

RADIO PERFORMANCE TEST REPORT

Test Report No. : OT-21N-RWD-055

Reception No. : 2110004459

Applicant : Hitachi-LG Data Storage Korea, Inc.

Address : (Gasam-dong), 189, Gasandigital1-ro, Geumcheon-gu, Seoul, Korea

Manufacturer : Hitachi-LG Data Storage Korea, Inc.

Address : (Gasam-dong), 189, Gasandigital1-ro, Geumcheon-gu, Seoul, Korea

Type of Equipment : Thermal Sensing Terminal

FCC ID. : 2AQ9F-HLT-SDBF1

Model Name : HLT-SDBF1

Multiple Model Name : 29KC5P2J-W

Serial number : N/A

Total page of Report : 80 pages (including this page)

Date of Incoming : October 11, 2021

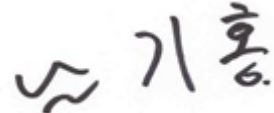
Date of issue : November 29, 2021

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.



Tested by	Reviewed by	Approved by
/Joon-Woo, Kim / Assistant Manager	/ Tae-Ho, Kim / Senior Manager	/ Ki-Hong, Nam / General Manager
ONETECH Corp.	ONETECH Corp.	ONETECH Corp.

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Revision History

Rev. No.	Issue Report No.	Issued Date	Revisions	Section Affected
0	OT-21N-RWD-055	November 29, 2021	Initial Release	All

1. VERIFICATION OF COMPLIANCE

Applicant : Hitachi-LG Data Storage Korea, Inc.
Address : (Gasan-dong), 189, Gasandigital1-ro, Geumcheon-gu, Seoul, Korea
Contact Person : Young-Jae Lee / Chief research engineer
Telephone No. : +82-10-5295-2800
FCC ID : 2AQ9F-HLT-SDBF1
Model Name : HLT-SDBF1
Brand Name : LG Electronics USA
Serial Number : N/A
Date : November 29, 2021

EQUIPMENT CLASS	DSS – PART 15 SPREAD SPECTRUM TRANSMITTER
E.U.T. DESCRIPTION	Thermal Sensing Terminal
THIS REPORT CONCERNS	Original Grant
MEASUREMENT PROCEDURES	ANSI C63.10: 2020
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	Met requirement / PASS
15.203	Antenna Requirement	Met requirement / PASS

2.2 Additions, deviations, exclusions from standards

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

2.3 Related Submittal(s) / Grant(s)

Original submittal only

2.4 Purpose of the test

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

2.5 Test Methodology

Both conducted and radiated testing was performed according to the procedures in ANSI C63.10: 2020. 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

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3. GENERAL INFORMATION

3.1 Product Description

The Hitachi-LG Data Storage Korea, Inc., Model HLT-SDBF1 (referred to as the EUT in this report) is a Thermal Sensing Terminal. The product specification described herein was obtained from product data sheet or user's manual.

Device Type	Thermal Sensing Terminal	
Operating Frequency	Bluetooth	2 402 MHz ~ 2 480 MHz
	Bluetooth LE	2 402 MHz ~ 2 480 MHz
	WLAN 2.4 GHz	2 412 MHz ~ 2 462 MHz (802.11b/g/n(HT20))
		2 422 MHz ~ 2 452 MHz (802.11n(HT40))
RF Output Power	Bluetooth	7.86 dBm
	Bluetooth LE	2.31 dBm
	WLAN 2.4 GHz	9.17 dBm(802.11b)
		5.30 dBm(802.11g)
Modulation Type	Bluetooth	GFSK for 1 Mbps, $\pi/4$ -DQPSK for 2 Mbps, 8-DPSK for 3 Mbps
	Bluetooth LE	GFSK
	WLAN 2.4 GHz	802.11b: DSSS Modulation(DBPSK/DQPSK/CCK)
		802.11g/n(HT20)/n(HT40): OFDM Modulation(BPSK/QPSK/16QAM/64QAM)
Antenna Type	PCB Antenna	
Antenna Gain	1.16 dBi	
Rated Supply Voltage	DC 12 V	
List of each Osc. or crystal Freq.(Freq. >= 1 MHz)	24 MHz	

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

-. The following lists consist of the added model and their differences.

Model Name	Differences	Tested
HLT-SDBF1	Basic Model	☒
29KC5P2J-W	This model is identical to the basic model except for the difference of the Vendor (LG) [See Note 3]	☐

Note: 1. Applicant consigns only basic model to test. Therefore this test report just guarantees the units, which have been tested.

2. The Applicant/manufacture is responsible for the compliance of all variants.

3. General product information and other remarks:

This product also included the stand as optional as follows;

- 1) Floor Stand(HLT-USBL2) for brand Hitachi-LG Data Storage
- 2) Floor Stand(ST-290FL(Stand Pole) & ST-290FP(Stand Plate)) for brand LG.

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	Hitachi-LG Data Storage Korea, Inc.	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
HLT-SDBF1	Hitachi-LG Data Storage Korea, Inc.	Thermal Sensing Terminal (EUT)	-
HP Probook	HP	Notebook PC	EUT
DZ048BHL120400V	KOORDA	AC Adapter	Notebook PC

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 441MHz, 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.

-. Frequency / Channel Operations

Channel	Frequency
0	2 402
39	2 441
78	2 480

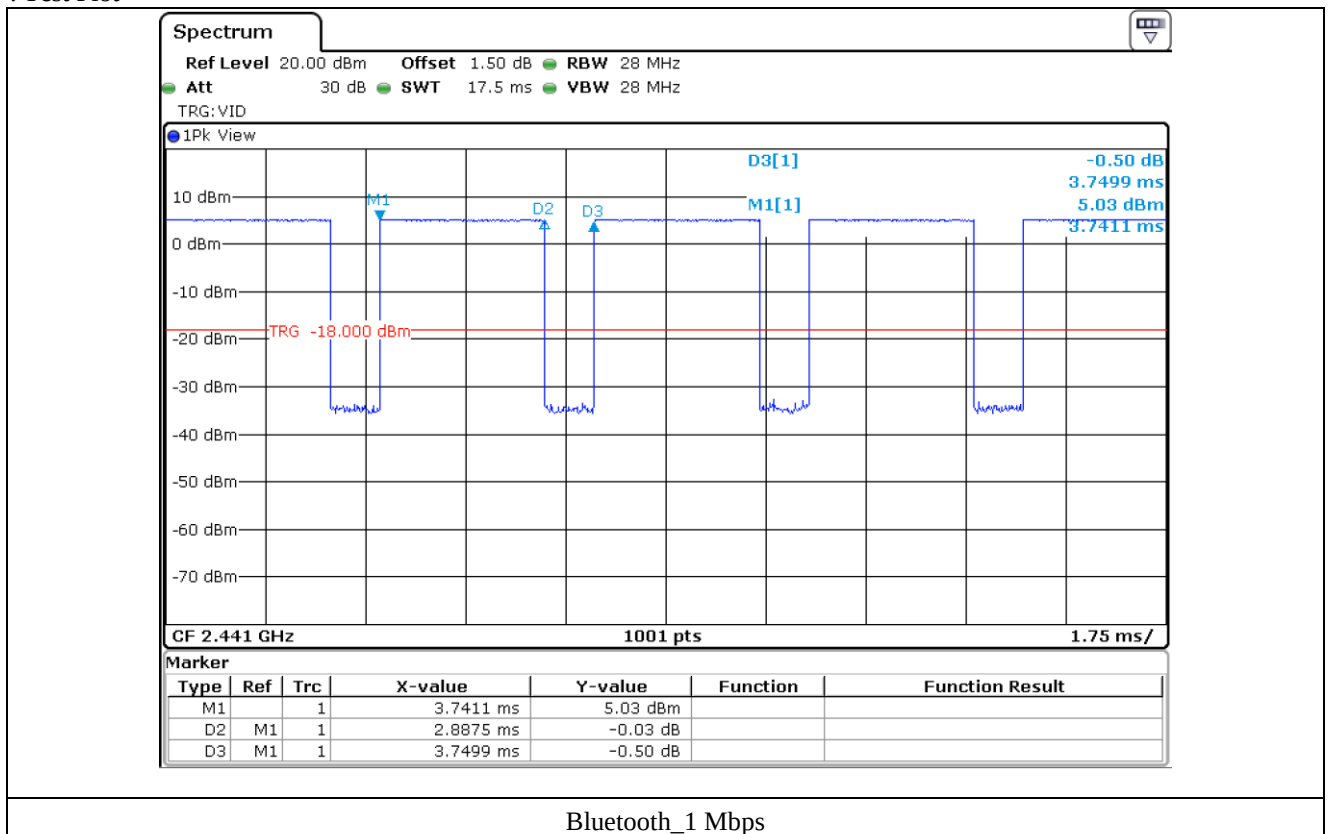
-. Duty Cycle

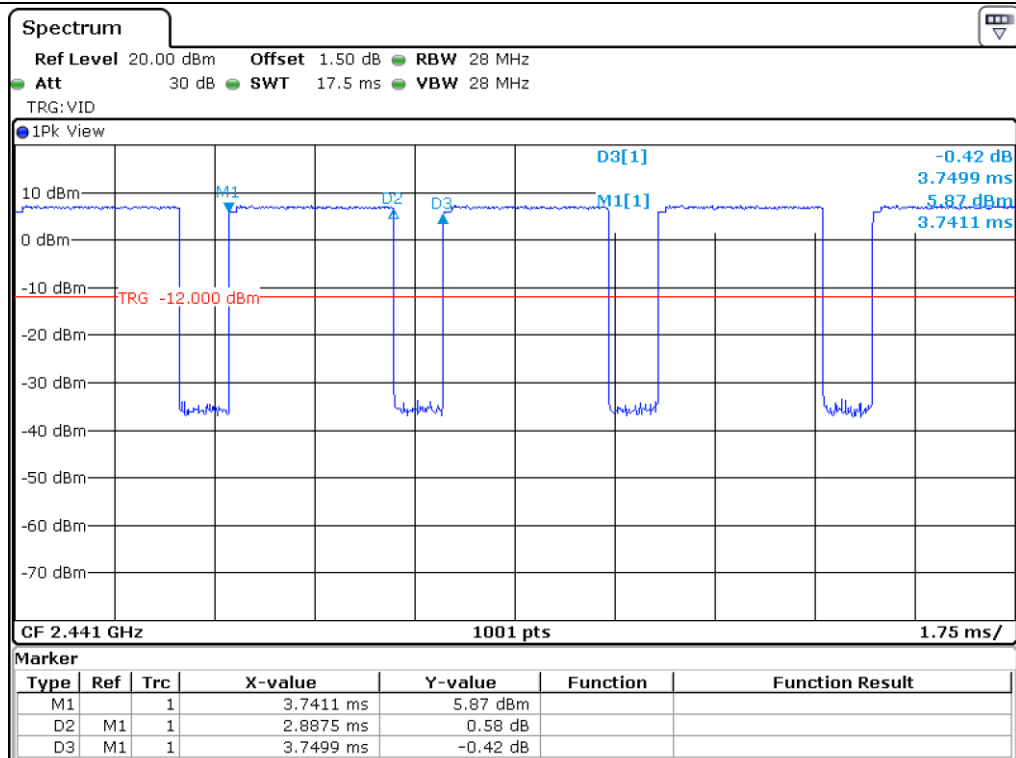
Mode	Tx On Time [ms]	Tx Off Time [ms]	Duty Cycle [%]	Correction Factor [dB]
Bluetooth [1 Mbps]	2.8875	0.8624	77.00	1.13
Bluetooth [2 Mbps]	2.8875	0.8624	77.00	1.13
Bluetooth [3 Mbps]	2.8875	0.8624	77.00	1.13

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

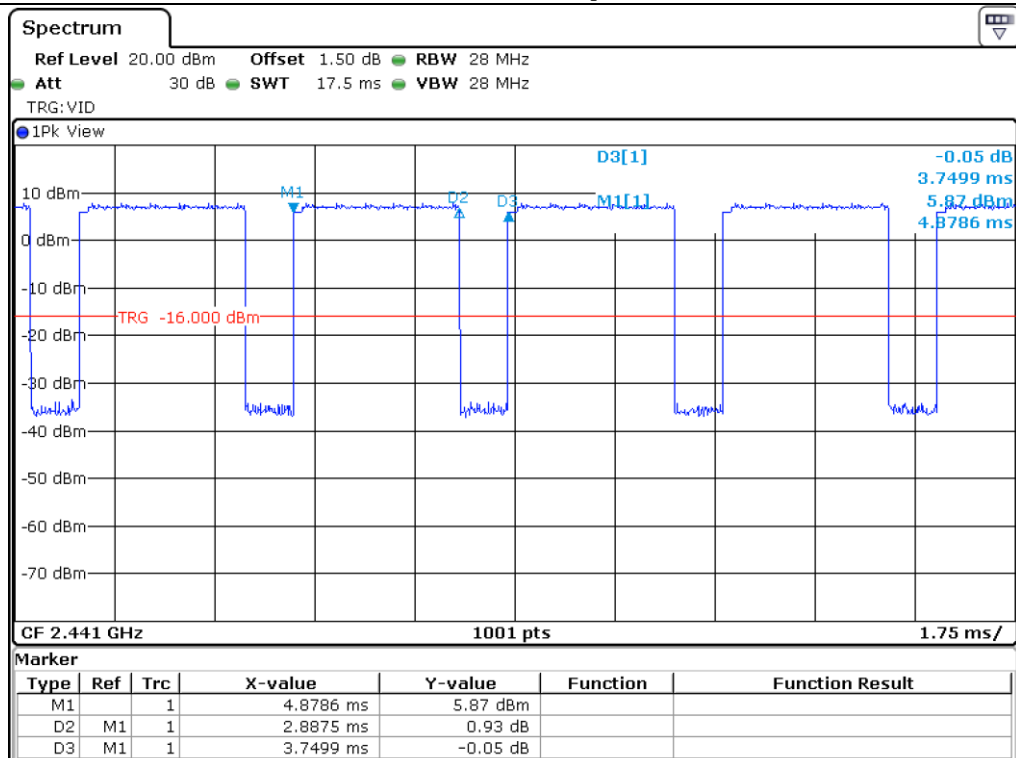
Correction Factor : 10 * Log(1 / (Duty Cycle / 100))

-. Test Plot





Bluetooth_2 Mbps



Bluetooth_3 Mbps

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5.4 Configuration of Test System

Line Conducted Test: The EUT was tested in the Transmitting mode. All supporting equipment were connected to another LISN. Preliminary Power line Conducted Emission test was performed by using the procedure in ANSI C63.10: 2020 to determine the worse operating conditions.

Radiated Emission Test: Preliminary radiated emissions test were conducted using the procedure in ANSI C63.10: 2020 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 PCB Antenna of the EUT is located the in the EUT internally, 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

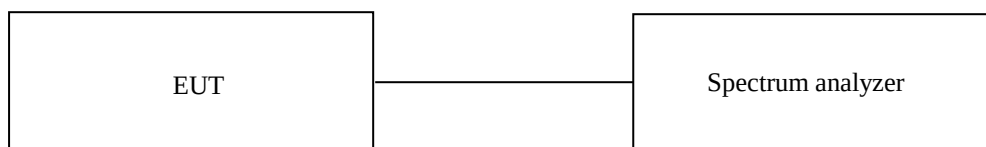
7. MINIMUM 20 dB BANDWIDTH

7.1 Operating environment

Temperature : 22.5 °C
Relative humidity : 53.5 % R.H.

7.2 Test set-up

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



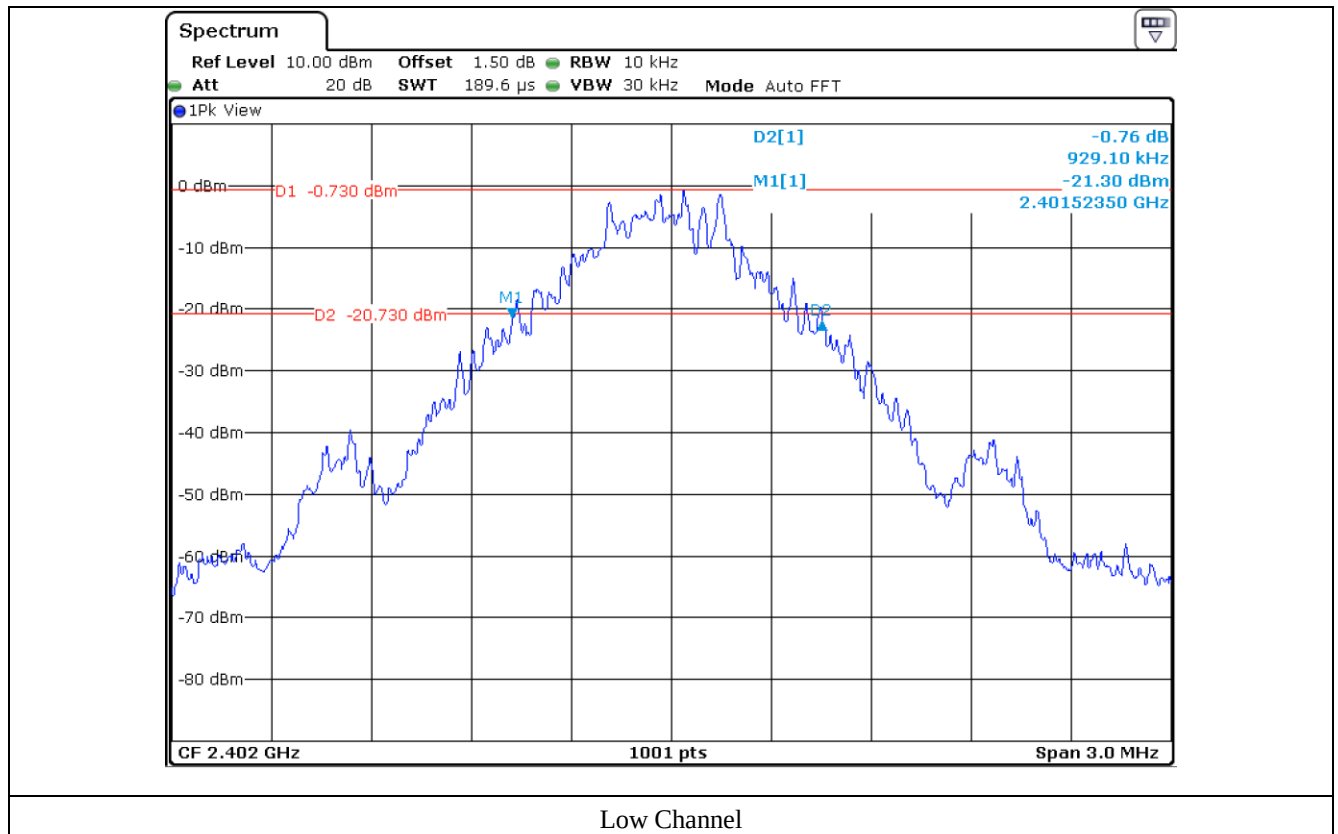
7.3 Test Date

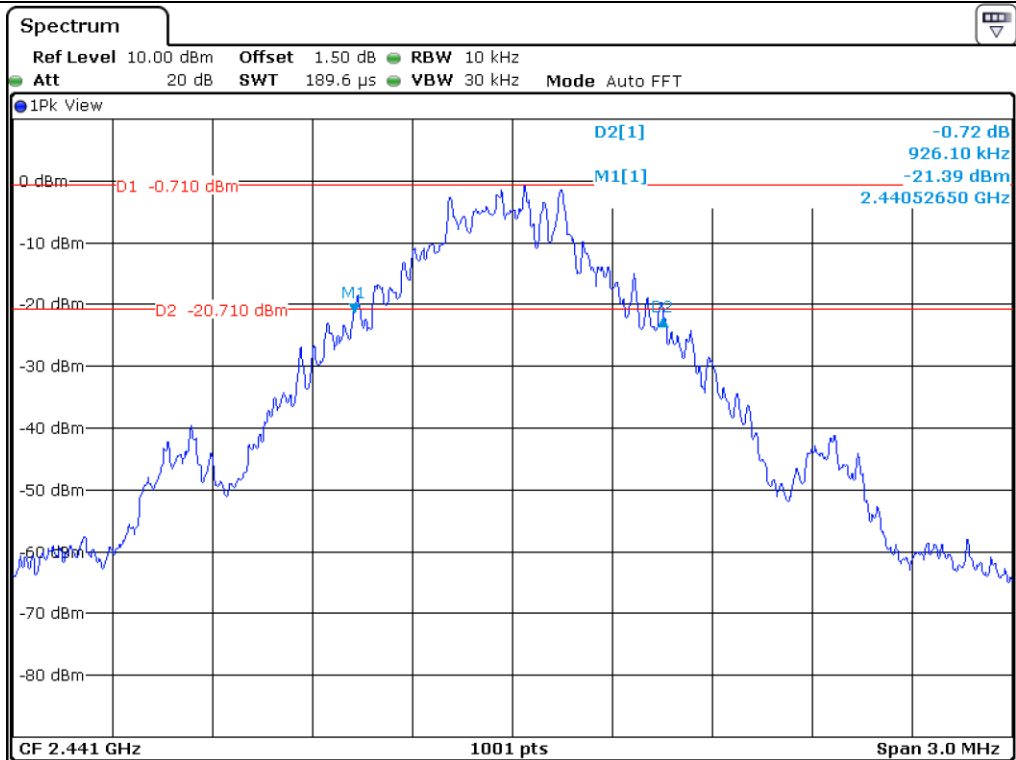
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7.4 Test Data

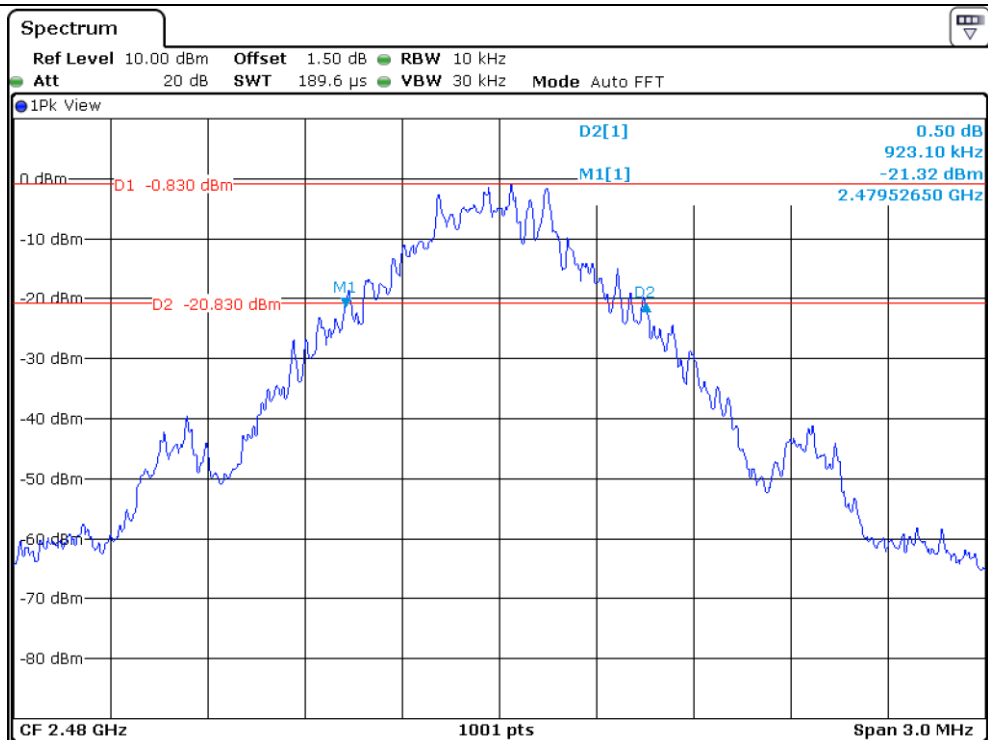
7.4.1 Test data for 1 Mbps

Channel	Frequency (MHz)	20 dB Bandwidth (kHz)
Low	2 402.00	929.10
Middle	2 441.00	926.10
High	2 480.00	923.10





Middle Channel



High Channel

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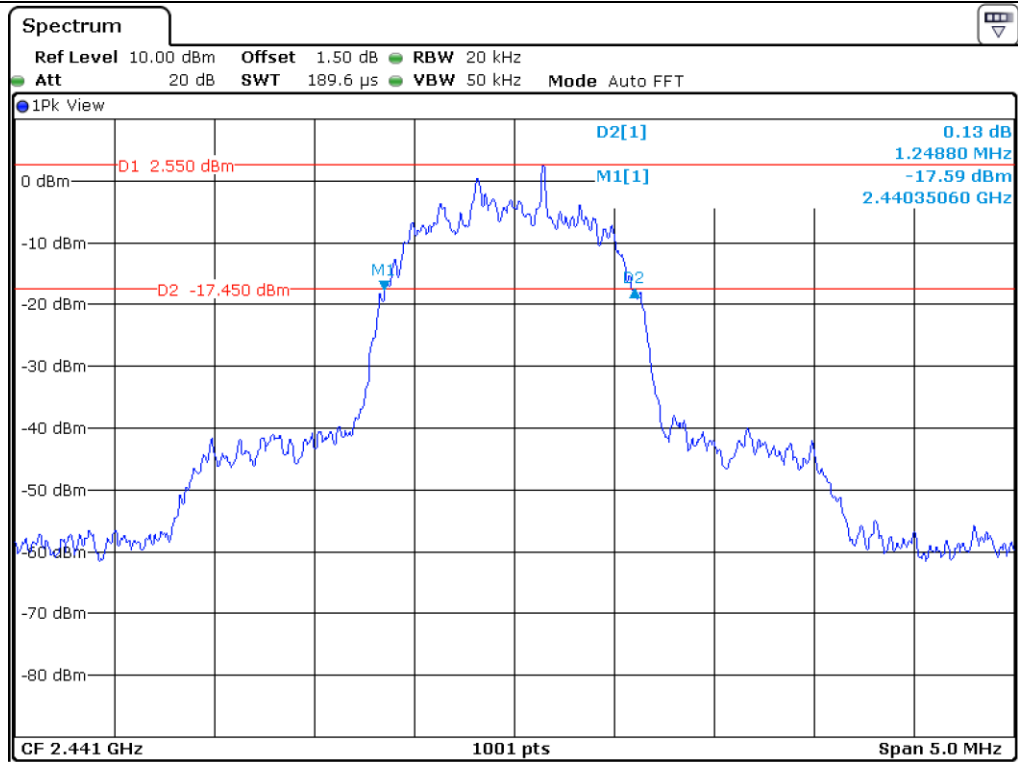
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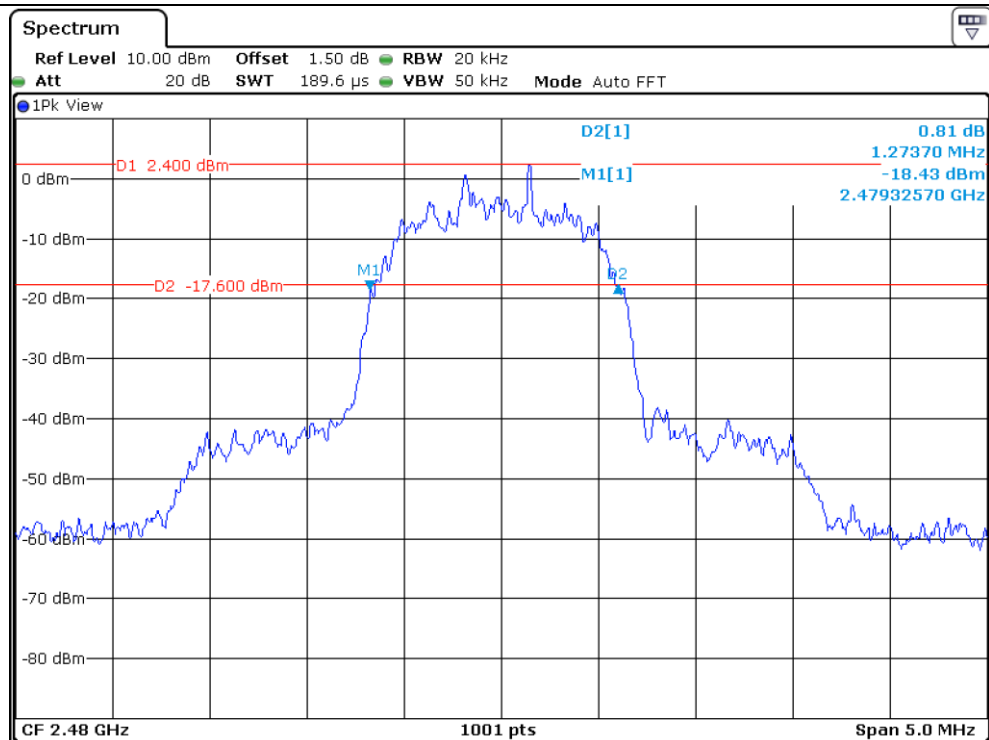
7.4.2 Test data for 2 Mbps

Channel	Frequency (MHz)	20 dB Bandwidth (kHz)
Low	2 402.00	1 251.70
Middle	2 441.00	1 248.80
High	2 480.00	1 273.70





