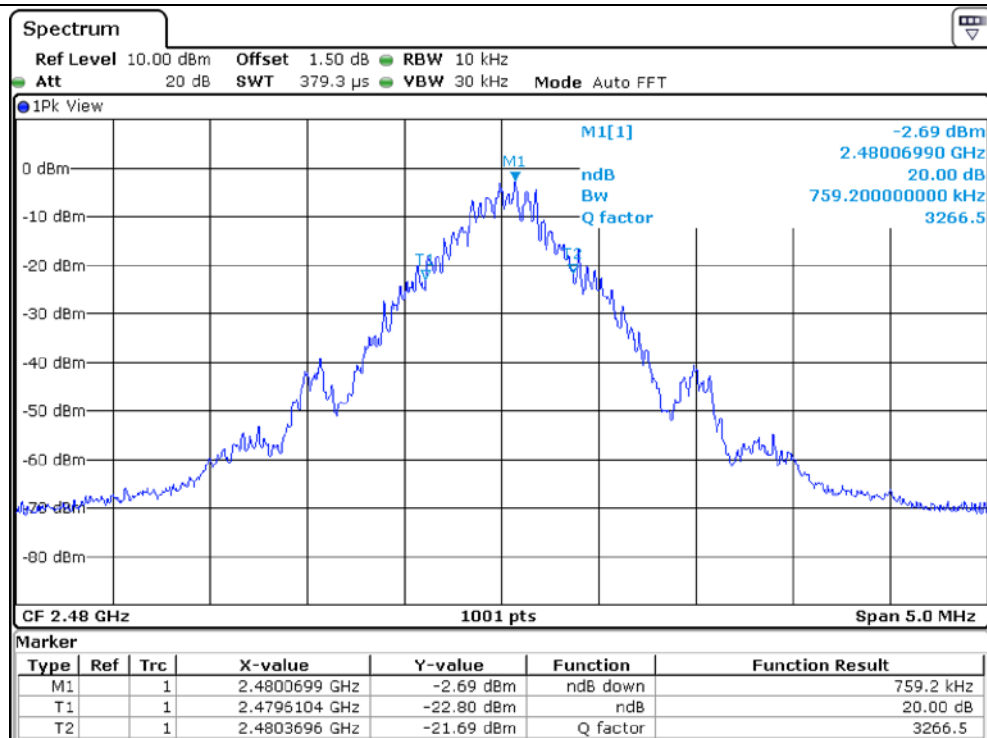
7.4 Test data for 1 Mbps

CHANNEL	FREQUENCY (MHz)	20 dB Bandwidth (kHz)
Low	2 402.00	764.20
Middle	2 441.00	764.20
High	2 480.00	759.20





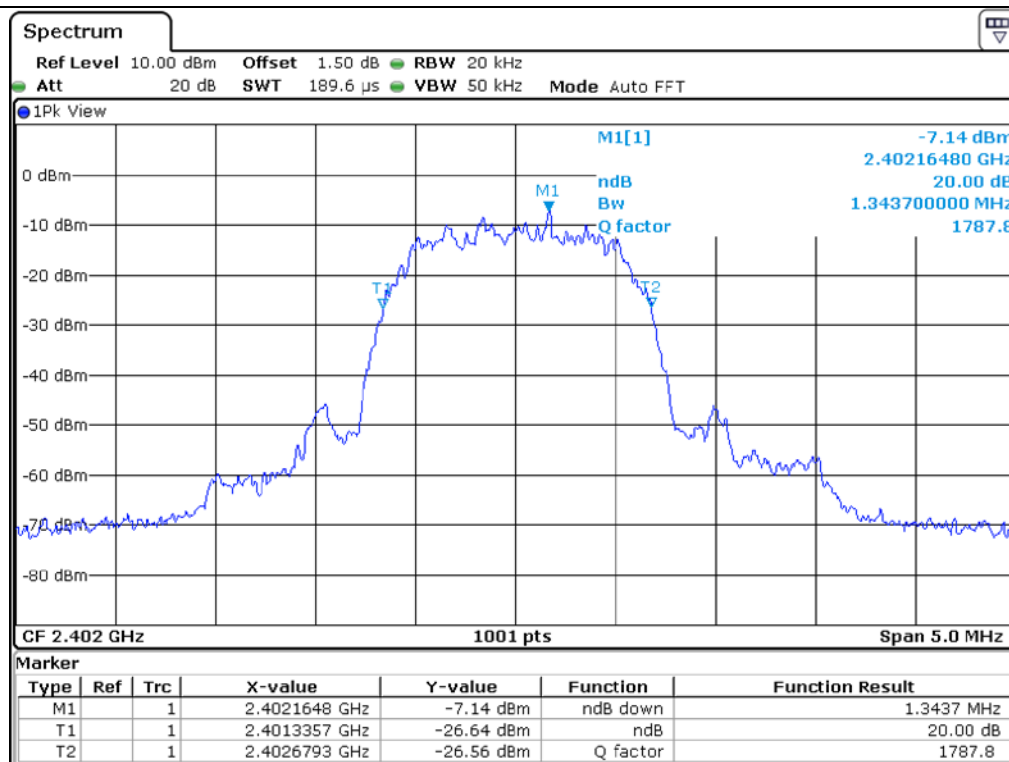
Middle Channel



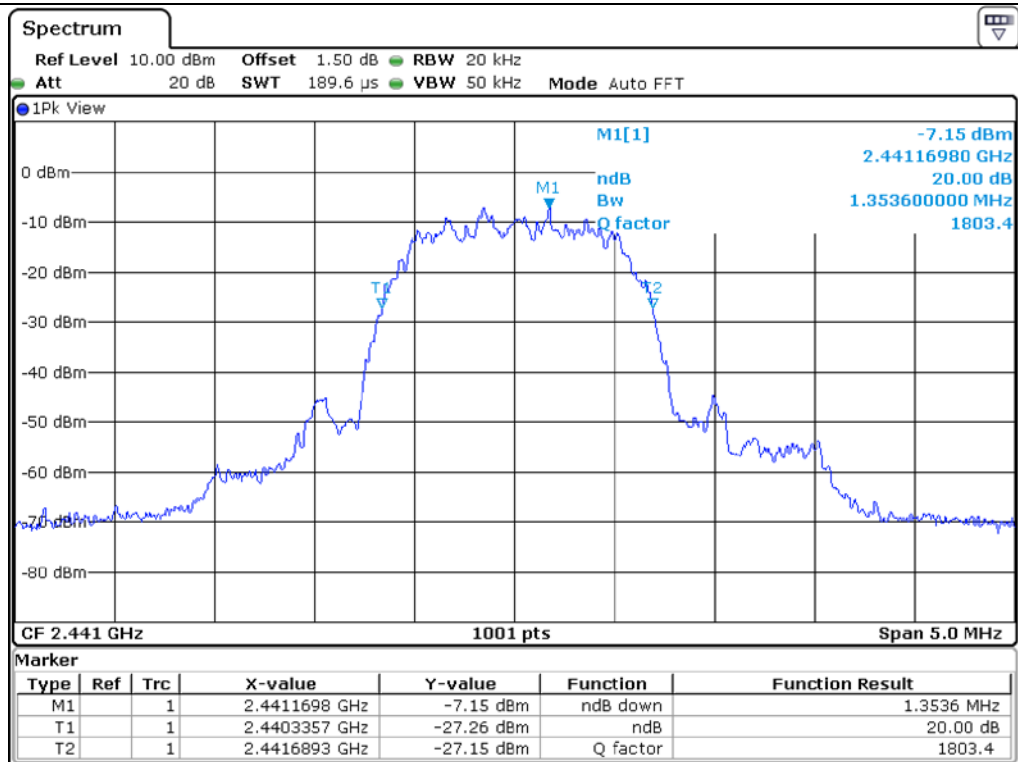
High Channel

7.5 Test data for 2 Mbps

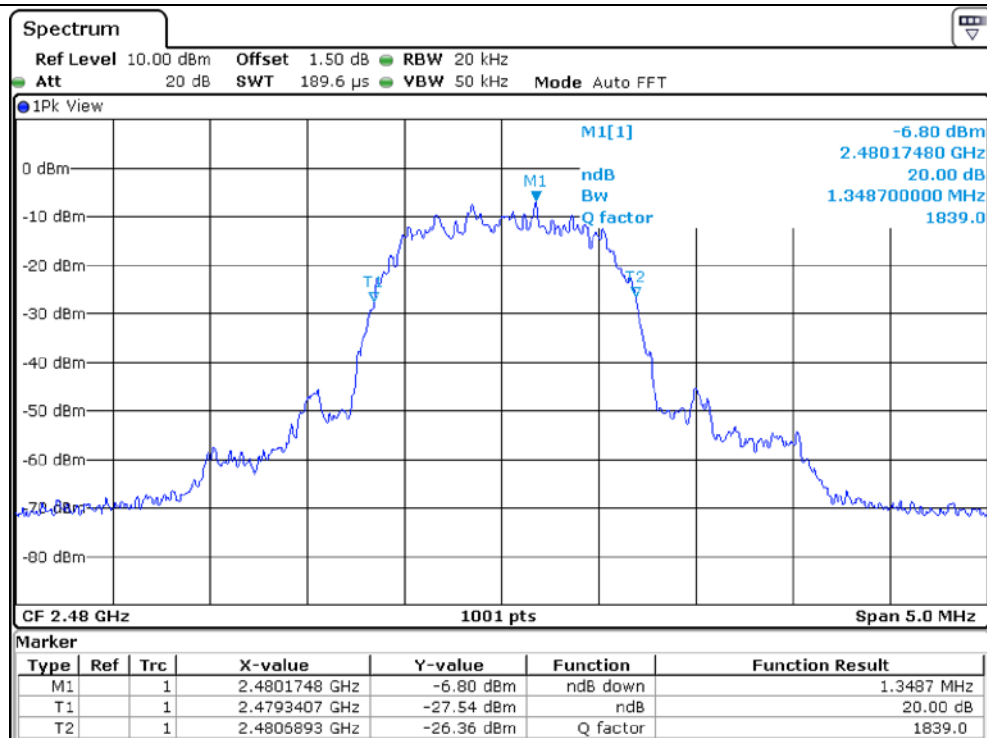
CHANNEL	FREQUENCY (MHz)	20 dB Bandwidth (kHz)
Low	2 402.00	1 343.70
Middle	2 441.00	1 353.60
High	2 480.00	1 348.70



Low Channel



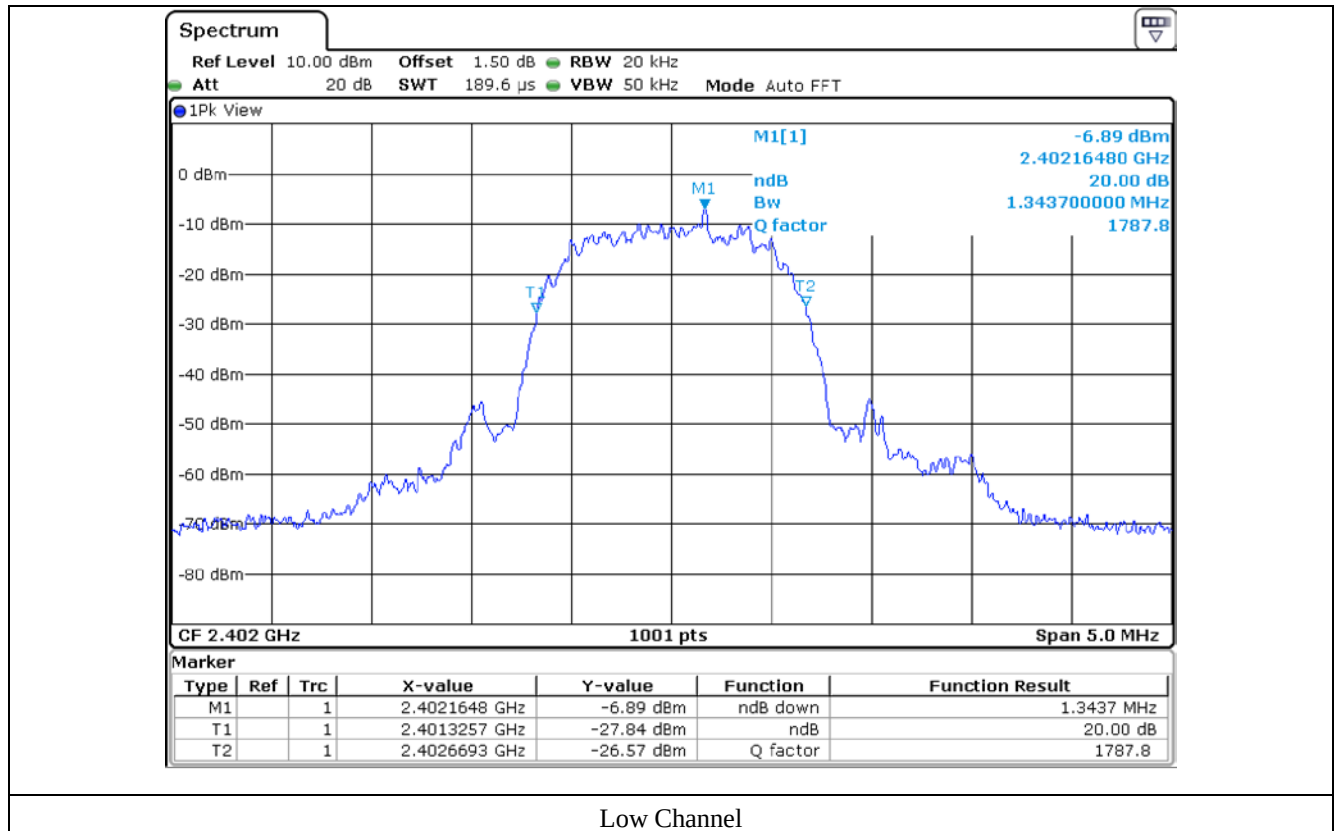
Middle Channel

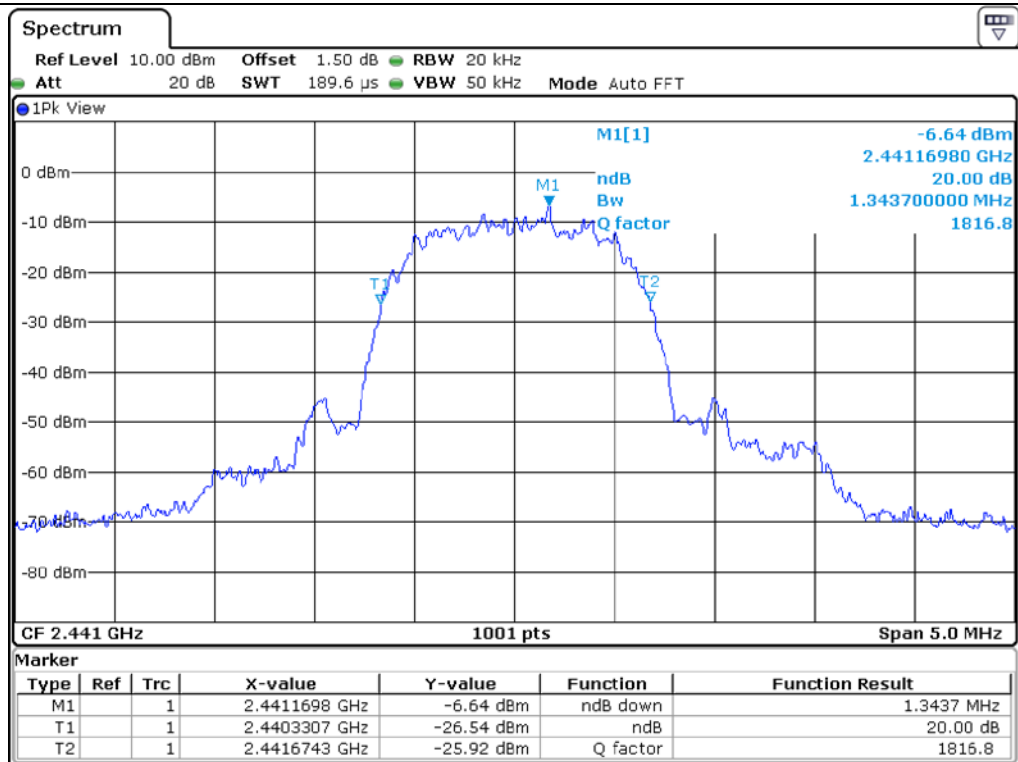


High Channel

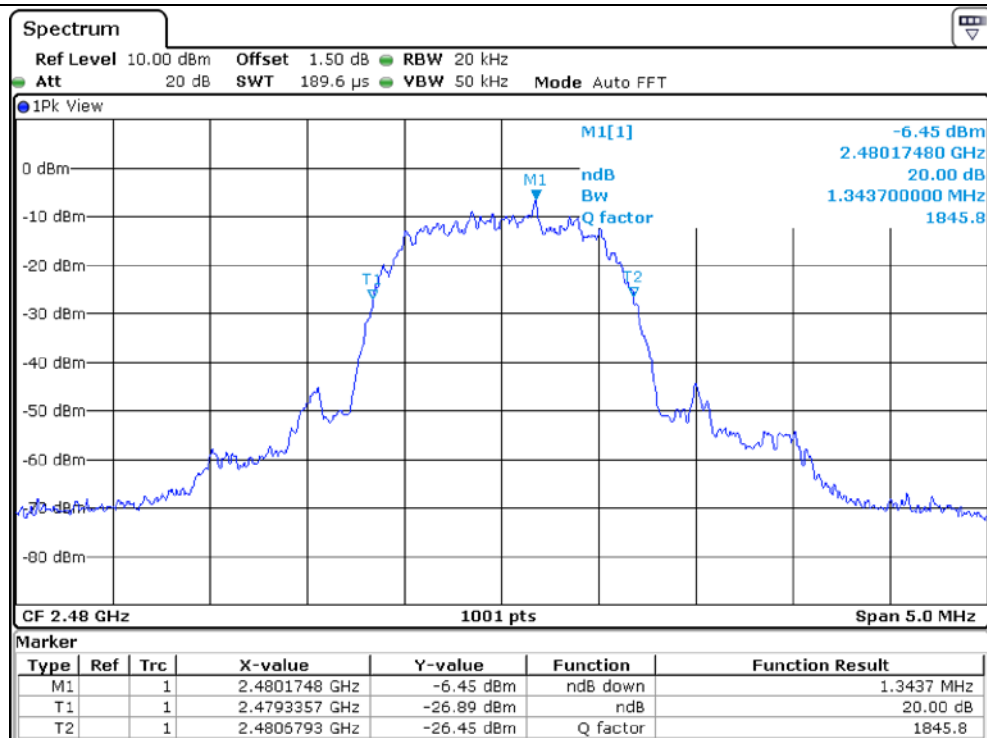
7.6 Test data for 3 Mbps

CHANNEL	FREQUENCY (MHz)	20 dB Bandwidth (kHz)
Low	2 402.00	1 343.70
Middle	2 441.00	1 343.70
High	2 480.00	1 343.70





Middle Channel



High Channel

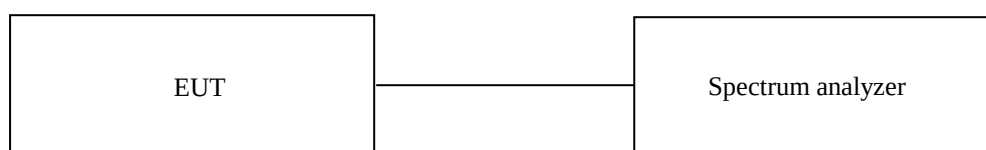
8. HOPPING FREQUENCY SEPARATION

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.



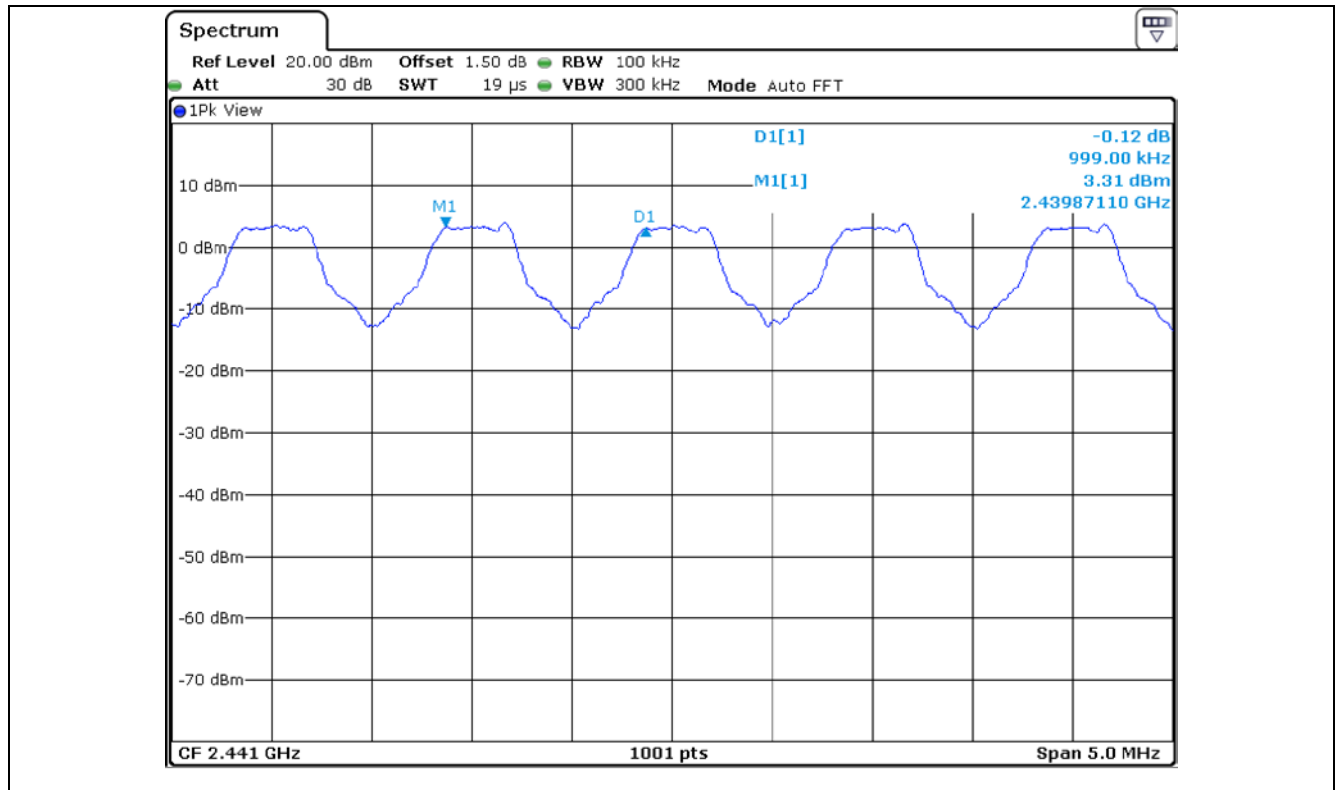
8.3 Test Date

December 03, 2020 ~ December 09, 2020

8.4 Test data for 1 Mbps

-. Test Result : Pass

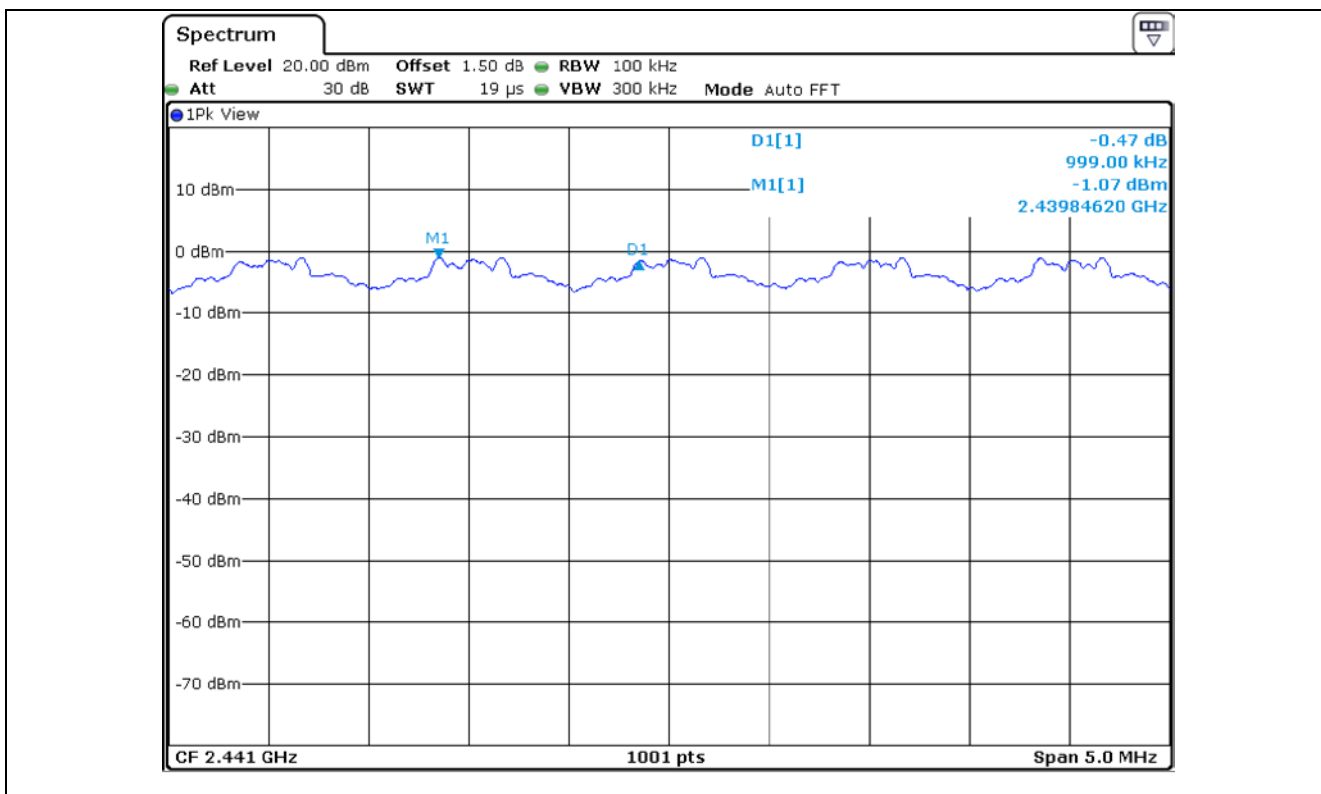
MEASURED VLAUE (kHz)	Two-third of 20 dB Bandwidth (kHz)	LIMIT
999.00	509.47	Separated by a minimum of 509.47 kHz



8.5 Test data for 2 Mbps

-. Test Result : Pass

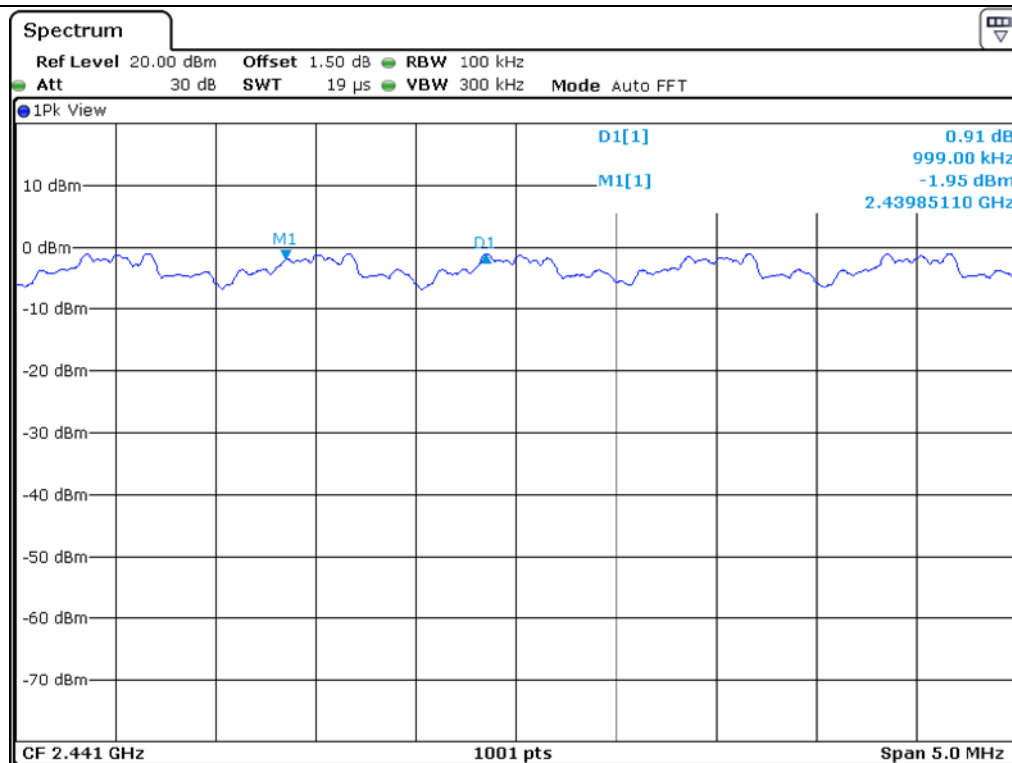
MEASURED VLAUE (kHz)	Two-third of 20 dB Bandwidth (kHz)	LIMIT
999.00	902.40	Separated by a minimum of 902.4 kHz



8.6 Test data for 3 Mbps

-. Test Result : Pass

MEASURED VLAUE (kHz)	Two-third of 20 dB Bandwidth (kHz)	LIMIT
999.00	895.80	Separated by a minimum of 895.80 kHz



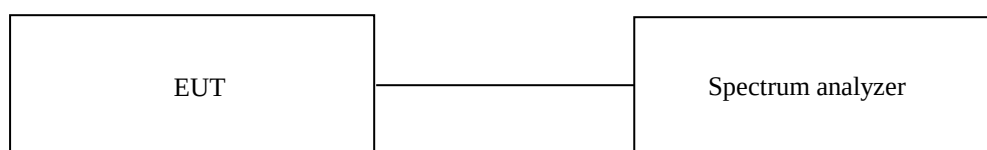
9. NUMBER OF HOPPING CHANNELS

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 kHz and the resolution bandwidth is set to 300 kHz. The analyzer is set to peak hold and then complete pseudo-random hopping sequence of the transmitter is captured.