Middle Channel



High Channel

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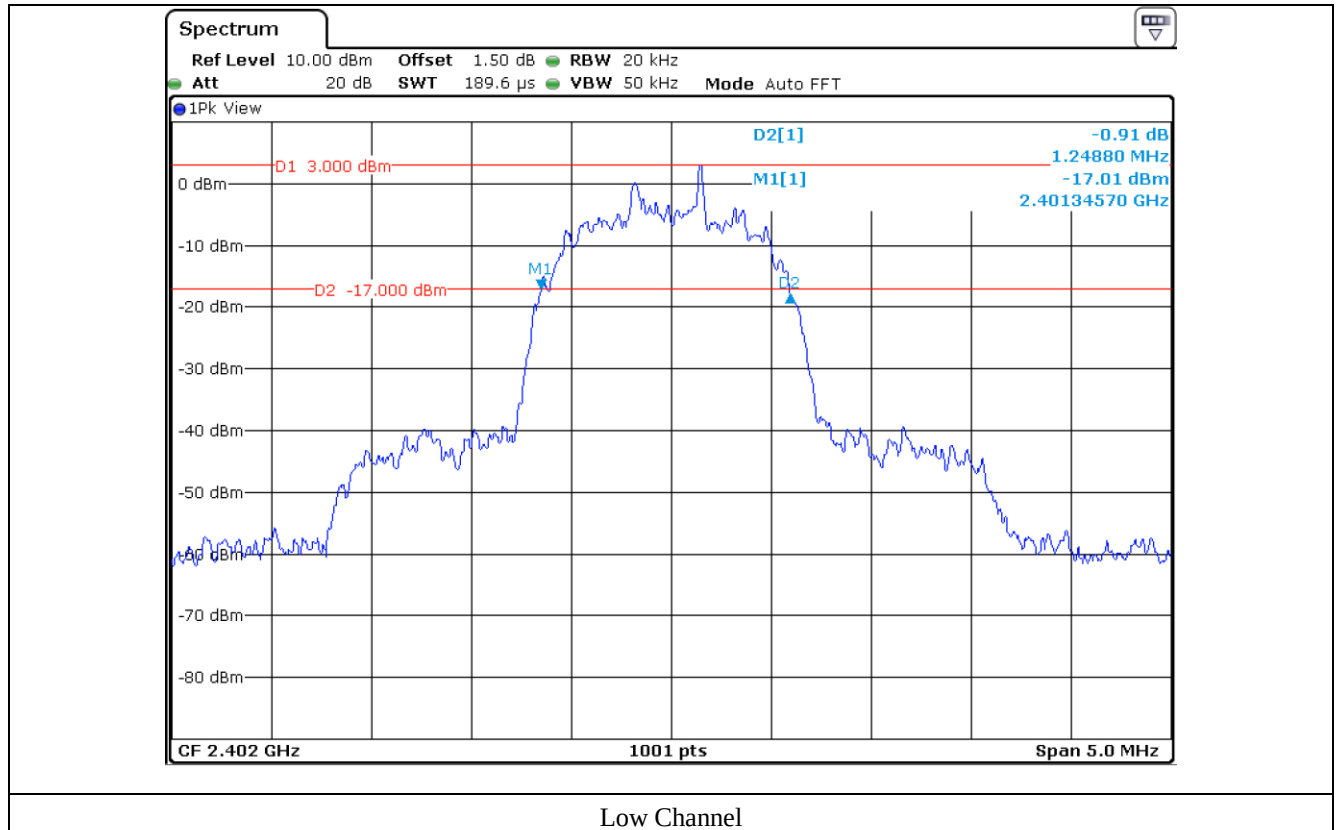
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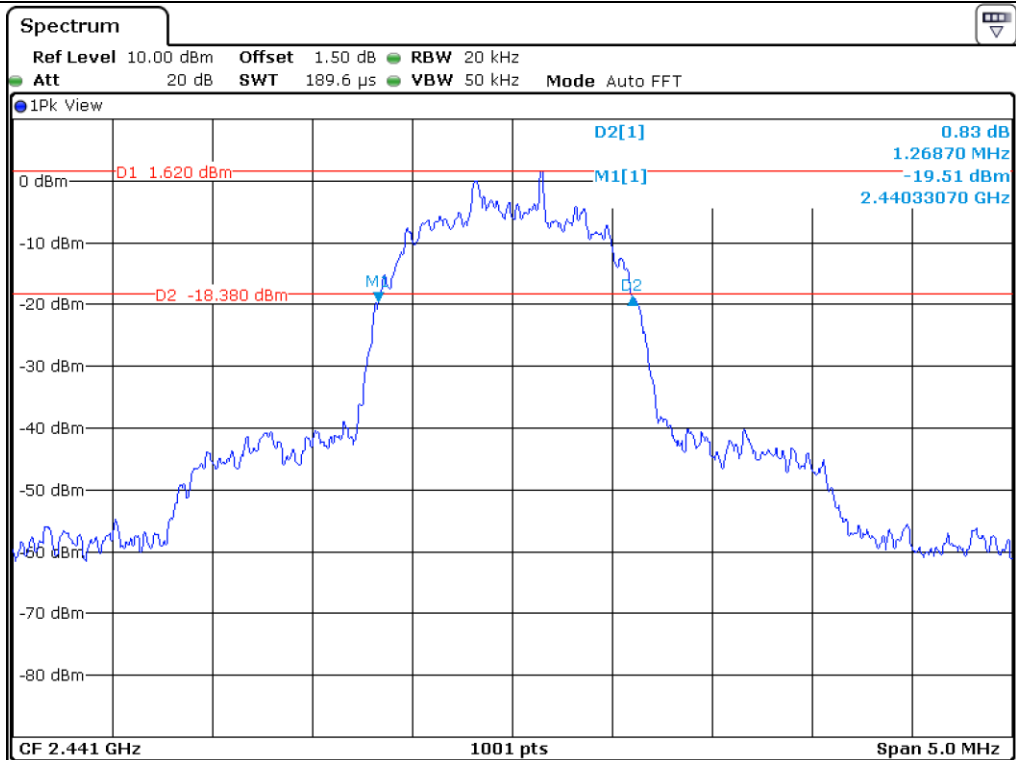
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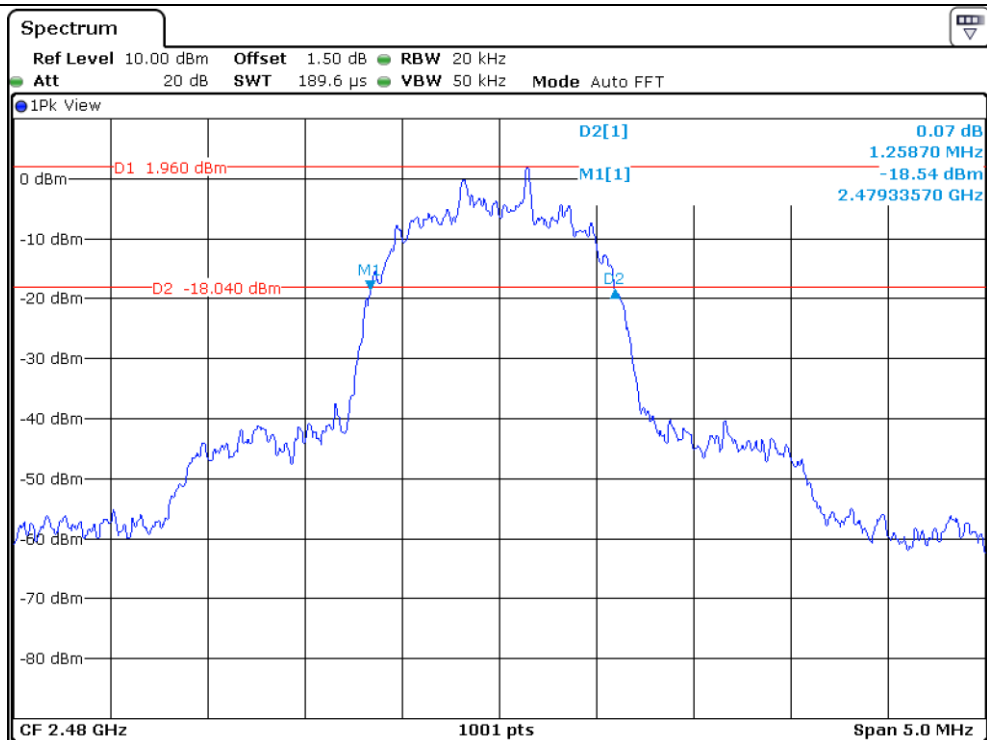
7.4.3 Test data for 3 Mbps

Channel	Frequency (MHz)	20 dB Bandwidth (kHz)
Low	2 402.00	1 248.80
Middle	2 441.00	1 268.70
High	2 480.00	1 258.70





Middle Channel



High Channel

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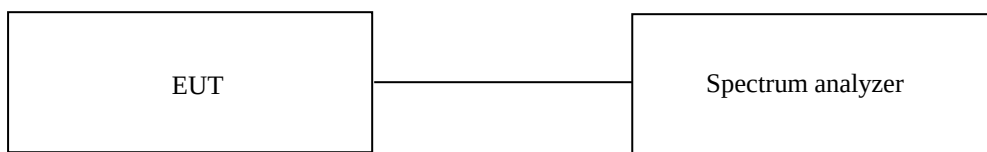
8. HOPPING FREQUENCY SEPARATION

8.1 Operating environment

Temperature : 22.5 °C
Relative humidity : 53.5 % 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

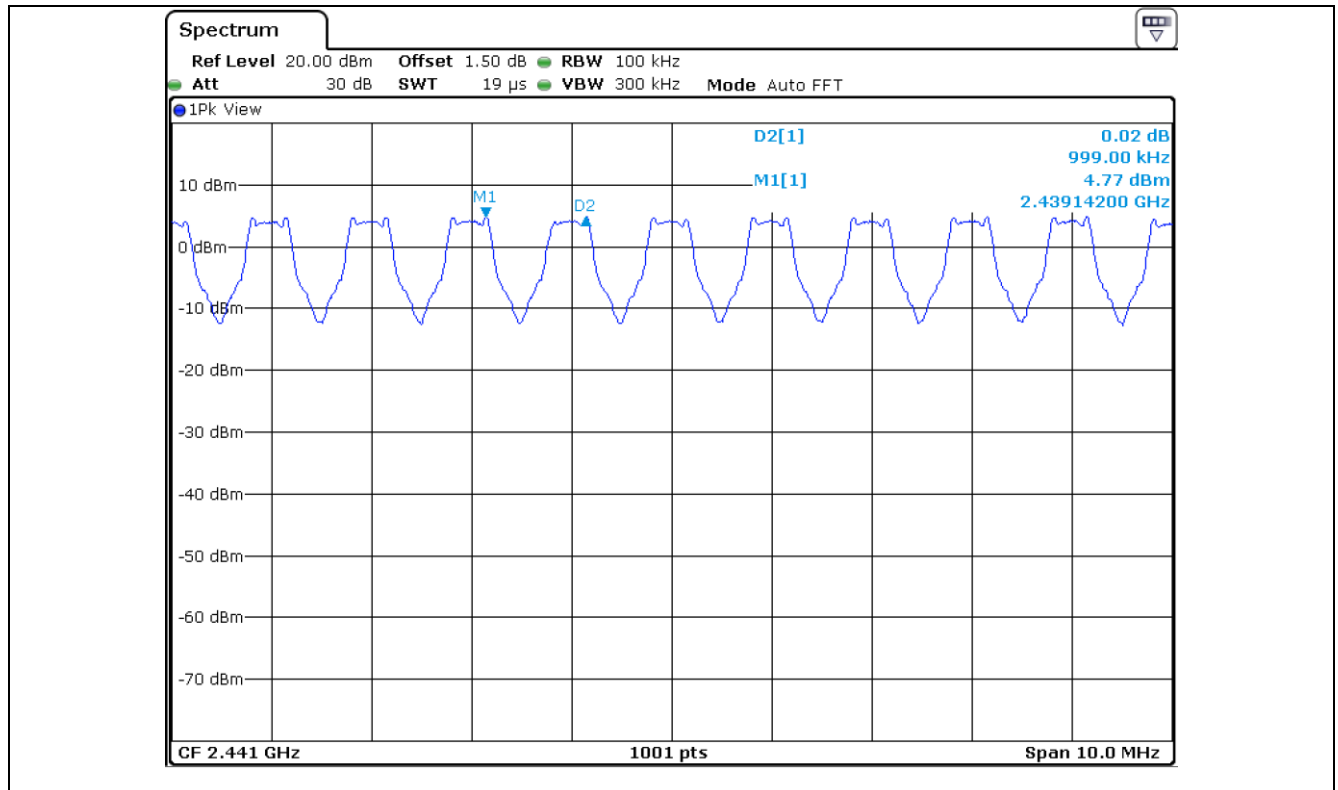
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8.4 Test Data

8.4.1 Test data for 1 Mbps

-. Test Result : Pass

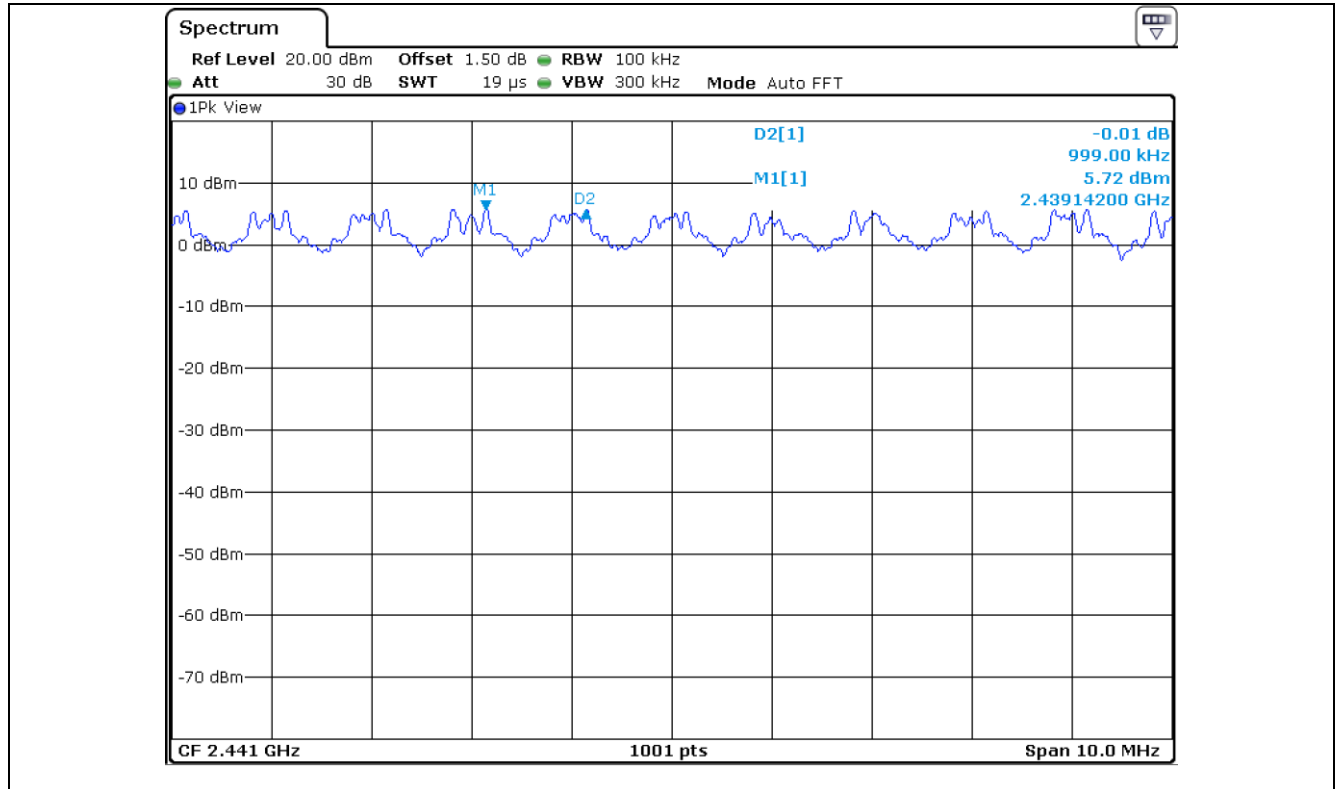
Measured Value (kHz)	Two-third of 20 dB Bandwidth (kHz)	Limit
999.00	617.40	Separated by a minimum of 617.40 kHz



8.4.2 Test data for 2 Mbps

-. Test Result : Pass

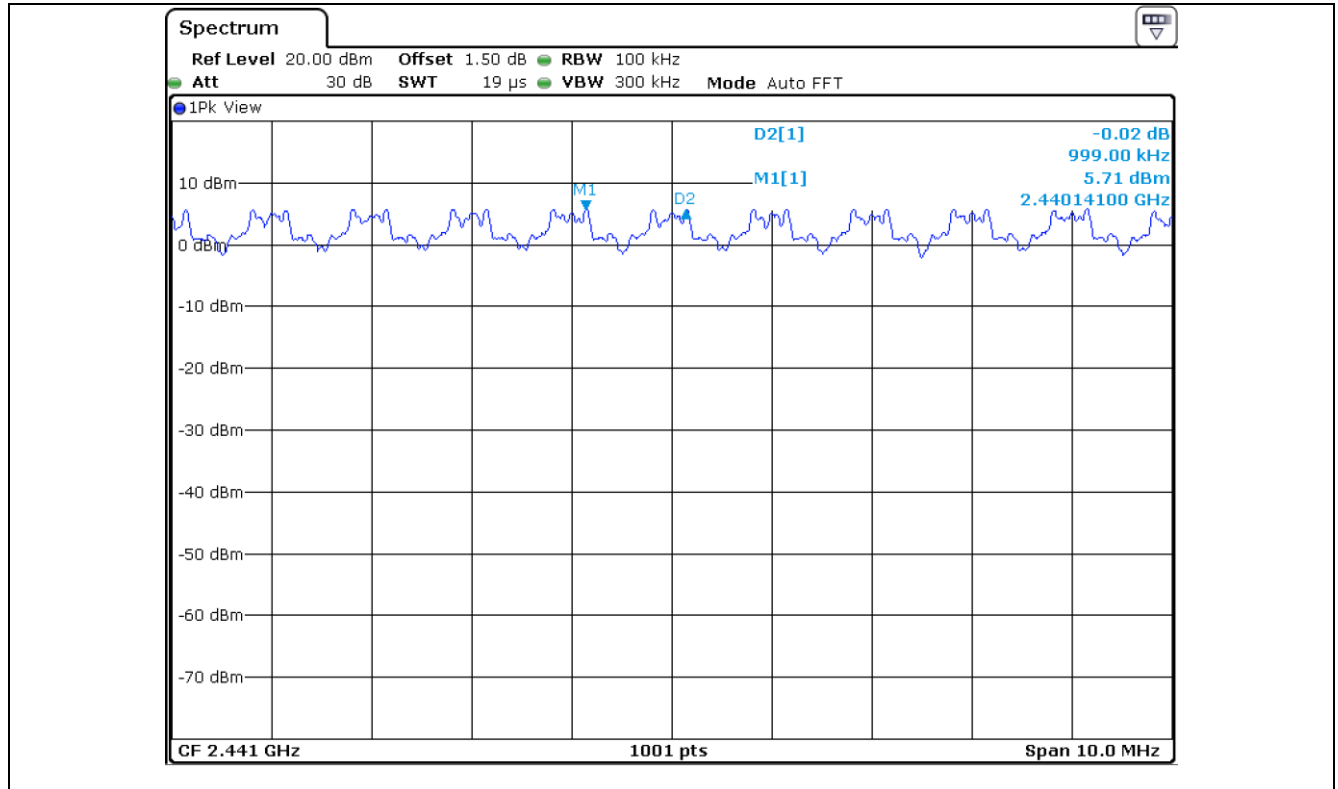
Measured Value (kHz)	Two-third of 20 dB Bandwidth (kHz)	Limit
999.00	832.53	Separated by a minimum of 832.53 kHz



8.4.3 Test data for 3 Mbps

-. Test Result : Pass

Measured Value (kHz)	Two-third of 20 dB Bandwidth (kHz)	Limit
999.00	845.80	Separated by a minimum of 845.80 kHz



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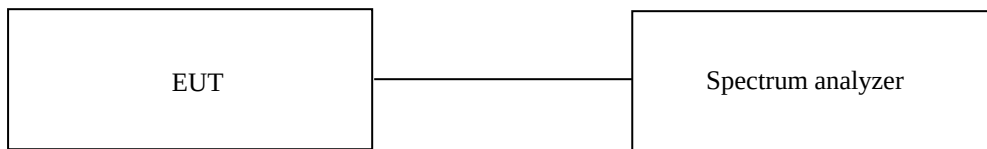
9. NUMBER OF HOPPING CHANNELS

9.1 Operating environment

Temperature : 22.5 °C
Relative humidity : 53.5 % R.H.

9.2 Test set-up

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



9.3 Test Date

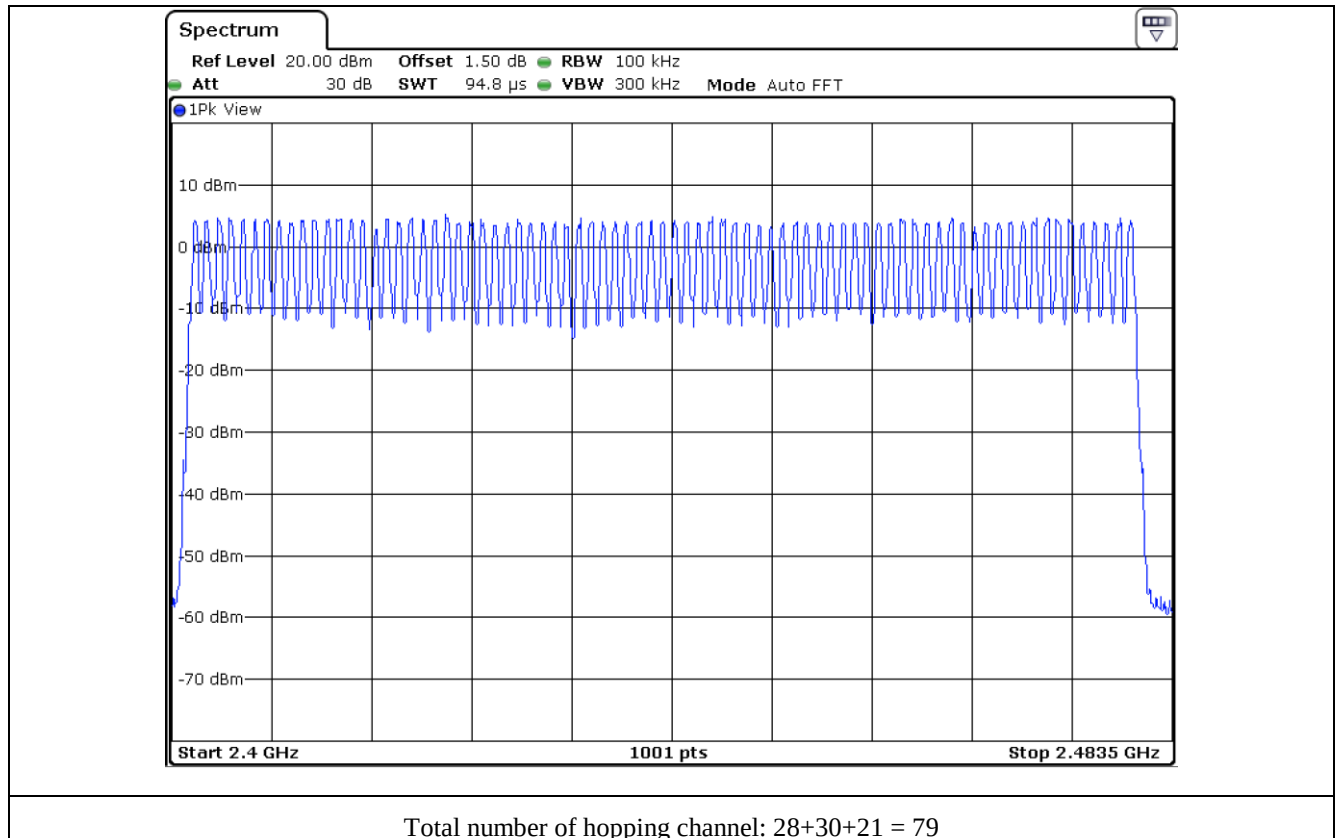
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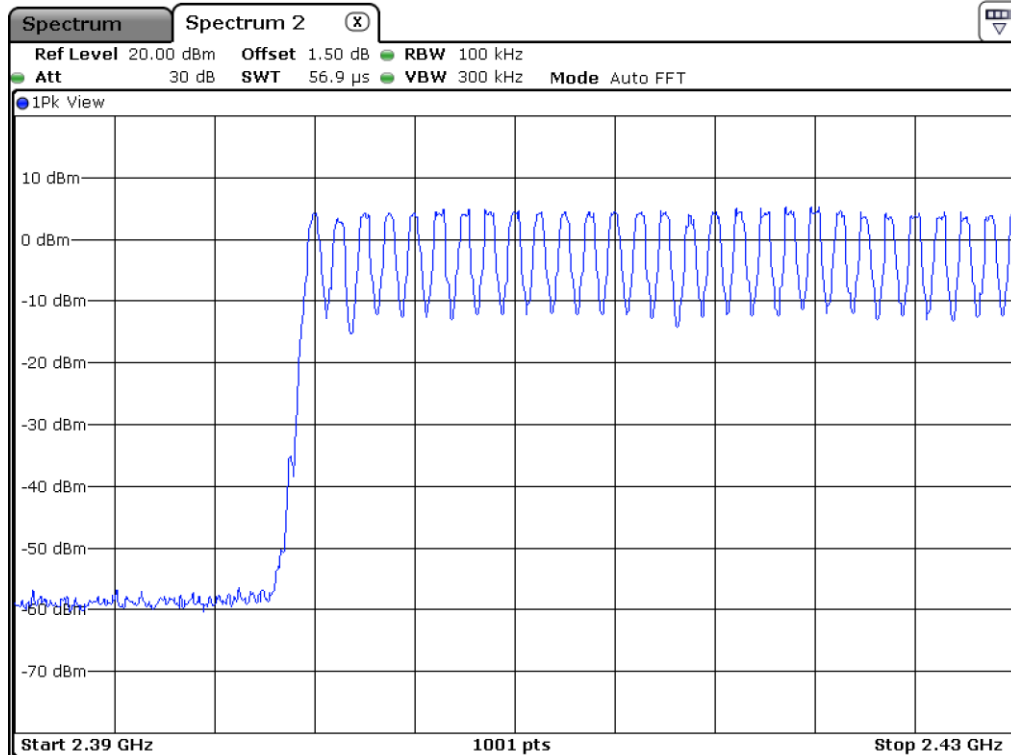
9.4 Test Data

9.4.1 Test data for 1 Mbps

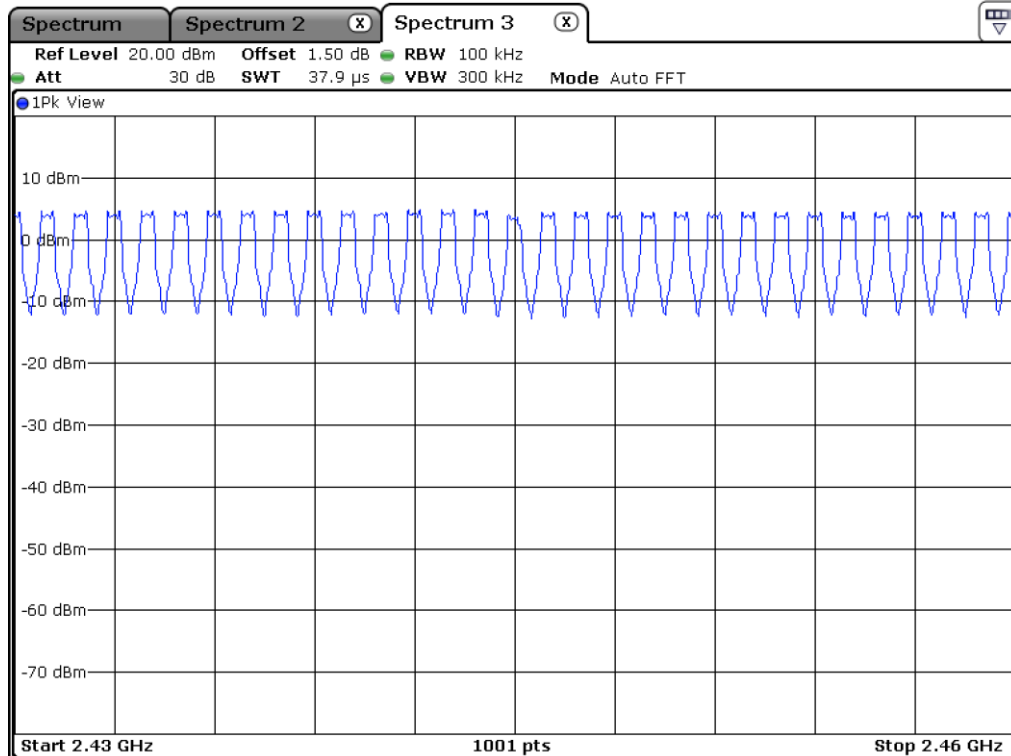
-. Test Result : Pass

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

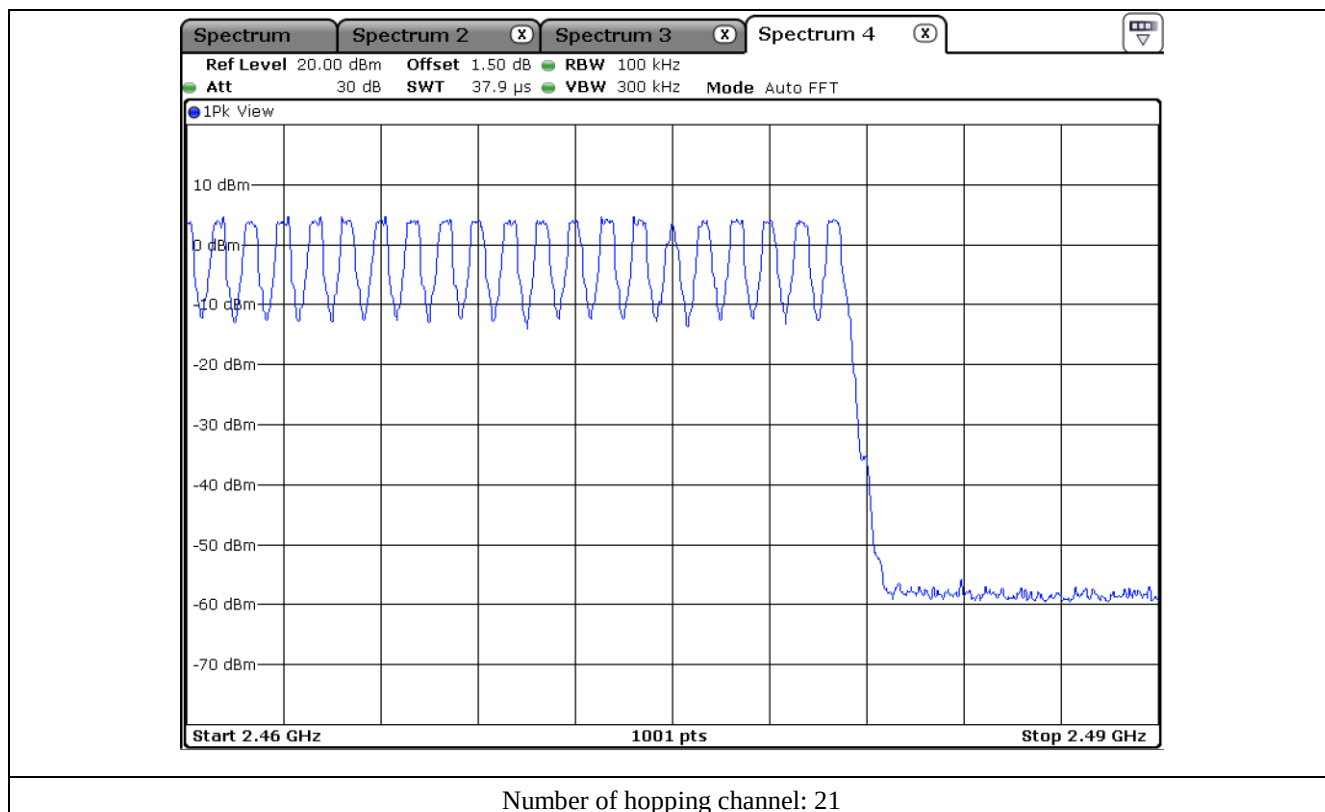




Number of hopping channel: 28



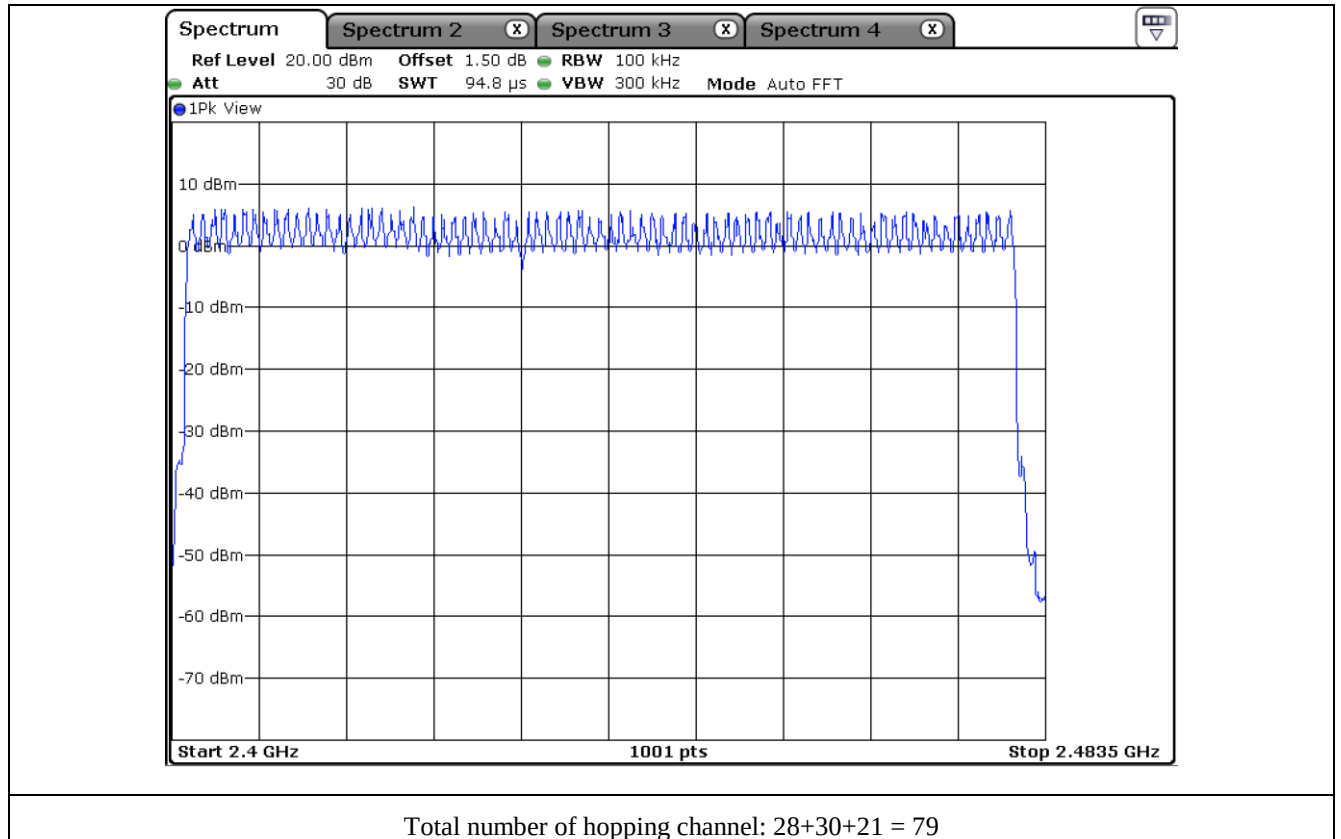
Number of hopping channel: 30

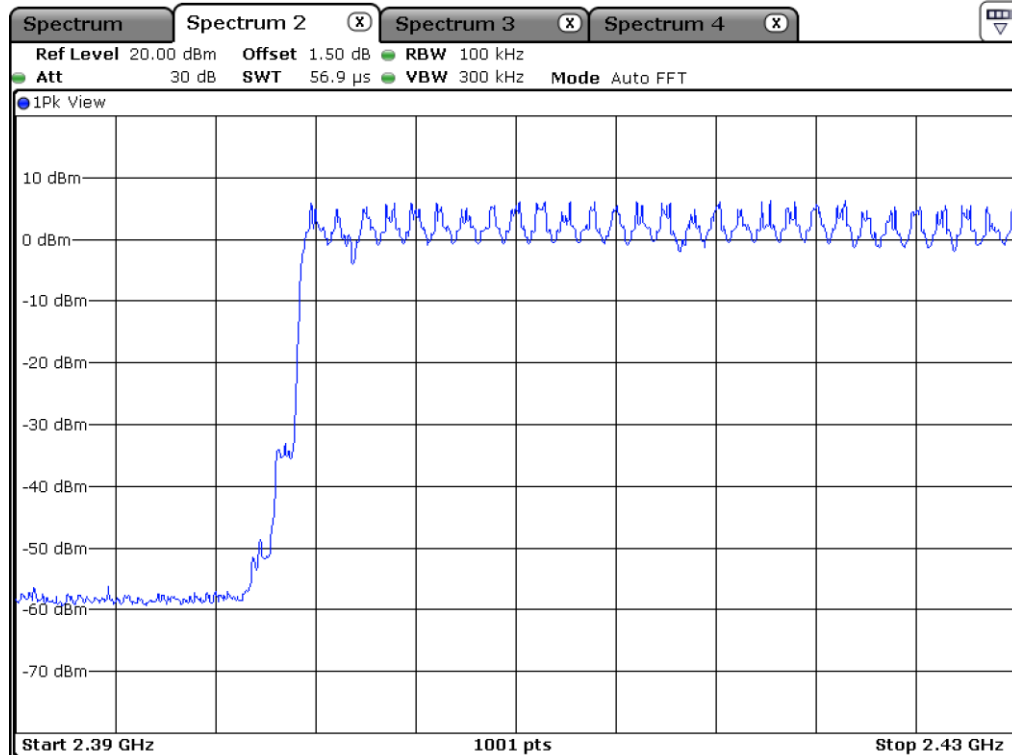


9.4.2 Test data for 2 Mbps

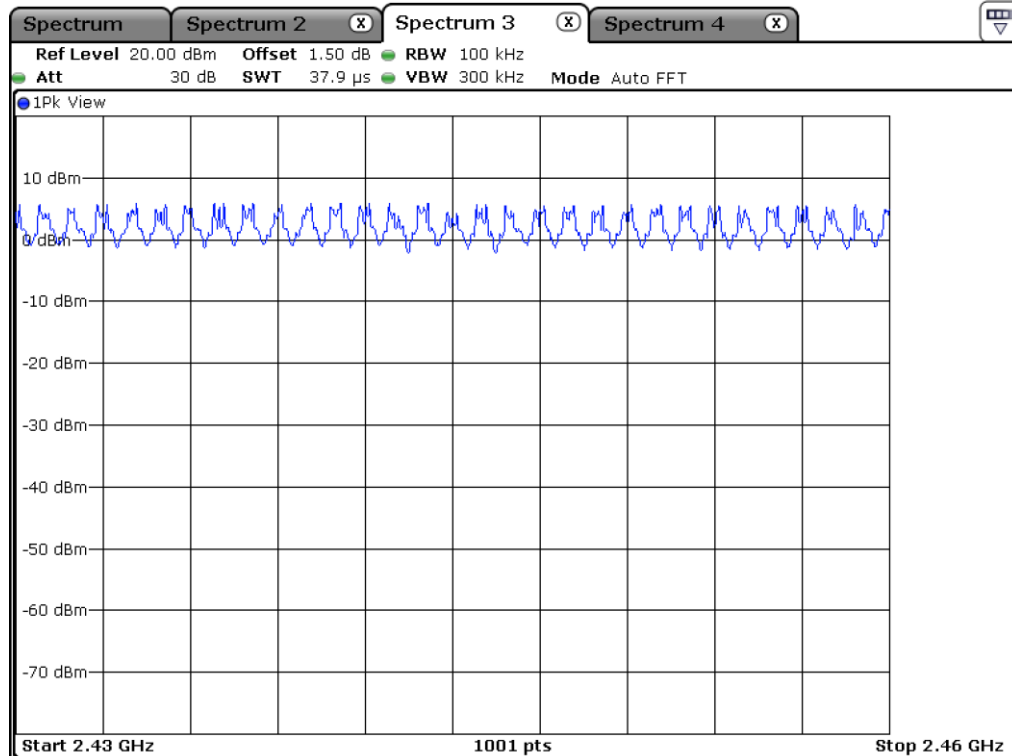
-. Test Result : Pass

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

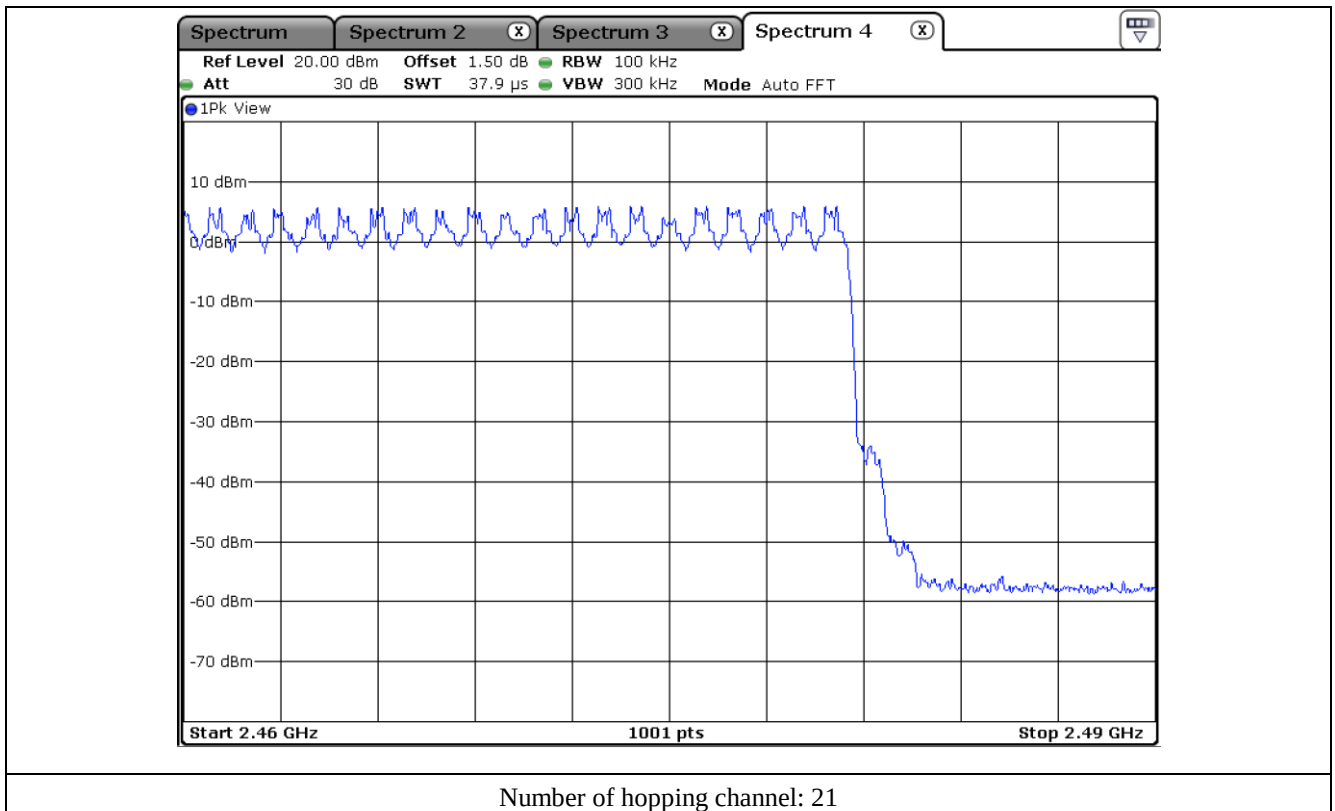




Number of hopping channel: 28



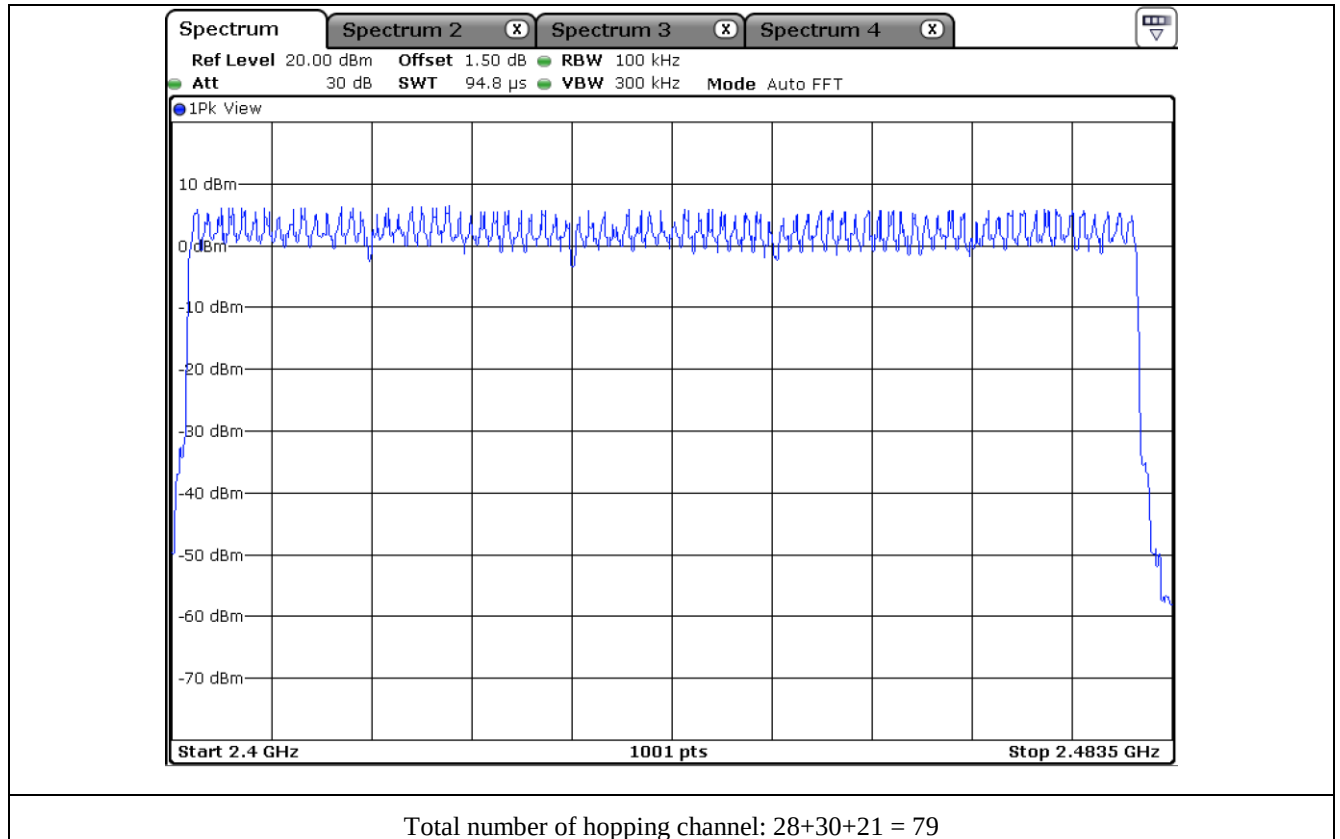
Number of hopping channel: 30

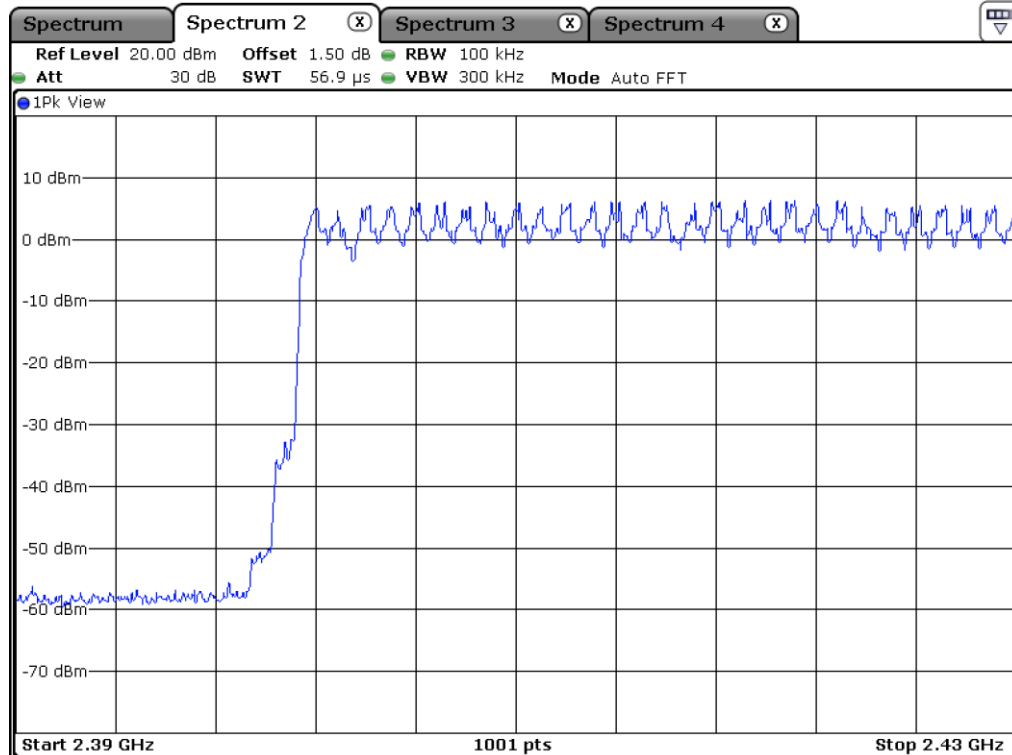


9.4.3 Test data for 3 Mbps

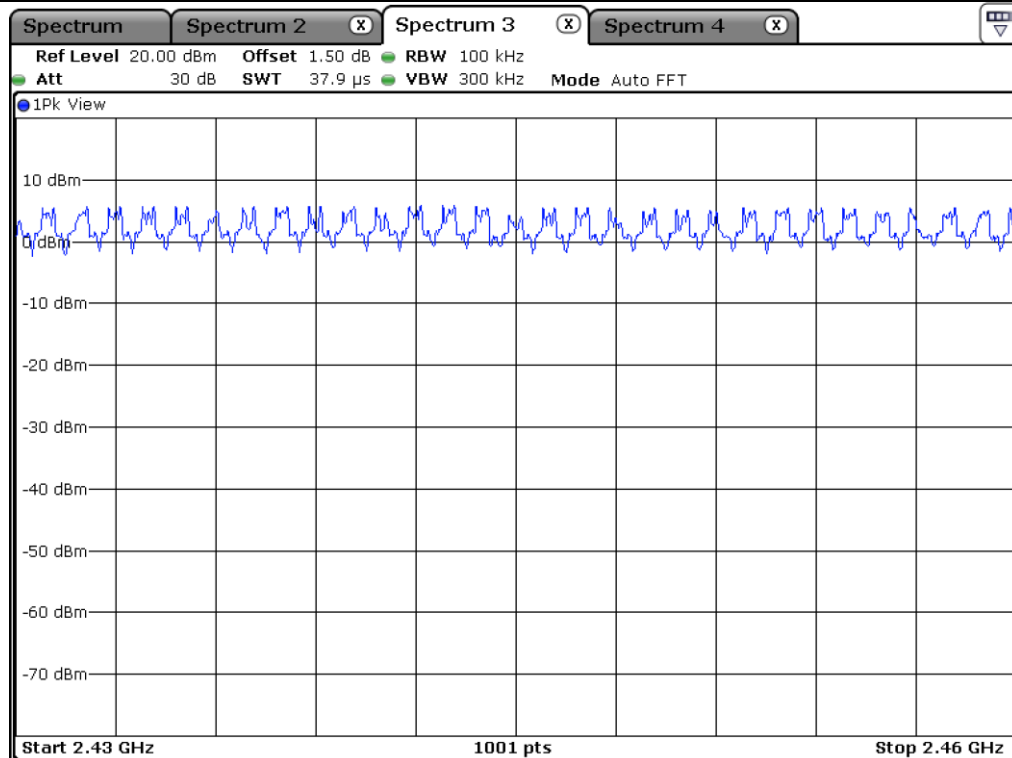
-. Test Result : Pass

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

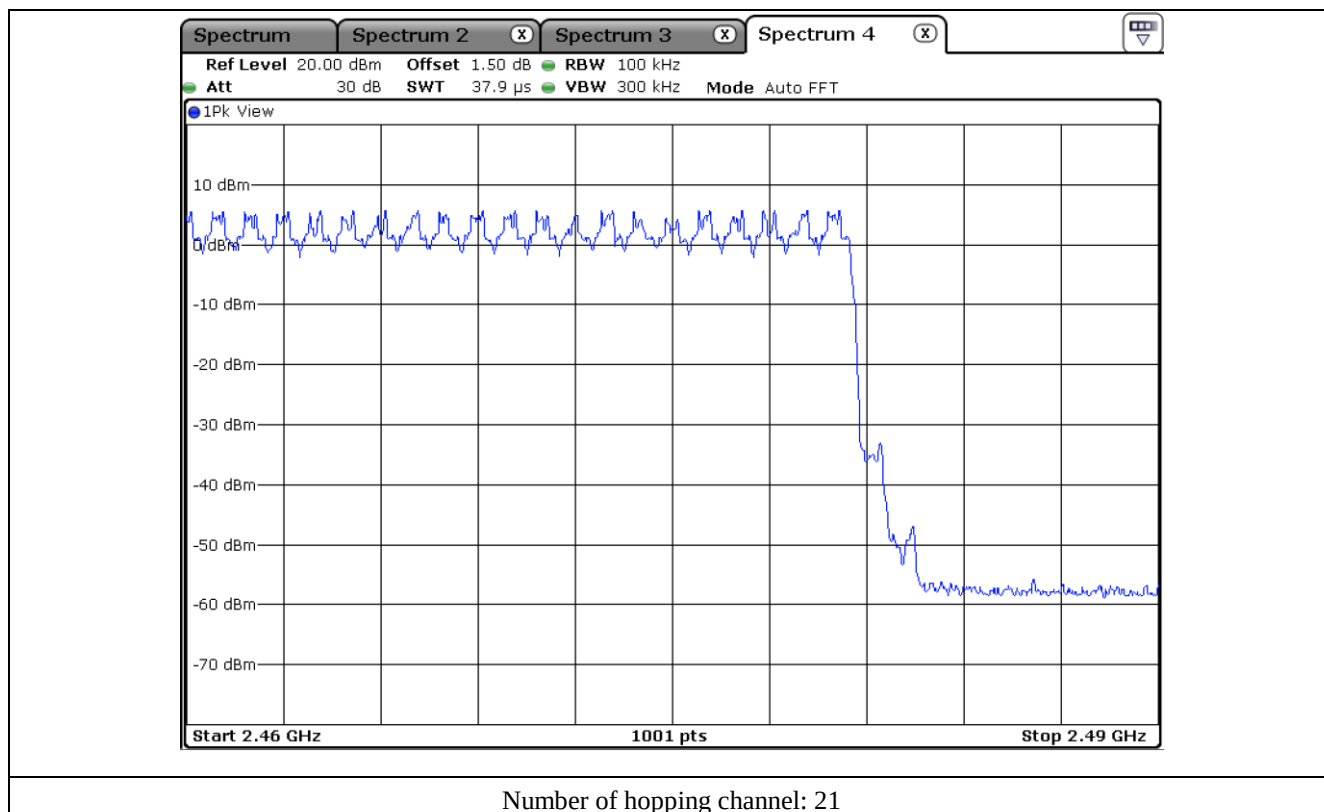




Number of hopping channel: 28



Number of hopping channel: 30



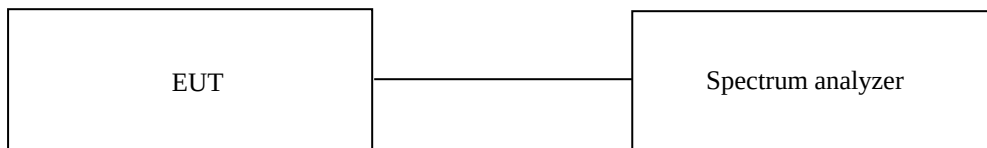
10. TIME OF OCCUPANCY

10.1 Operating environment

Temperature : 22.5 °C
Relative humidity : 53.5 % 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

November 26, 2021

10.4 Test Data

10.4.1 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.