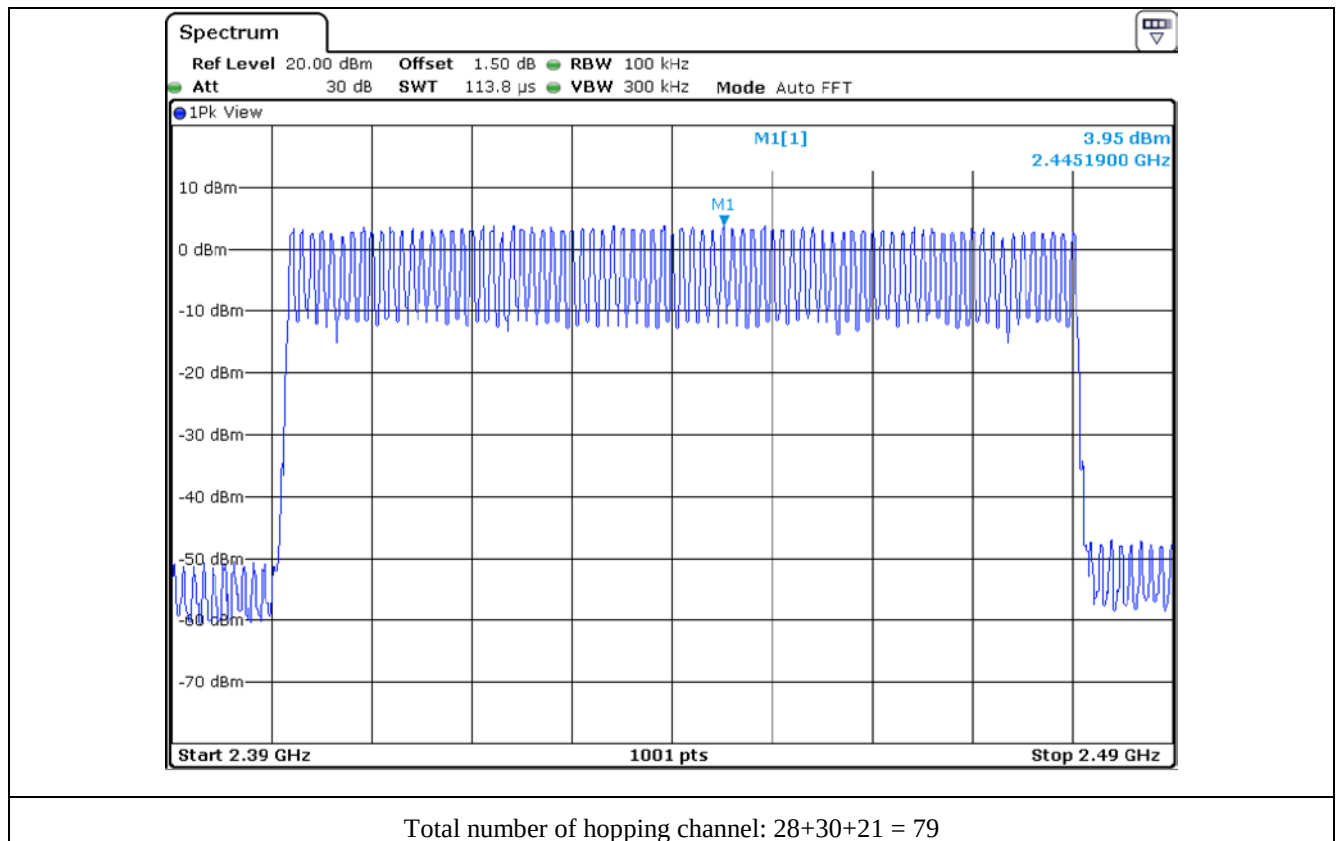
9.3 Test Date

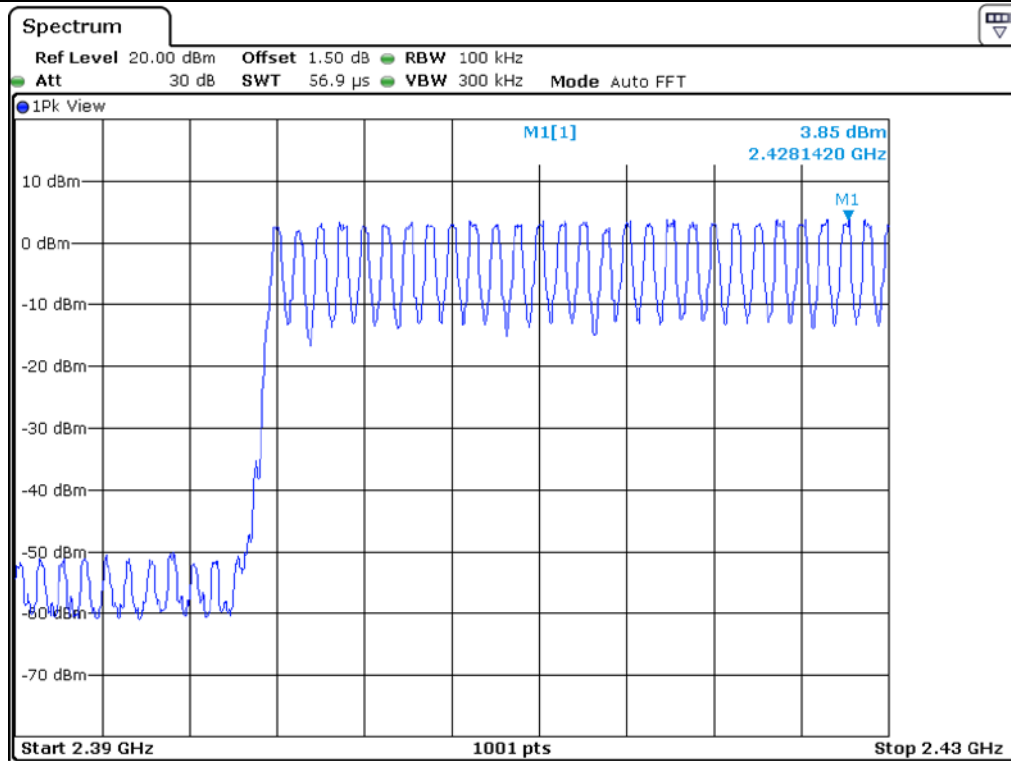
December 03, 2020 ~ December 09, 2020

9.4 Test data for 1 Mbps

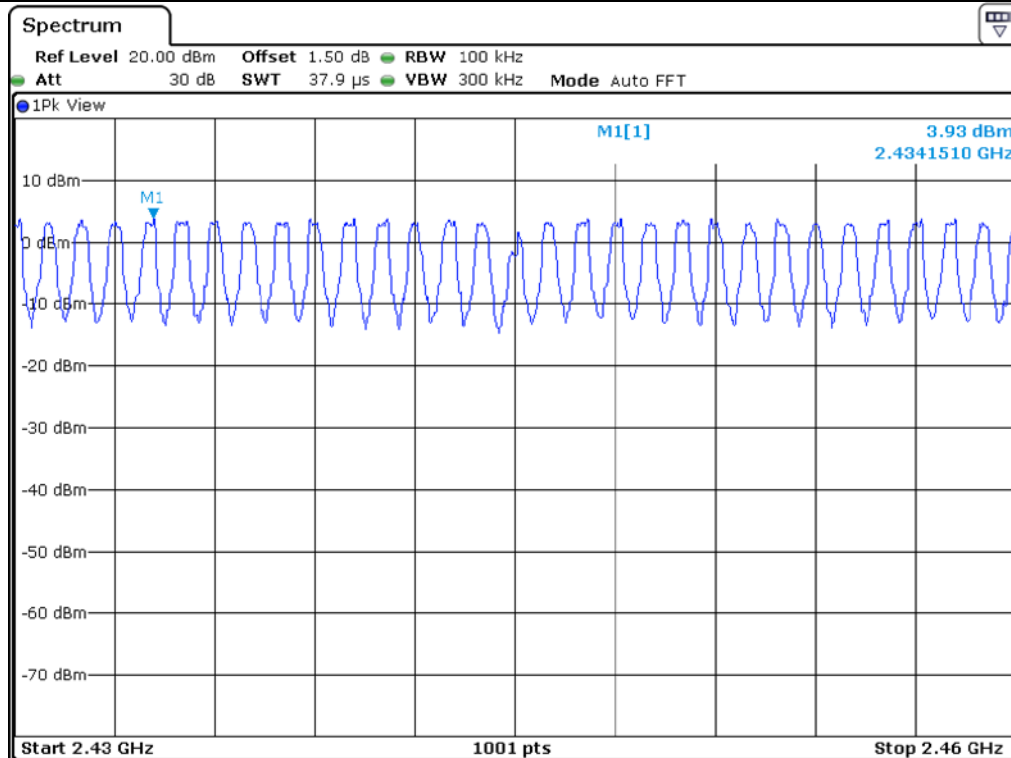
-. Test Result : Pass

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

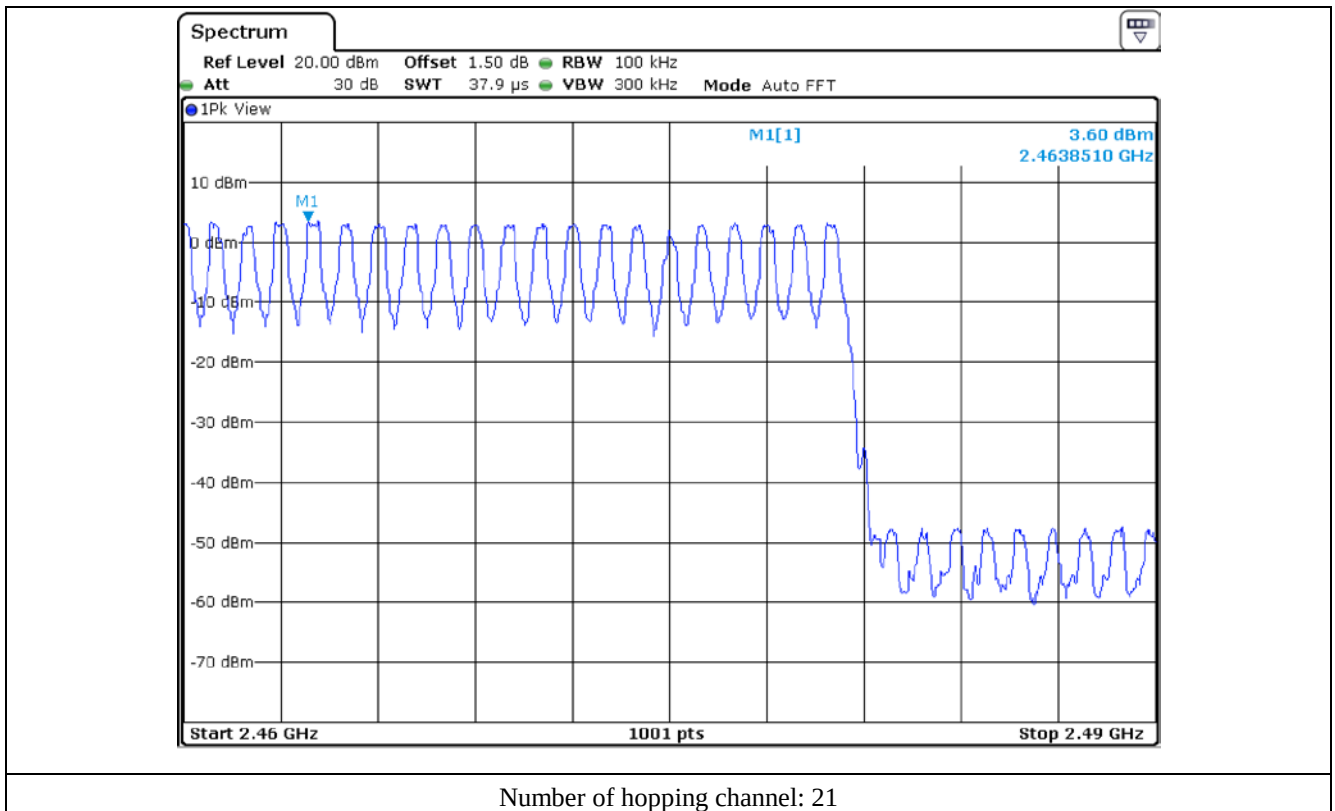




Number of hopping channel: 28



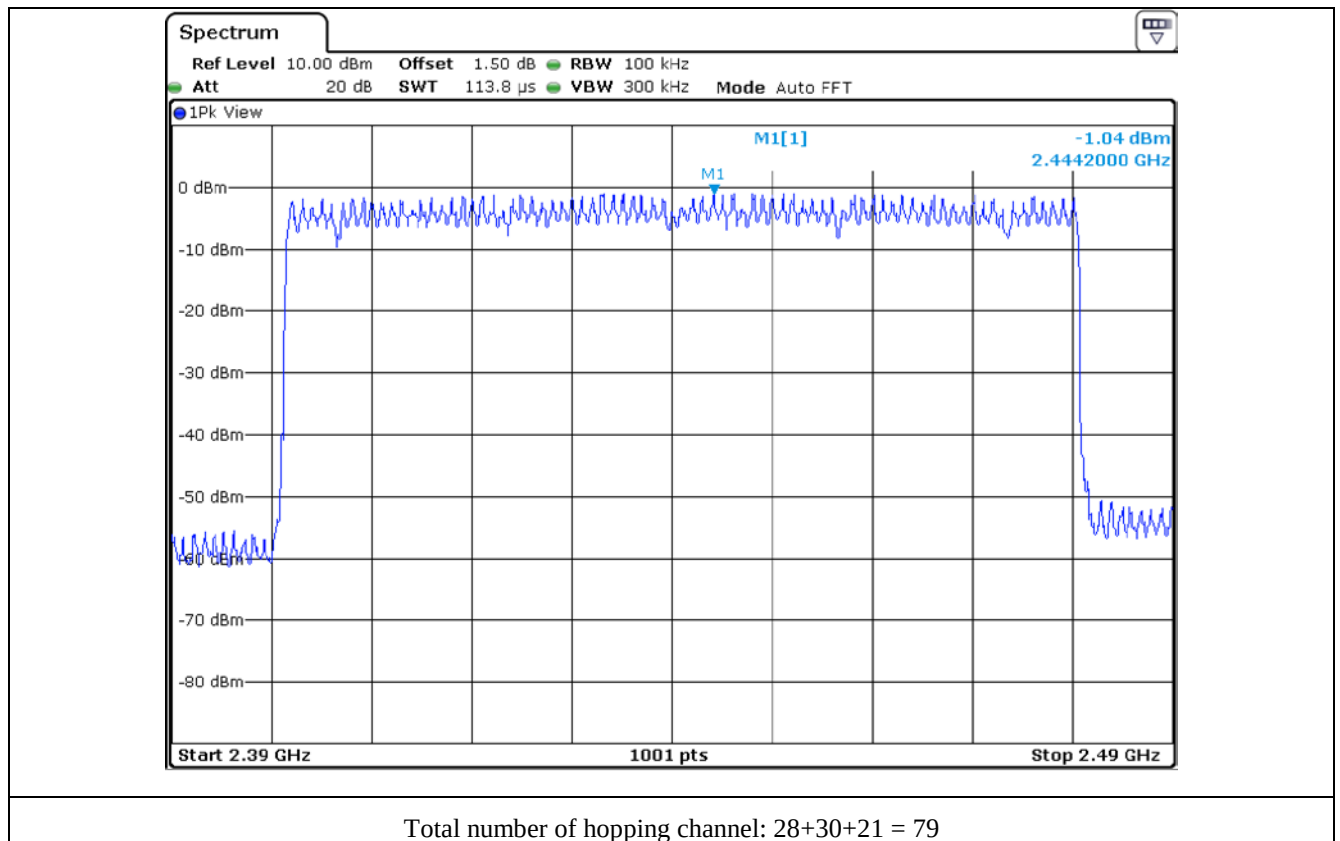
Number of hopping channel: 30

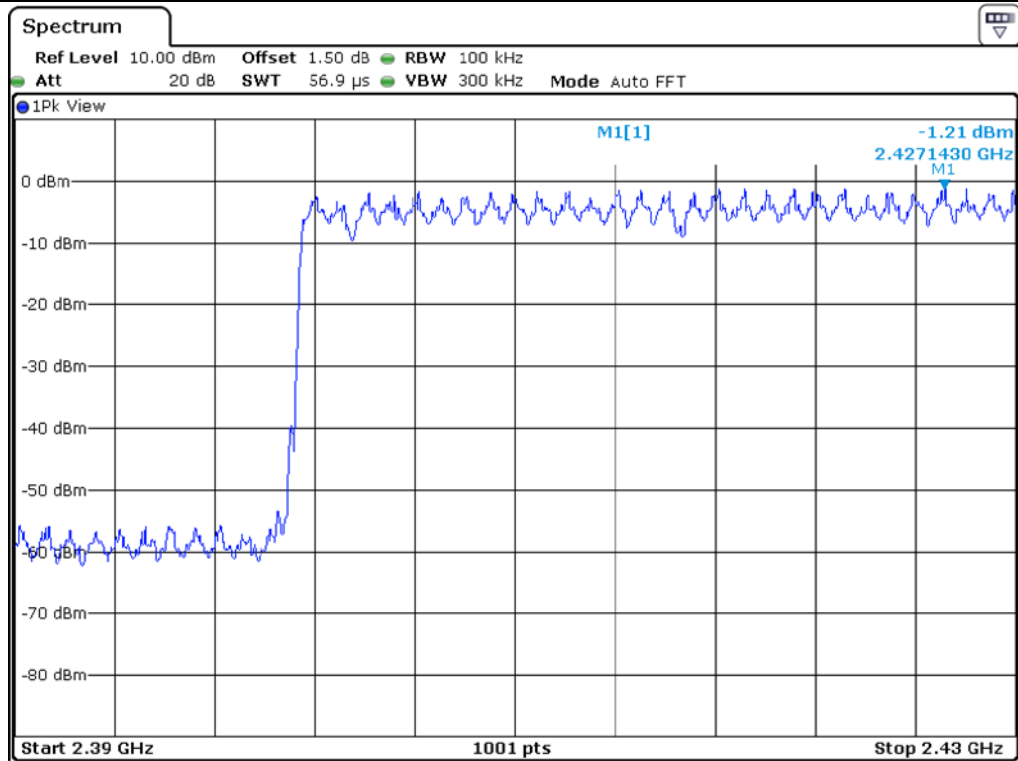


9.5 Test data for 2 Mbps

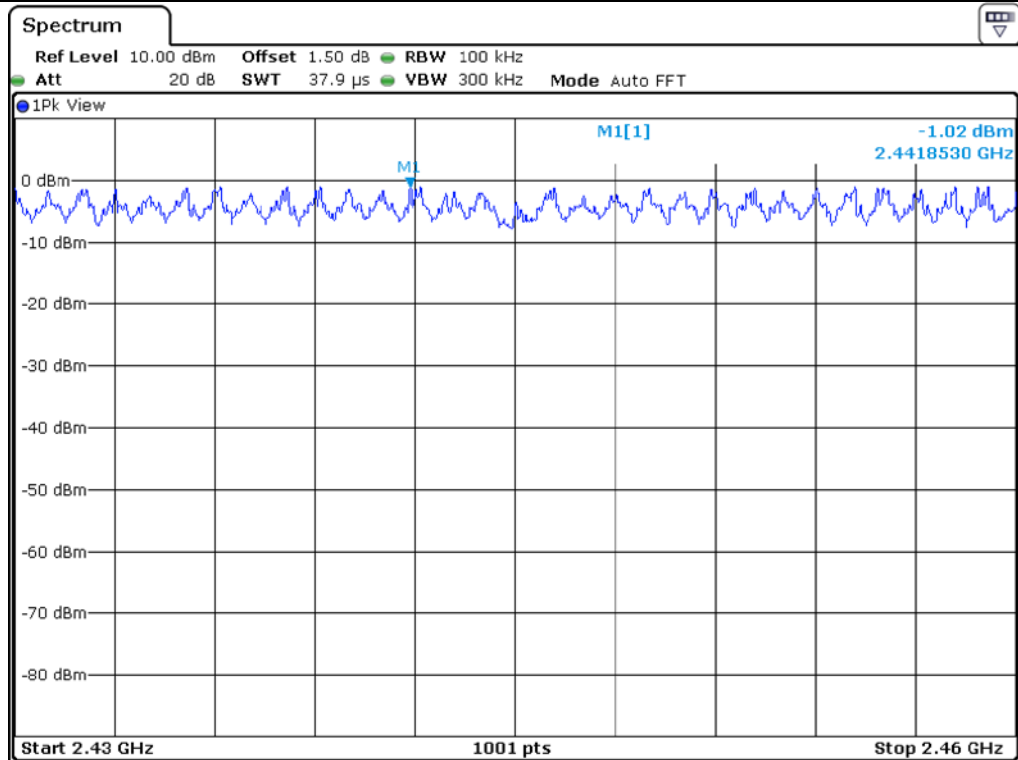
-. Test Result : Pass

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

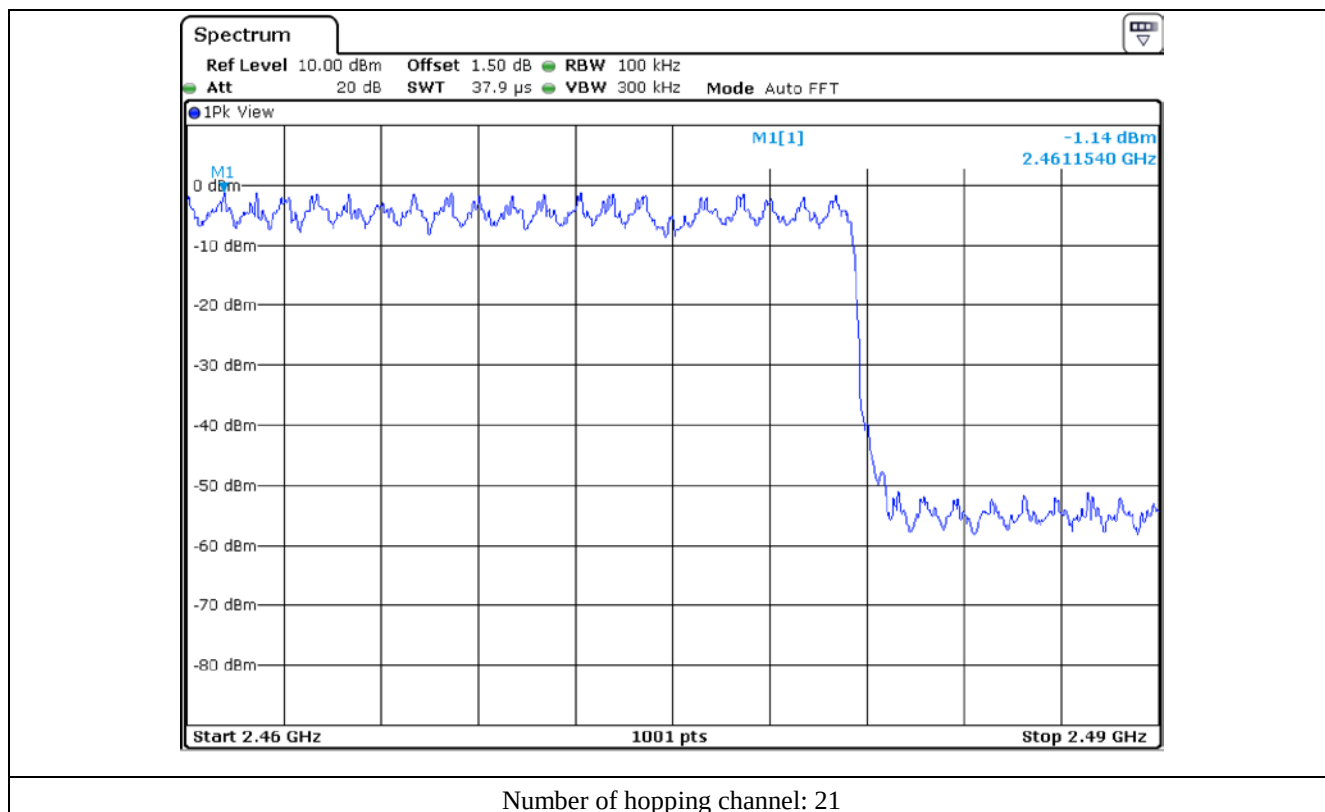




Number of hopping channel: 28



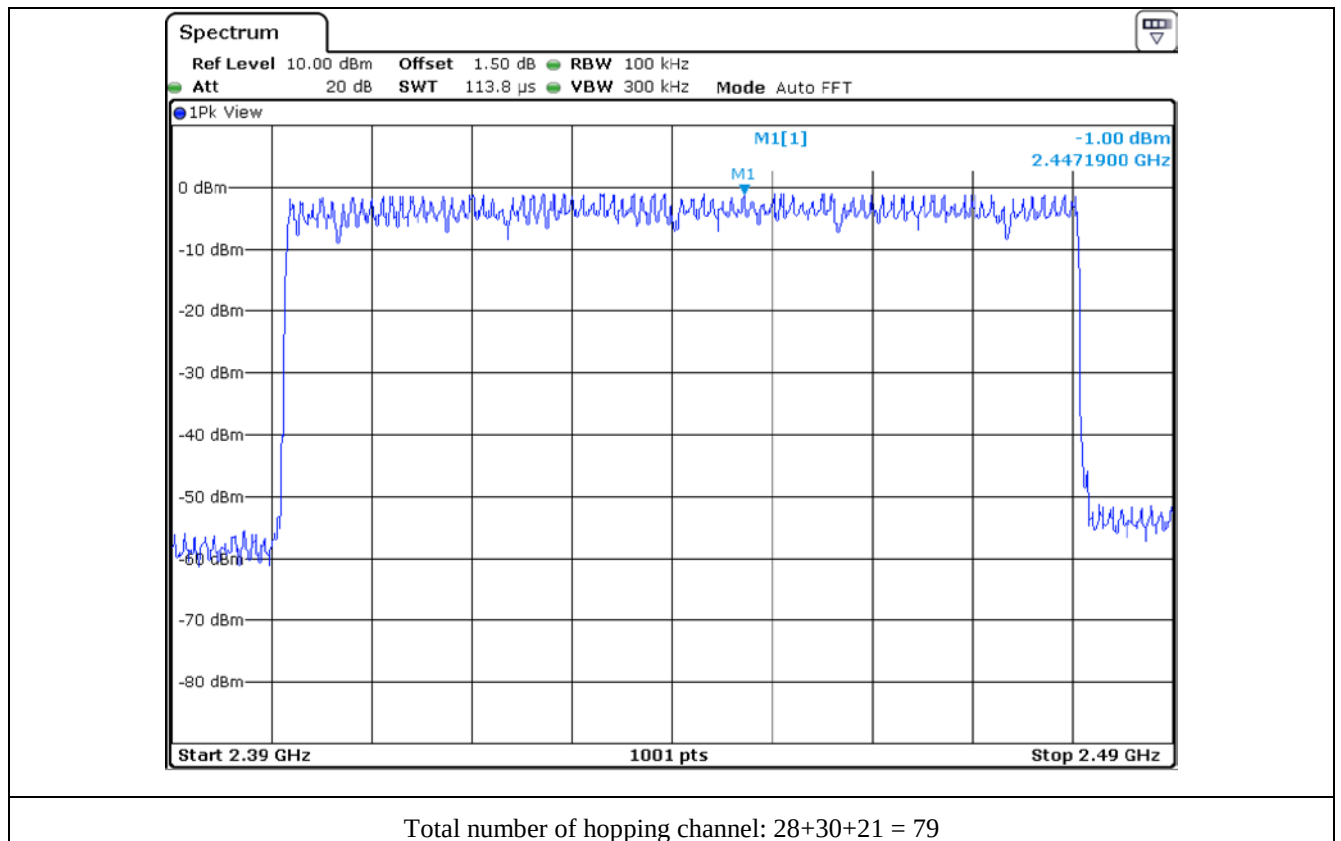
Number of hopping channel: 30

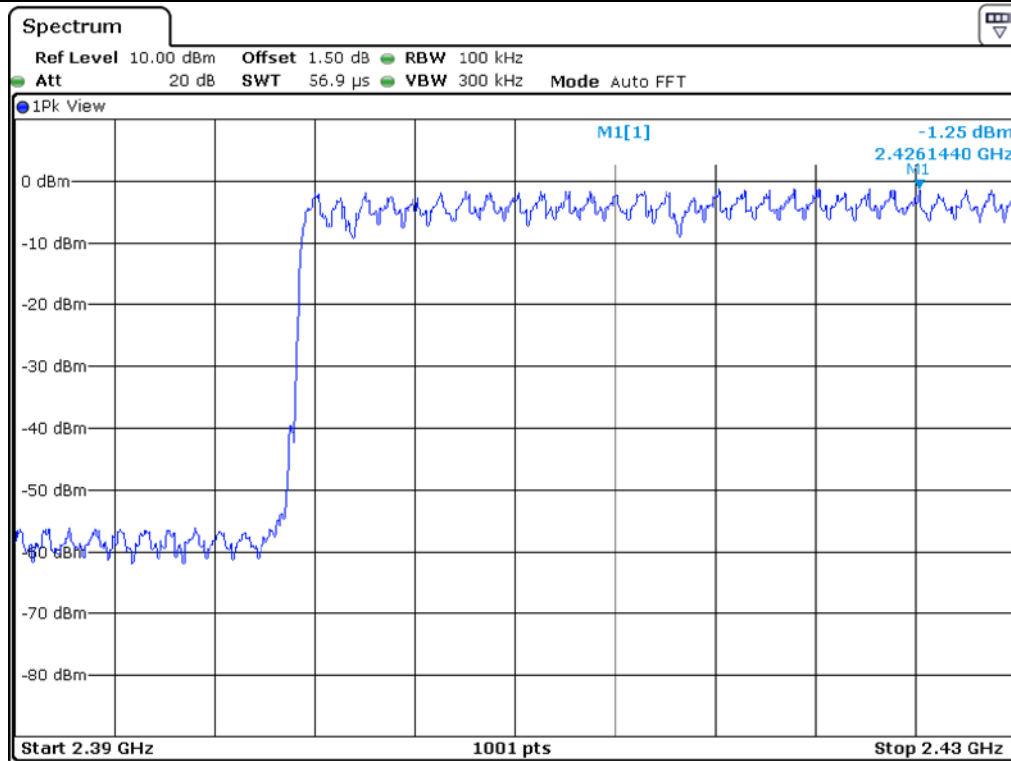


9.6 Test data for 3 Mbps

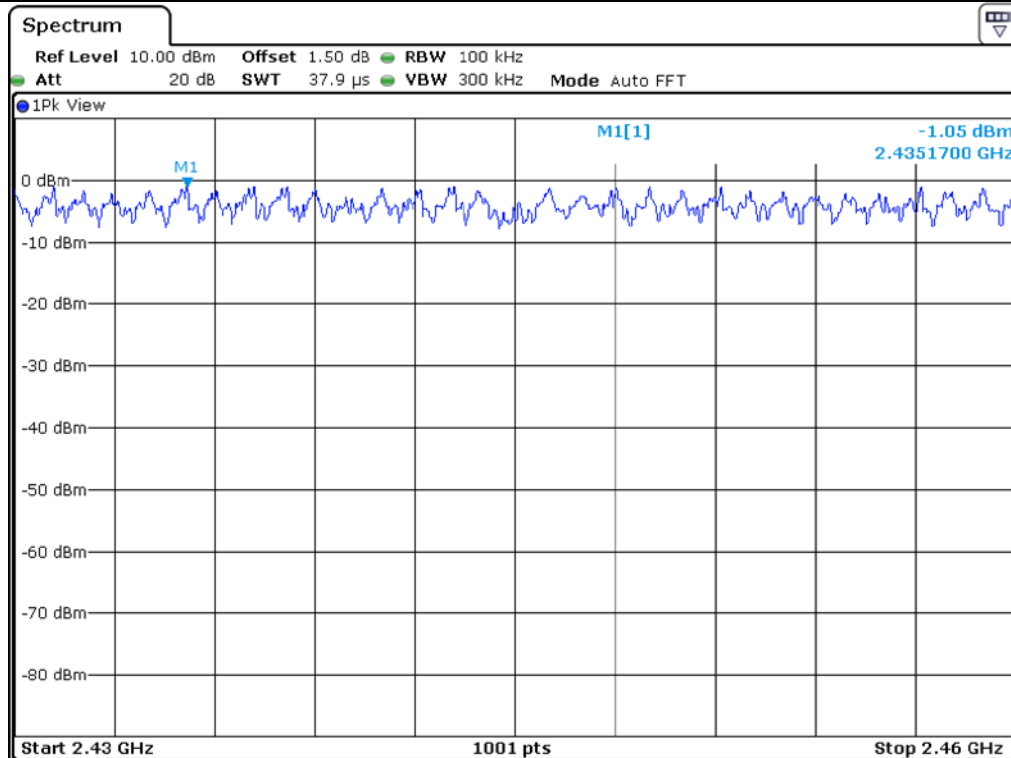
-. Test Result : Pass

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

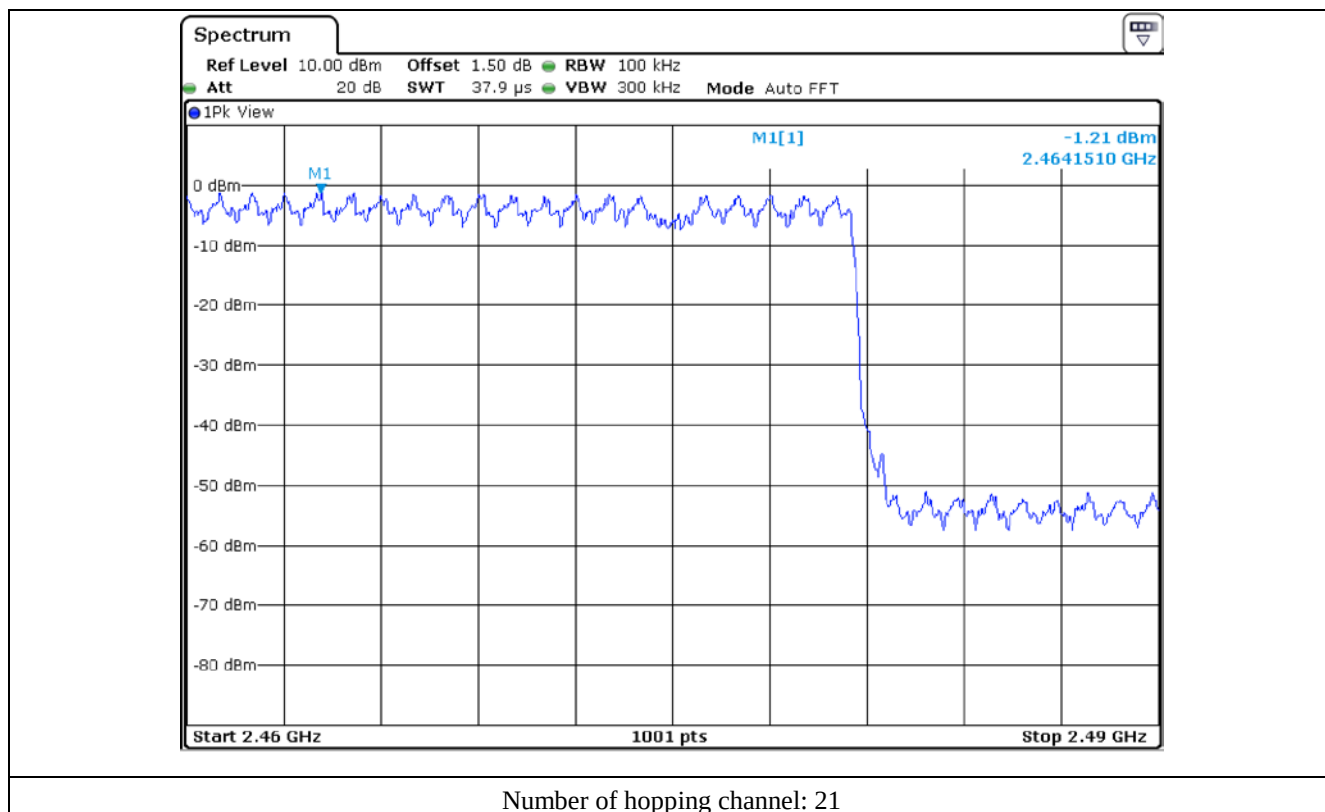




Number of hopping channel: 28



Number of hopping channel: 30



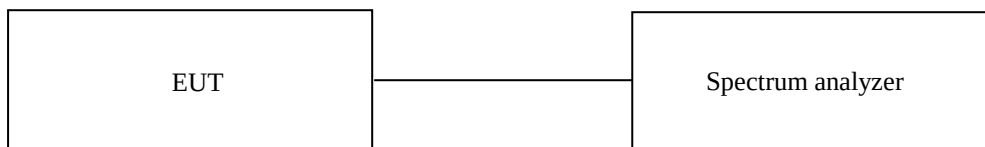
10. TIME OF OCCUPANCY

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 Date

December 03, 2020 ~ December 09, 2020

10.4 Test data for 1 Mbps

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

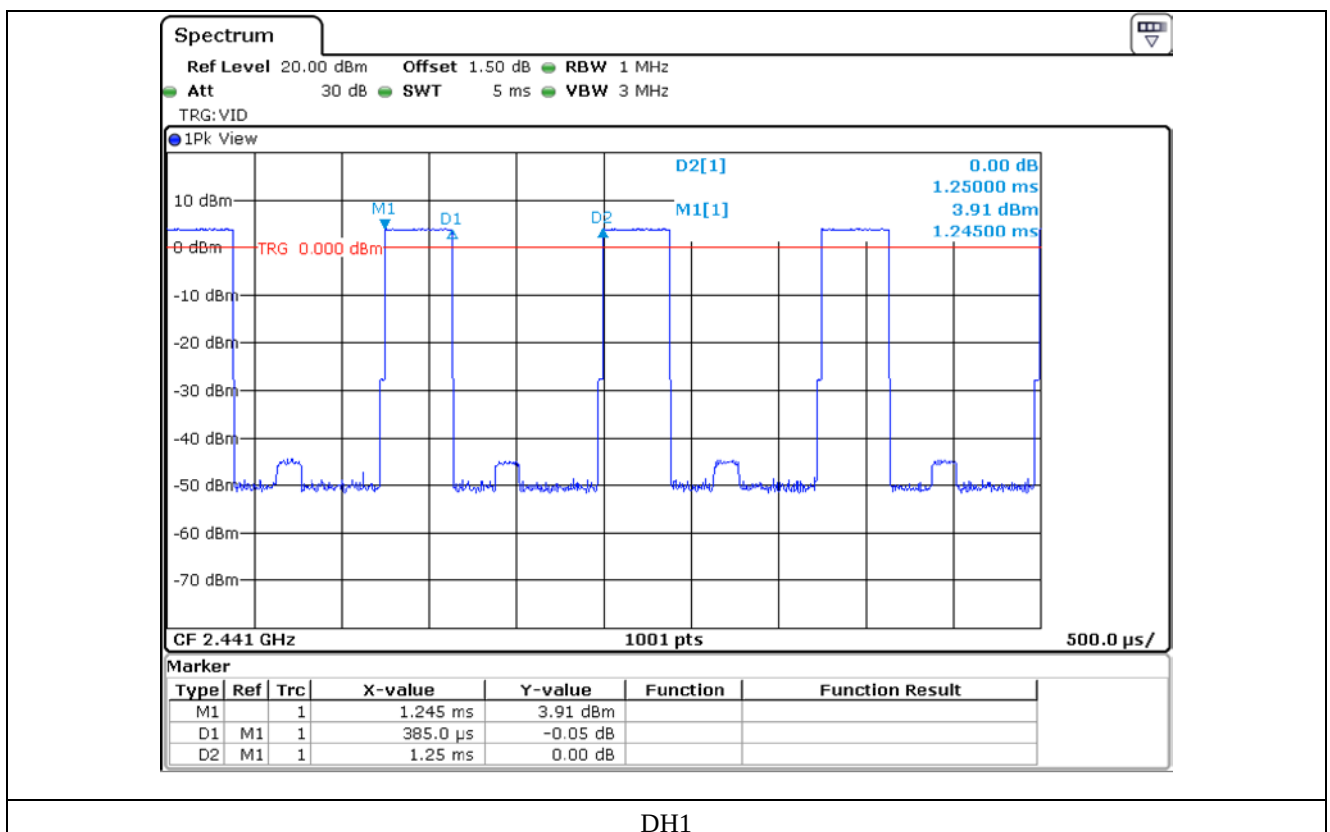