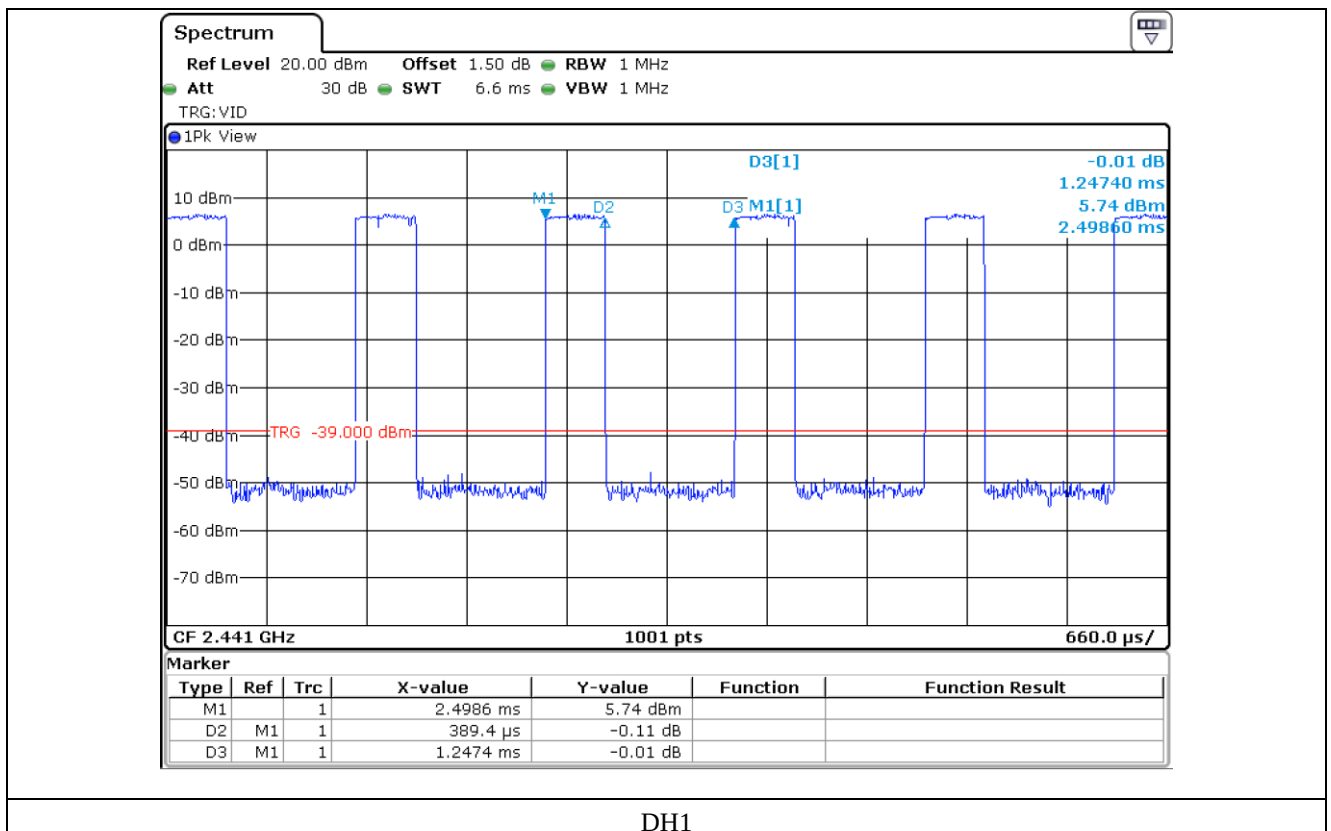
For DH1 packet type, the EUT needs 1 time slot for transmitting and 1 time slot for receiving and for DH3 packet type, the EUT needs 3 times slots for transmitting and 1 time slot for receiving, and DH5 packet needs 5 times slots for transmitting and 1 time slot for receiving. So The EUT has each channel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

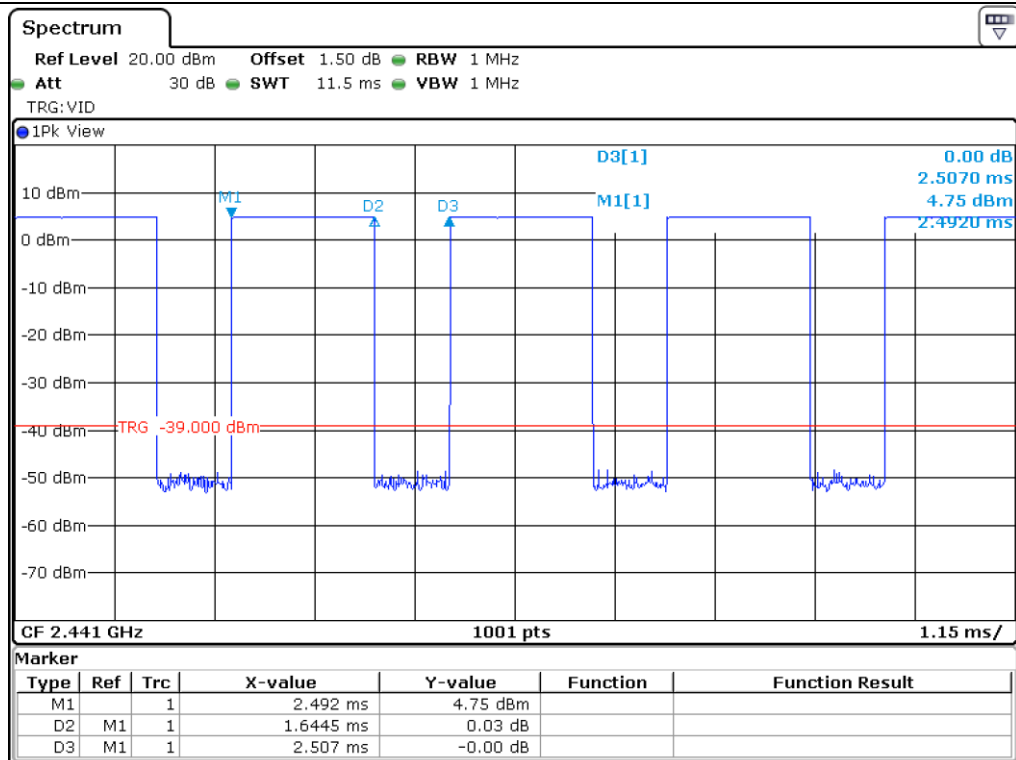
Packet Type	Pulse Time (ms)	Hops per second with channels	Period Time (ms)	Total Dwell Time (ms)	Limit (ms)	Test Result
DH1	0.39	10.13	31.60	124.65	400.00	PASS
DH3	1.64	5.06	31.60	262.95	400.00	
DH5	2.88	3.38	31.60	307.71	400.00	

Total dwell time is calculated as following.

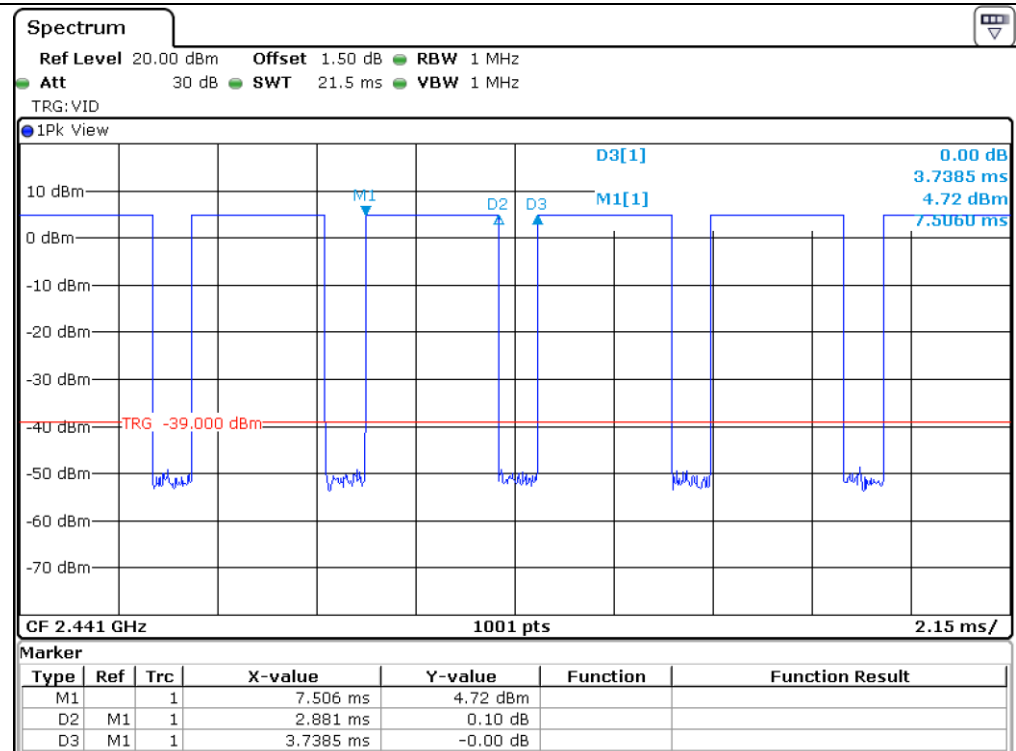
Total Dwell Time = Pulse time * Hops per second with channels * period time

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





DH3



DH5

10.4.2 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.

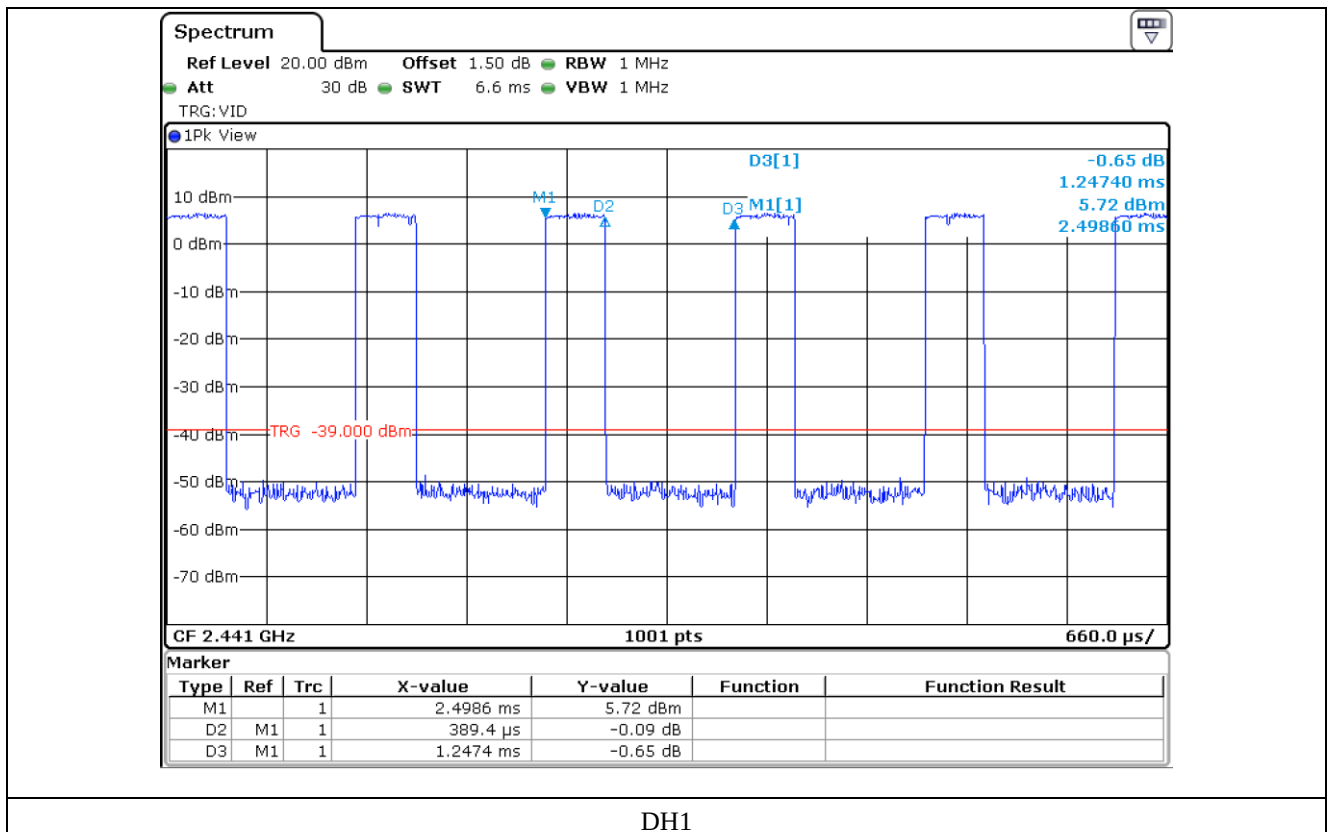
For DH1 packet type, the EUT needs 1 time slot for transmitting and 1 time slot for receiving and for DH3 packet type, the EUT needs 3 times slots for transmitting and 1 time slot for receiving, and DH5 packet needs 5 times slots for transmitting and 1 time slot for receiving. So The EUT has each channel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

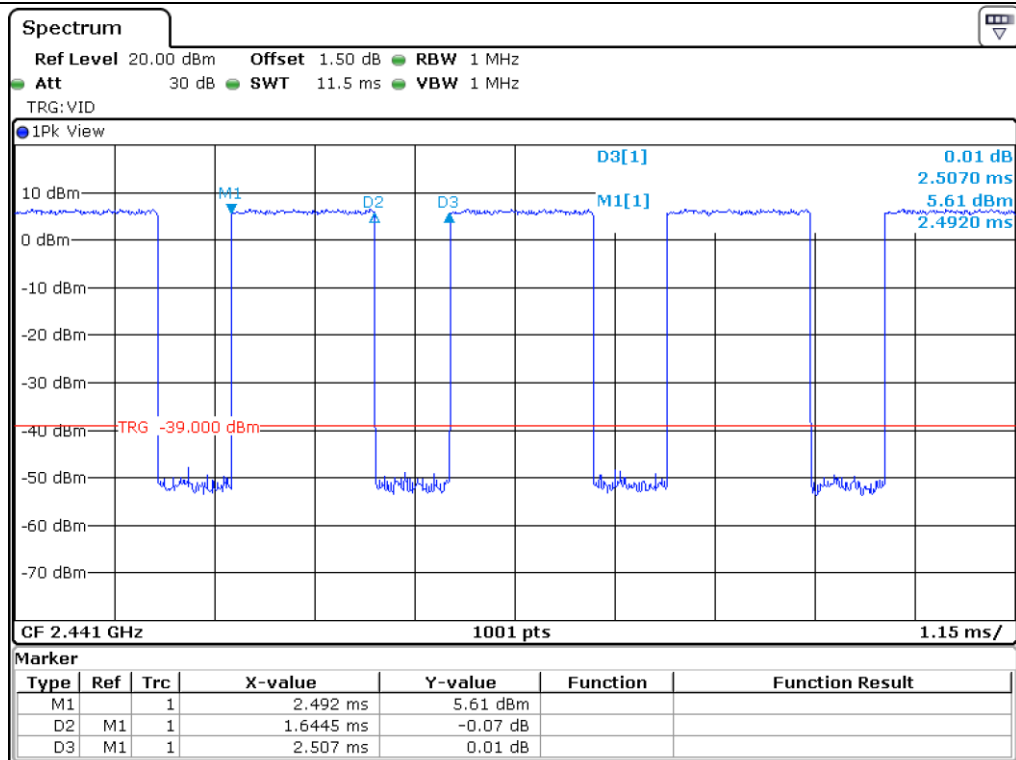
Packet Type	Pulse Time (ms)	Hops per second with channels	Period Time (ms)	Total Dwell Time (ms)	Limit (ms)	Test Result
DH1	0.39	10.13	31.60	124.65	400.00	PASS
DH3	1.64	5.06	31.60	262.95	400.00	
DH5	2.88	3.38	31.60	307.71	400.00	

Total dwell time is calculated as following.

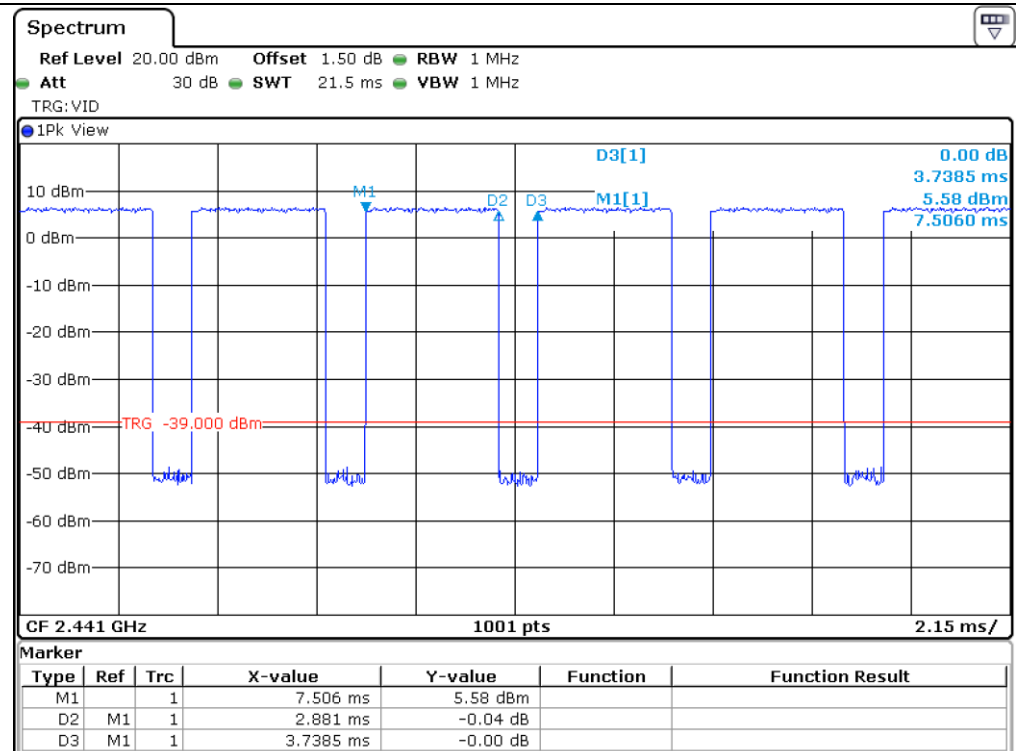
Total Dwell Time = Pulse time * Hops per second with channels * period time

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





DH3



DH5

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10.4.3 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.

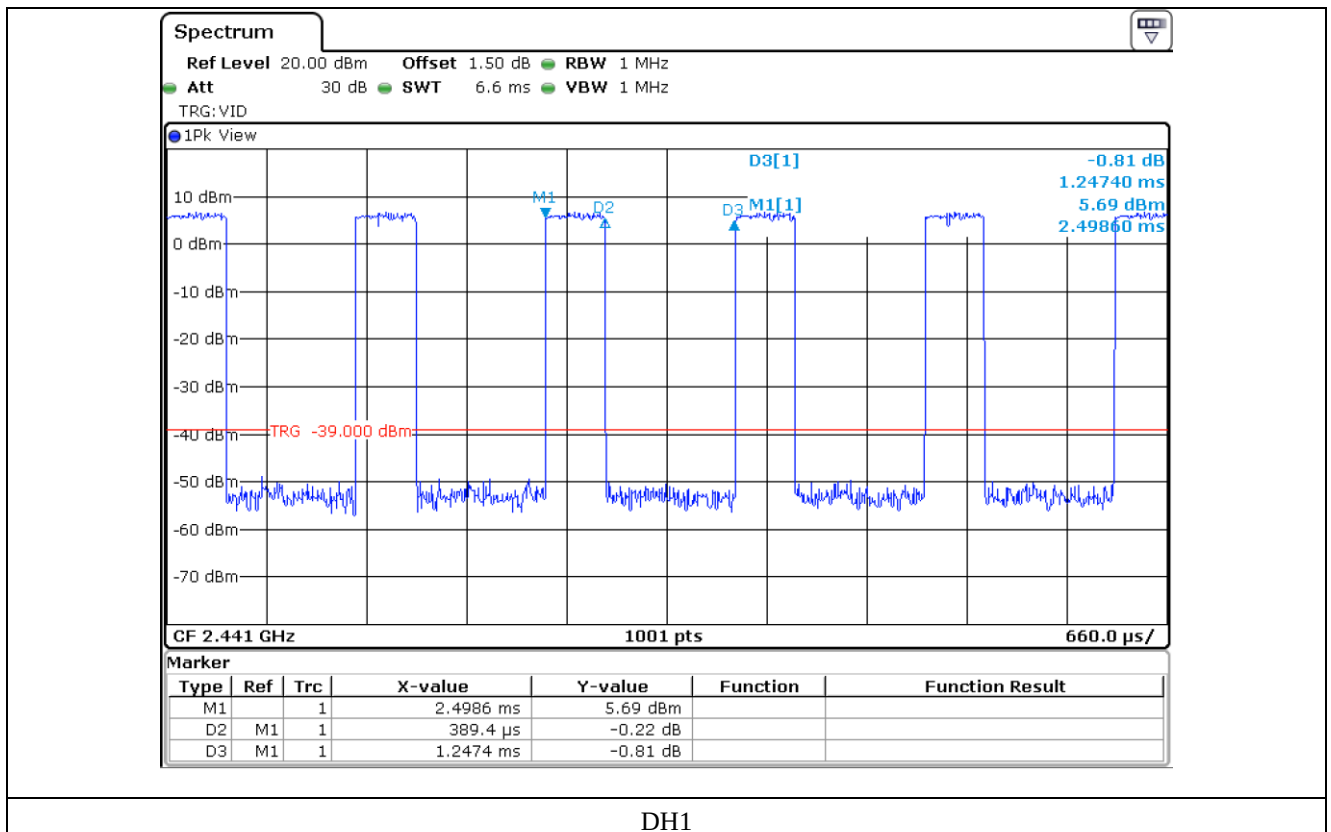
For DH1 packet type, the EUT needs 1 time slot for transmitting and 1 time slot for receiving and for DH3 packet type, the EUT needs 3 times slots for transmitting and 1 time slot for receiving, and DH5 packet needs 5 times slots for transmitting and 1 time slot for receiving. So The EUT has each channel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

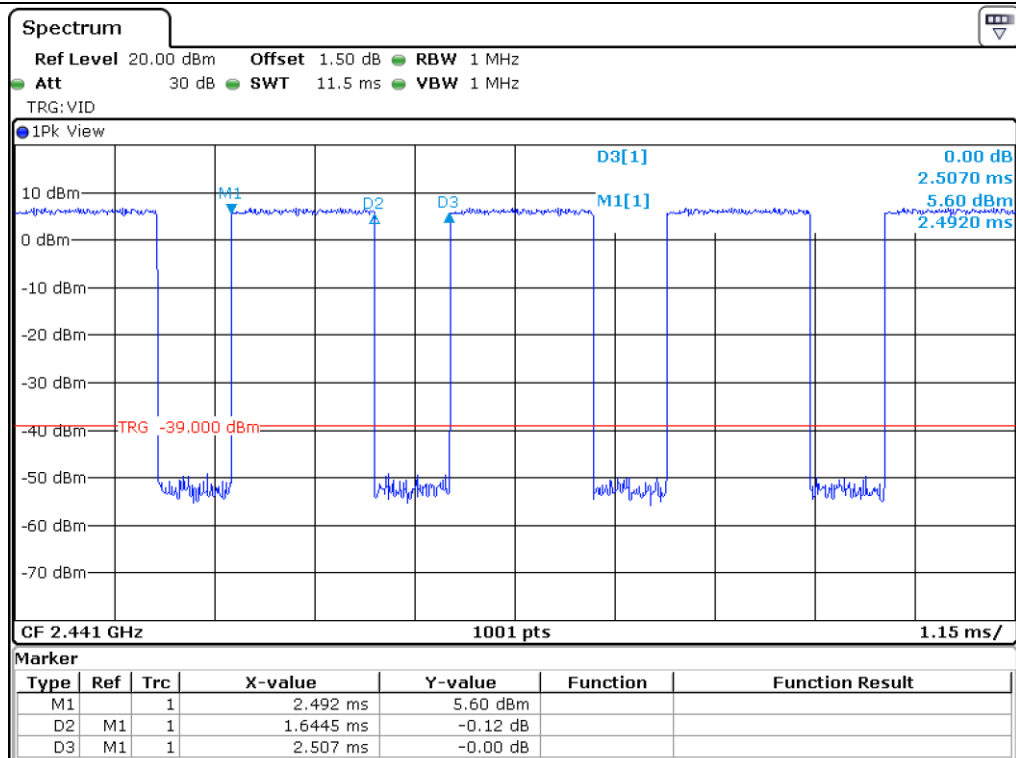
Packet Type	Pulse Time (ms)	Hops per second with channels	Period Time (ms)	Total Dwell Time (ms)	Limit (ms)	Test Result
DH1	0.39	10.13	31.60	124.65	400.00	PASS
DH3	1.64	5.06	31.60	262.95	400.00	
DH5	2.88	3.38	31.60	307.71	400.00	

Total dwell time is calculated as following.

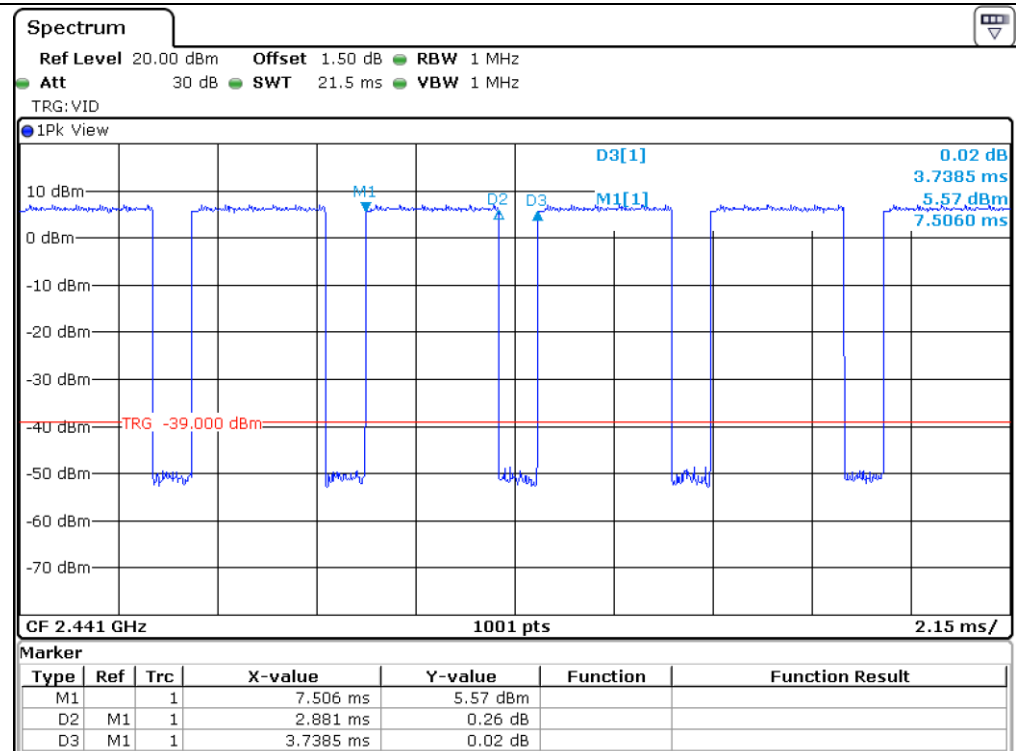
Total Dwell Time = Pulse time * Hops per second with channels * period time

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





DH3



DH5

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11. MAXIMUM PEAK OUTPUT POWER

11.1 Operating environment

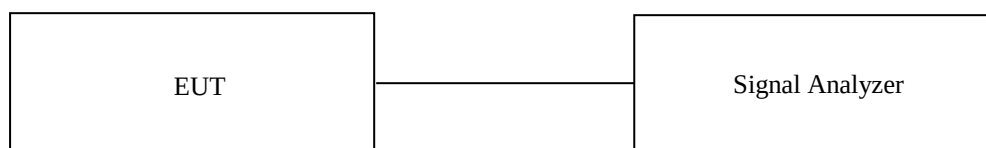
Temperature : 22.5 °C

Relative humidity : 53.5 % 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

November 26, 2021

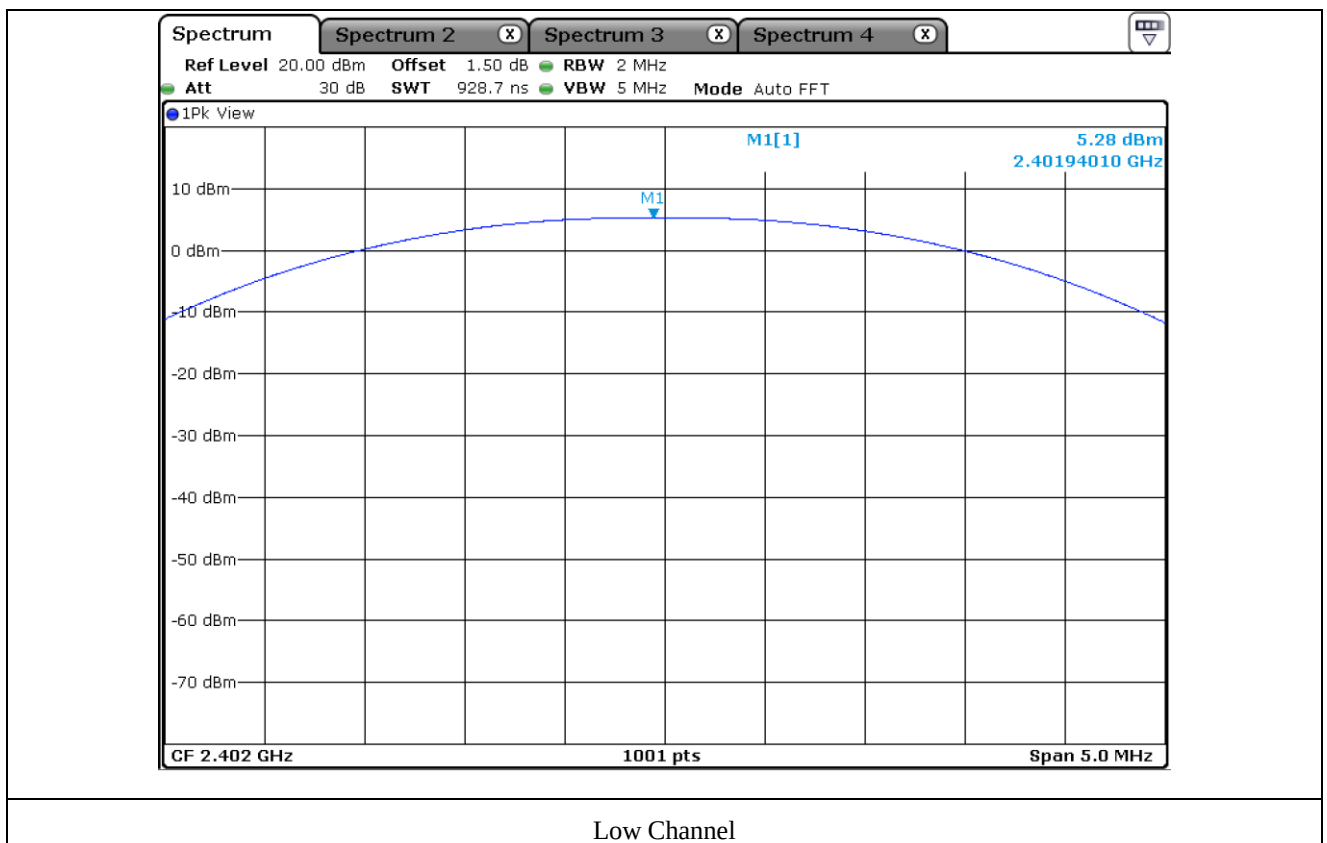
11.4 Test Data

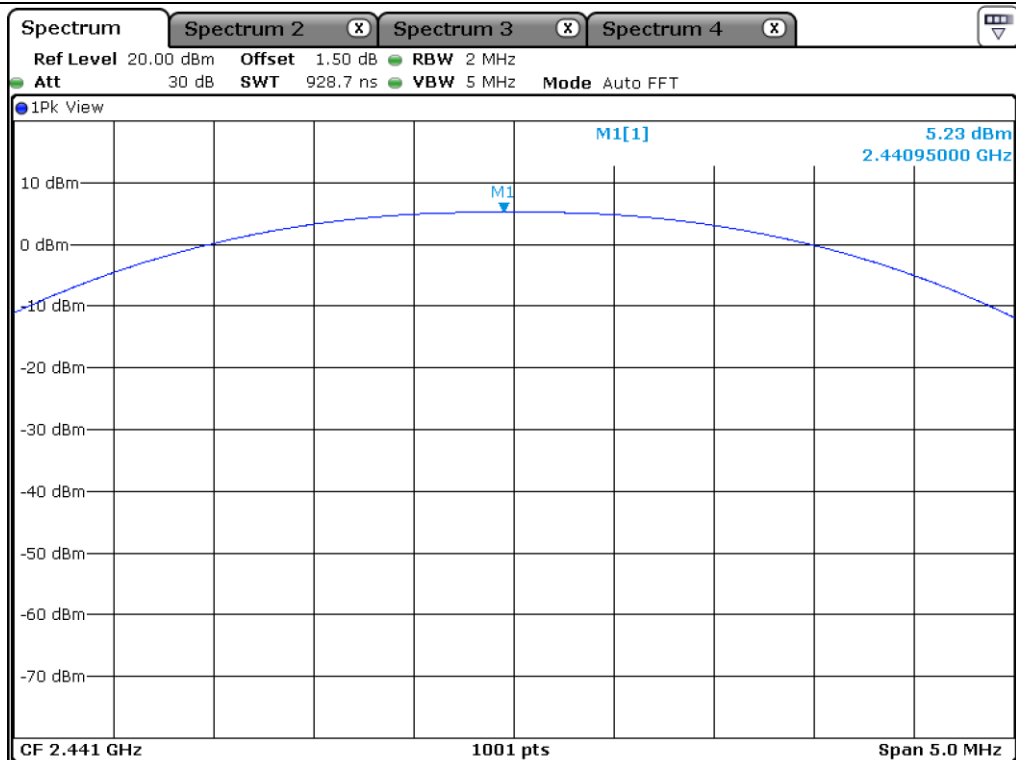
11.4.1 Test data for 1 Mbps

-. Test Result : Pass

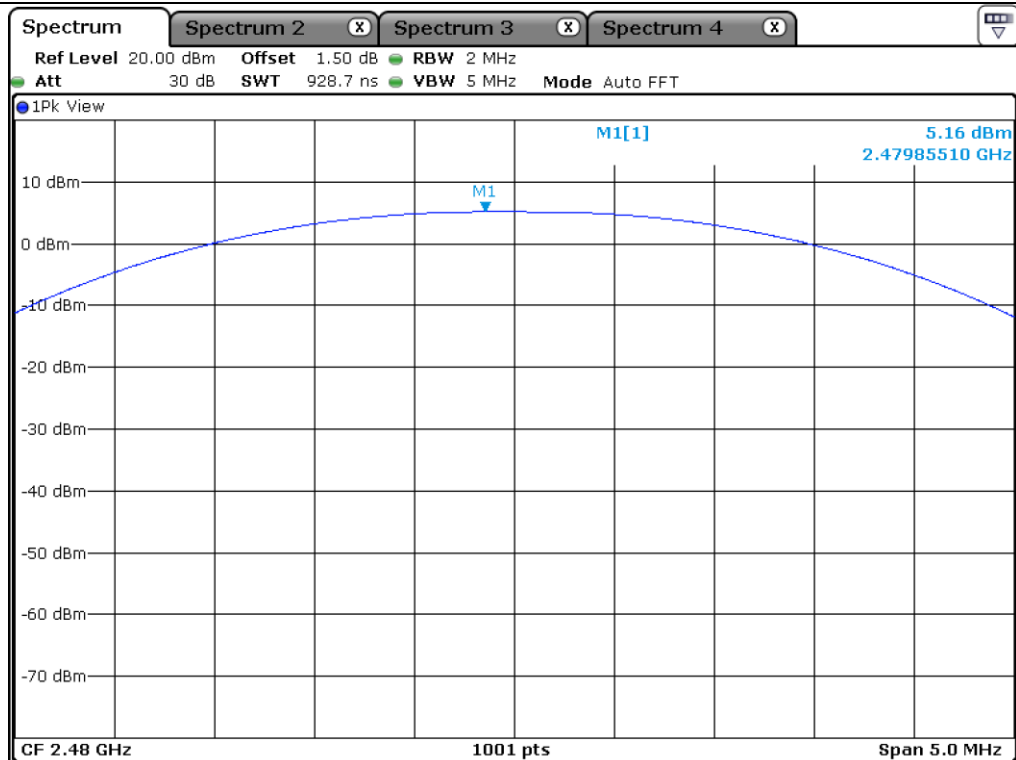
Channel	Frequency (MHz)	Measured Value (dBm)	Limit (dBm)	Margin (dB)
Low	2 402.00	5.28	21.00	15.72
Middle	2 441.00	5.23	21.00	15.77
High	2 480.00	5.16	21.00	15.84

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





Middle Channel



High Channel

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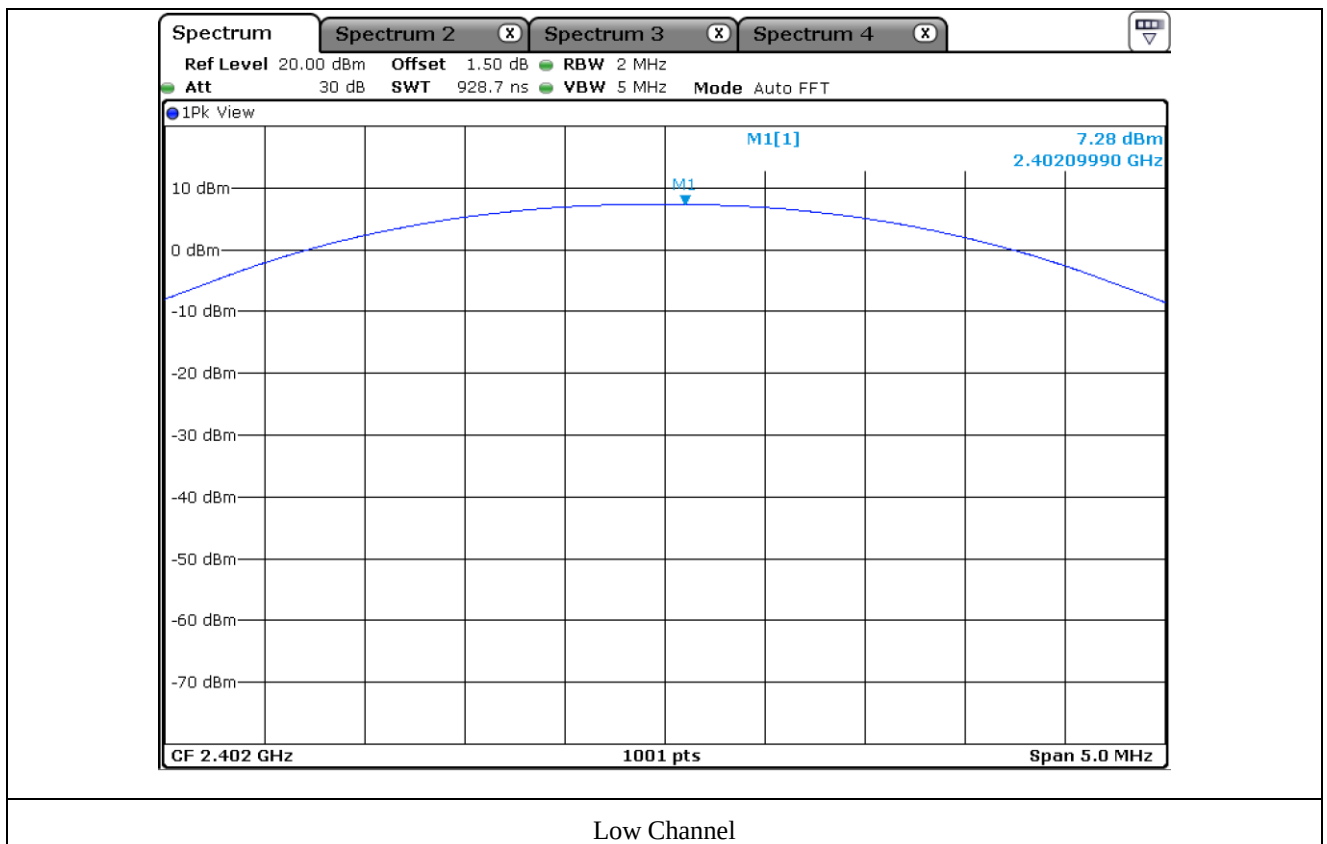
ONETECH Corp.: 43-14, Jinsaegol-gil, Chowol-eup, Gwangju-si, Gyeonggi-do, 12735, Korea (TEL: 82-31-799-9500, FAX: 82-31-799-9599)

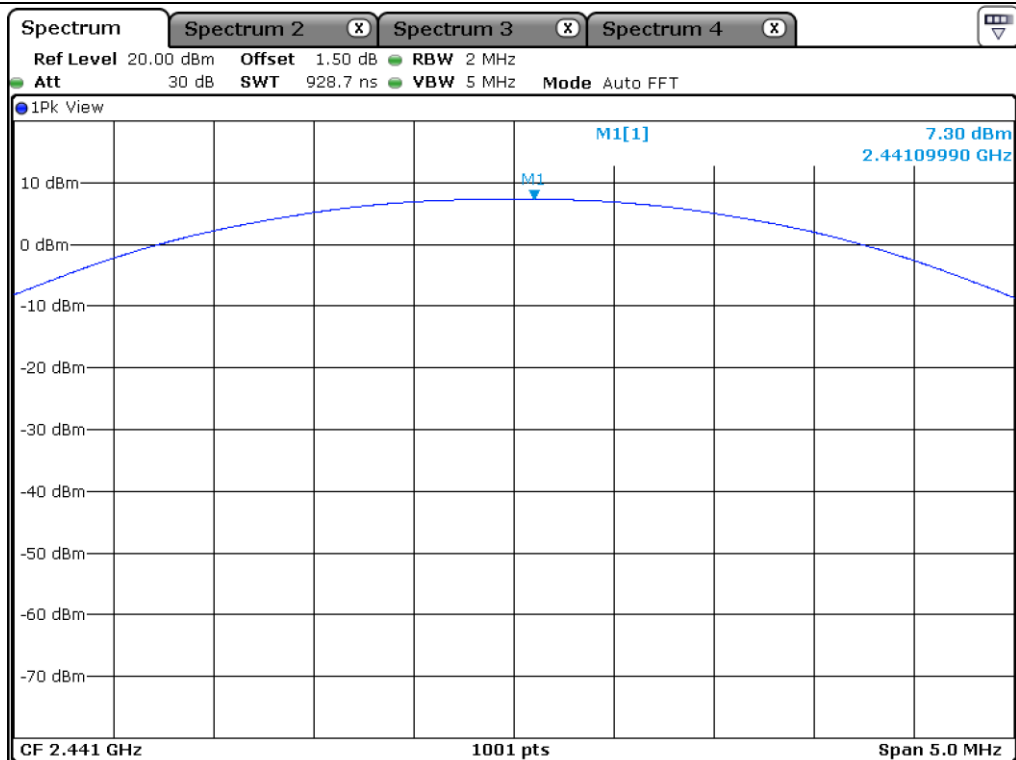
11.4.2 Test data for 2 Mbps

-. Test Result : Pass

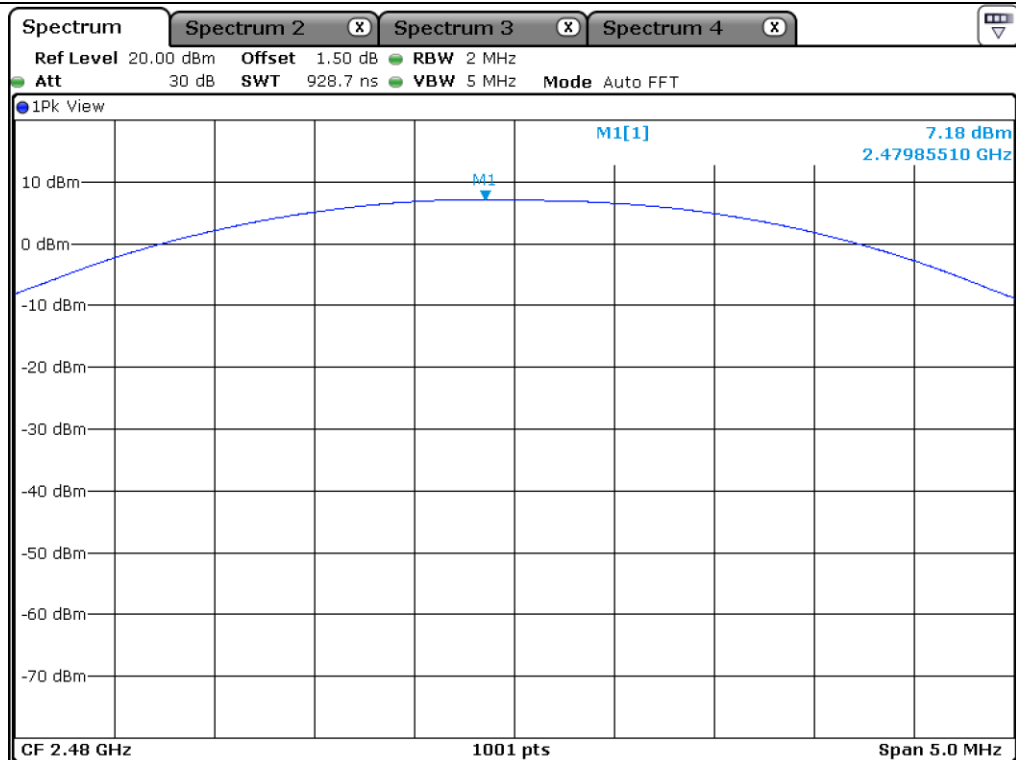
Channel	Frequency (MHz)	Measured Value (dBm)	Limit (dBm)	Margin (dB)
Low	2 402.00	7.28	21.00	13.72
Middle	2 441.00	7.30	21.00	13.70
High	2 480.00	7.18	21.00	13.82

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





Middle Channel



High Channel

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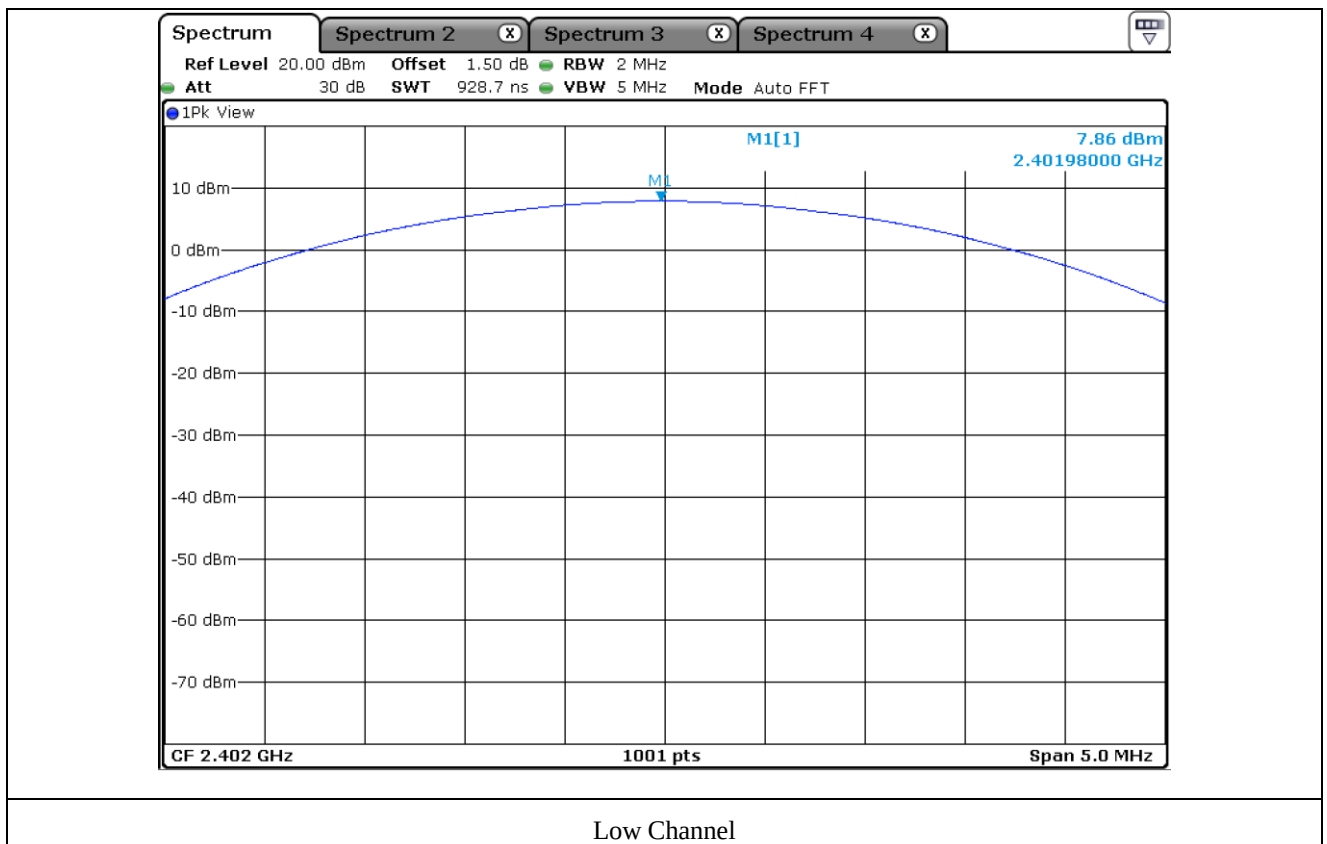
ONETECH Corp.: 43-14, Jinsaegol-gil, Chowol-eup, Gwangju-si, Gyeonggi-do, 12735, Korea (TEL: 82-31-799-9500, FAX: 82-31-799-9599)

11.4.3 Test data for 3 Mbps

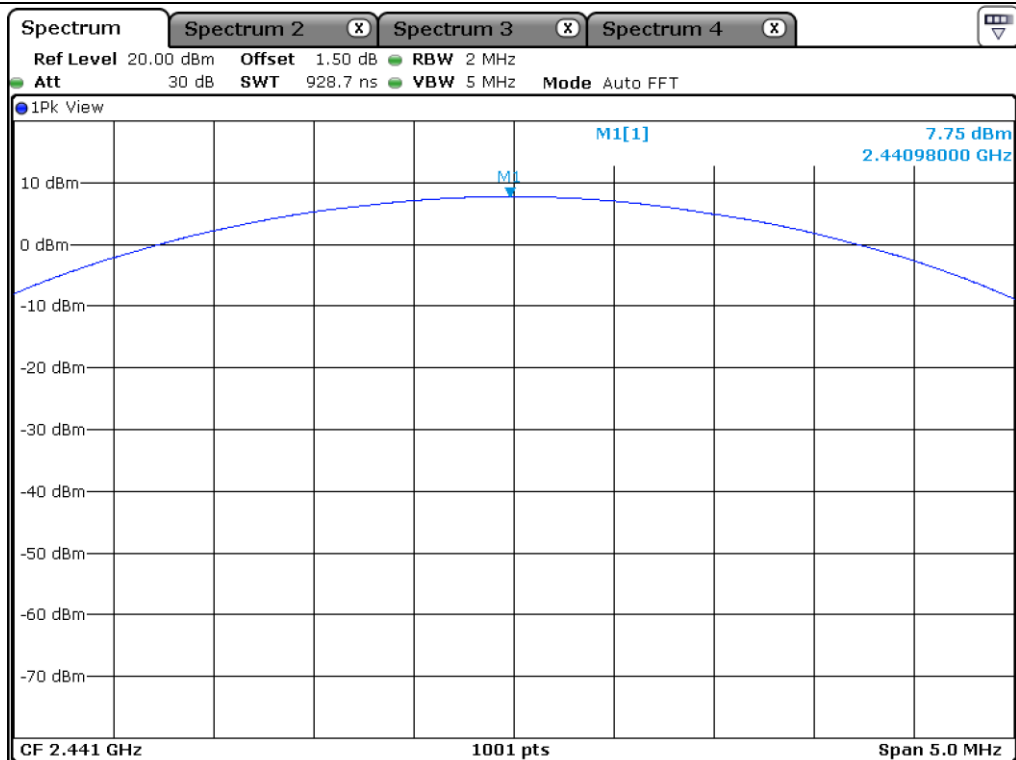
-. Test Result : Pass

Channel	Frequency (MHz)	Measured Value (dBm)	Limit (dBm)	Margin (dB)
Low	2 402.00	7.86	21.00	13.14
Middle	2 441.00	7.75	21.00	13.25
High	2 480.00	7.76	21.00	13.24

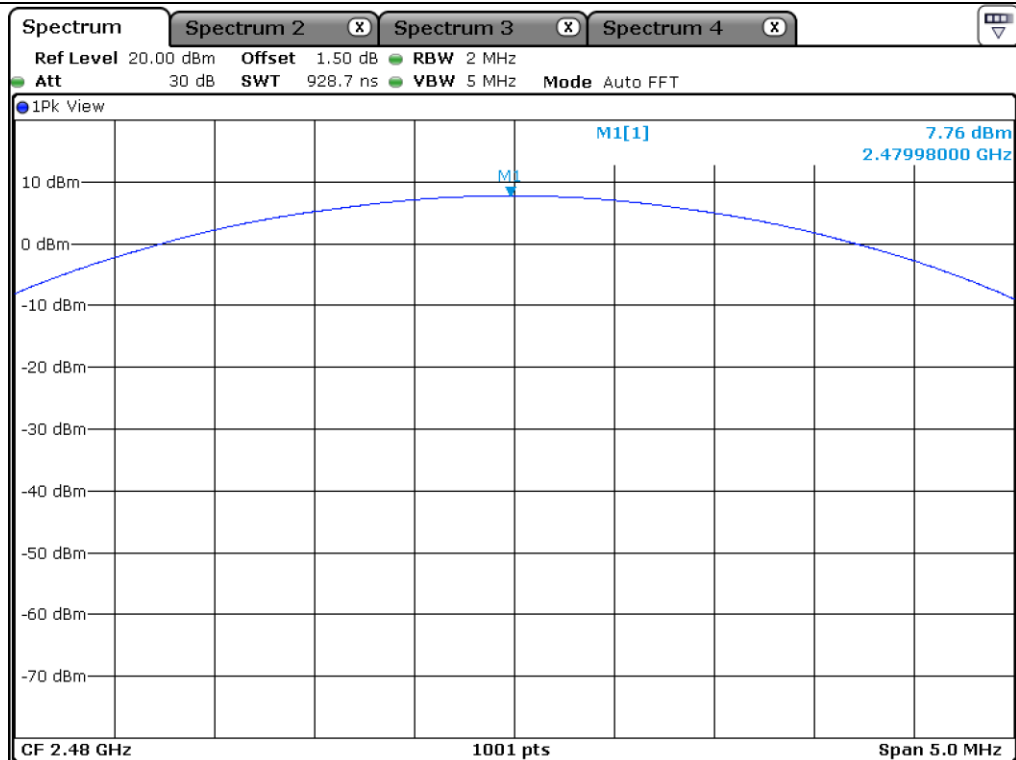
Remark. Margin = Limit – Measured Value (=Receiver Reading + Cable Loss)



Low Channel



Middle Channel



High Channel

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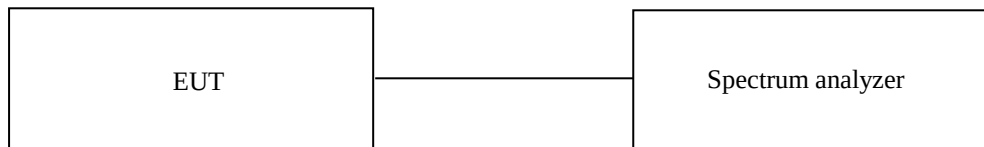
12. 100 kHz BANDWIDTH OUTSIDE THE FREQUENCY BAND

12.1 Operating environment

Temperature : 22.5 °C
Relative humidity : 53.5 % 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.

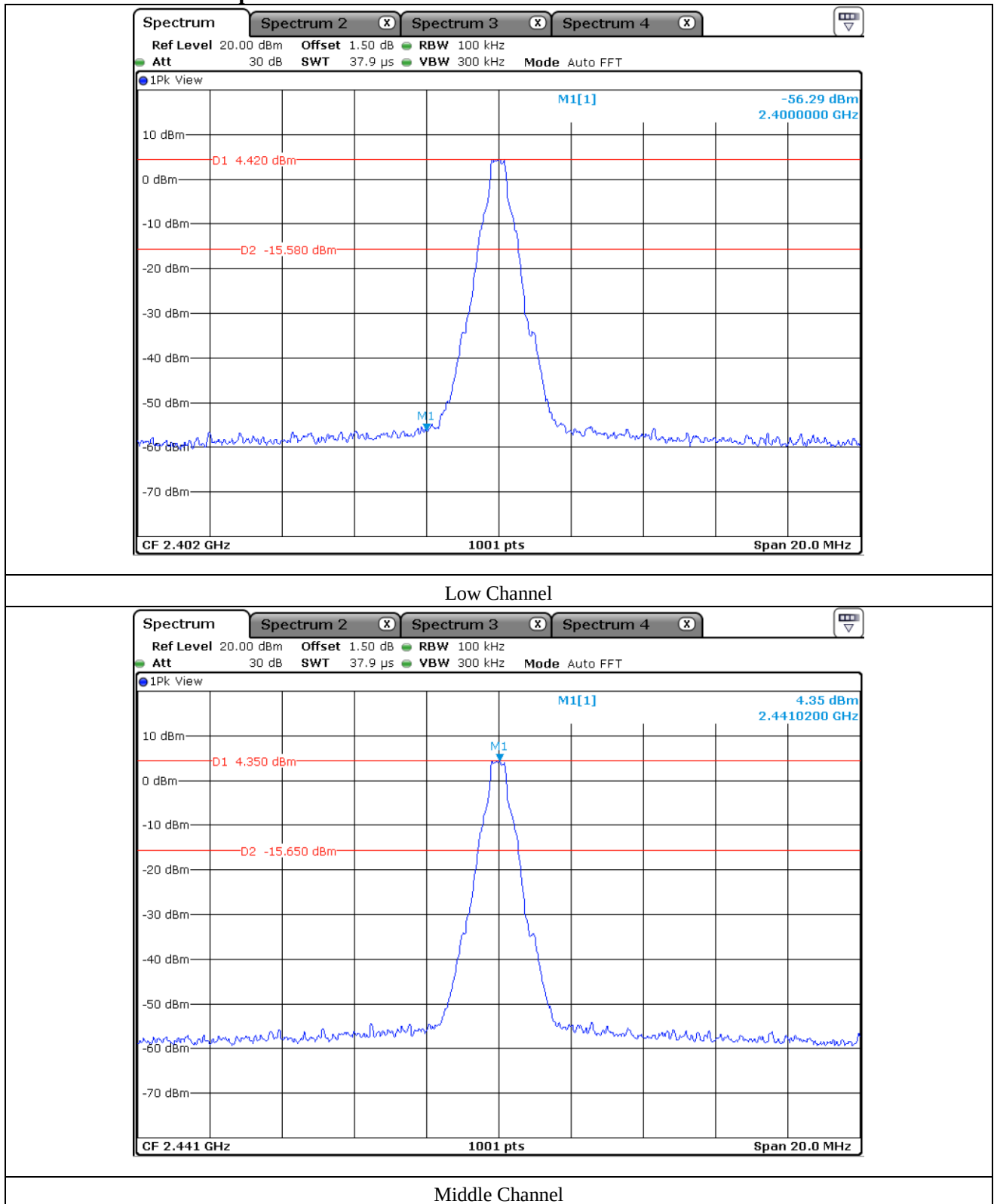
The frequency spectrum from 30 MHz to 26.5 GHz was scanned and maximum emission levels at each frequency recorded. The system was rotated 360°, and the antenna was varied in the height between 1.0 m and 4.0 m in order to determine the maximum emission levels. This procedure was performed for horizontal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