For DH1 packet type, the EUT needs 1 time slot for transmitting and 1 time slot for receiving and for DH3 packet type, the EUT needs 3 times slots for transmitting and 1 time slot for receiving, and DH5 packet needs 5 times slots for transmitting and 1 time slot for receiving. So The EUT has each channel 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.

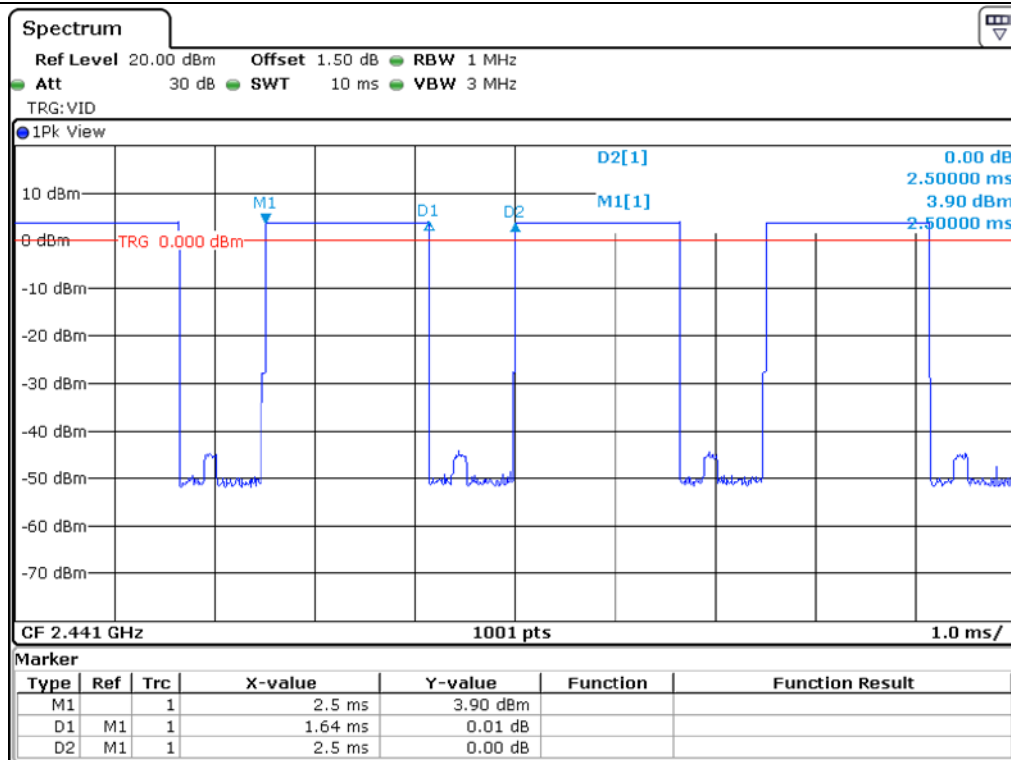
Packet Type	Pulse Time (ms)	Hops per second with channels	Period Time (ms)	Total Dwell Time (ms)	Limit (ms)	Test Result
DH1	0.385	10.13	31.60	123.24	400.00	PASS
DH3	1.640	5.06	31.60	262.23	400.00	
DH5	2.880	3.38	31.60	307.61	400.00	

Total dwell time is calculated as following.

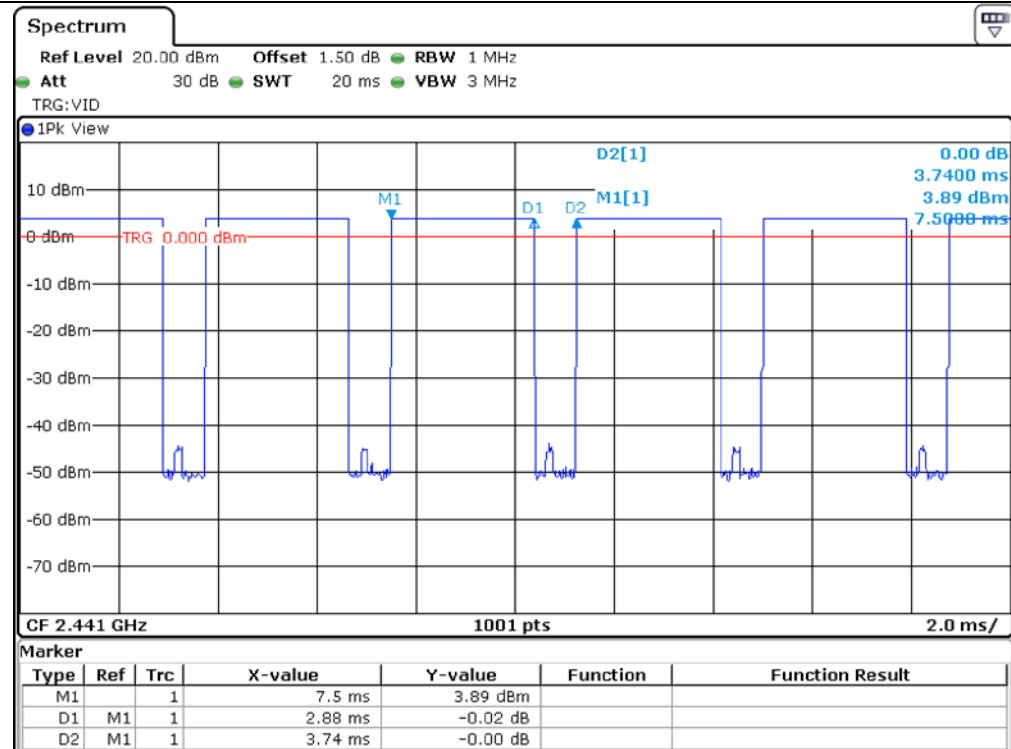
Total Dwell Time = Pulse time * Hops per second with channels * period time

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





DH3



DH5

10.5 Test data for 2 Mbps

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

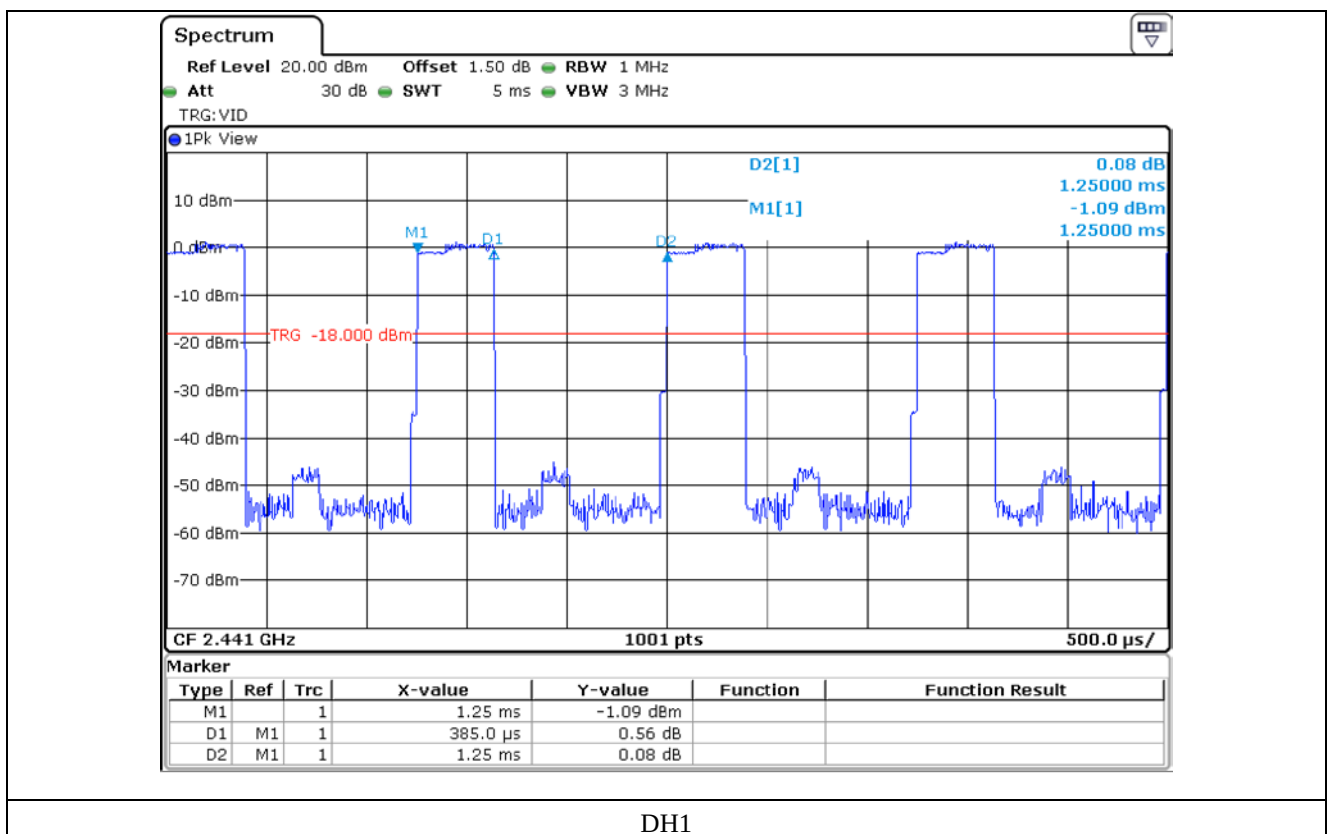
For DH1 packet type, the EUT needs 1 time slot for transmitting and 1 time slot for receiving and for DH3 packet type, the EUT needs 3 times slots for transmitting and 1 time slot for receiving, and DH5 packet needs 5 times slots for transmitting and 1 time slot for receiving. So The EUT has each channel 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.

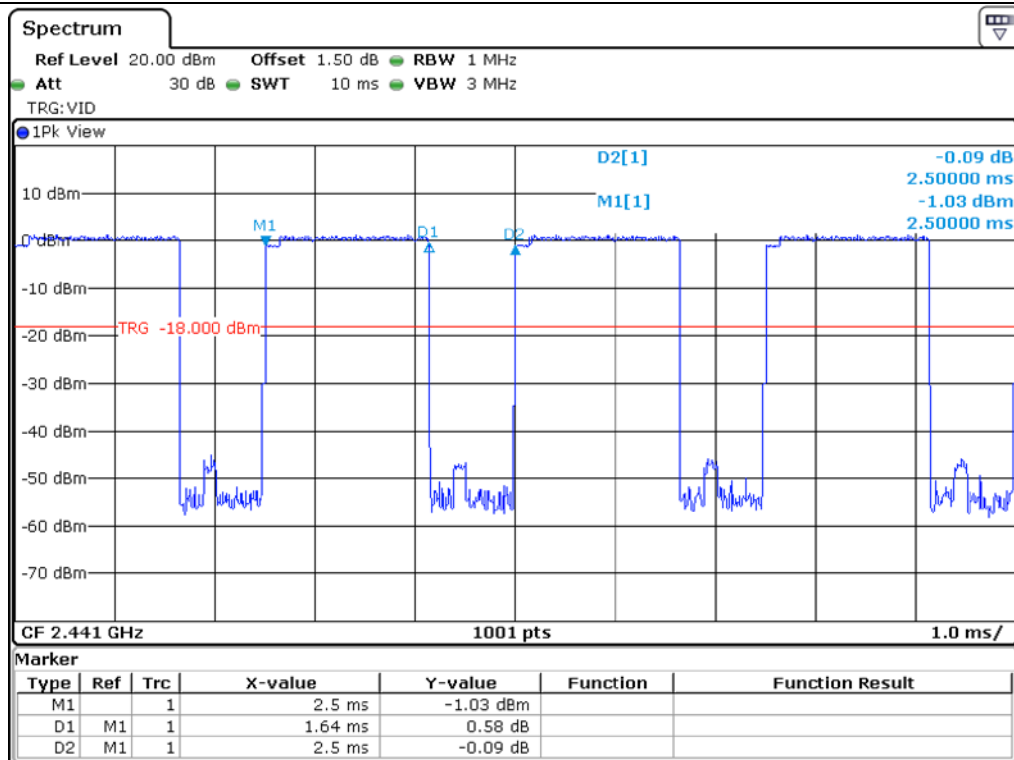
Packet Type	Pulse Time (ms)	Hops per second with channels	Period Time (ms)	Total Dwell Time (ms)	Limit (ms)	Test Result
DH1	0.385	10.13	31.60	123.24	400.00	PASS
DH3	1.640	5.06	31.60	262.23	400.00	
DH5	2.900	3.38	31.60	309.74	400.00	

Total dwell time is calculated as following.