12.4 Test Date

November 26, 2021

12.5 Test data for conducted emission

12.5.1 Test data for 1 Mbps

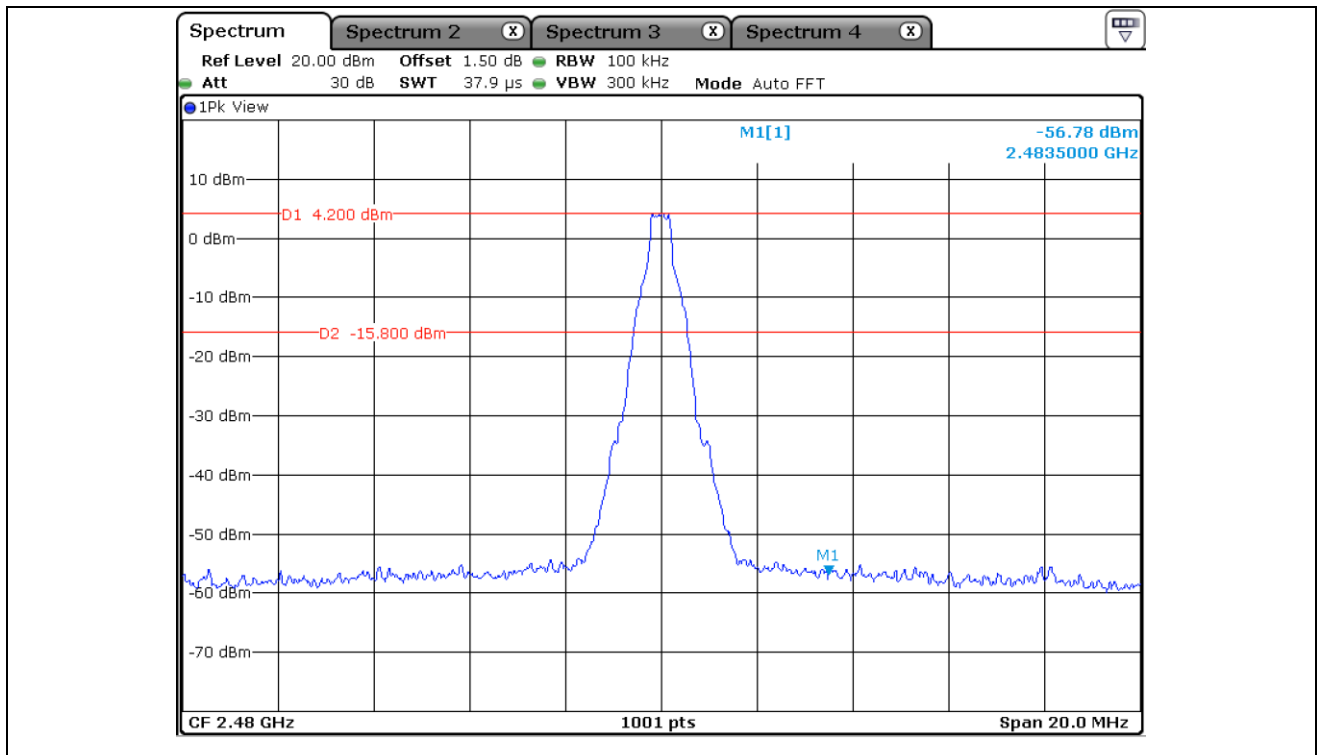


This Report is not correlated with the authentication of KOLAS

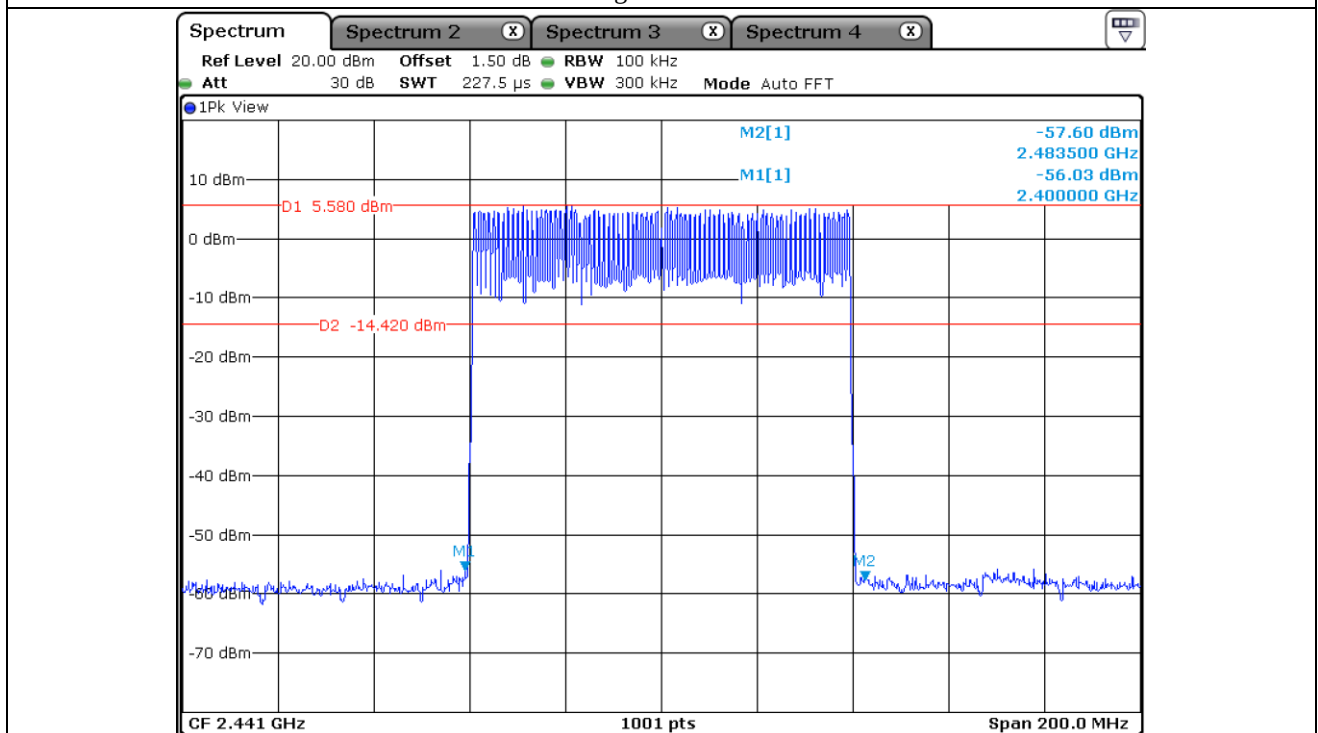
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High Channel



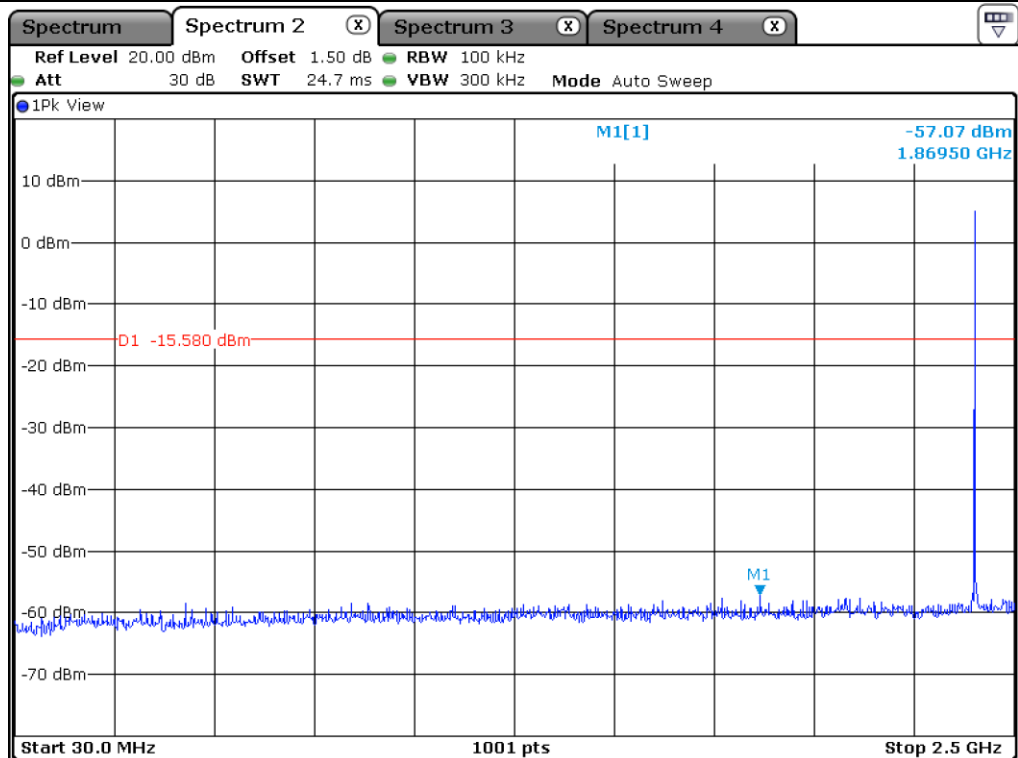
Hopping Mode

This Report is not correlated with the authentication of KOLAS

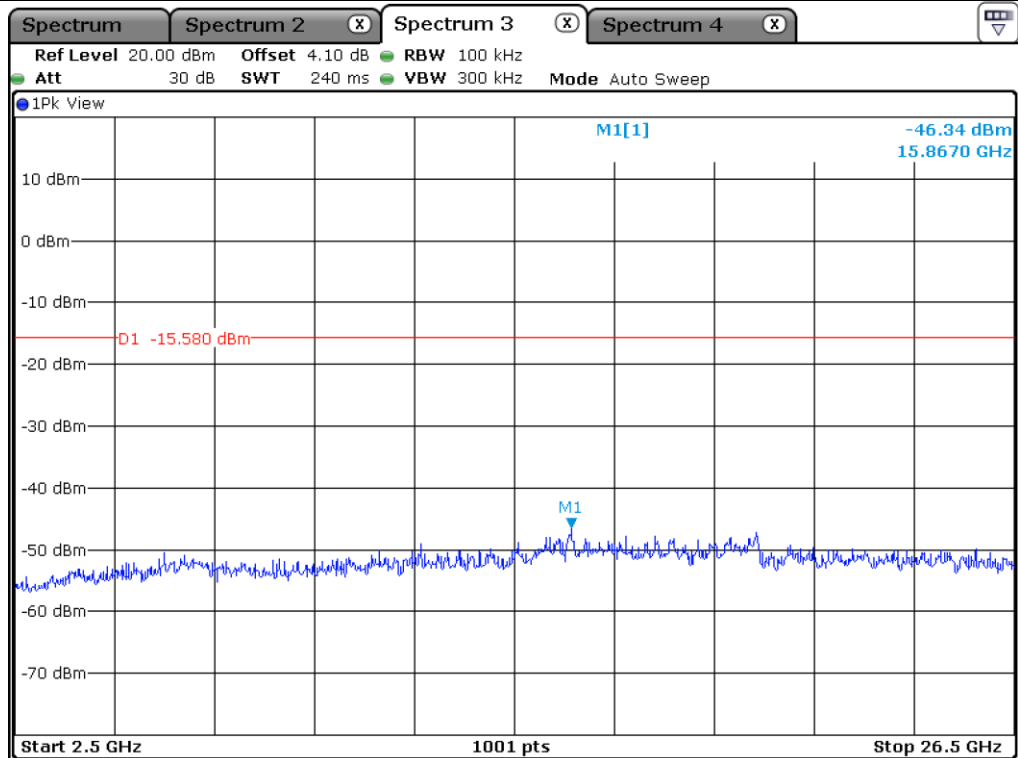
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Low Channel



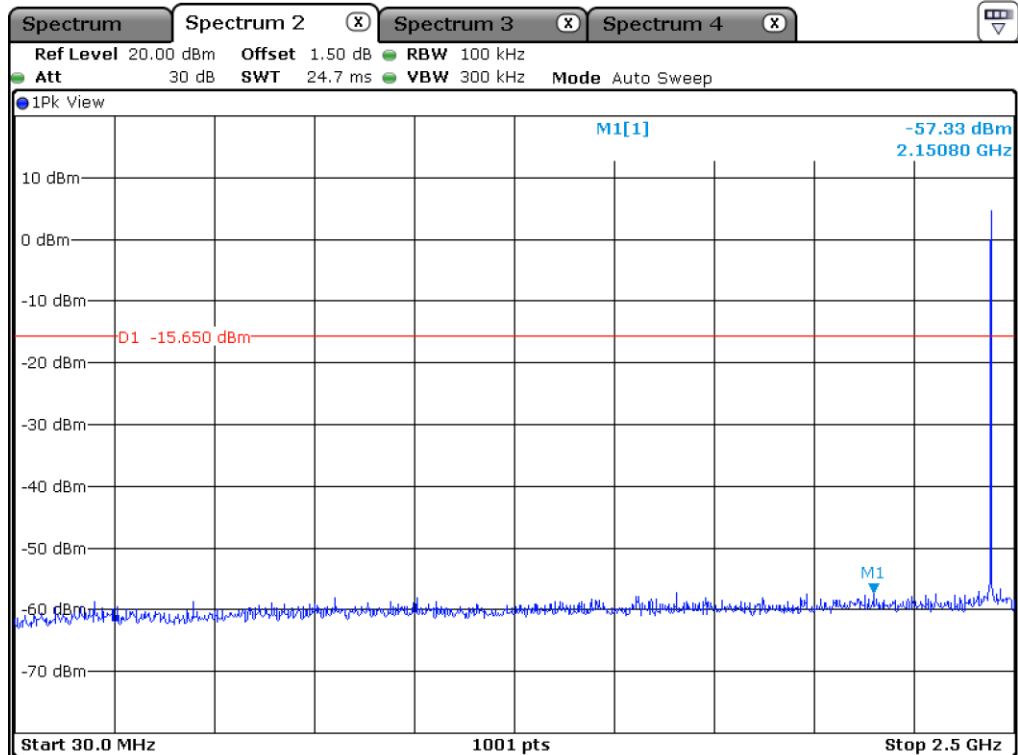
Low Channel

This Report is not correlated with the authentication of KOLAS

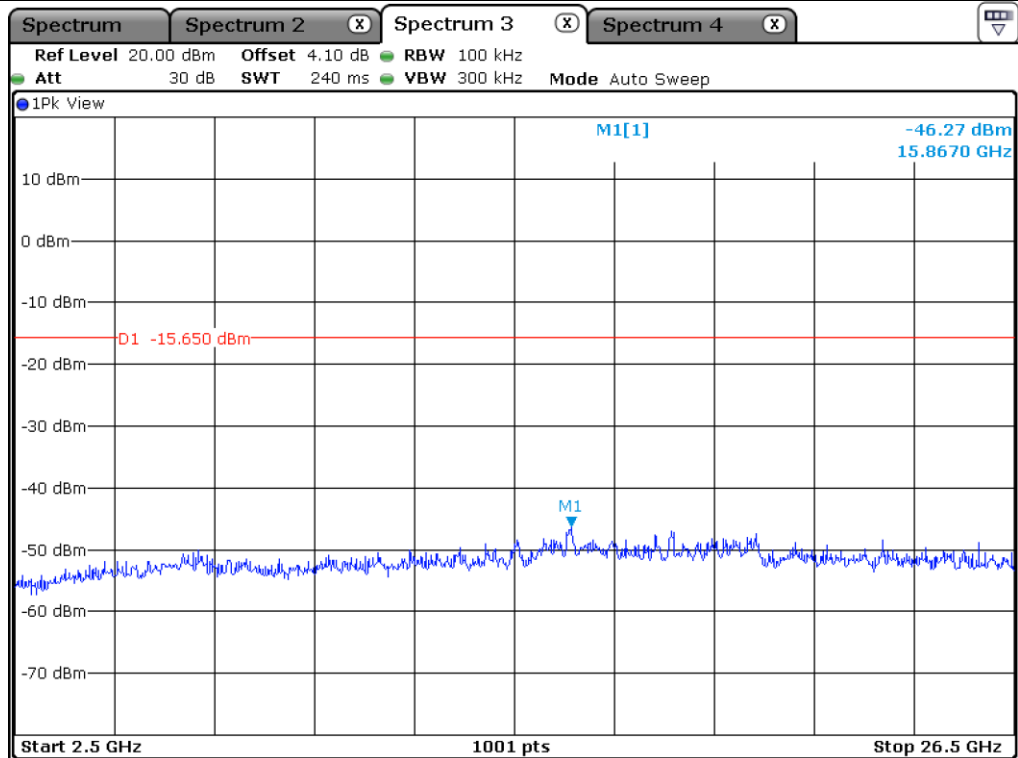
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Middle Channel



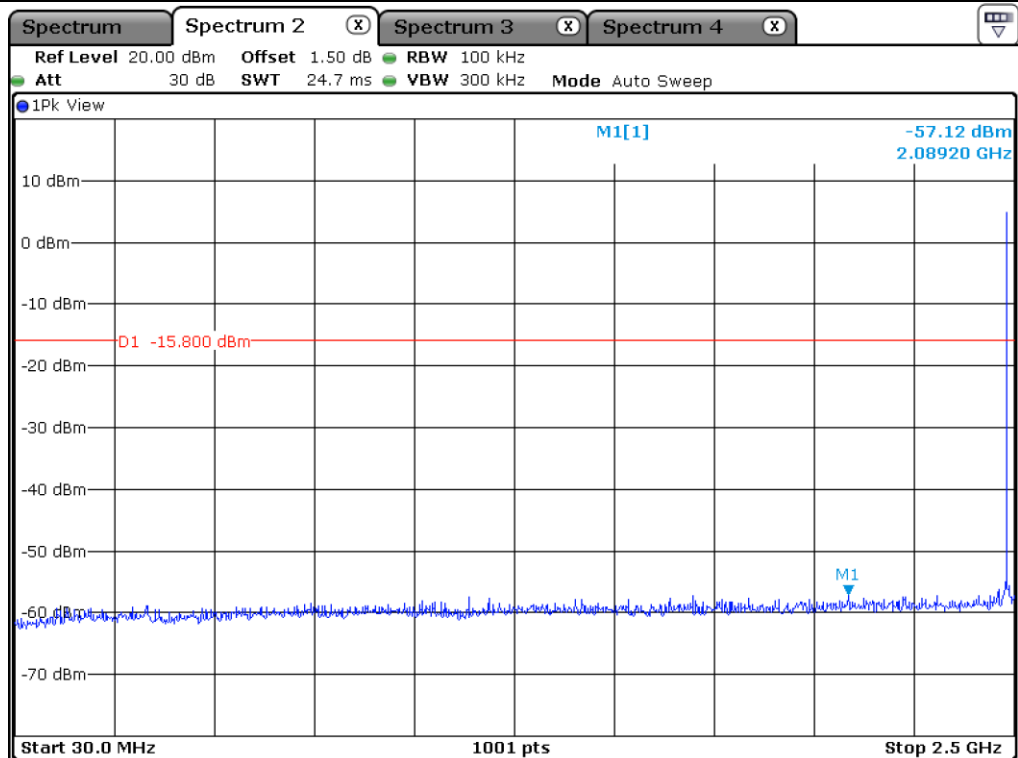
Middle Channel

This Report is not correlated with the authentication of KOLAS

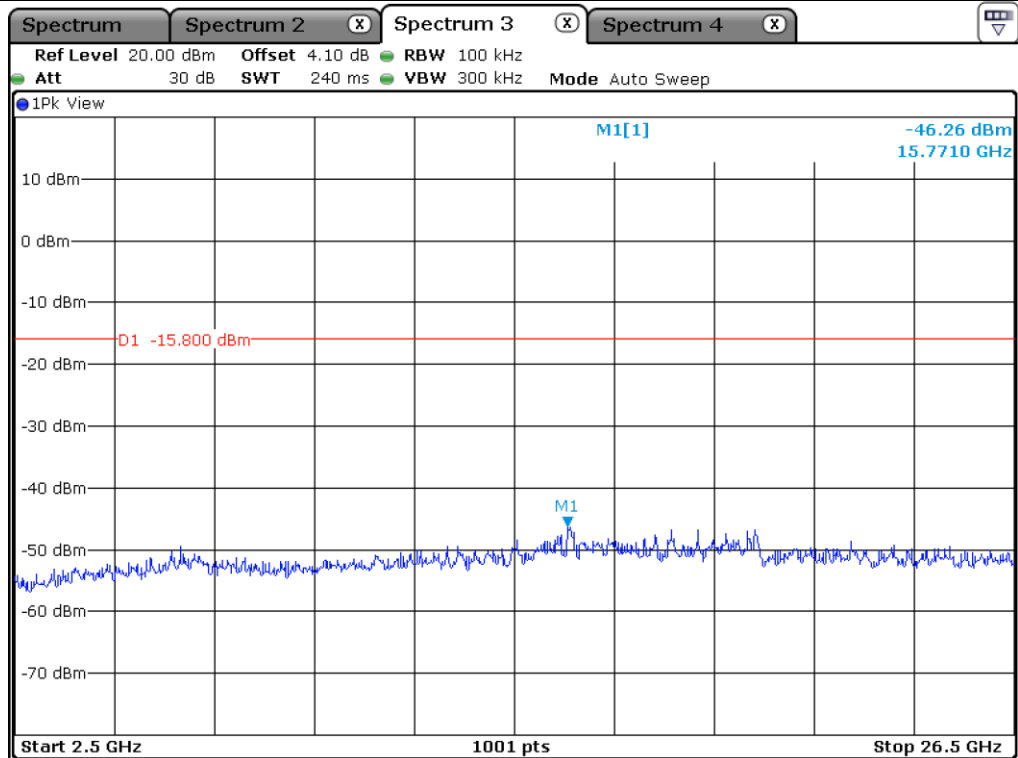
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High Channel



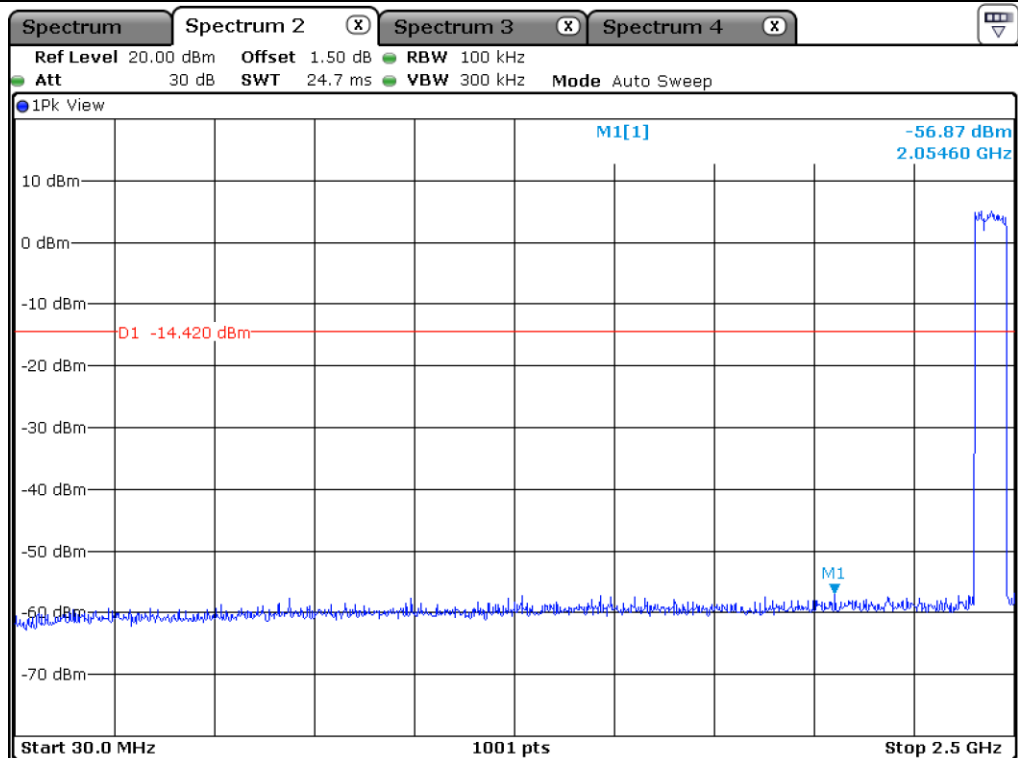
High Channel

This Report is not correlated with the authentication of KOLAS

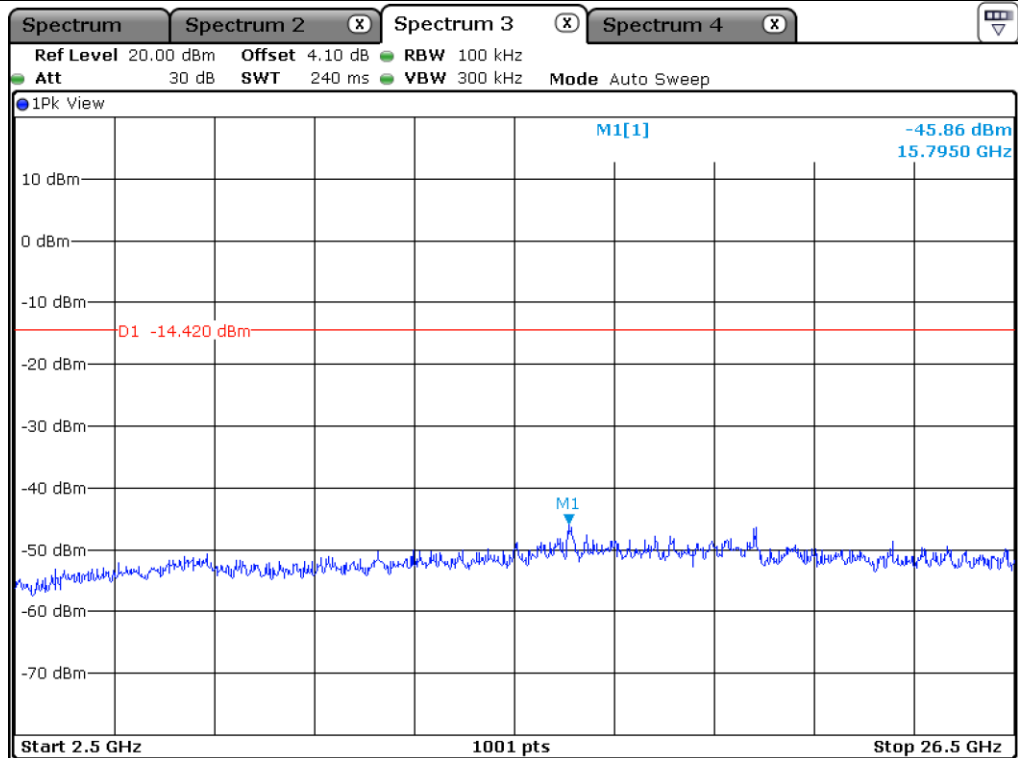
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Hopping Mode



Hopping Mode

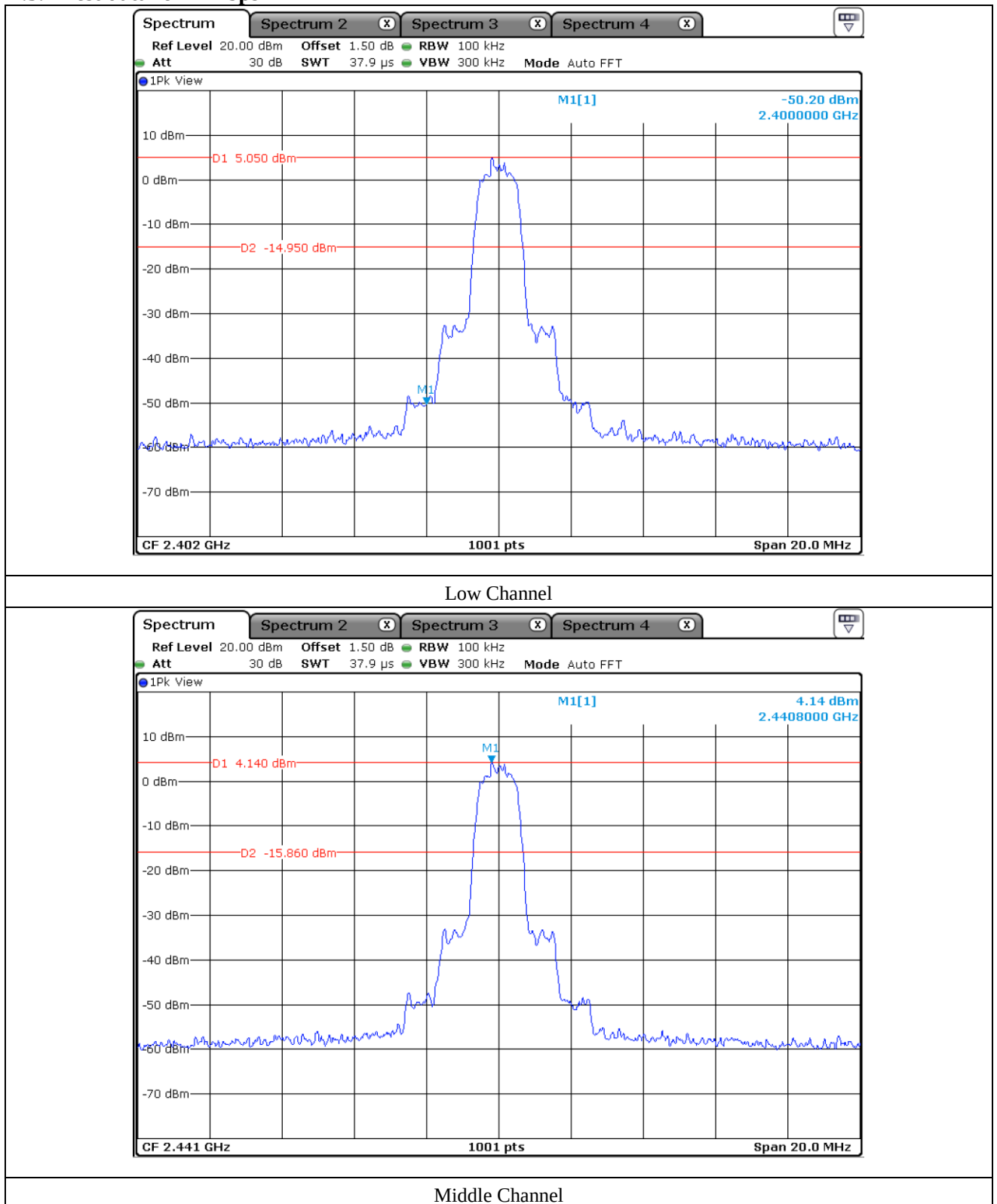
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12.5.2 Test data for 2 Mbps