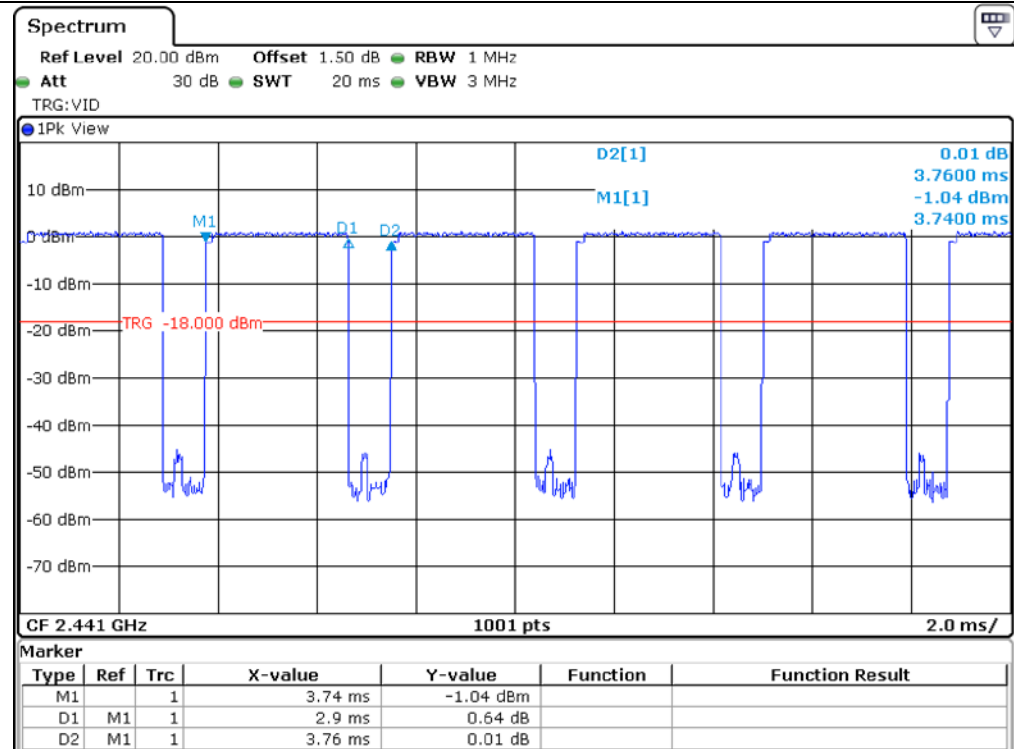
Total Dwell Time = Pulse time * Hops per second with channels * period time

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





DH3



DH5

10.6 Test data for 3 Mbps

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

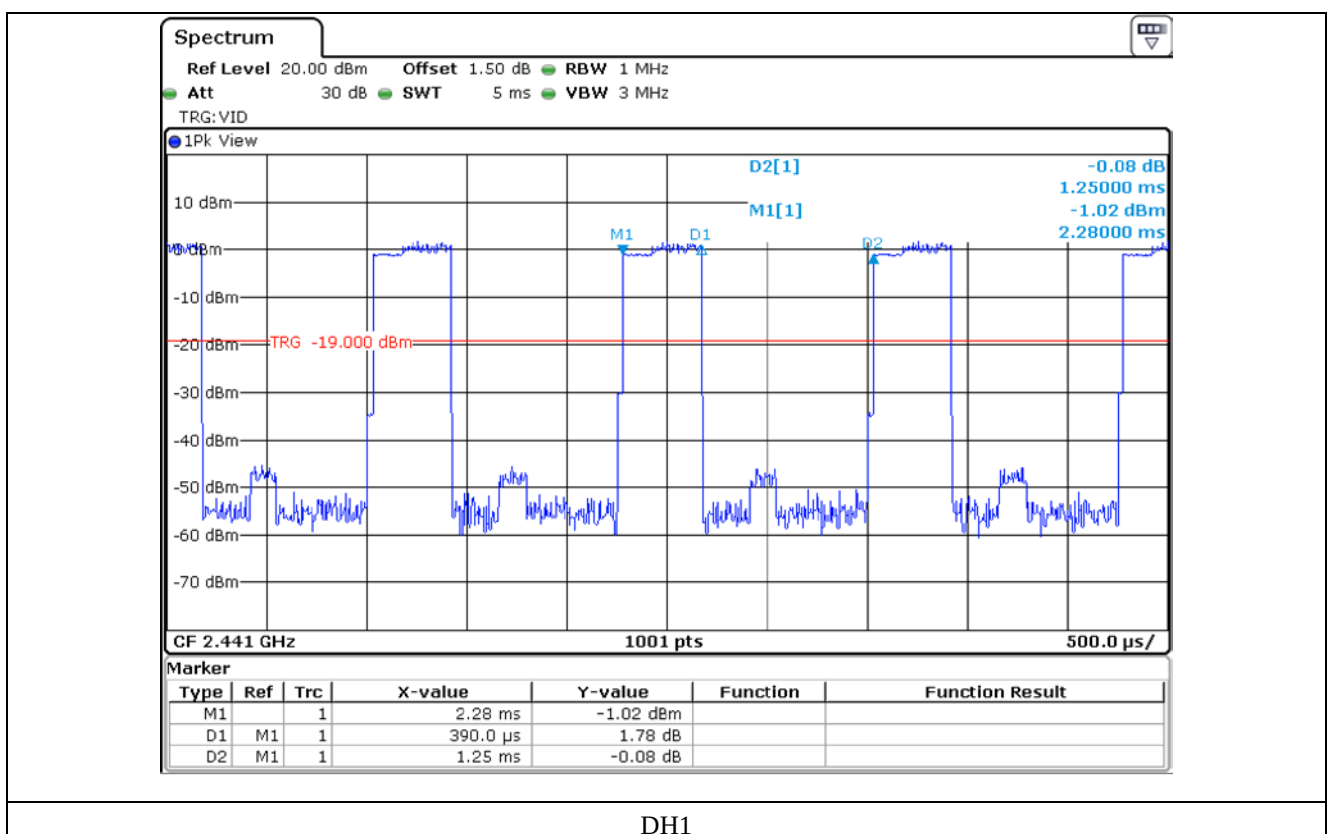
For DH1 packet type, the EUT needs 1 time slot for transmitting and 1 time slot for receiving and for DH3 packet type, the EUT needs 3 times slots for transmitting and 1 time slot for receiving, and DH5 packet needs 5 times slots for transmitting and 1 time slot for receiving. So The EUT has each channel 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.

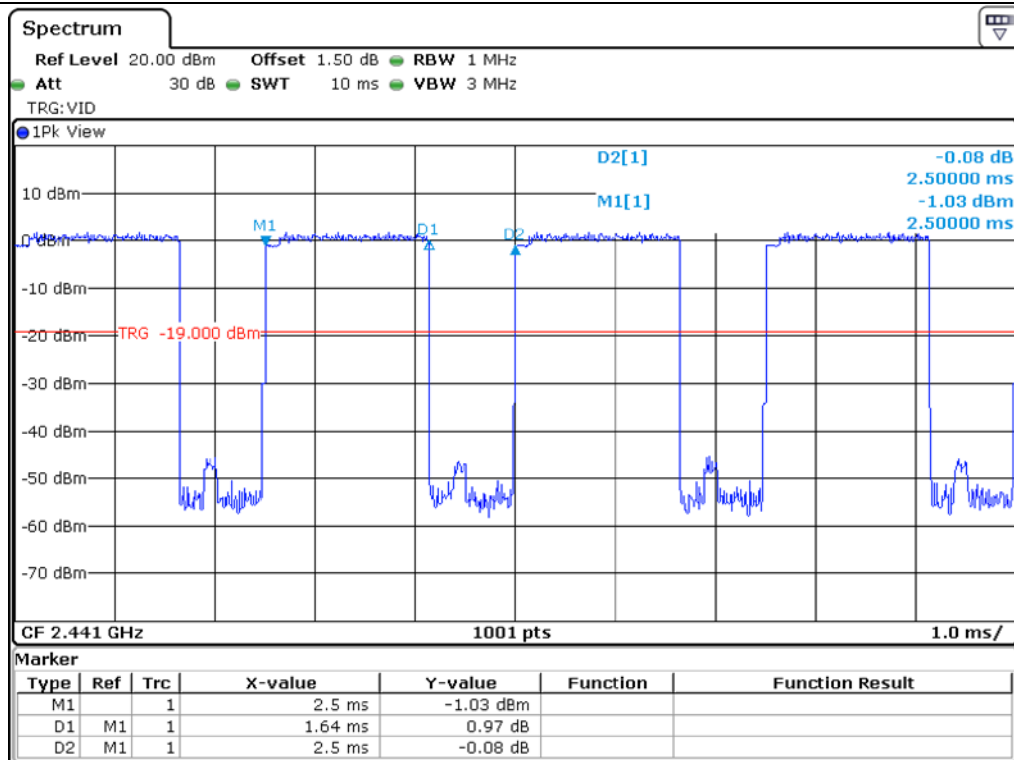
Packet Type	Pulse Time (ms)	Hops per second with channels	Period Time (ms)	Total Dwell Time (ms)	Limit (ms)	Test Result
DH1	0.390	10.13	31.60	124.84	400.00	PASS
DH3	1.640	5.06	31.60	262.23	400.00	
DH5	2.900	3.38	31.60	309.74	400.00	

Total dwell time is calculated as following.

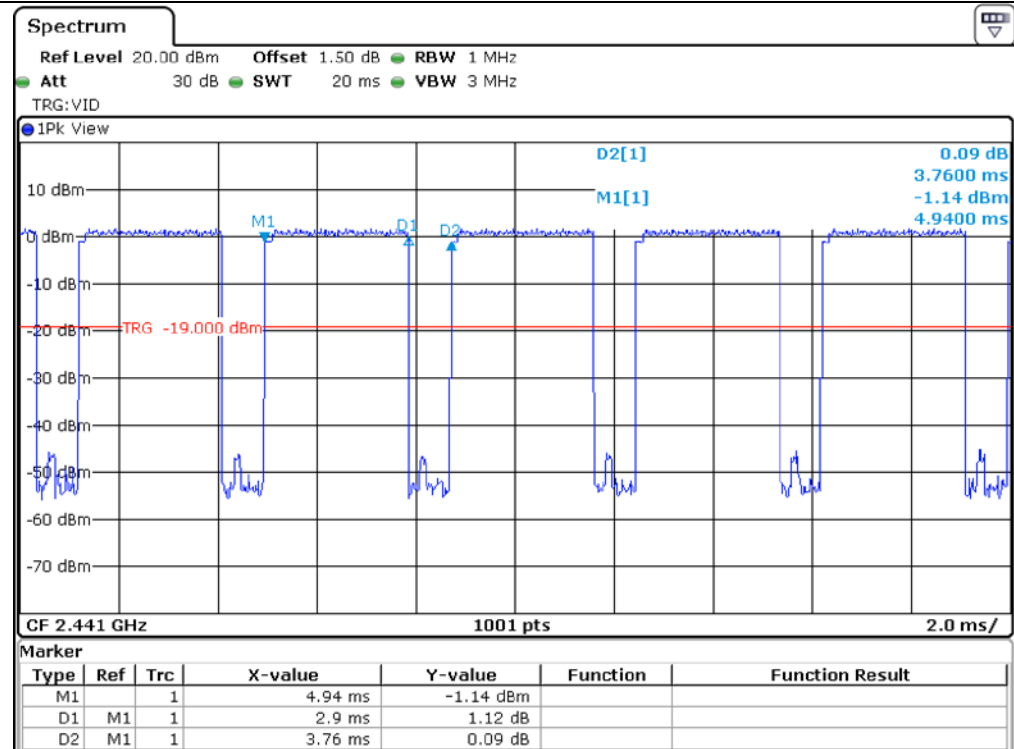
Total Dwell Time = Pulse time * Hops per second with channels * period time

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





DH3



DH5

11. MAXIMUM PEAK OUTPUT POWER

11.1 Operating environment

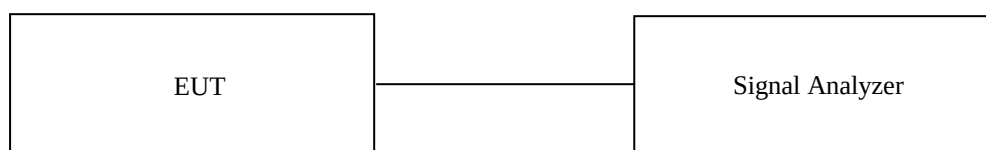
Temperature : 23 °C

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 Date

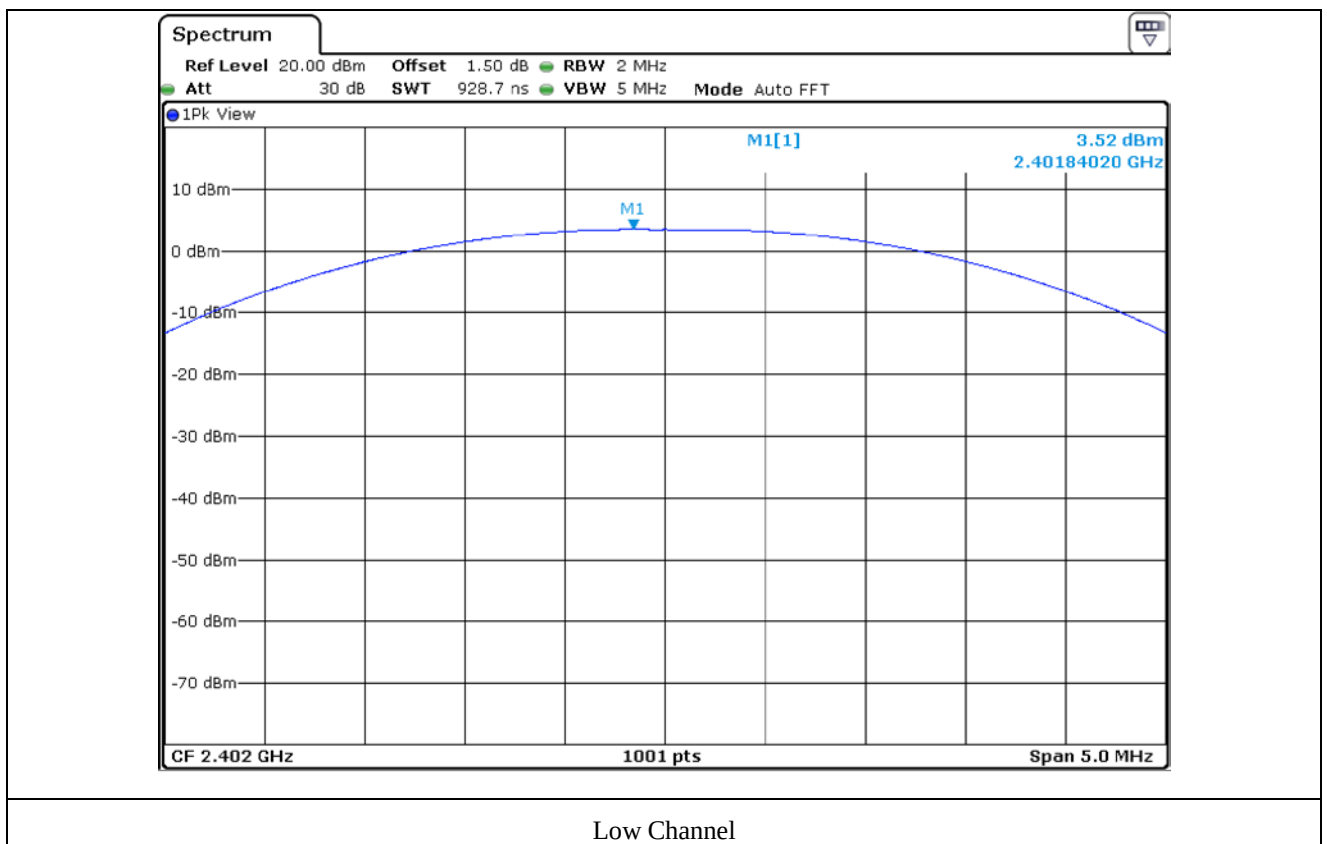
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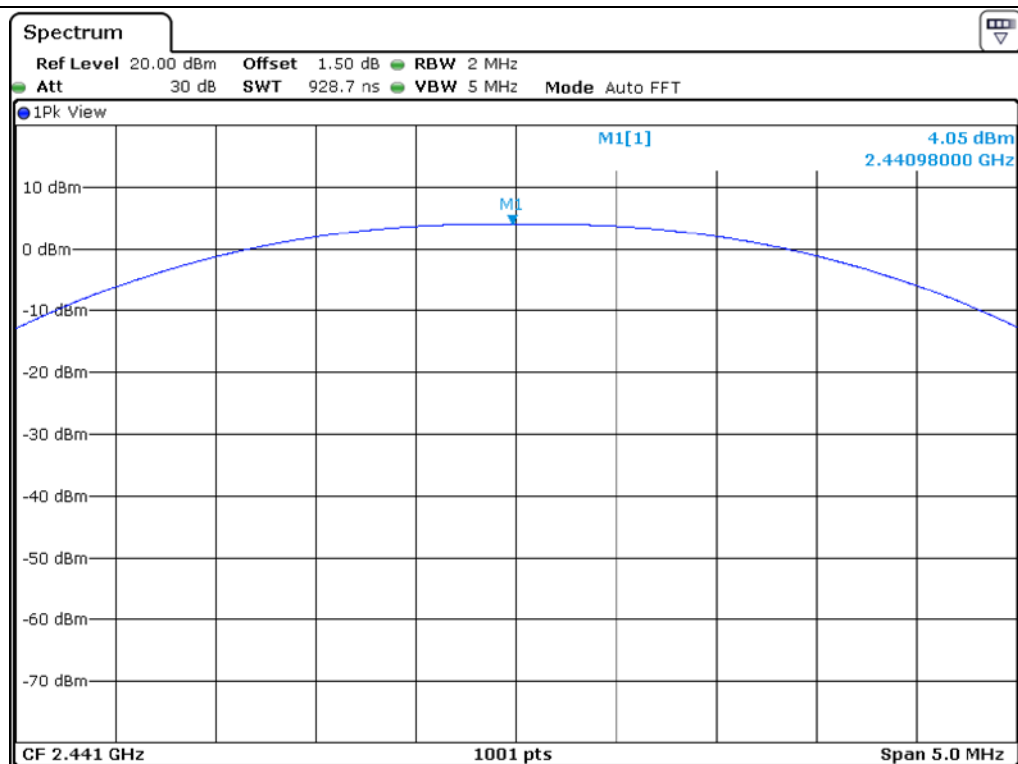
11.4 Test data for 1 Mbps

-. Test Result : Pass

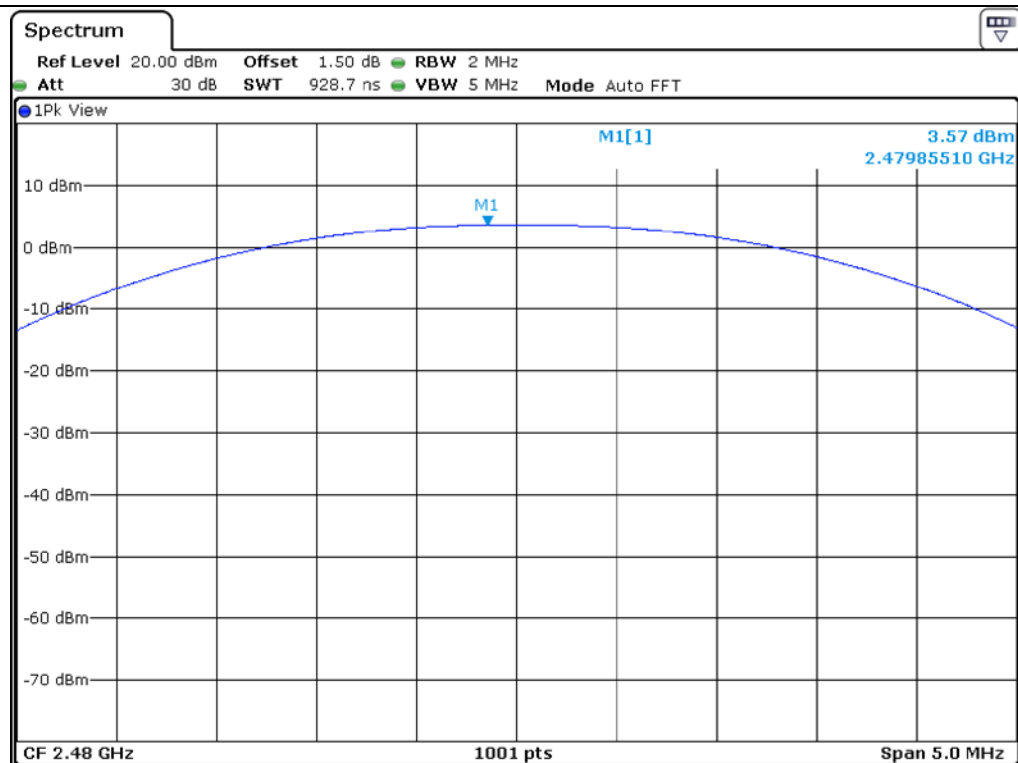
CHANNEL	FREQUENCY (MHz)	MEASURED VALUE (dBm)	LIMIT (dBm)	MARGIN (dB)
LOW	2 402.00	3.52	21.00	17.48
MIDDLE	2 441.00	4.05	21.00	16.95
HIGH	2 480.00	3.57	21.00	17.43