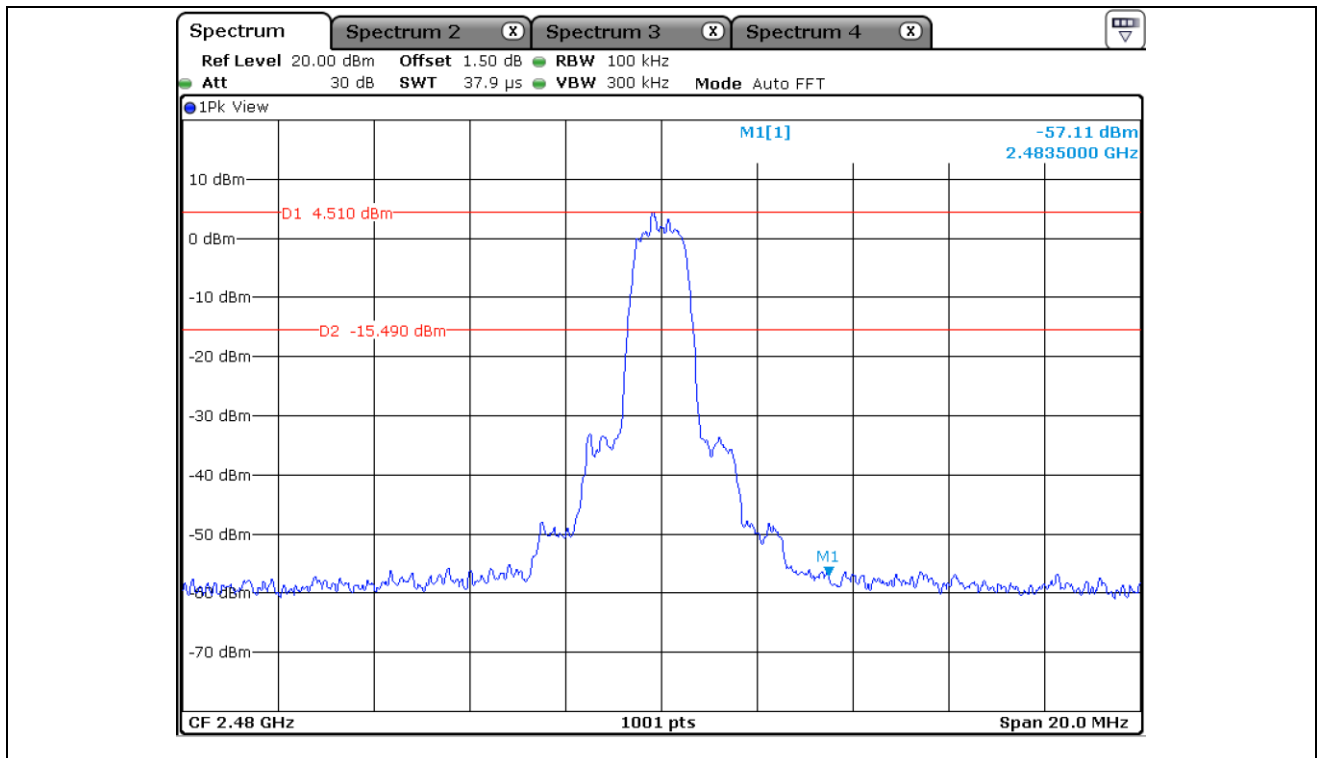


This Report is not correlated with the authentication of KOLAS

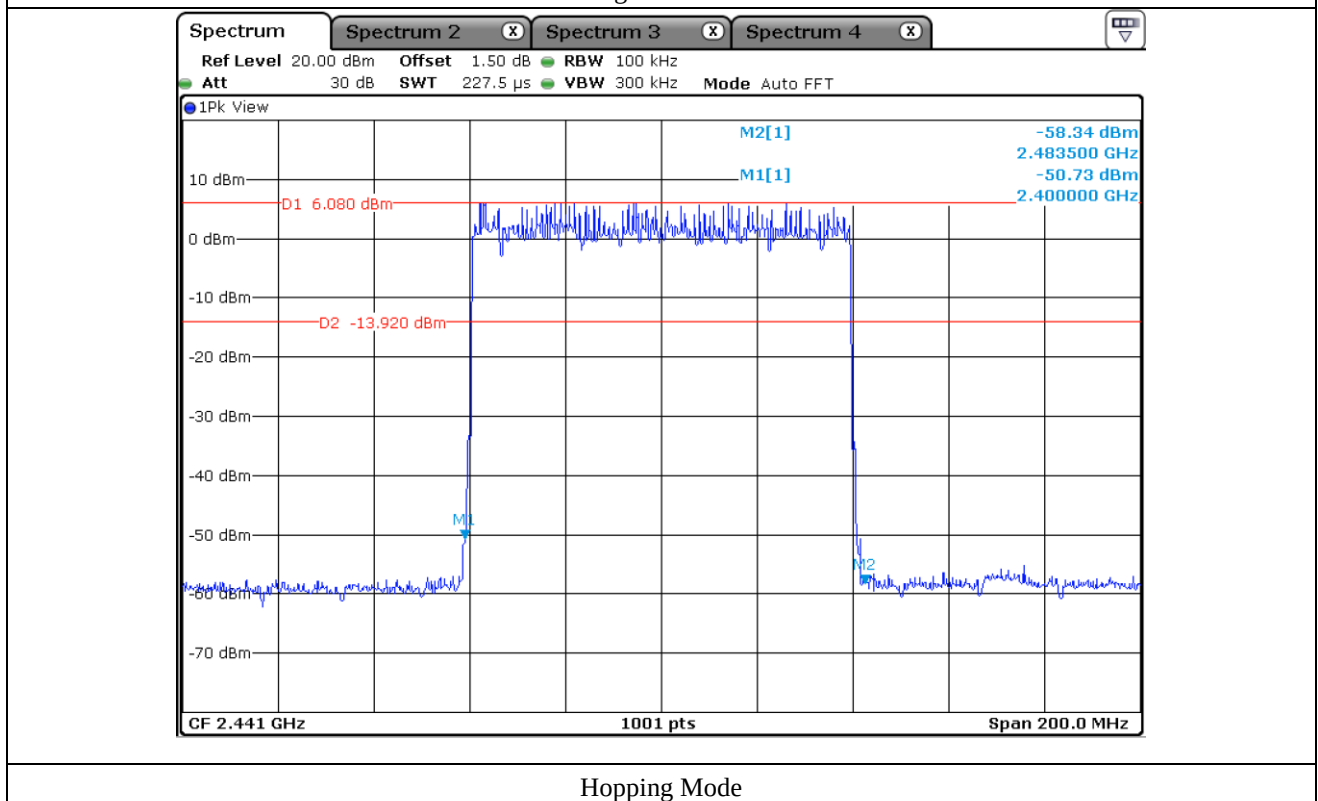
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OTC-TRF-RF-001(0)

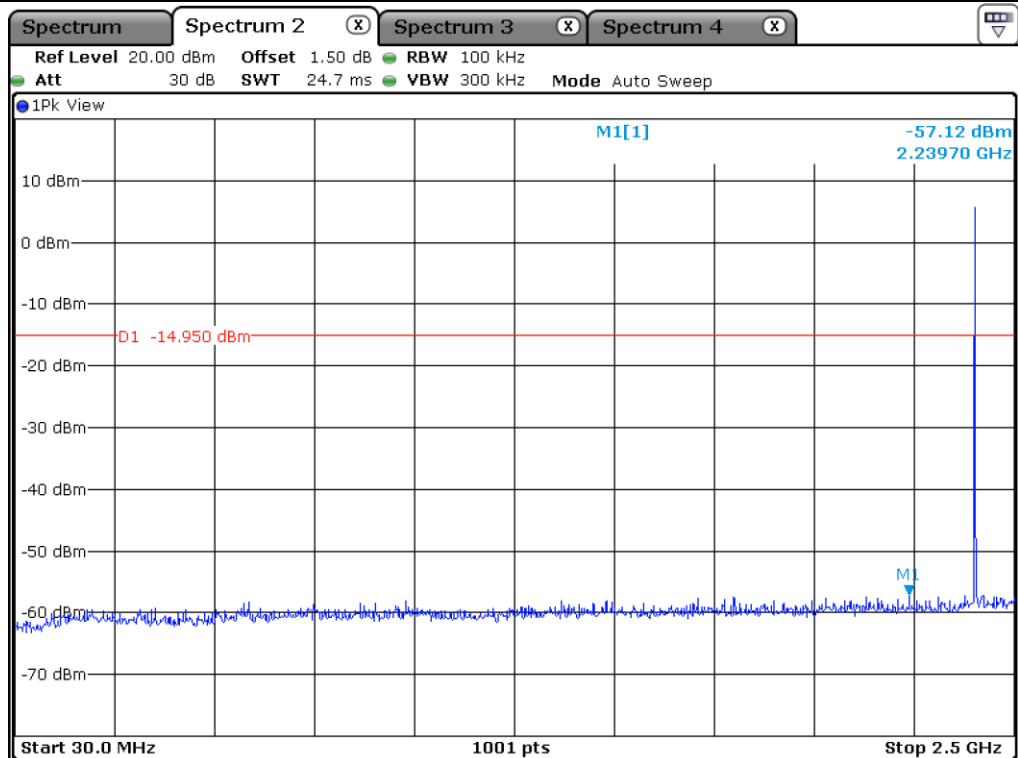
ONETECH Corp.: 43-14, Jinsaegol-gil, Chowol-eup, Gwangju-si, Gyeonggi-do, 12735, Korea (TEL: 82-31-799-9500, FAX: 82-31-799-9599)



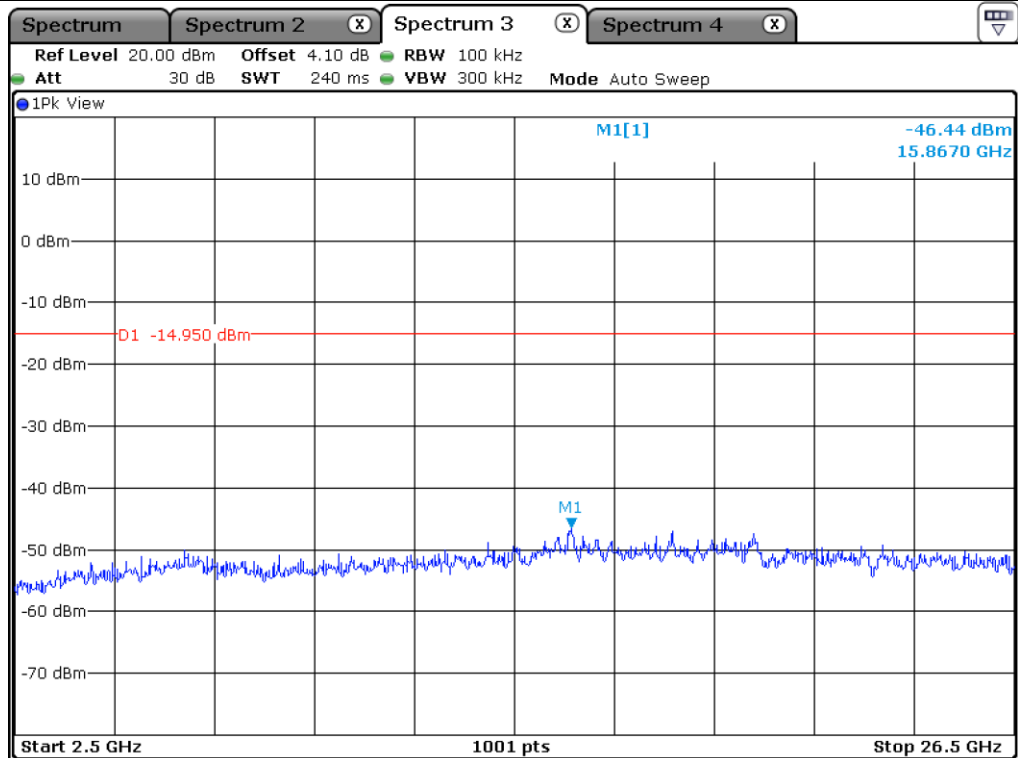
High Channel



Hopping Mode



Low Channel



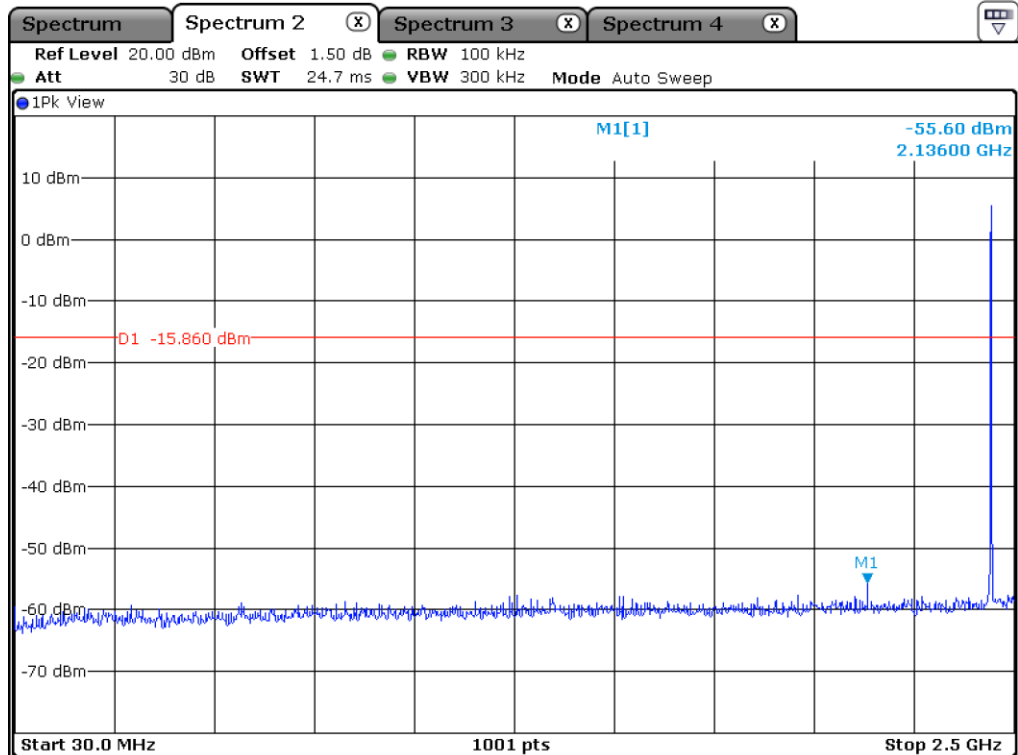
Low Channel

This Report is not correlated with the authentication of KOLAS

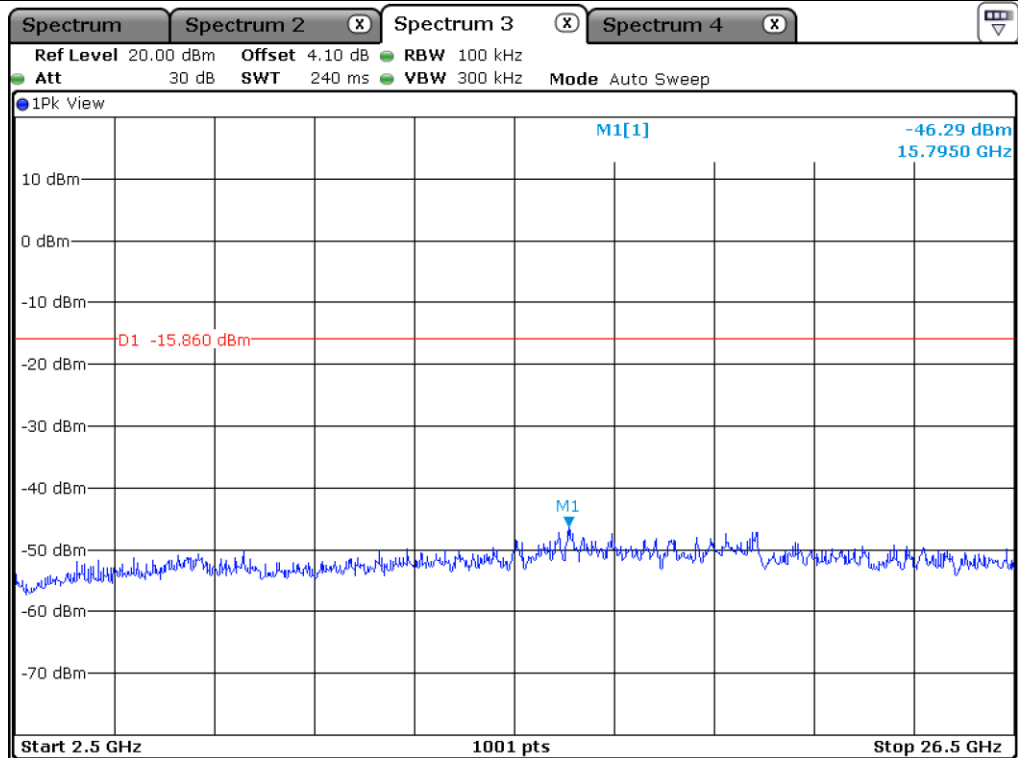
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Middle Channel



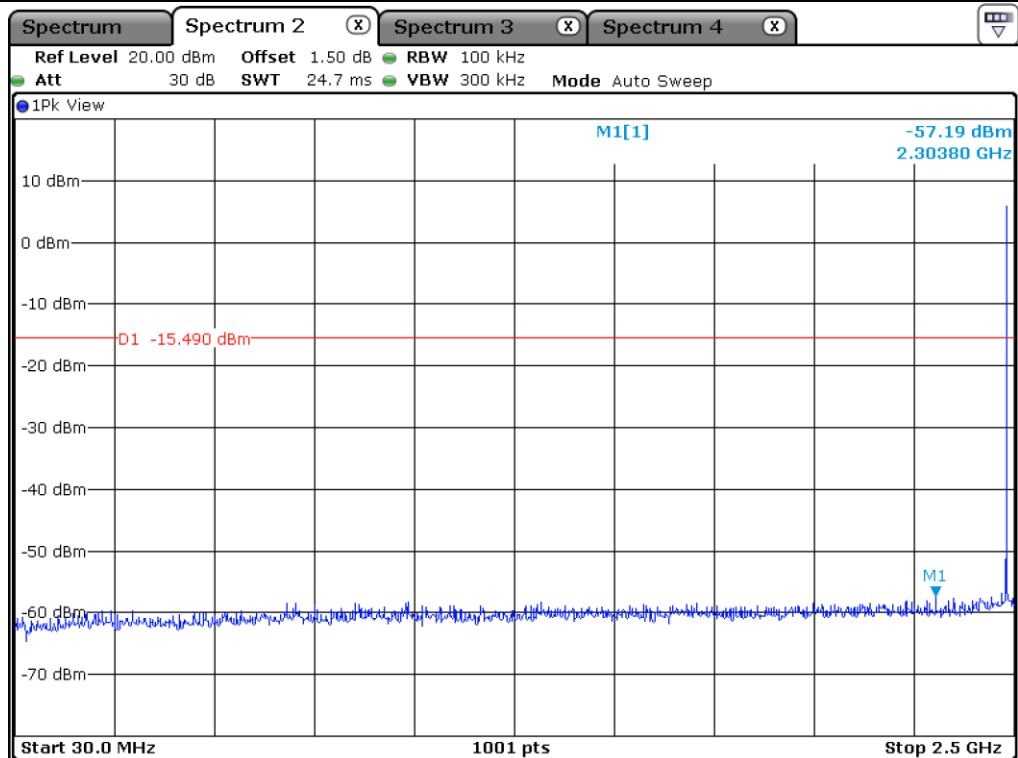
Middle Channel

This Report is not correlated with the authentication of KOLAS

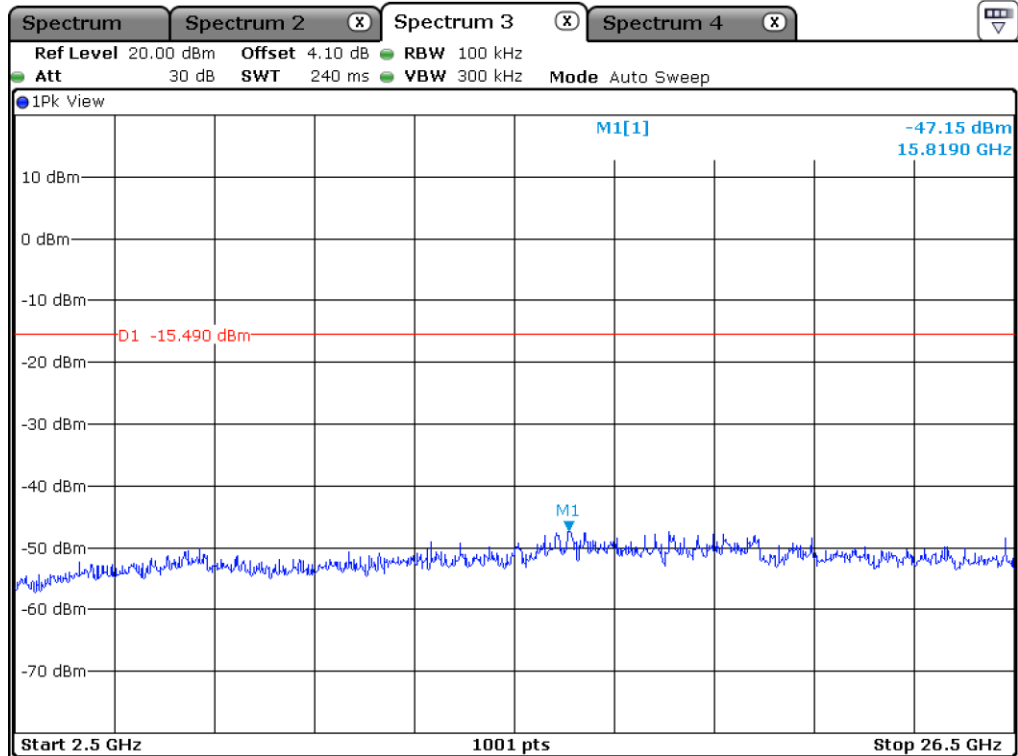
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High Channel



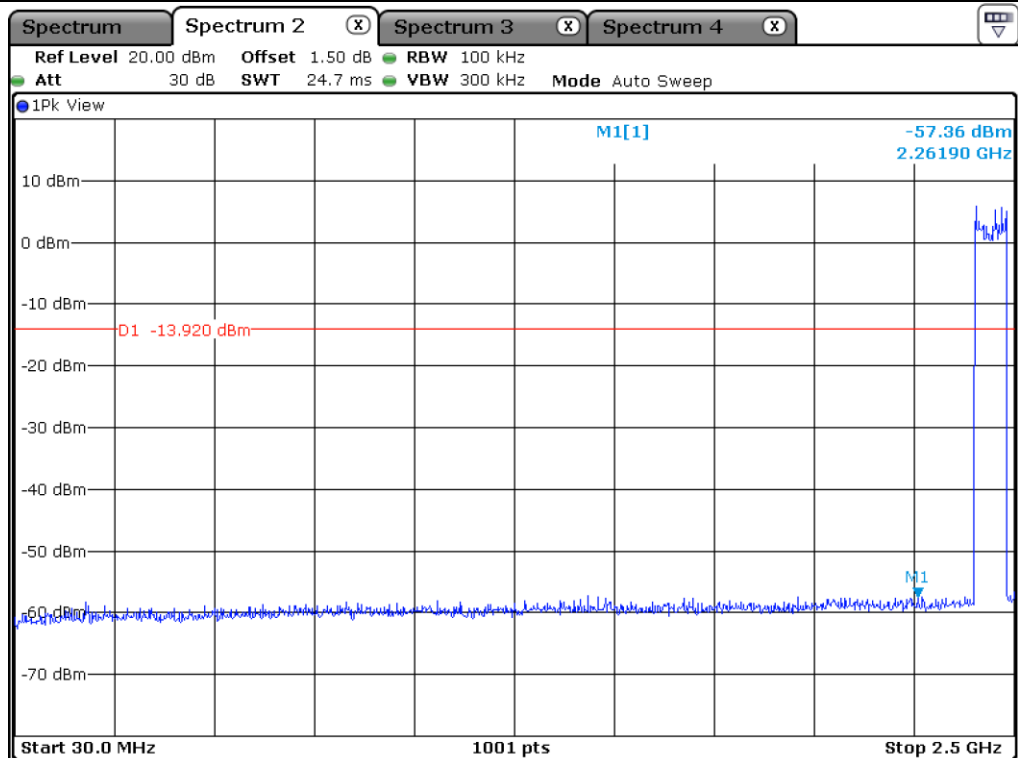
High Channel

This Report is not correlated with the authentication of KOLAS

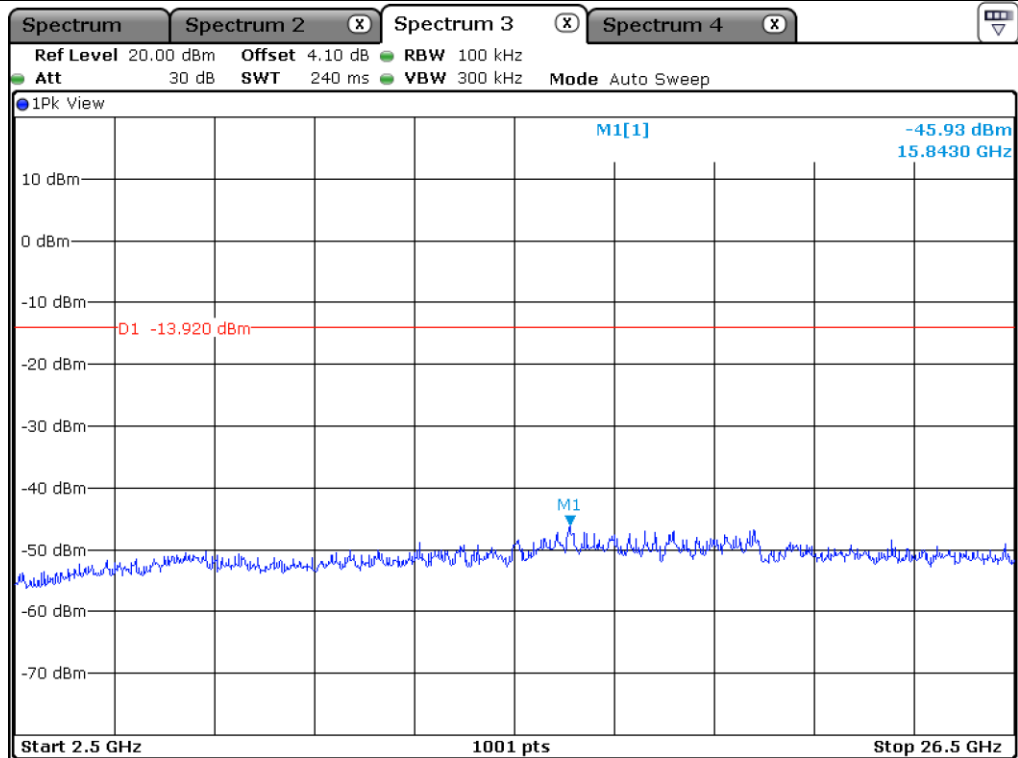
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Hopping Mode



Hopping Mode

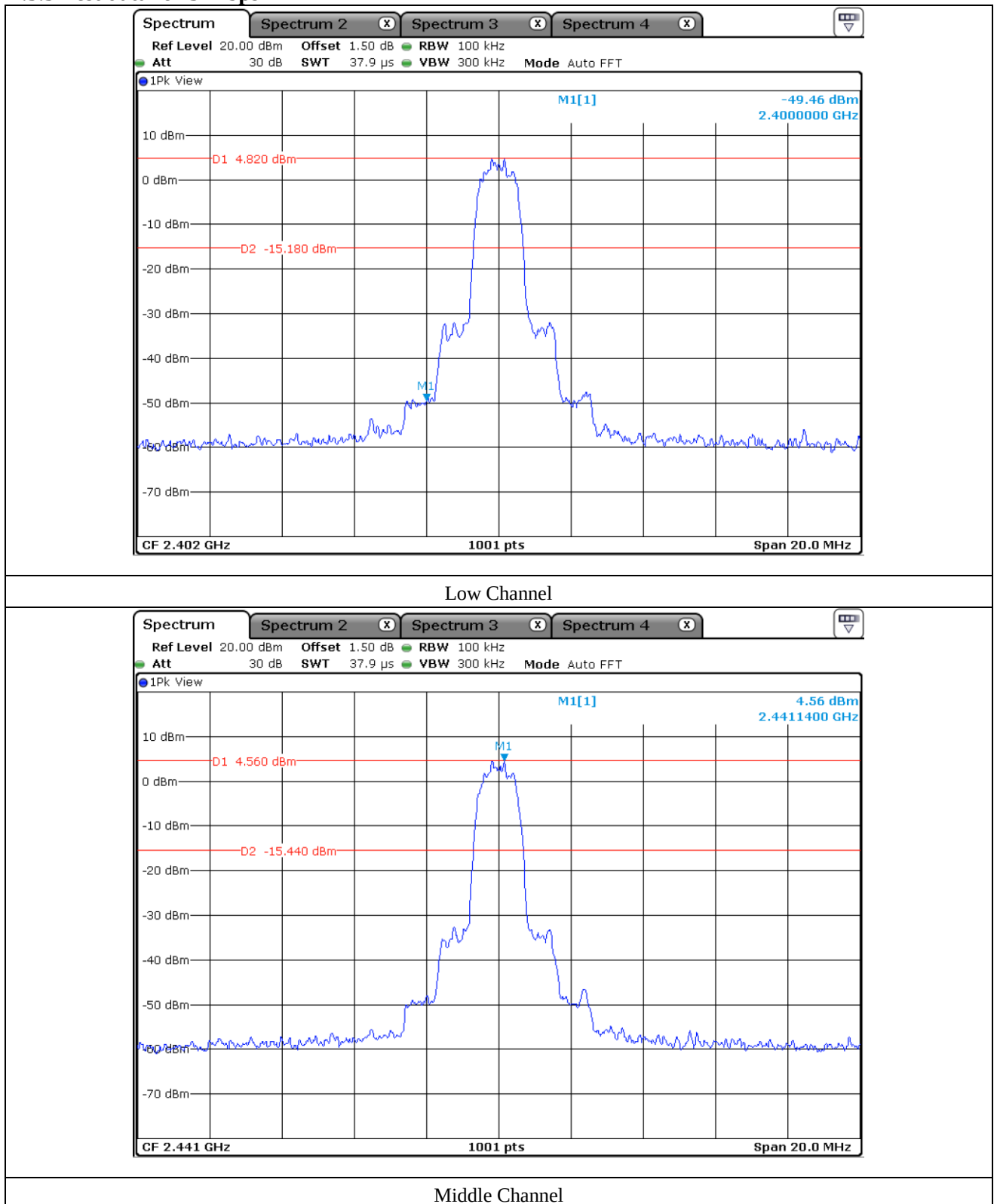
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12.5.3 Test data for 3 Mbps