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





Middle Channel



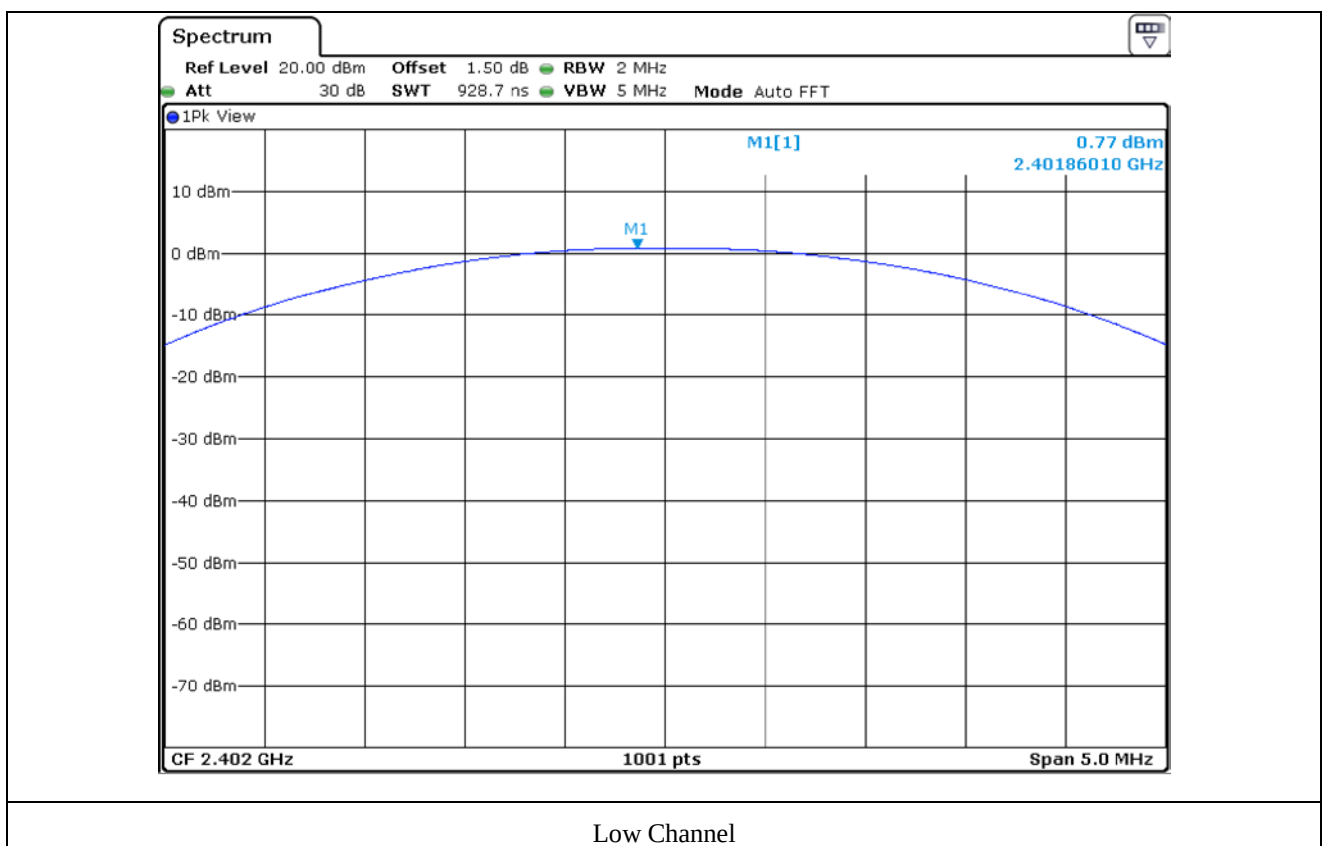
High Channel

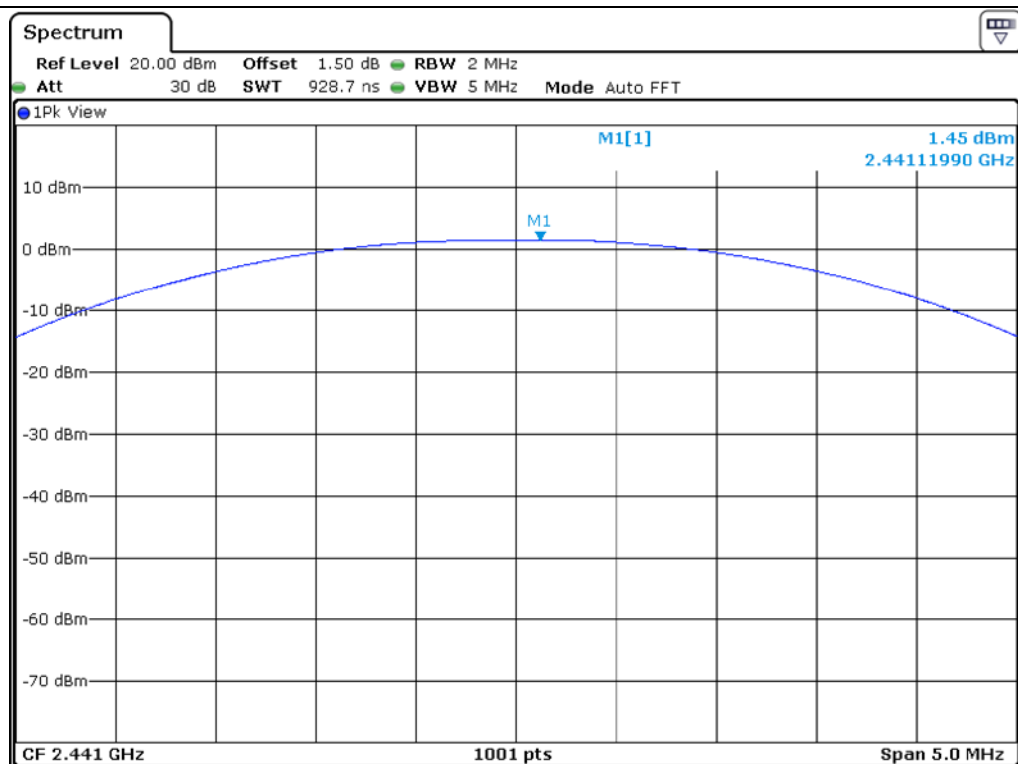
11.5 Test data for 2 Mbps

-. Test Result : Pass

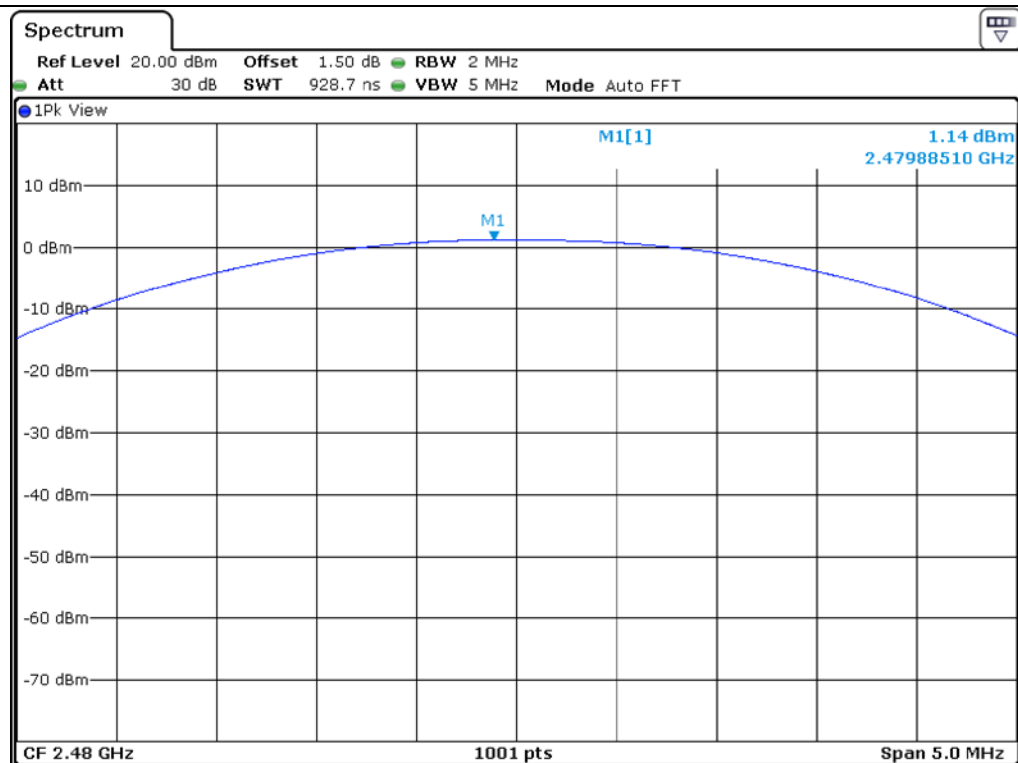
CHANNEL	FREQUENCY (MHz)	MEASURED VALUE (dBm)	LIMIT (dBm)	MARGIN (dB)
LOW	2 402.00	0.77	21.00	20.23
MIDDLE	2 441.00	1.45	21.00	19.55
HIGH	2 480.00	1.14	21.00	19.86

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





Middle Channel



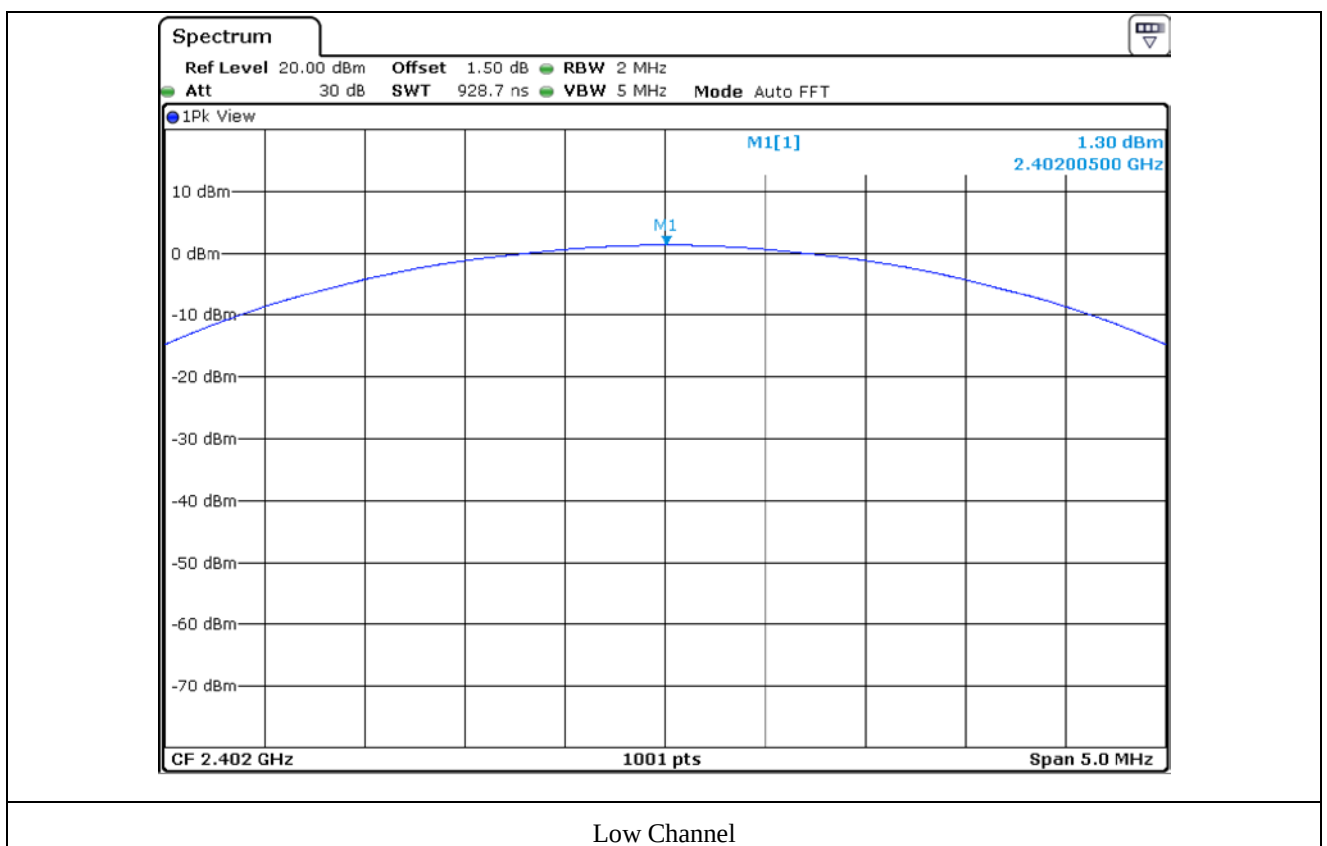
High Channel

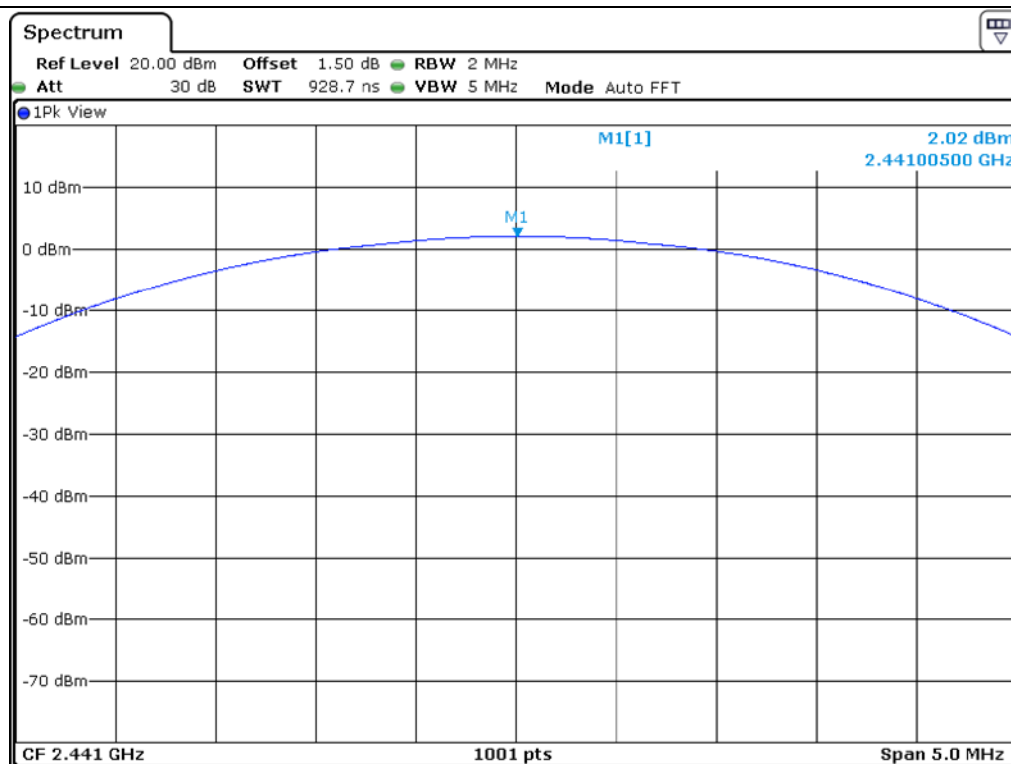
11.6 Test data for 3 Mbps

-. Test Result : Pass

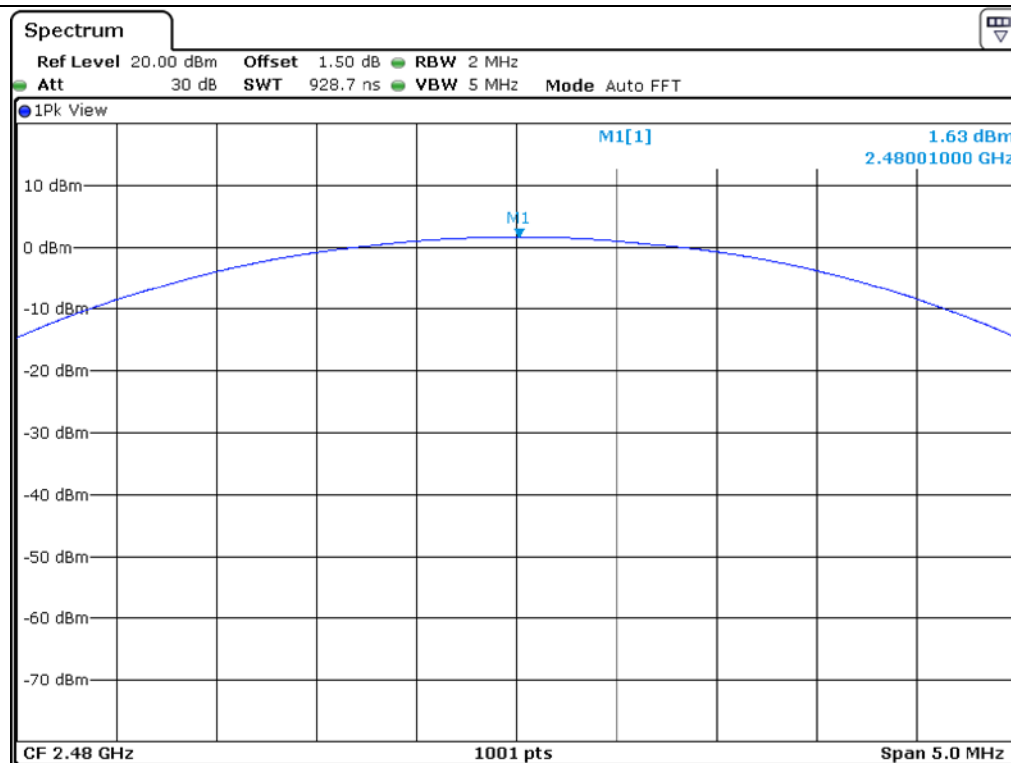
CHANNEL	FREQUENCY (MHz)	MEASURED VALUE (dBm)	LIMIT (dBm)	MARGIN (dB)
LOW	2 402.00	1.30	21.00	19.70
MIDDLE	2 441.00	2.02	21.00	18.98
HIGH	2 480.00	1.63	21.00	19.37

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





Middle Channel



High Channel

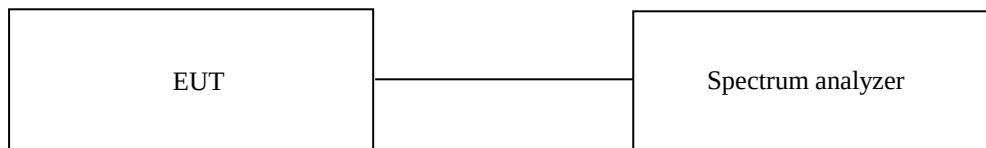
12. 100 kHz BANDWIDTH OUTSIDE THE FREQUENCY BAND

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.

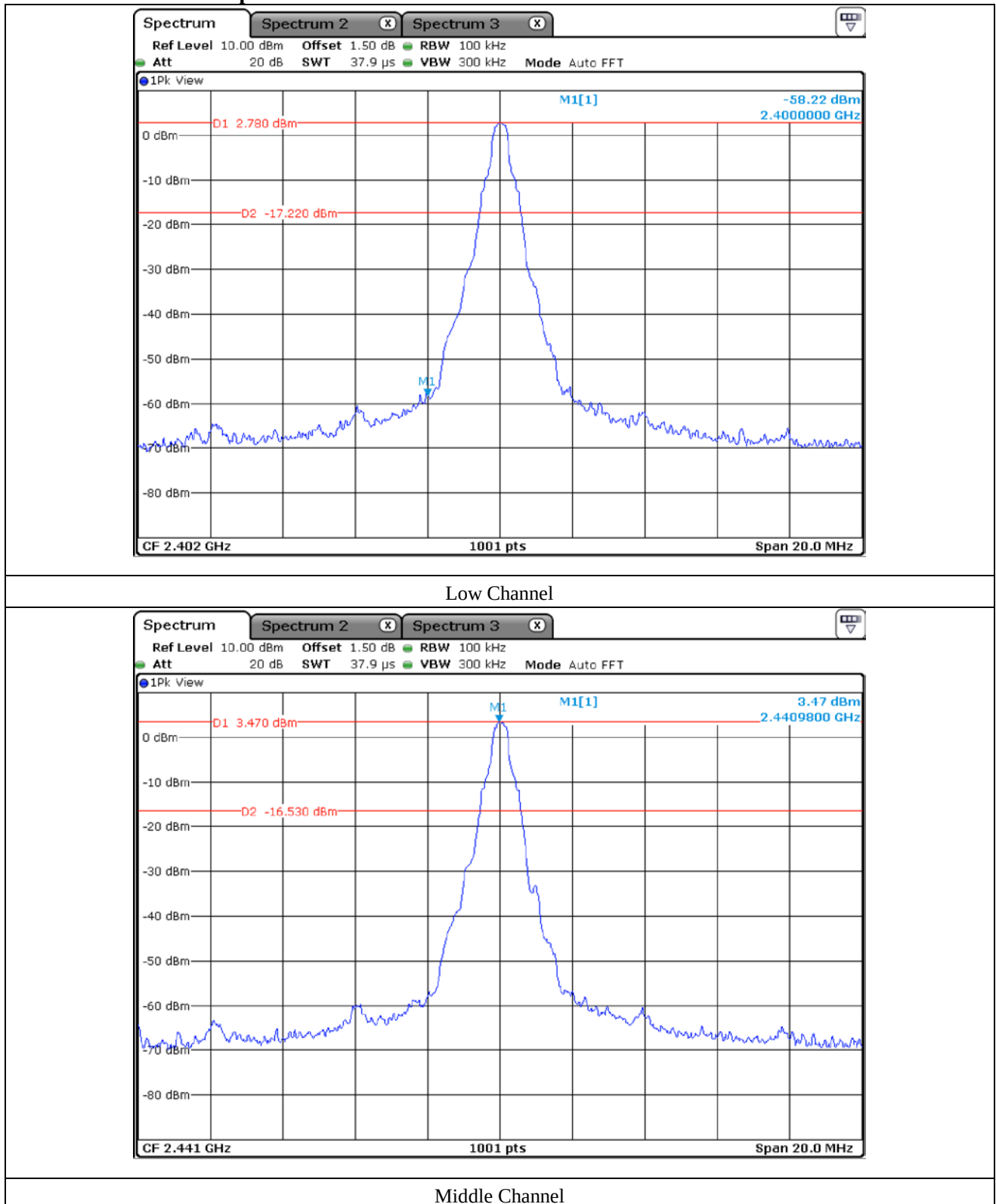
The frequency spectrum from 30 MHz to 26.5 GHz was scanned and maximum emission levels at each frequency recorded. The system was rotated 360°, and the antenna was varied in the height between 1.0 m and 4.0 m in order to determine the maximum emission levels. This procedure was performed for horizontal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

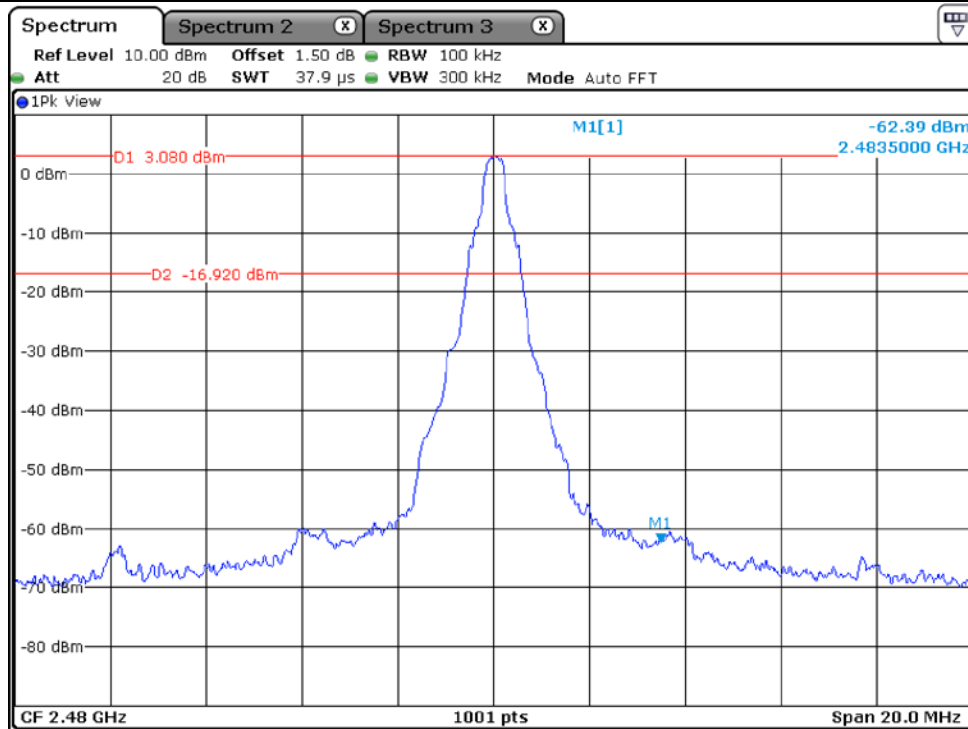
12.4 Test Date

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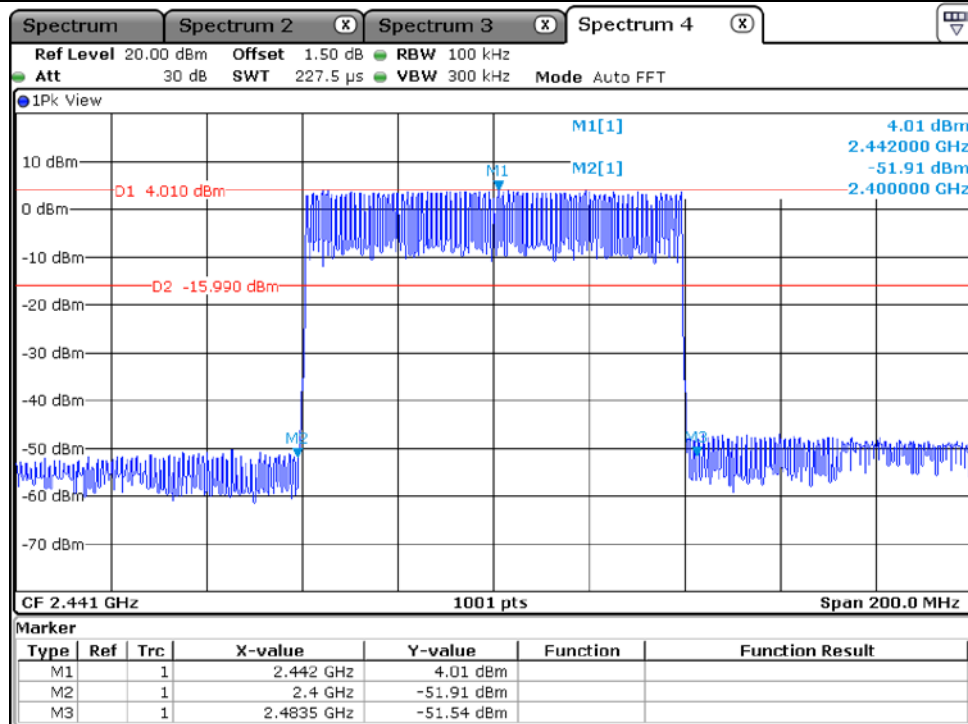
12.5 Test data for conducted emission

12.5.1 Test data for 1 Mbps

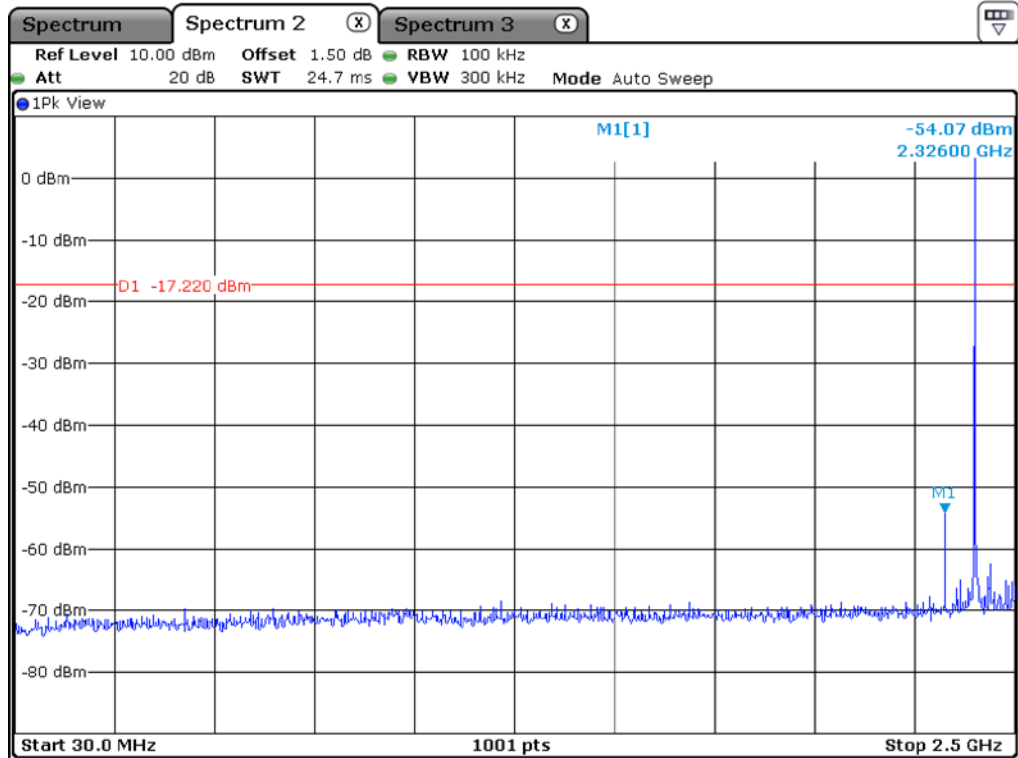




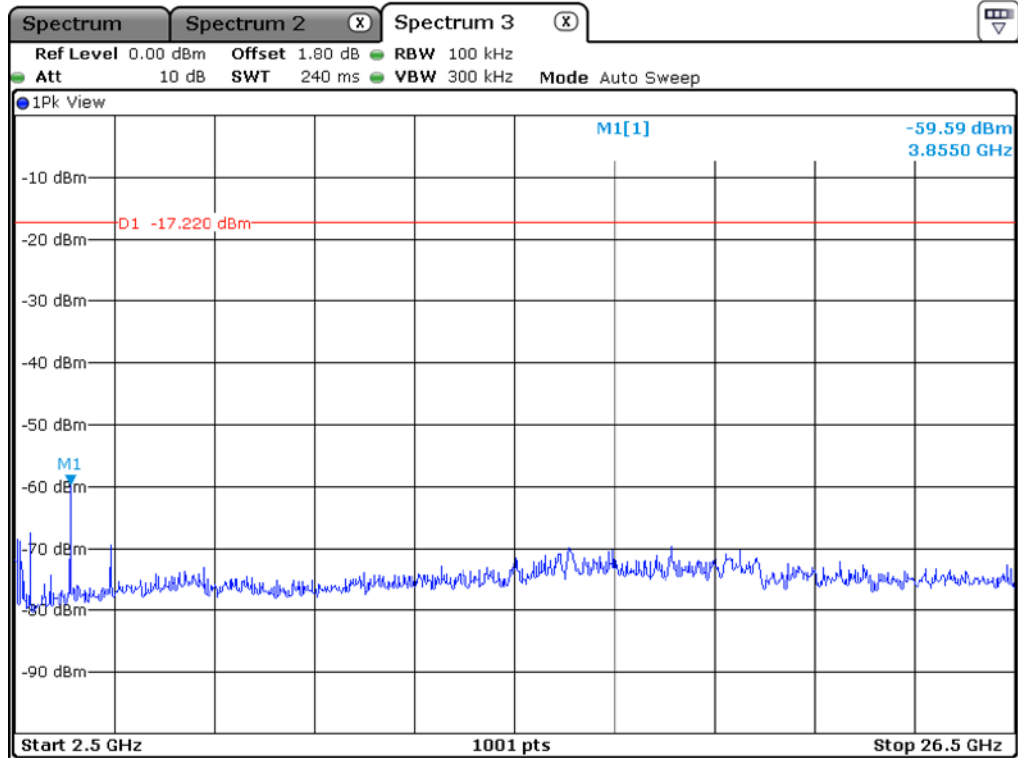
High Channel



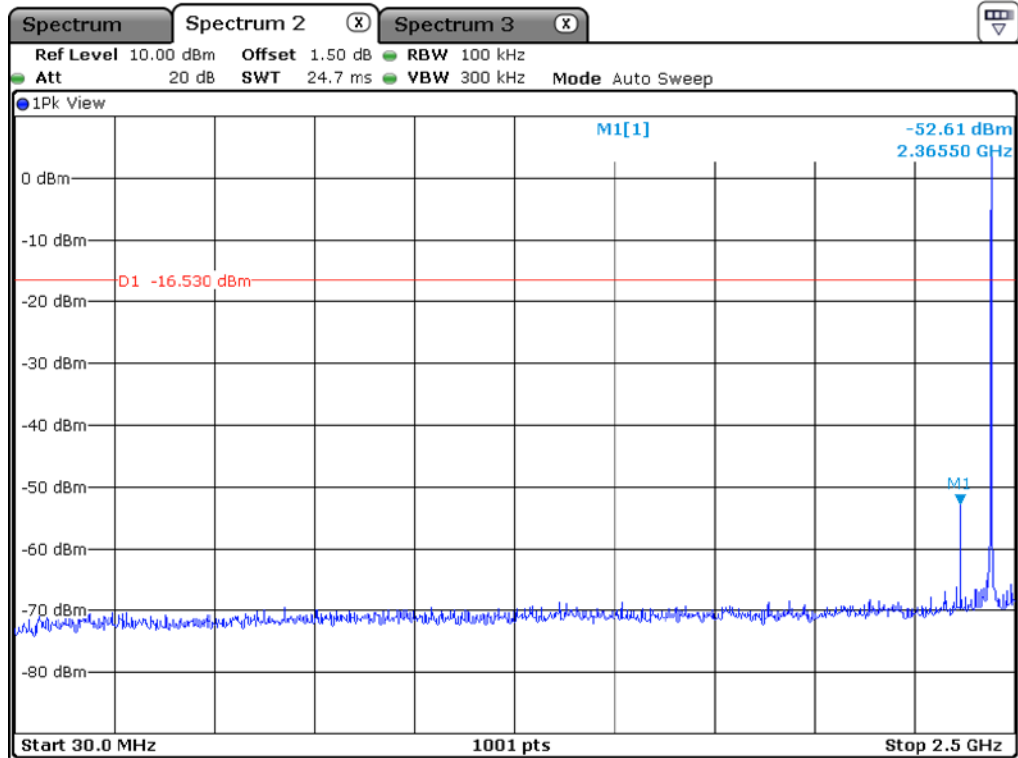
Hopping Mode



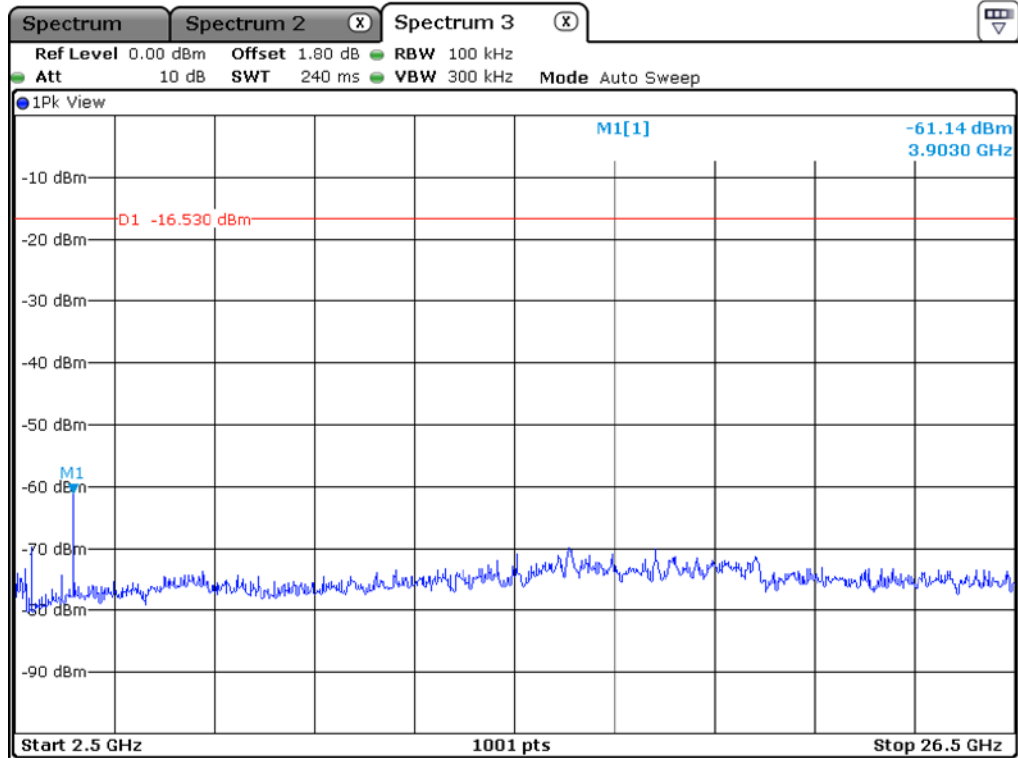
Low Channel



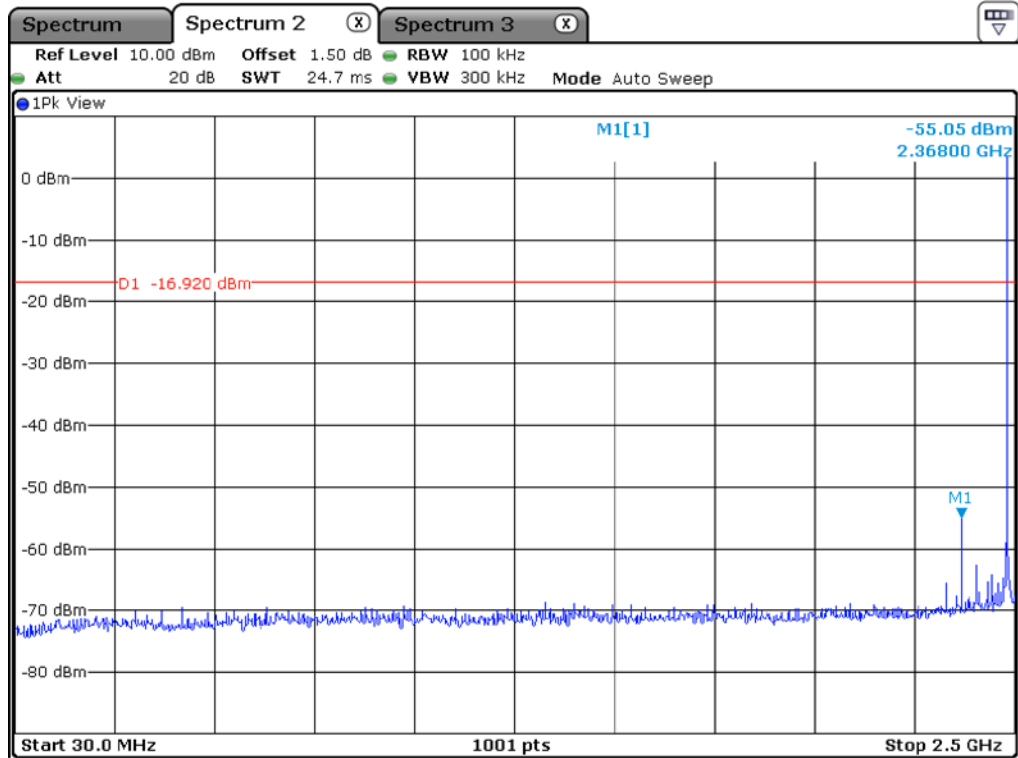
Low Channel



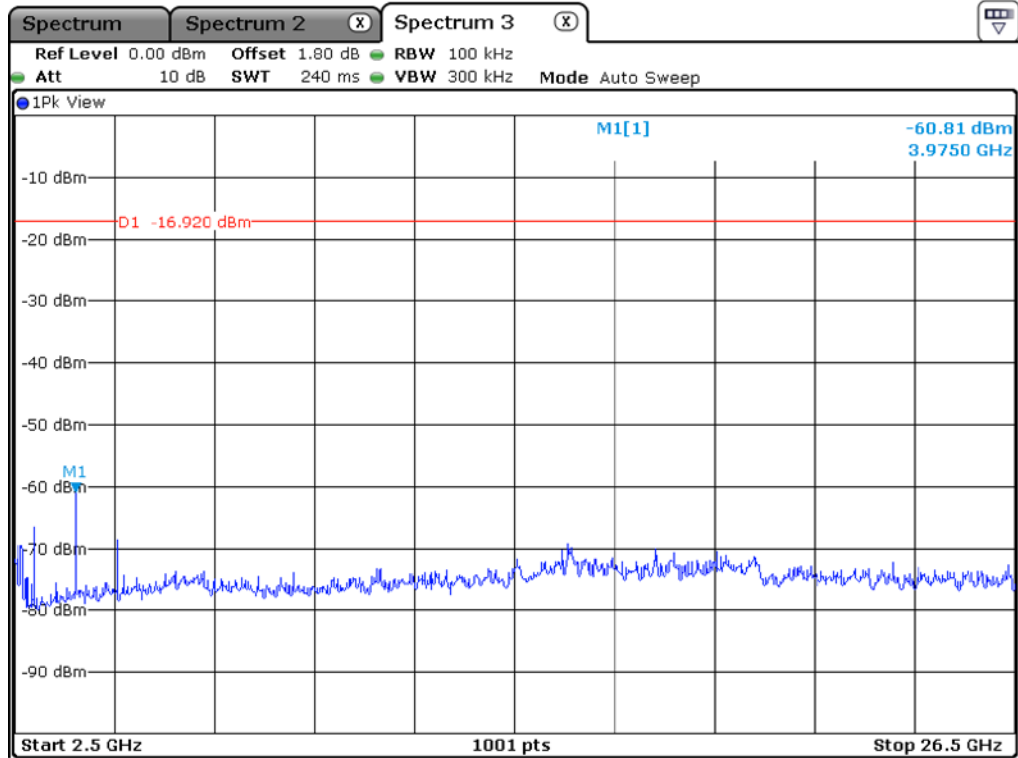
Middle Channel



Middle Channel

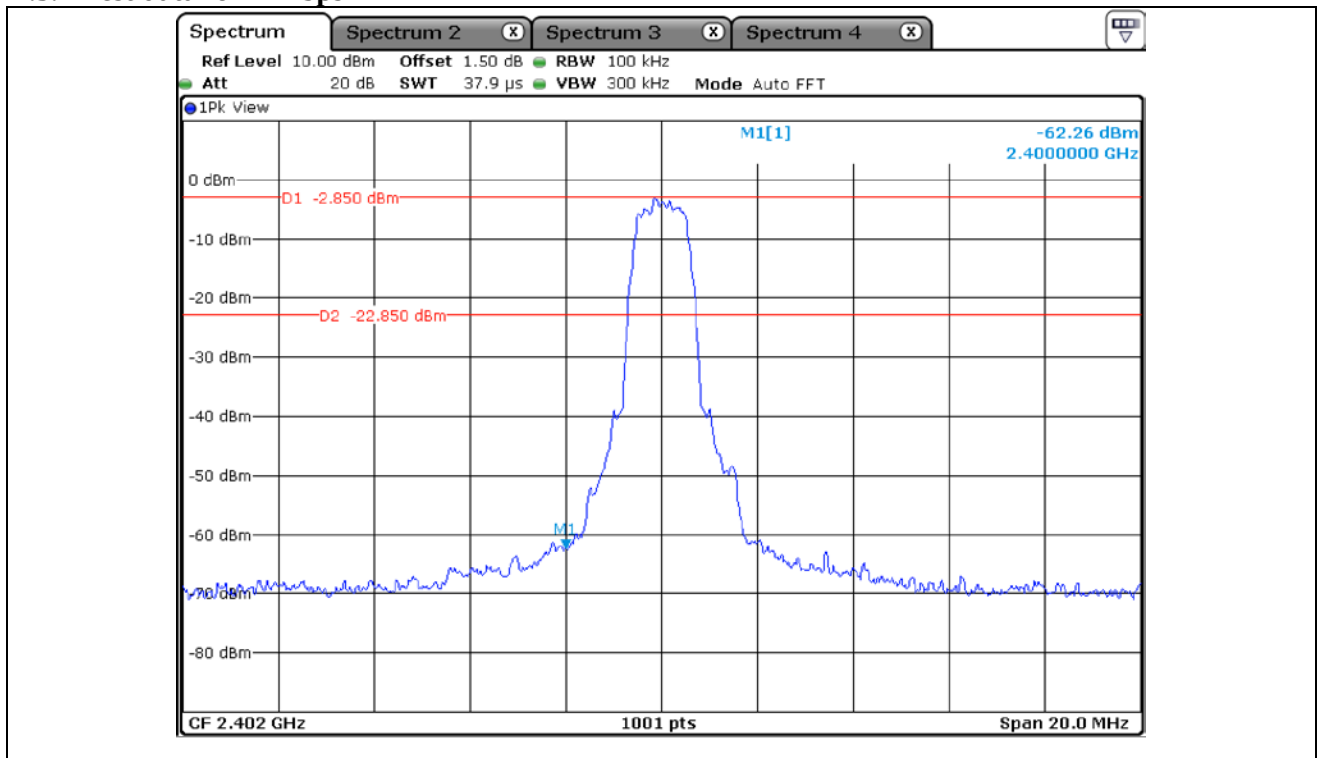


High Channel

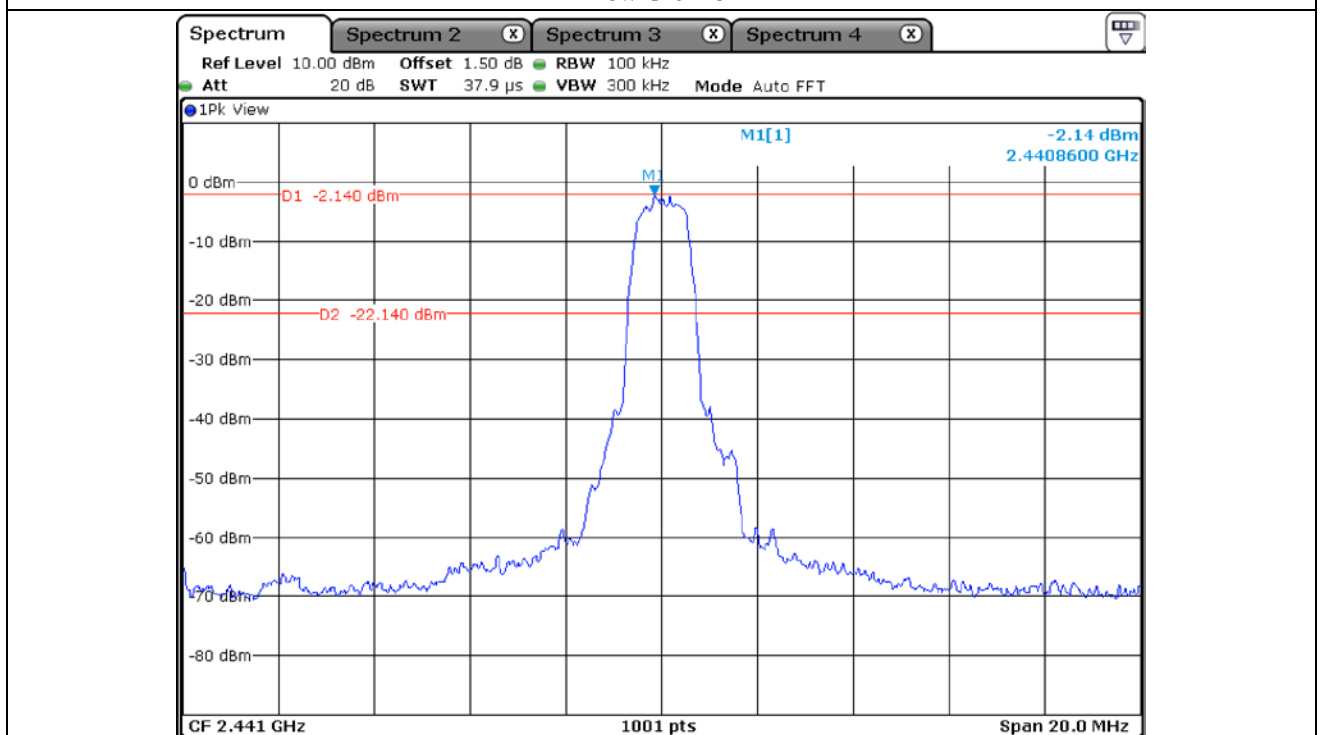


High Channel

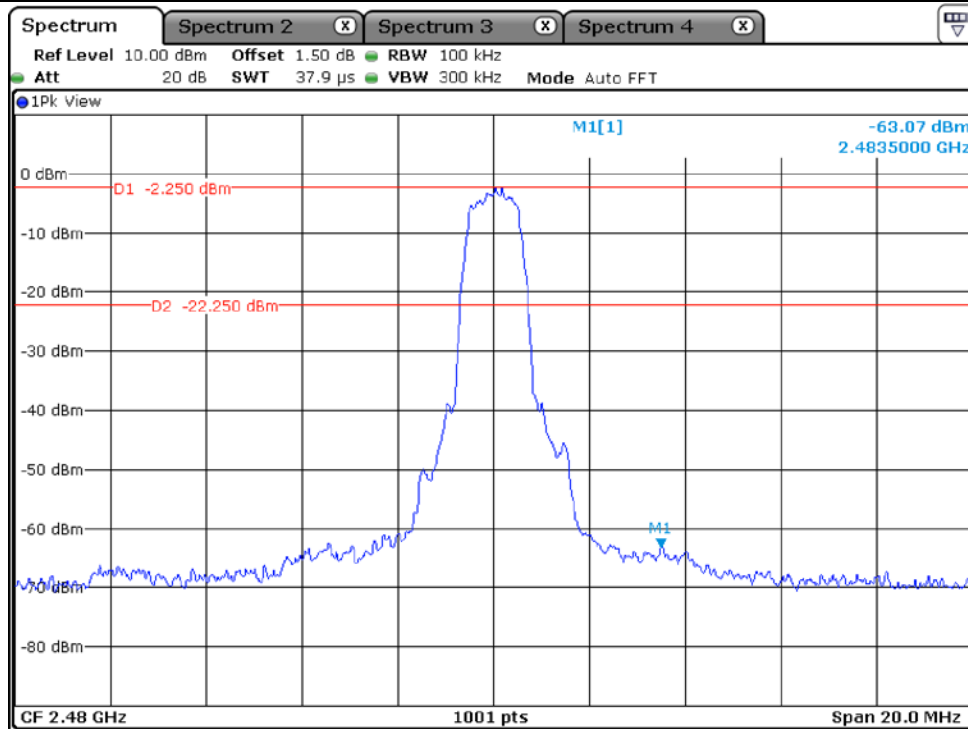
12.5.2 Test data for 2 Mbps



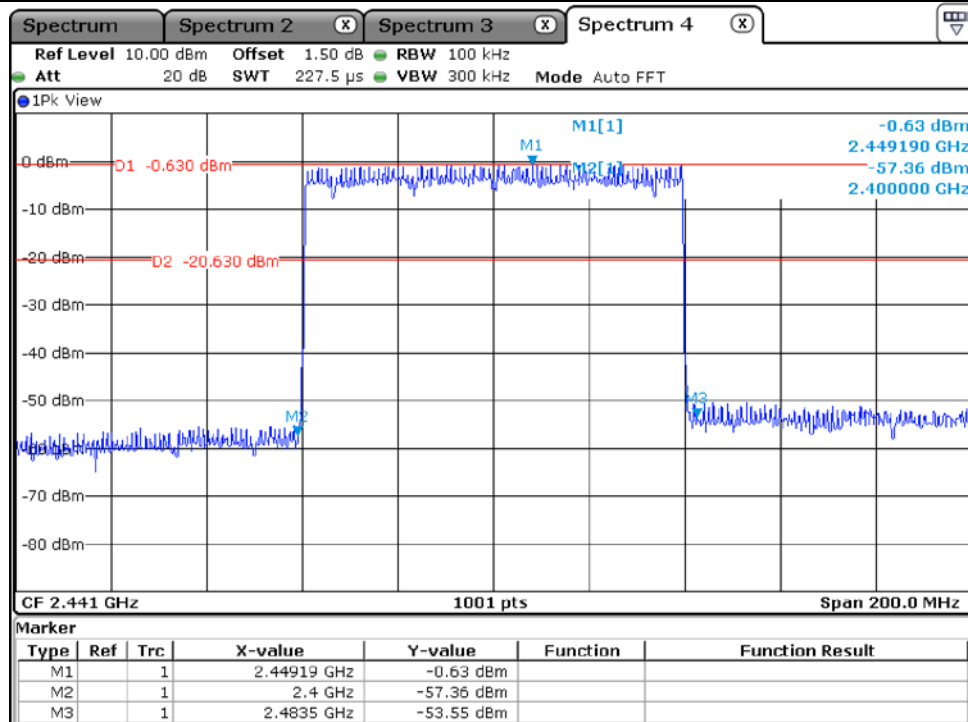
Low Channel



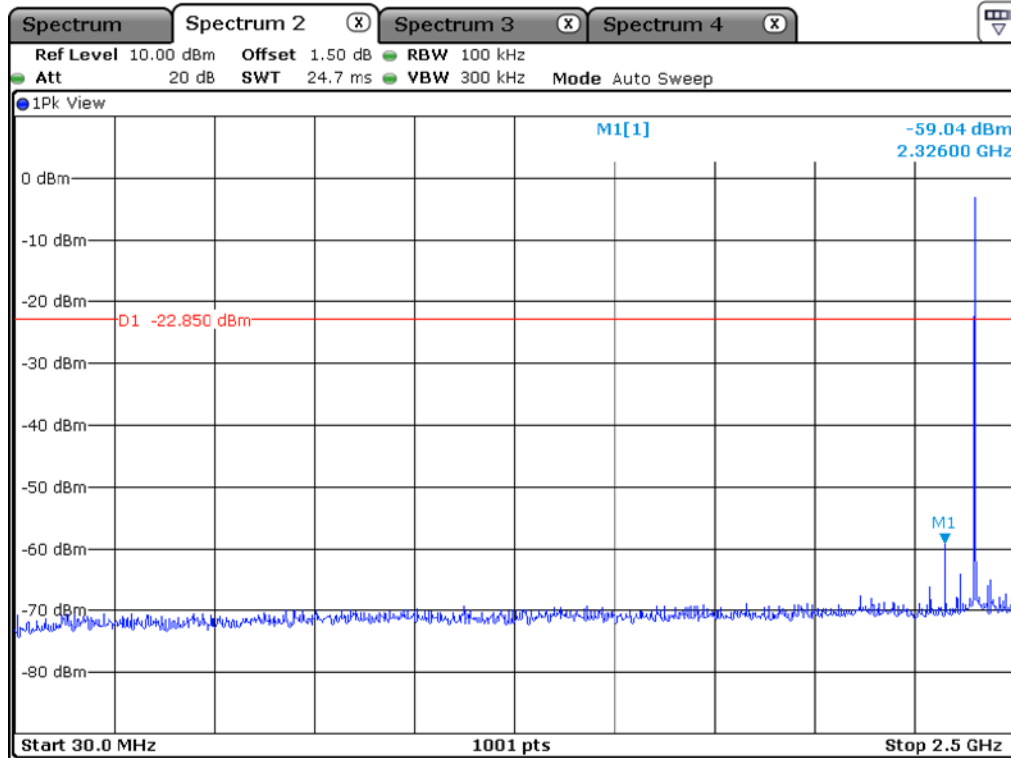
Middle Channel



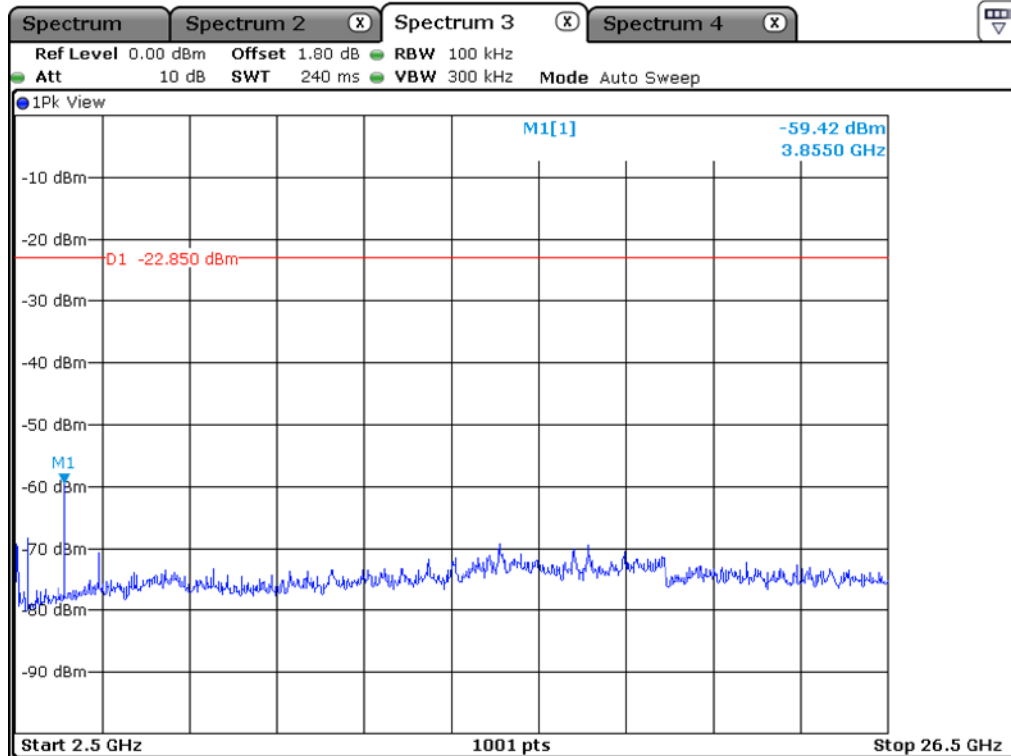
High Channel



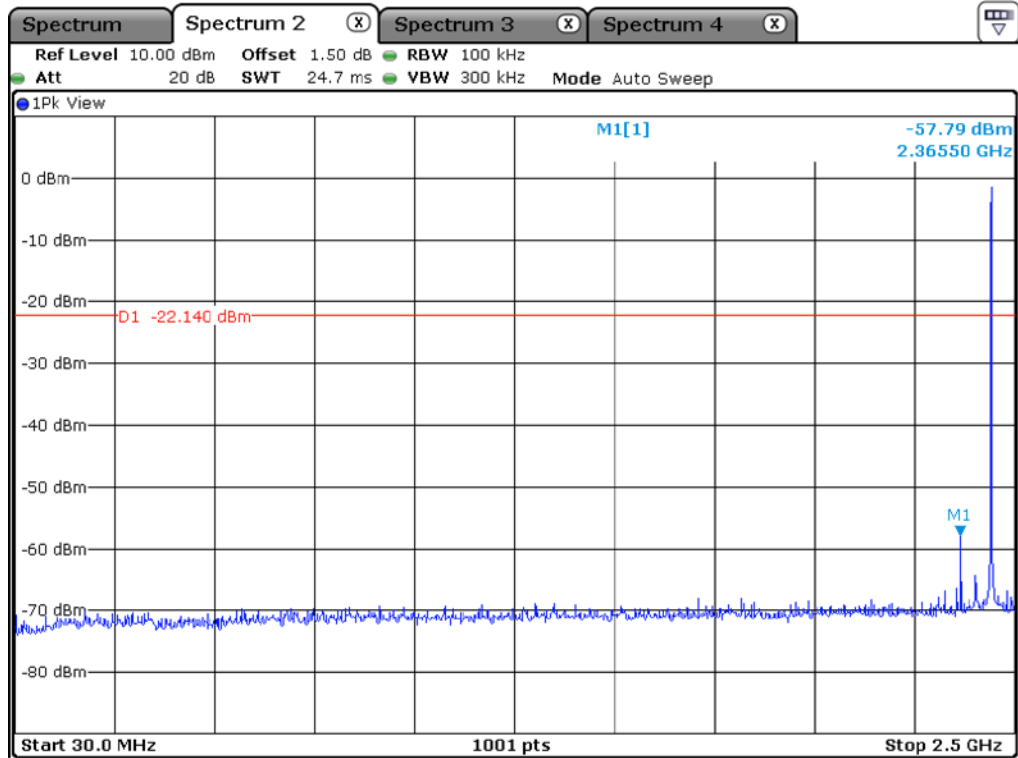
Hopping Mode



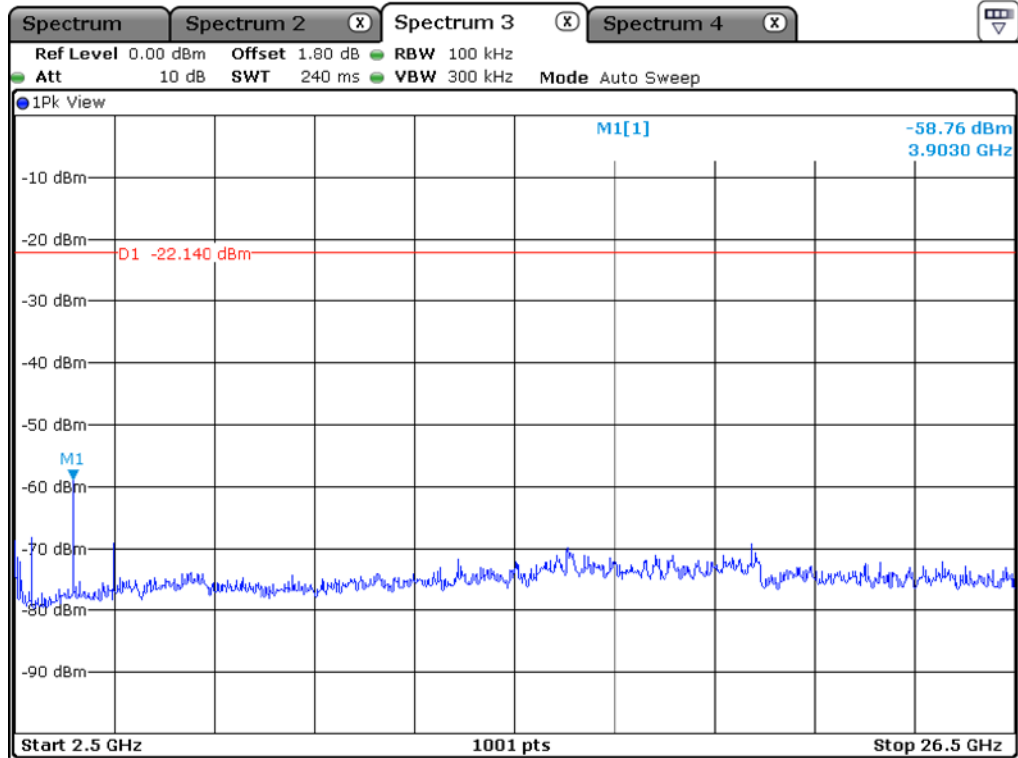
Low Channel



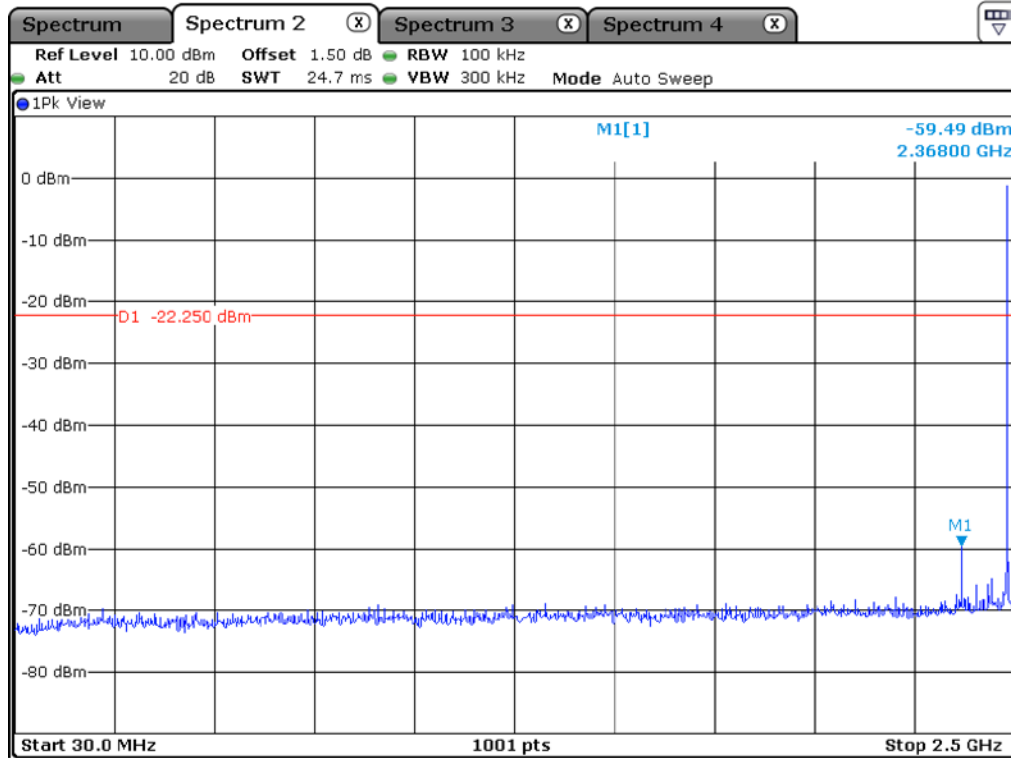
Low Channel



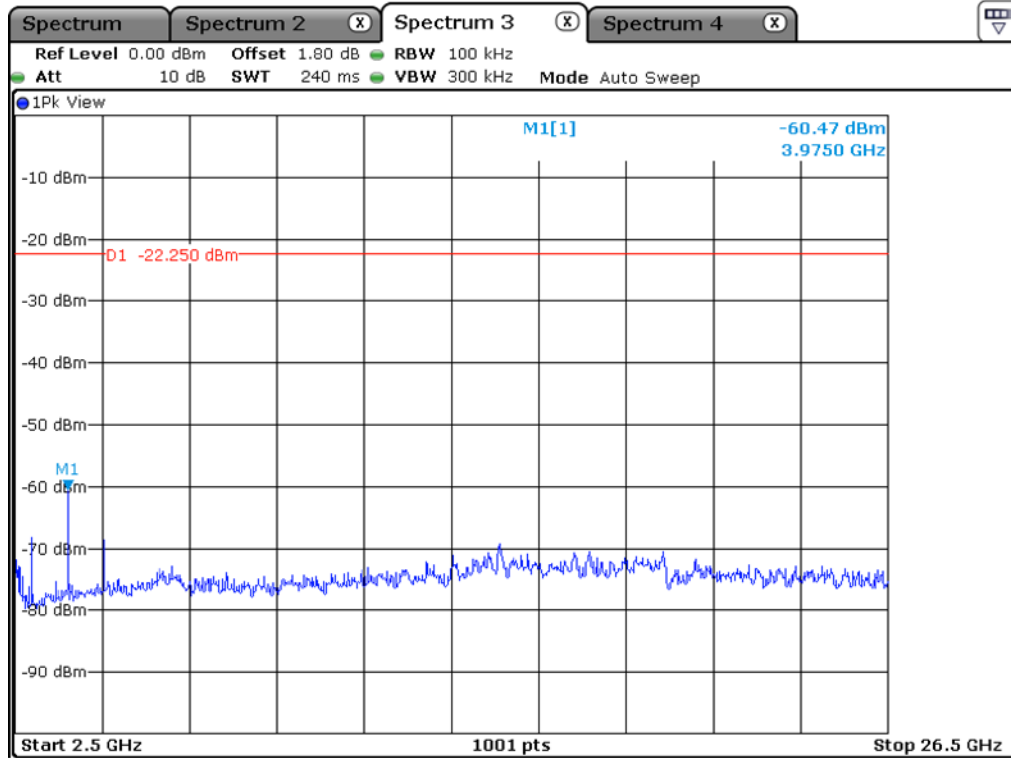
Middle Channel



Middle Channel

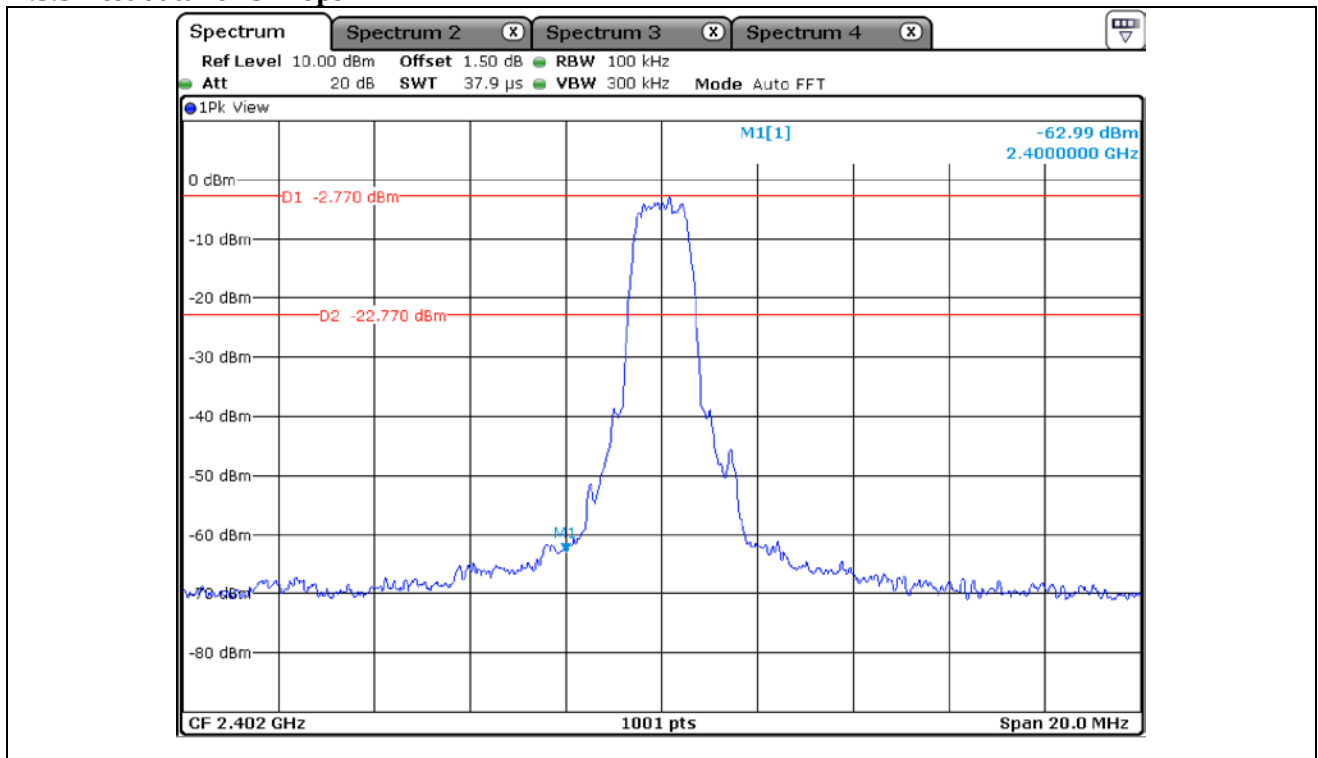


High Channel

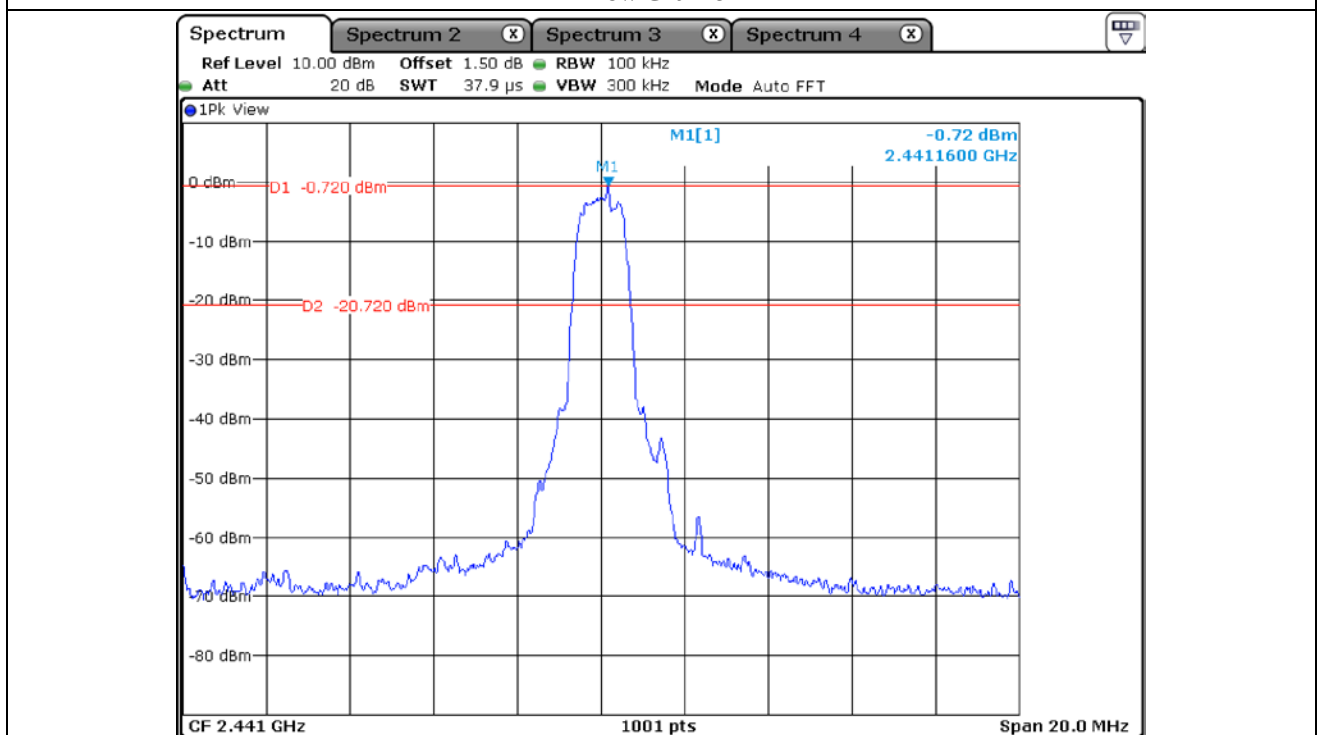


High Channel

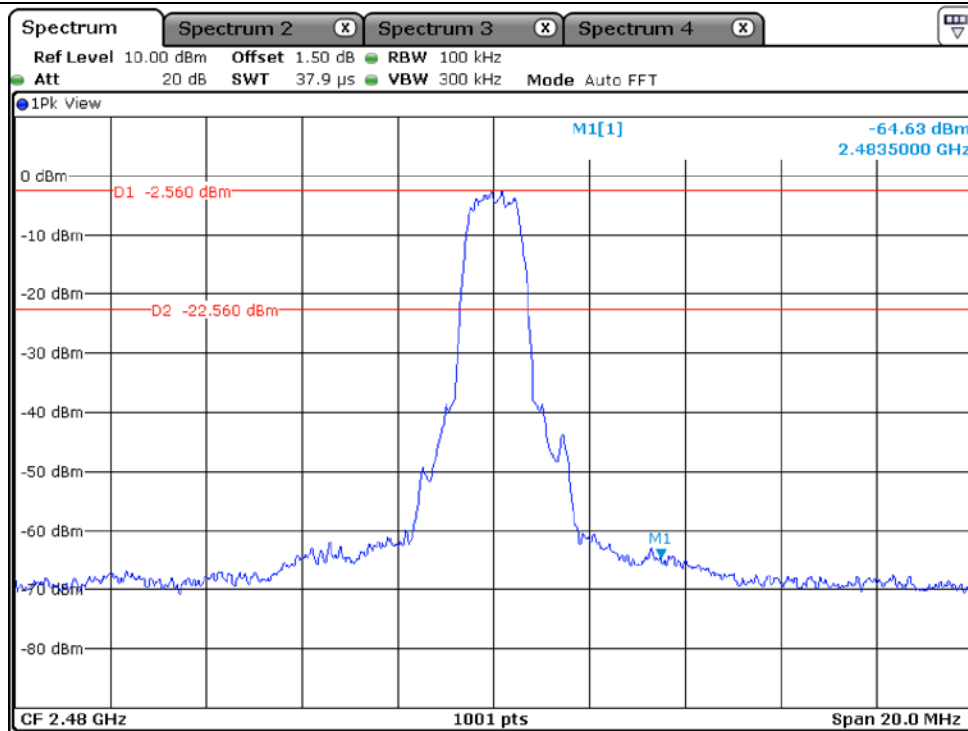
12.5.3 Test data for 3 Mbps



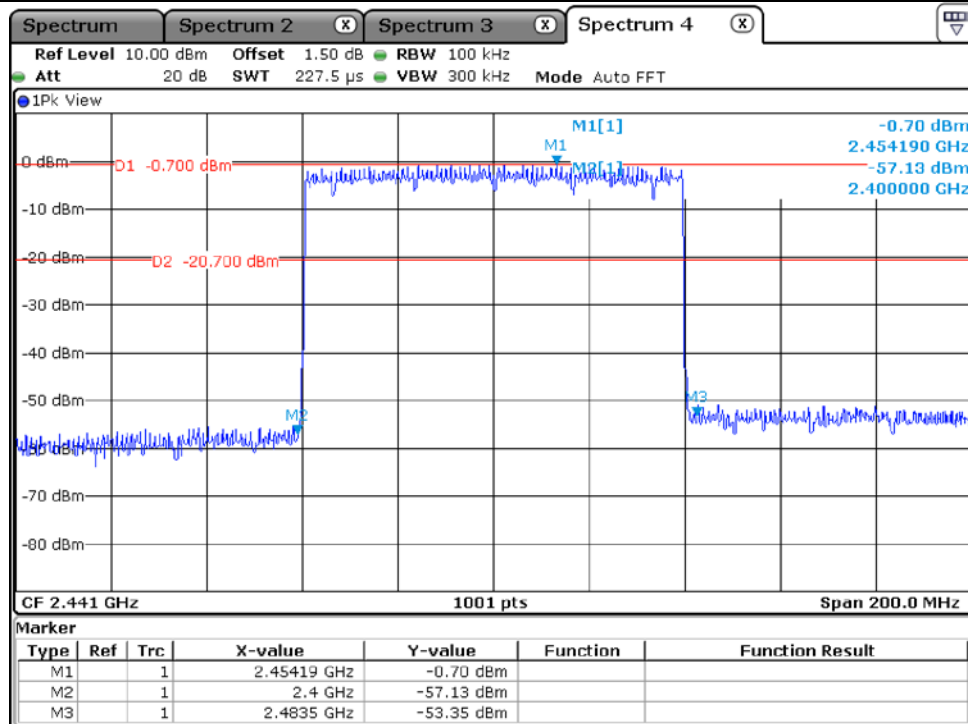
Low Channel



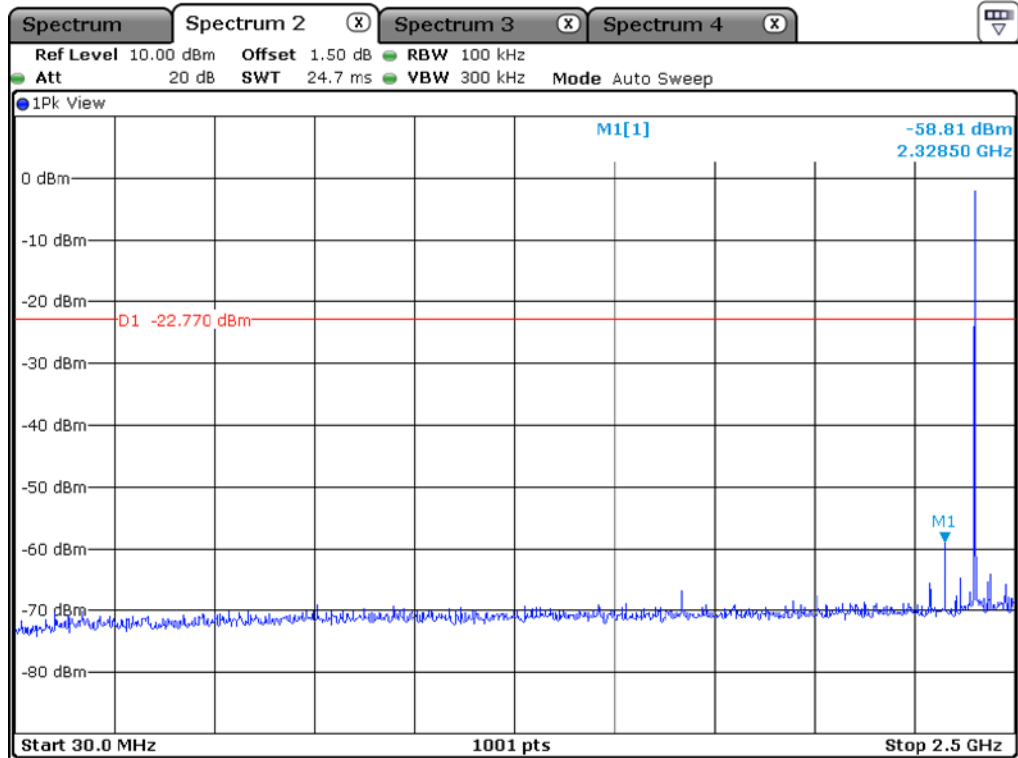
Middle Channel



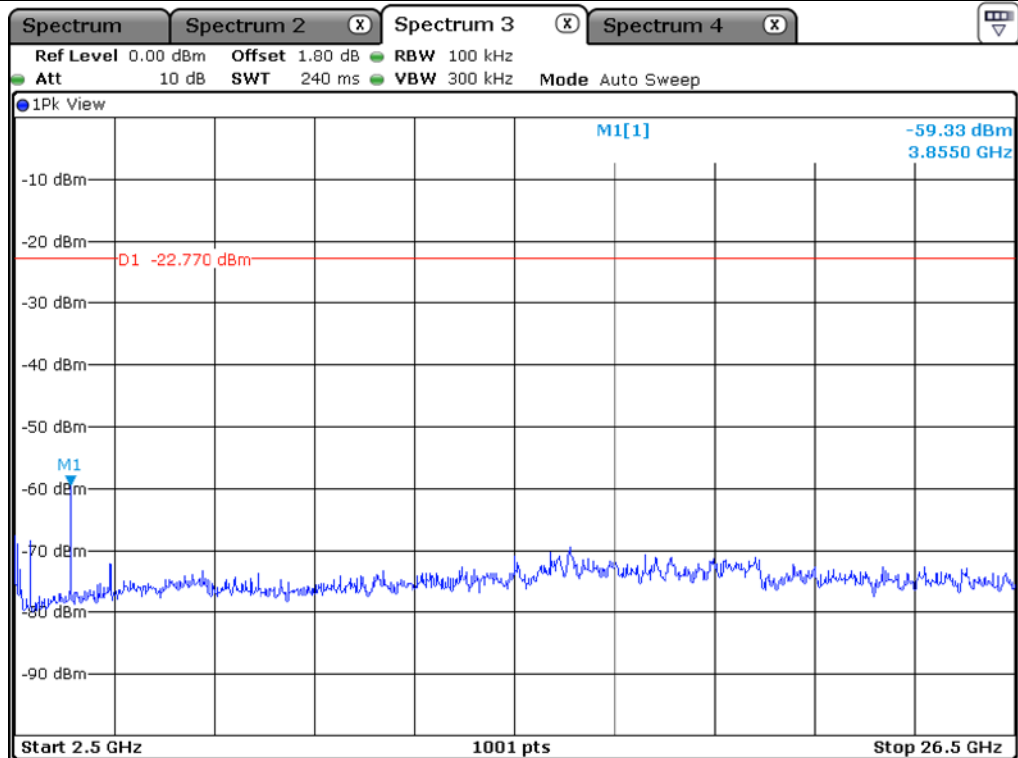
High Channel



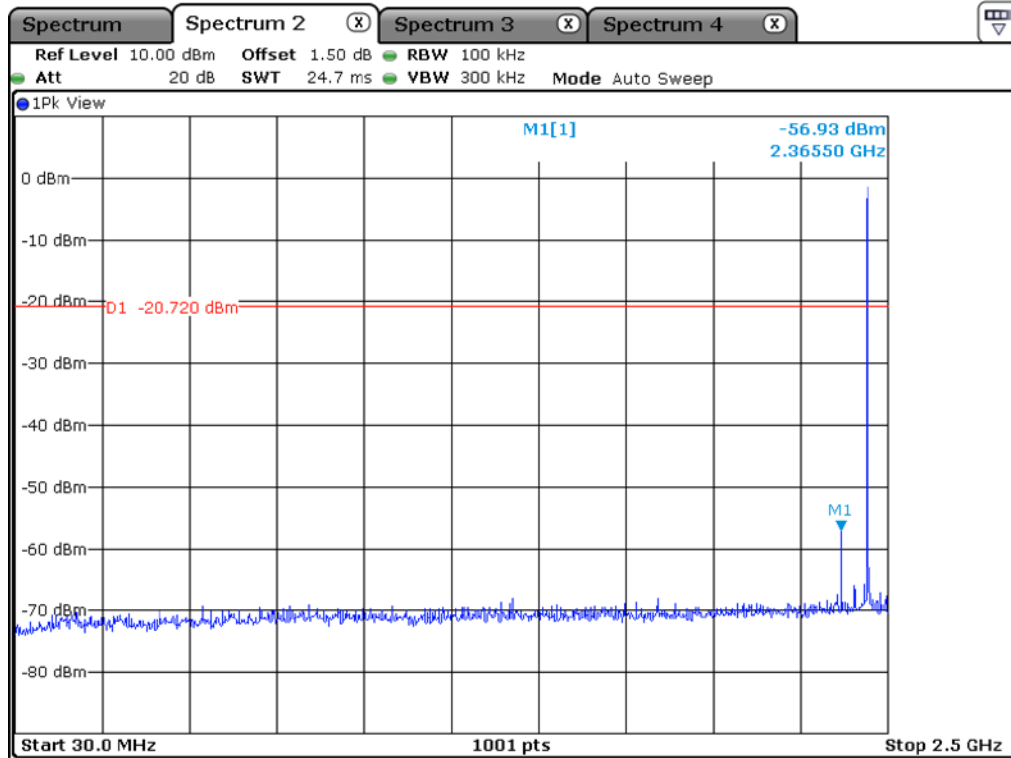
Hopping Mode



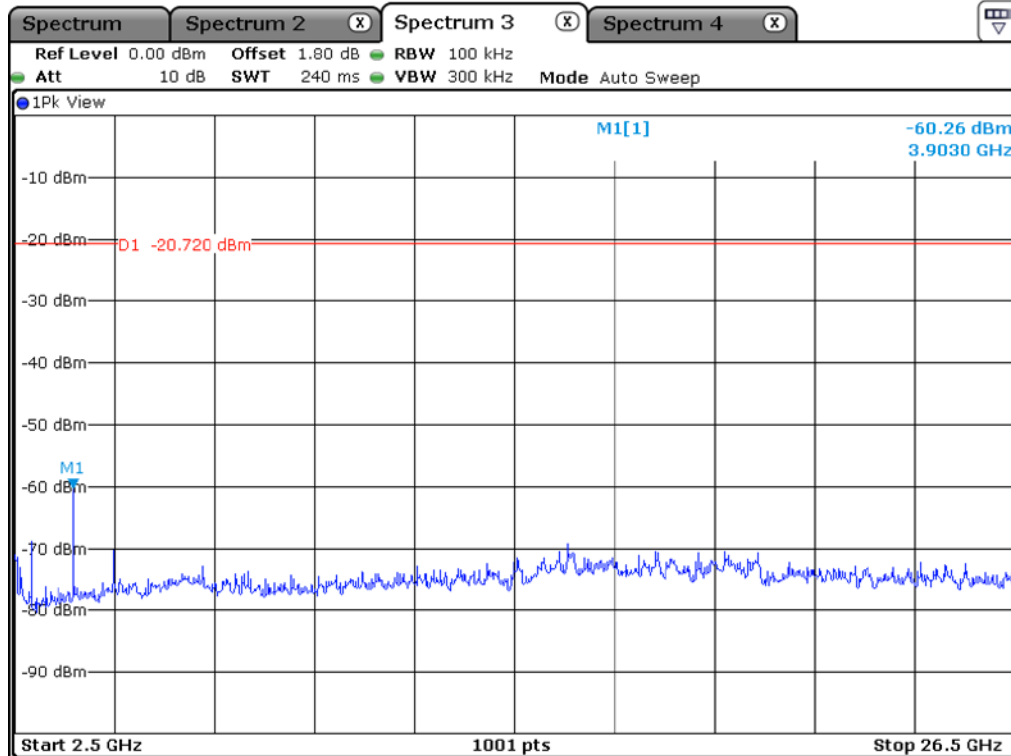
Low Channel



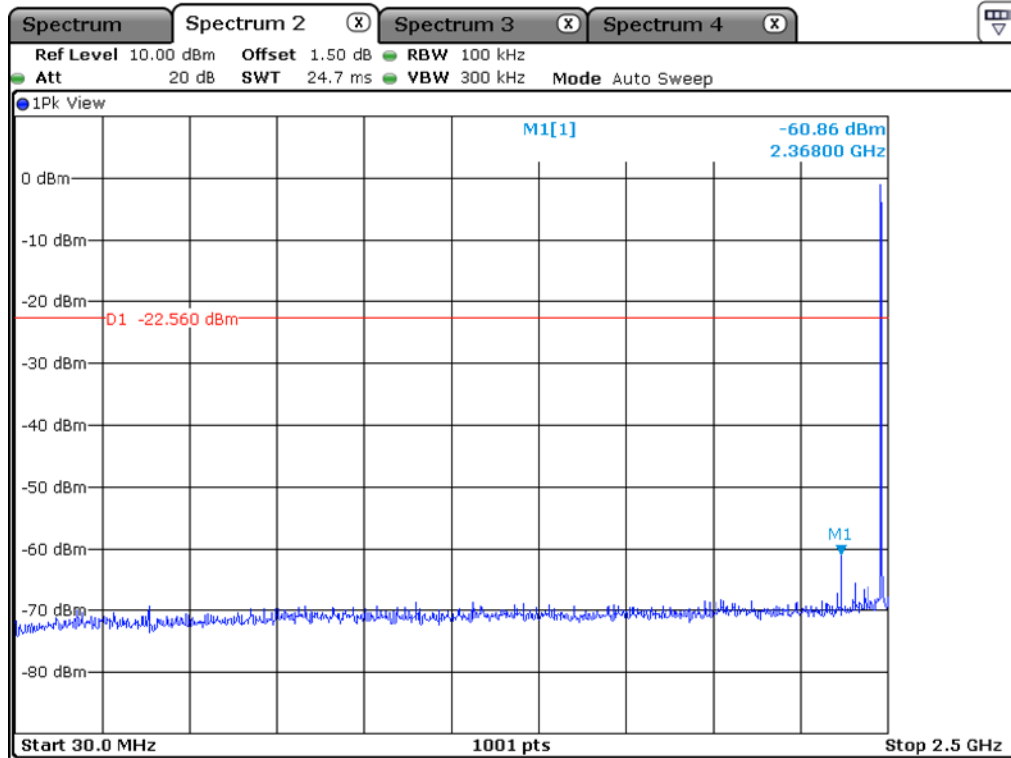
Low Channel



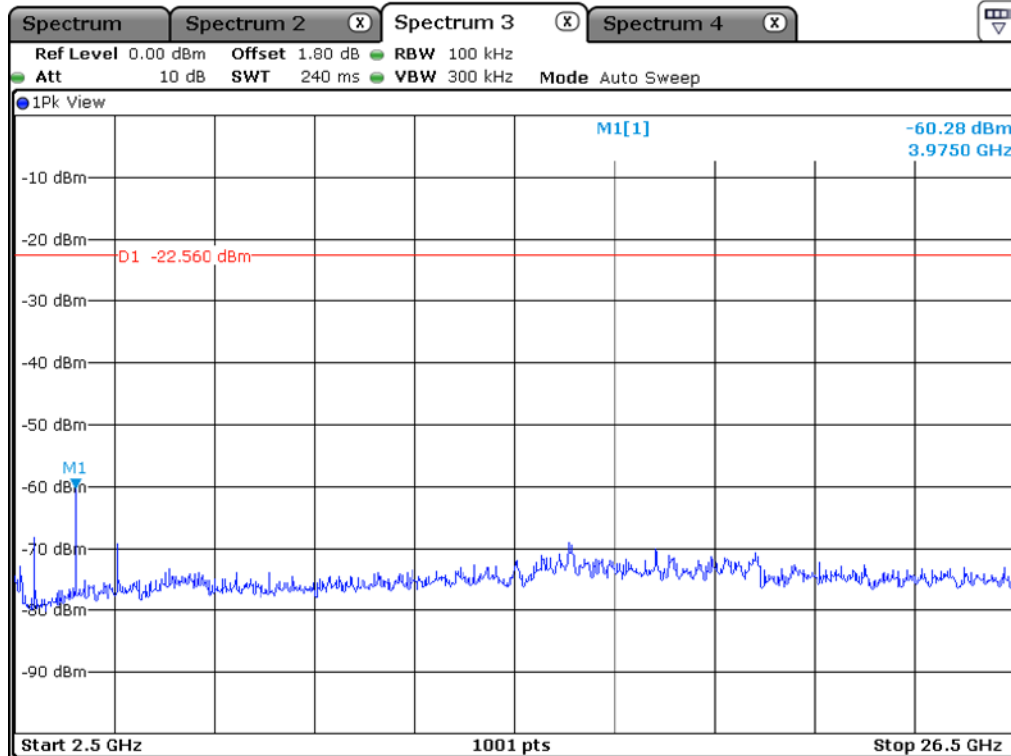
Middle Channel



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

- 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
- Duty Cycle : 77.01 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	AMP Factor	C.F (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
2 327.420	51.61	Peak	H	28.30	8.21	45.31	-	42.81	74.00	31.19
2 327.080	48.60	Average	H				1.13	40.93	54.00	13.07
2 326.960	51.03	Peak	V				-	42.23	74.00	31.77
2 327.190	48.65	Average	V				1.13	40.98	54.00	13.02
Test Data for High Channel										
2 484.252	52.27	Peak	H	28.80	8.33	45.81	-	43.59	74.00	30.41
2 483.751	40.18	Average	H				1.13	32.63	54.00	21.37
2 483.918	51.76	Peak	V				-	43.08	74.00	30.92
2 483.512	40.04	Average	V				1.13	32.49	54.00	21.51

Tabulated test data for Restricted Band

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

$$\text{Margin (dB)} = \text{Limits (dB}\mu\text{V/m)} - \text{Total Level (dB}\mu\text{V/m)}$$

$$\text{Total Level} = \text{Reading} + \text{Antenna Factor} + \text{Cable Loss} + \text{Correction Factor} - \text{AMP Factor}$$

12.6.1.2 Test data for 2 Mbps

- . 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
- . Duty Cycle : 77.13 %
- . Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	AMP Factor	C.F (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
2 327.770	50.58	Peak	H	28.30	8.21	45.31	-	41.78	74.00	32.22
2 346.530	47.14	Average	H				1.13	39.47	54.00	14.53
2 327.310	51.72	Peak	V				-	42.92	74.00	31.08
2 389.830	45.24	Average	V				1.13	37.57	54.00	16.43
Test Data for High Channel										
2 488.526	50.90	Peak	H	28.80	8.33	45.81	-	42.22	74.00	31.78
2 491.774	45.68	Average	H				1.13	38.13	54.00	15.87
2 485.422	50.62	Peak	V				-	41.94	74.00	32.06
2 483.966	45.00	Average	V				1.13	37.45	54.00	16.55

Tabulated test data for Restricted Band

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

Margin (dB) = Limits (dBμV/m) - Total Level (dBμV/m)

Total Level = Reading + Antenna Factor + Cable Loss + Correction Factor – AMP Factor

12.6.1.3 Test data for 3 Mbps

- 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
- Duty Cycle : 77.13 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	AMP Factor	C.F (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
2 378.940	50.06	Peak	H	28.30	8.21	45.31	-	41.26	74.00	32.74
2 327.540	47.14	Average	H				1.13	39.47	54.00	14.53
2 389.830	52.36	Peak	V				-	43.56	74.00	30.44
2 327.310	47.71	Average	V				1.13	40.04	54.00	13.96
Test Data for High Channel										
2 495.762	51.74	Peak	H	28.80	8.33	45.81	-	43.06	74.00	30.94
2 483.512	38.82	Average	H				1.13	31.27	54.00	22.73
2 490.914	50.73	Peak	V				-	42.05	74.00	31.95
2 487.189	38.75	Average	V				1.13	31.20	54.00	22.80

Tabulated test data for Restricted Band

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

Margin (dB) = Limits (dBμV/m) - Total Level (dBμV/m)

Total Level = Reading + Antenna Factor + Cable Loss + Correction Factor – AMP Factor

12.6.2 Spurious & Harmonic Radiated Emission above 1 GHz

12.6.2.1 Test data for 1 Mbps

- . 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
- . Duty Cycle : 77.01 %
- . Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	AMP Factor	C.F (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
4 804.000	51.17	Peak	H	33.40	11.18	46.33	-	49.42	74.00	24.58
	39.48	Average	H				1.13	38.86	54.00	15.14
	51.30	Peak	V				-	49.55	74.00	24.45
	39.82	Average	V				1.13	39.20	54.00	14.80
Test Data for Middle Channel										
4 882.000	51.20	Peak	H	33.30	11.31	46.35	-	49.46	74.00	24.54
	39.27	Average	H				1.13	38.66	54.00	15.34
	51.48	Peak	V				-	49.74	74.00	24.26
	39.90	Average	V				1.13	39.29	54.00	14.71
Test Data for High Channel										
4 960.000	51.13	Peak	H	33.30	11.41	46.35	-	49.49	74.00	24.51
	39.40	Average	H				1.13	38.89	54.00	15.11
	51.26	Peak	V				-	49.62	74.00	24.38
	39.77	Average	V				1.13	39.26	54.00	14.74

Test Data

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

$$\text{Margin (dB)} = \text{Limits (dB}\mu\text{V/m)} - \text{Total Level (dB}\mu\text{V/m)}$$

$$\text{Total Level} = \text{Reading} + \text{Antenna Factor} + \text{Cable Loss} + \text{Correction Factor} - \text{AMP Factor}$$

12.6.2.2 Test data for 2 Mbps

- 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
- Duty Cycle : 77.13 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	AMP Factor	C.F (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
4 804.000	51.24	Peak	H	33.40	11.18	46.33	-	49.49	74.00	24.51
	39.56	Average	H				1.13	38.94	54.00	15.06
	51.33	Peak	V				-	49.58	74.00	24.42
	39.74	Average	V				1.13	39.12	54.00	14.88
Test Data for Middle Channel										
4 882.000	51.27	Peak	H	33.30	11.31	46.35	-	49.53	74.00	24.47
	39.35	Average	H				1.13	38.74	54.00	15.26
	51.60	Peak	V				-	49.86	74.00	24.14
	39.92	Average	V				1.13	39.31	54.00	14.69
Test Data for High Channel										
4 960.000	51.24	Peak	H	33.30	11.41	46.35	-	49.60	74.00	24.40
	39.46	Average	H				1.13	38.95	54.00	15.05
	51.33	Peak	V				-	49.69	74.00	24.31
	39.80	Average	V				1.13	39.29	54.00	14.71

Test Data

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

Margin (dB) = Limits (dBμV/m) - Total Level (dBμV/m)

Total Level = Reading + Antenna Factor + Cable Loss + Correction Factor – AMP Factor

12.6.2.3 Test data for 3 Mbps

- 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
- Duty Cycle : 77.13 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	AMP Factor	C.F (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
4 804.000	51.15	Peak	H	33.40	11.18	46.33	-	49.40	74.00	24.60
	39.44	Average	H				1.13	38.82	54.00	15.18
	51.26	Peak	V				-	49.51	74.00	24.49
	39.74	Average	V				1.13	39.12	54.00	14.88
Test Data for Middle Channel										
4 882.000	51.23	Peak	H	33.30	11.31	46.35	-	49.49	74.00	24.51
	39.31	Average	H				1.13	38.70	54.00	15.30
	51.50	Peak	V				-	49.76	74.00	24.24
	39.93	Average	V				1.13	39.32	54.00	14.68
Test Data for High Channel										
4 960.000	51.20	Peak	H	33.30	11.41	46.35	-	49.56	74.00	24.44
	39.45	Average	H				1.13	38.94	54.00	15.06
	51.22	Peak	V				-	49.58	74.00	24.42
	39.74	Average	V				1.13	39.23	54.00	14.77

Test Data

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

Margin (dB) = Limits (dBμV/m) - Total Level (dBμV/m)

Total Level = Reading + Antenna Factor + Cable Loss + Correction Factor – AMP Factor

13. RADIATED EMISSION TEST

13.1 Operating environment

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

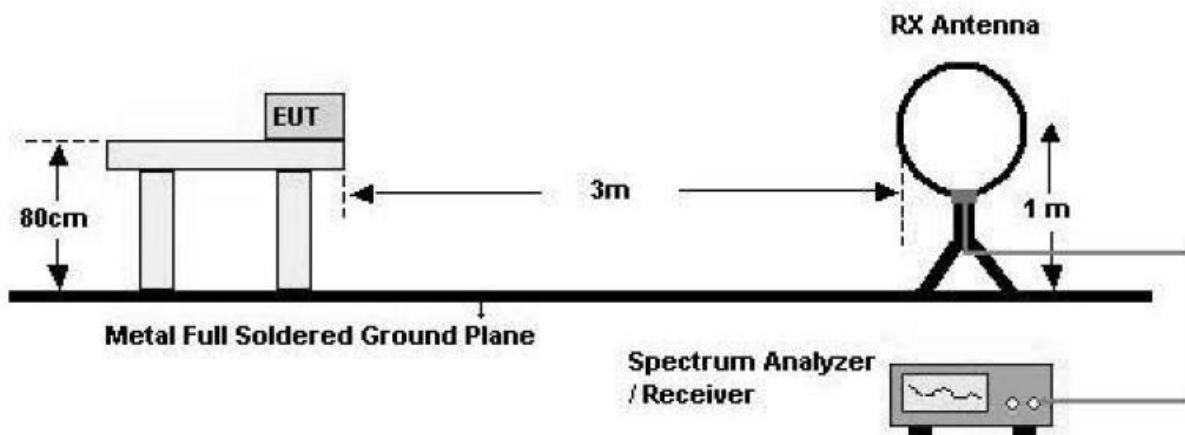
13.2 Test set-up

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.

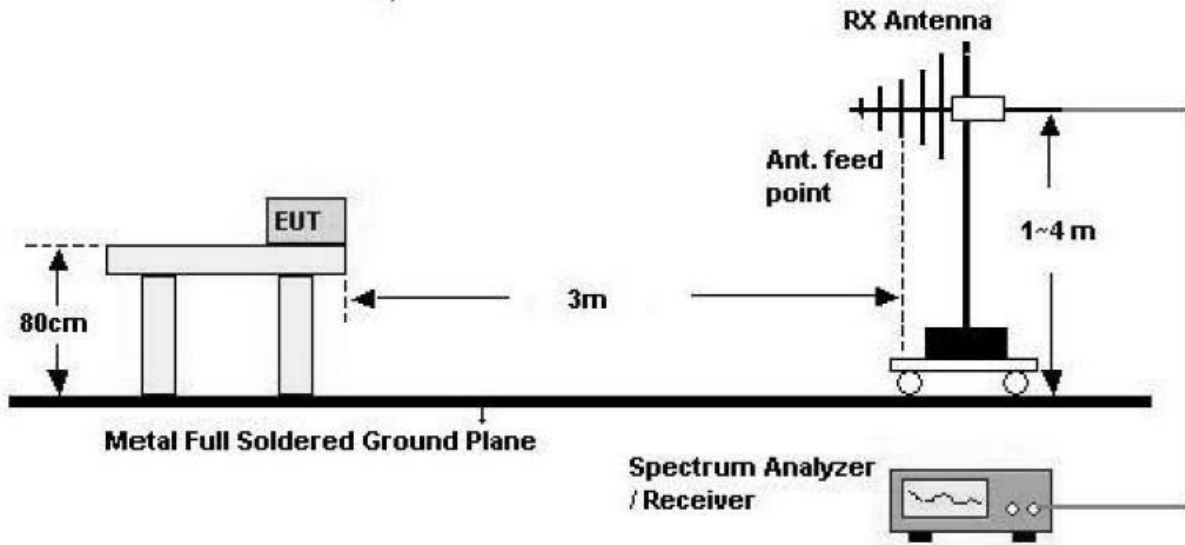
The frequency spectrum from 30 MHz to 26.5 GHz was scanned and emission levels maximized at each frequency recorded. The system was rotated 360°, and the antenna was varied in height between 1.0 m and 4.0 m in order to determine the maximum emission levels. This procedure was performed for both horizontal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

- Test Configuration

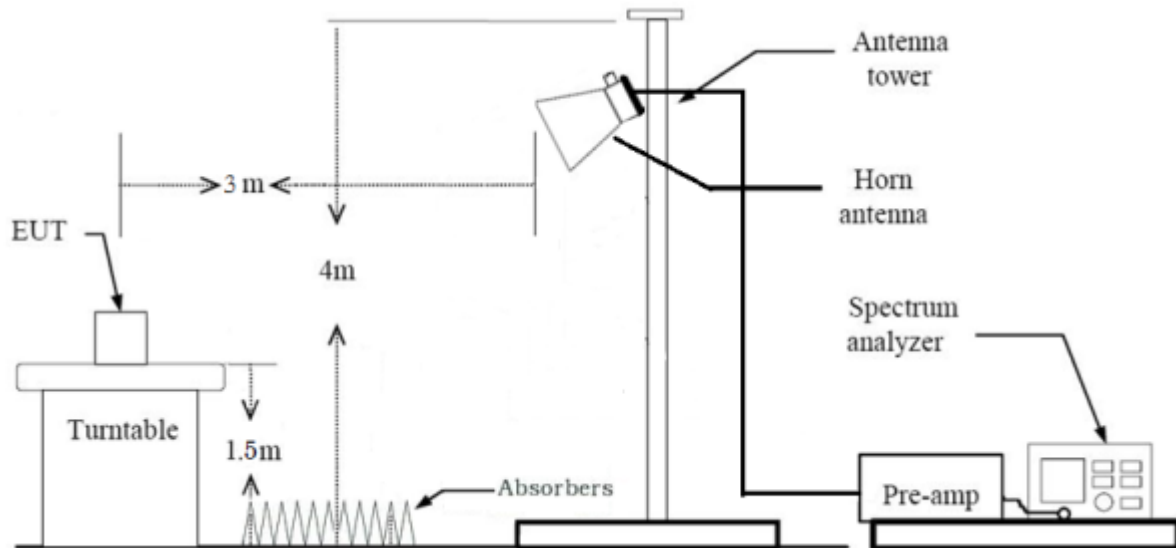
1. Below 30 MHz



2. 30 MHz - 1 GHz



3. Above 1 GHz



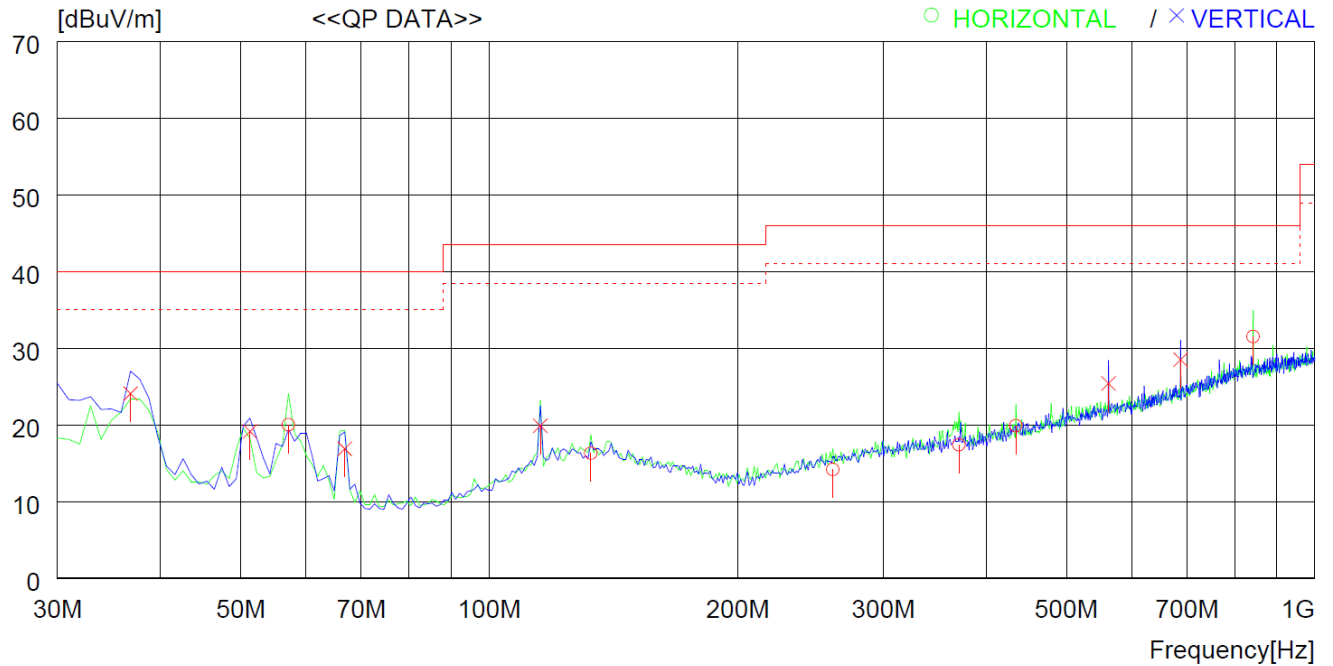
13.3 Test Date

December 03, 2020 ~ December 09, 2020

13.4 Test data for 30 MHz ~ 1 GHz

13.4.1 Test data for Bluetooth Mode

- 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 [dBuV]	FACTOR [dB]	[dB]	[dB]	[dBuV/m]	[dBuV/m]	[dB]	[cm]	[DEG]
----- Horizontal -----										
1	57.160	42.5	9.5	0.7	32.7	20.0	40.0	20.0	400	0
2	132.820	37.1	10.8	1.1	32.7	16.3	43.5	27.2	400	0
3	260.860	34.5	10.8	1.6	32.7	14.2	46.0	31.8	100	359
4	370.470	32.6	15.6	1.9	32.7	17.4	46.0	28.6	100	198
5	434.491	33.8	16.9	2.0	32.8	19.9	46.0	26.1	200	0
6	841.881	38.9	22.5	2.4	32.3	31.5	46.0	14.5	400	0
----- Vertical -----										
7	36.790	45.3	11.0	0.5	32.7	24.1	40.0	15.9	300	53
8	51.340	41.6	9.7	0.6	32.7	19.2	40.0	20.8	200	37
9	66.860	39.9	9.0	0.7	32.7	16.9	40.0	23.1	200	359
10	115.360	41.1	10.5	1.0	32.7	19.9	43.5	23.6	200	359
11	562.529	37.0	19.1	2.3	33.0	25.4	46.0	20.6	100	0
12	687.655	38.1	20.8	2.5	32.9	28.5	46.0	17.5	100	0

13.5 Test data for Below 30 MHz

-. 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)
Emission from the EUT more than 20 dB below the limit in each frequency range.								

13.6 Test data for above 1 GHz

-. 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

-. 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)
Emission from the EUT more than 20 dB below the limit in each frequency range.								

14. LIST OF TEST EQUIPMENT

Model Number	Manufacturer	Description	Serial Number	Last Cal.(Interval)
FSV40-N	Rohde & Schwarz	Signal Analyzer	102177	Apr. 21, 2020 (1Y)
ESW	Rohde & Schwarz	EMI Test Receiver	101851	Mar. 27, 2020 (1Y)
310N	Sonoma Instrument	Pre-Amplifier	312544	Mar. 16, 2020 (1Y)
BBV 9718 B	Schwarzbeck	Broadband Preamplifier	00009	Mar. 16, 2020 (1Y)
SCU40A	Rohde & Schwarz	Signal Conditioning unit	100436	Feb. 20, 2020 (1Y)
SCU18	Rohde & Schwarz	Signal Conditioning unit	102266	Jul. 15, 2020 (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. 08, 2020 (2Y)
BBHA 9120D	Schwarzbeck	Horn Antenna	9120D-1366	Jul. 23, 2020 (1Y)
BBHA9170	Schwarzbeck	Horn Antenna	BBHA9170178	Jan. 07, 2020(1Y)
FMZB1513	Schwarzbeck	Active Loop Antenna	1513-235	Oct.28.2020(2Y)