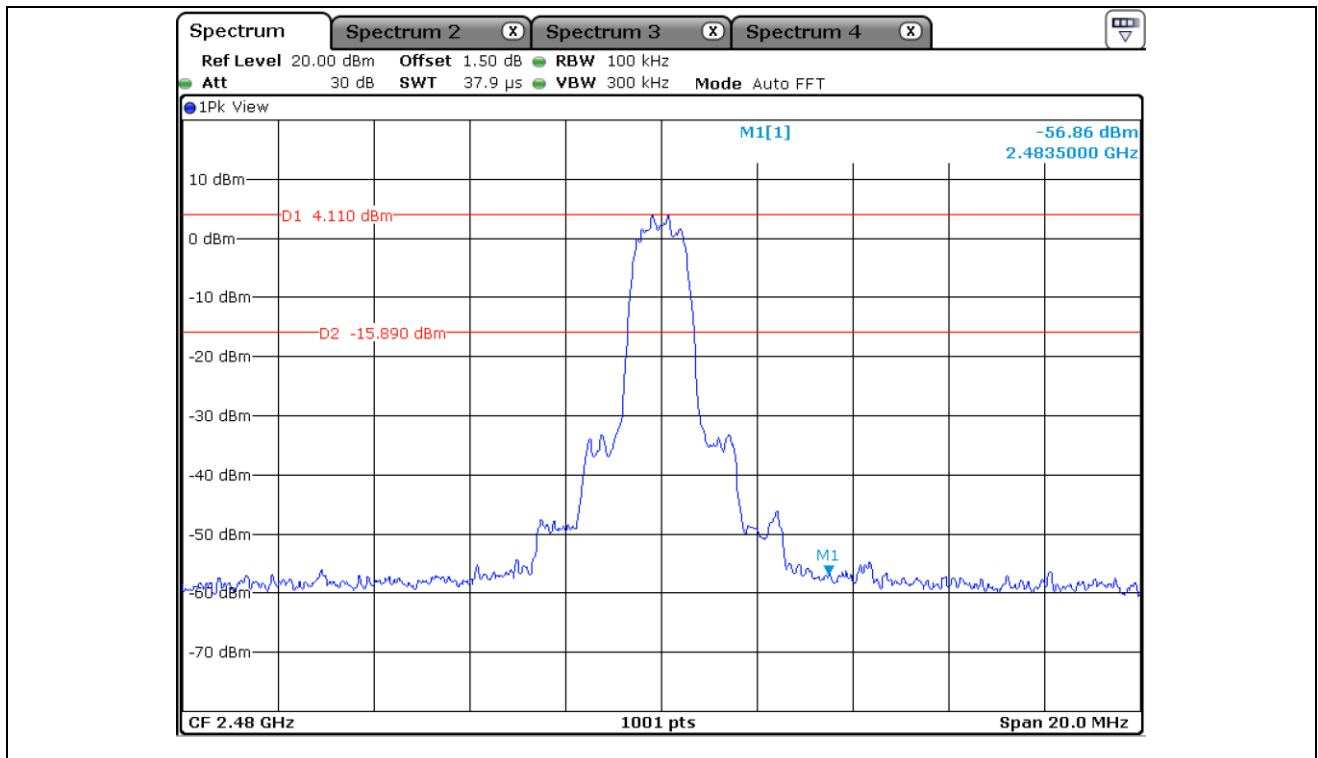


This Report is not correlated with the authentication of KOLAS

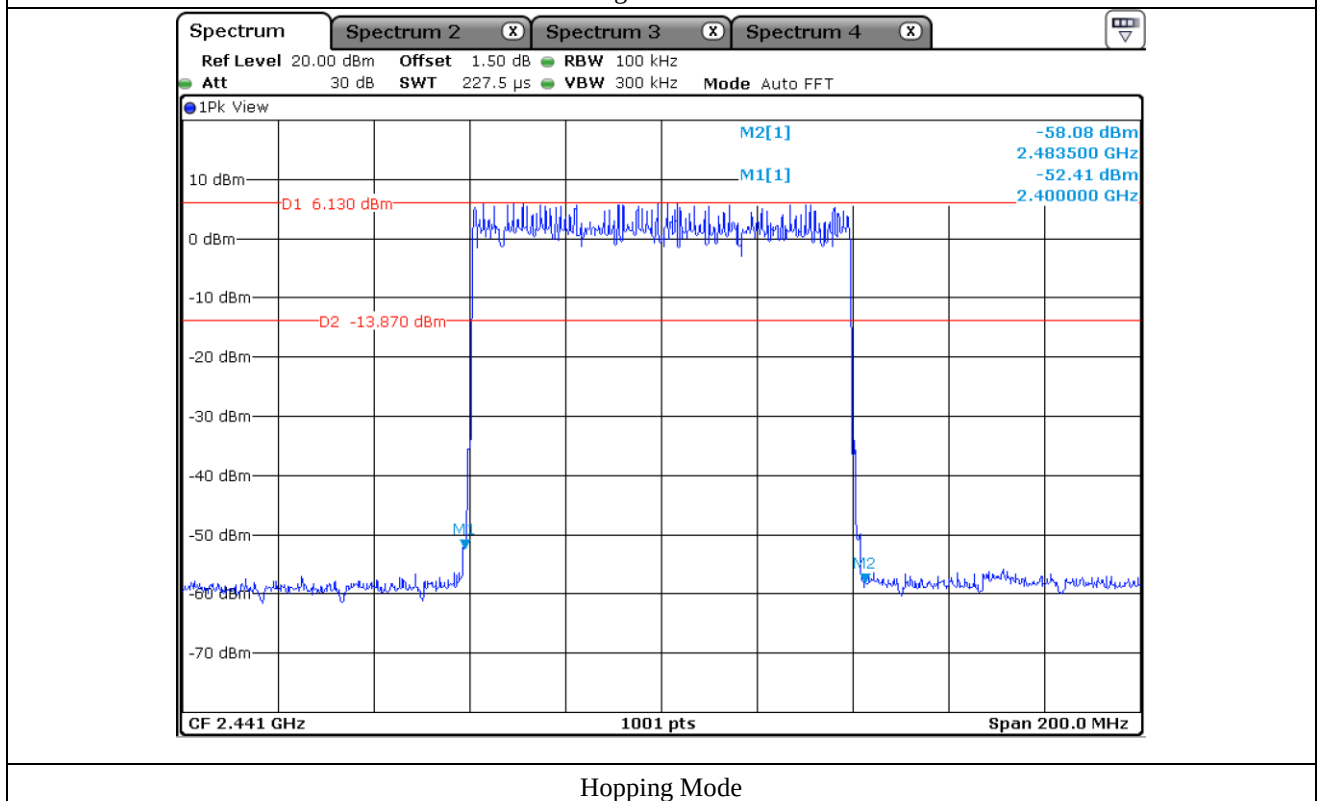
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OTC-TRF-RF-001(0)

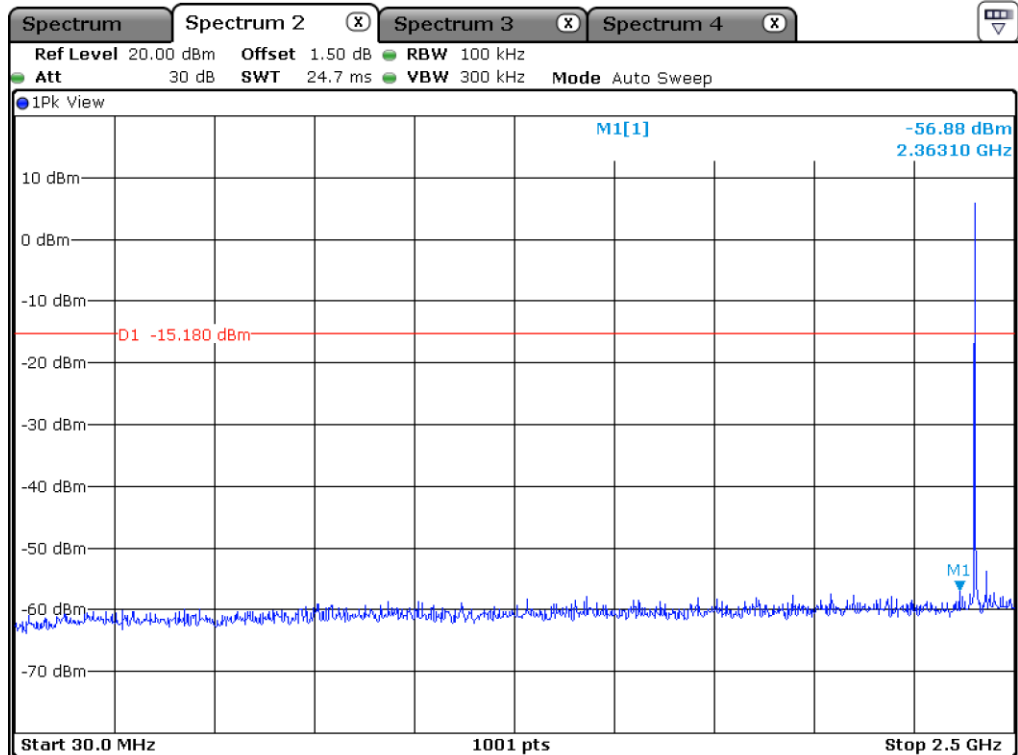
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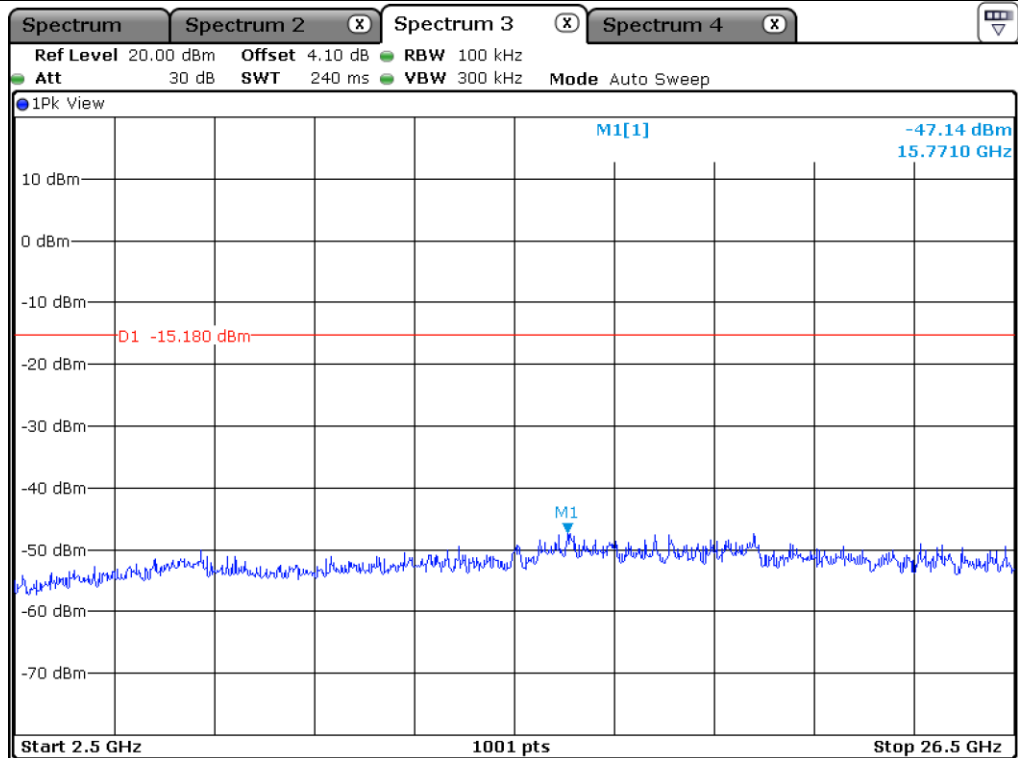
High Channel



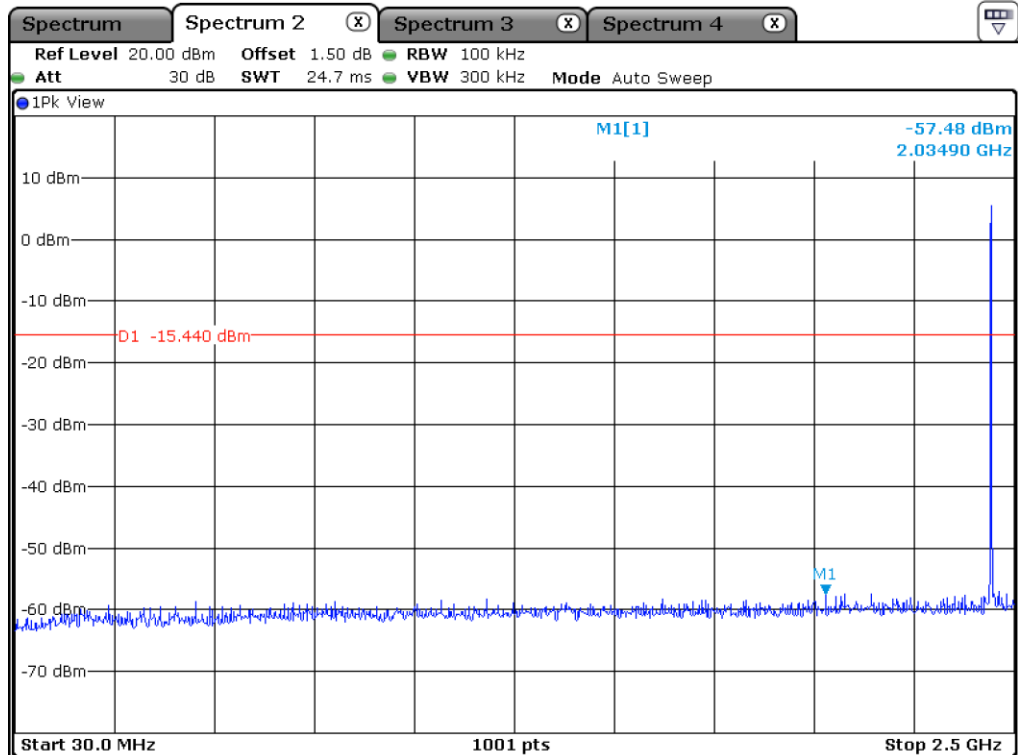
Hopping Mode



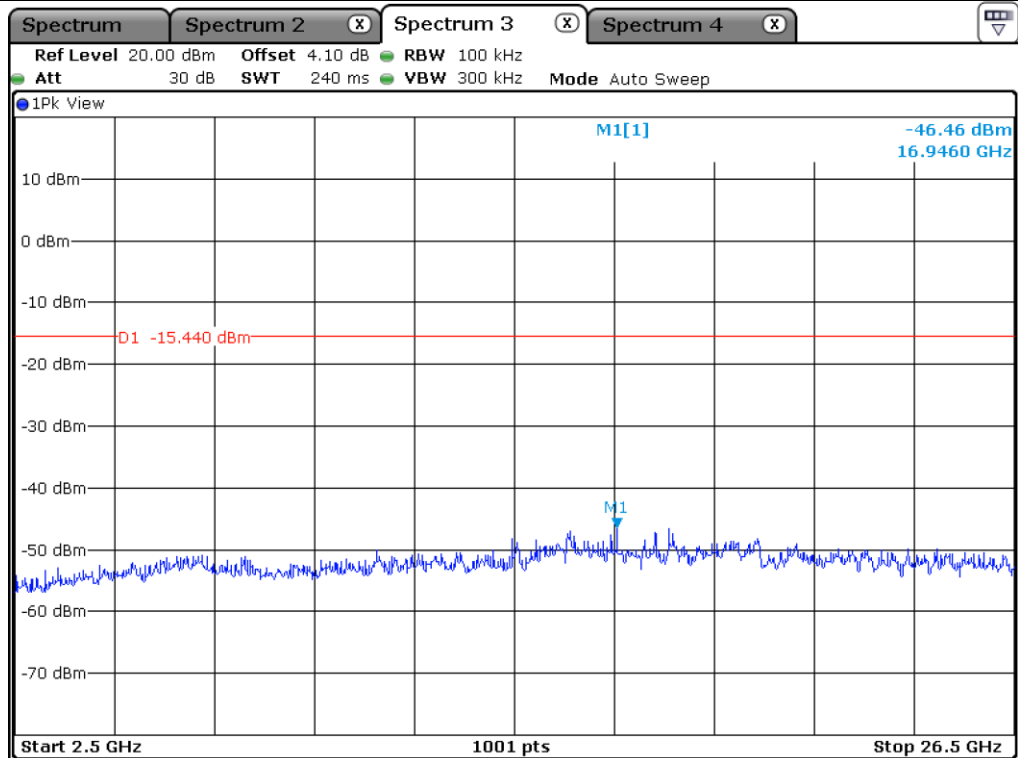
Low Channel



Low Channel



Middle Channel



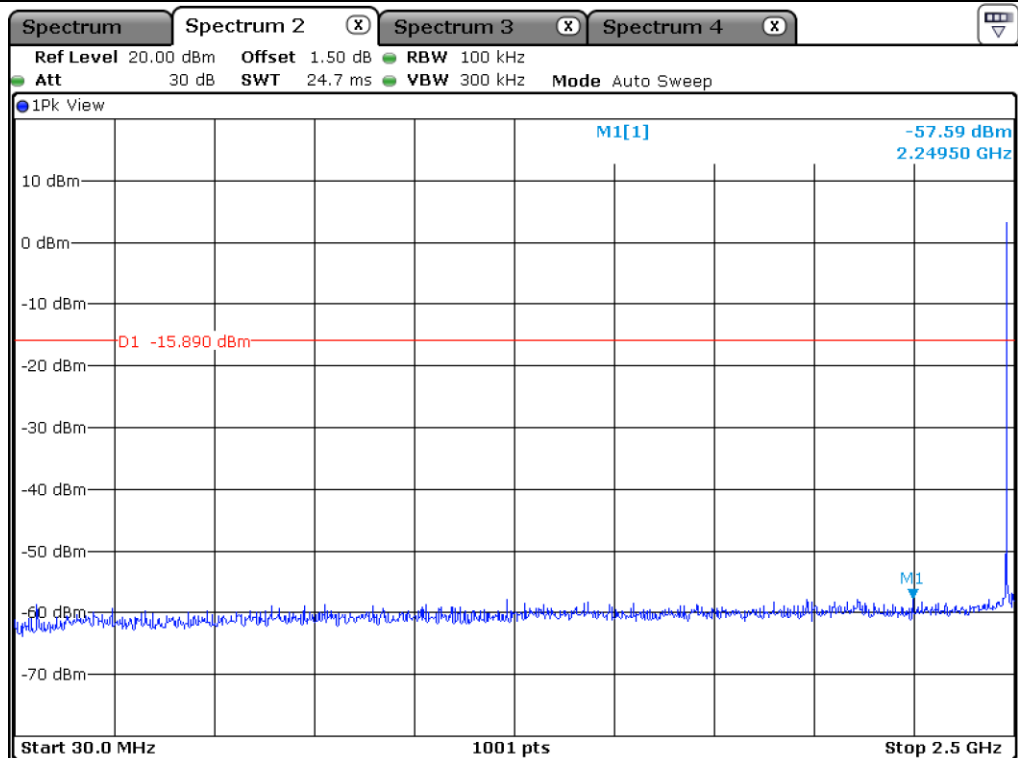
Middle Channel

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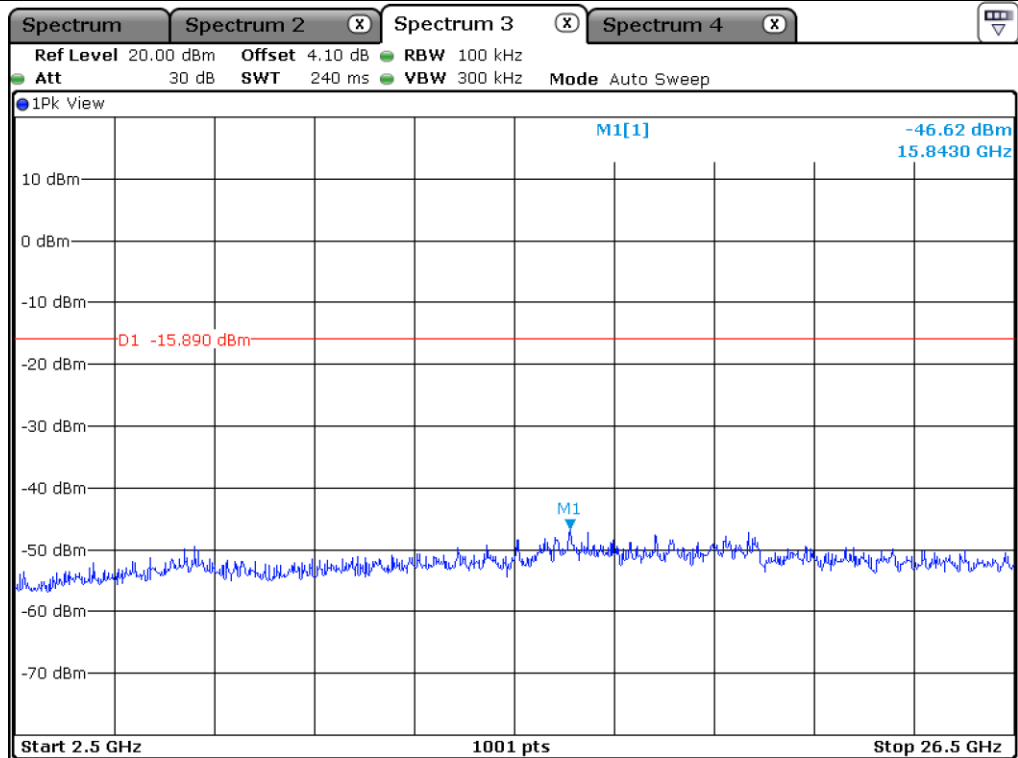
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High Channel



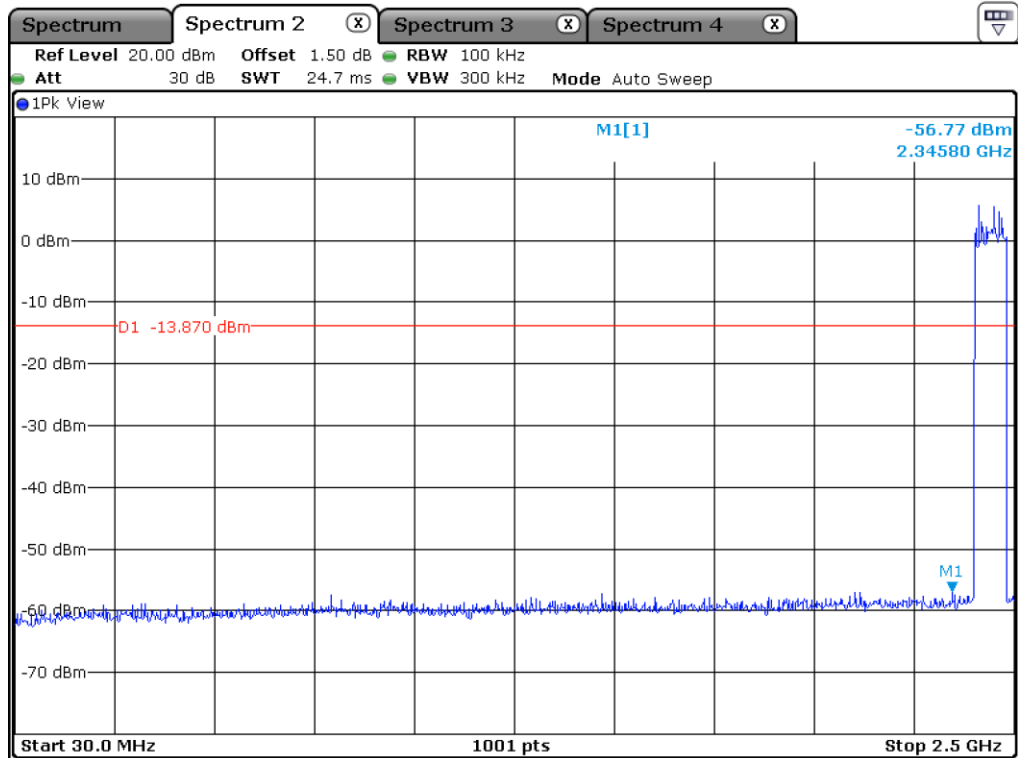
High Channel

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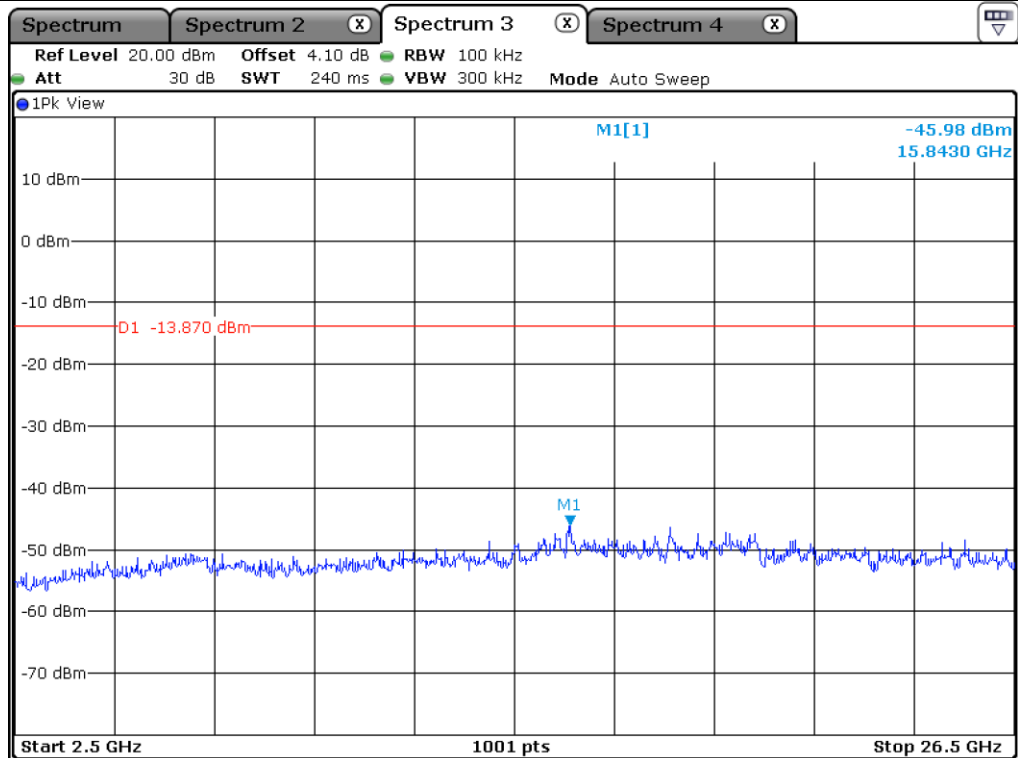
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Hopping Mode



Hopping Mode

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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 : 77.00 %
- . Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	AMP Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
2 378 017	51.16	Peak	H	28.30	6.71	45.14	-	41.03	74.00	32.97
2 382 243	41.72	Average	H	28.30	6.71	45.14	1.13	32.72	54.00	21.28
2 381 523	53.69	Peak	V	28.30	6.71	45.14	-	43.56	74.00	30.44
2 378 017	44.94	Average	V	28.30	6.71	45.14	1.13	35.94	54.00	18.06
Test Data for High Channel										
2 493 317	58.80	Peak	H	27.70	6.87	45.14	-	48.23	74.00	25.77
2 487 782	48.80	Average	H	27.70	6.87	45.14	1.13	39.36	54.00	14.64
2 488 721	58.92	Peak	V	27.70	6.87	45.14	-	48.35	74.00	25.65
2 490 140	48.56	Average	V	27.70	6.87	45.14	1.13	39.12	54.00	14.88

Tabulated test data for Restricted Band

Remark: “H”: Horizontal, “V”: Vertical

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

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

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 : 77.00 %
- . Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	AMP Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
2 379 114	51.44	Peak	H	28.30	6.71	45.14	-	41.31	74.00	32.69
2 380 015	41.30	Average	H	28.30	6.71	45.14	1.13	32.30	54.00	21.70
2 381 101	52.17	Peak	V	28.30	6.71	45.14	-	42.04	74.00	31.96
2 383 453	42.18	Average	V	28.30	6.71	45.14	1.13	33.18	54.00	20.82
Test Data for High Channel										
2 488 503	58.13	Peak	H	27.70	6.87	45.14	-	47.56	74.00	26.44
2 487 633	48.44	Average	H	27.70	6.87	45.14	1.13	39.00	54.00	15.00
2 490 330	58.97	Peak	V	27.70	6.87	45.14	-	48.40	74.00	25.60
2 488 170	47.53	Average	V	27.70	6.87	45.14	1.13	38.09	54.00	15.91

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 – AMP Gain + Duty 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 : 77.00 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	AMP Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
2 382 233	51.86	Peak	H	28.30	6.71	45.14	-	41.73	74.00	32.27
2 377 837	41.81	Average	H	28.30	6.71	45.14	1.13	32.81	54.00	21.19
2 378 197	51.80	Peak	V	28.30	6.71	45.14	-	41.67	74.00	32.33
2 378 017	42.08	Average	V	28.30	6.71	45.14	1.13	33.08	54.00	20.92
Test Data for High Channel										
2 490 440	58.25	Peak	H	27.70	6.87	45.14	-	47.68	74.00	26.32
2 489 081	48.80	Average	H	27.70	6.87	45.14	1.13	39.36	54.00	14.64
2 488 302	60.10	Peak	V	27.70	6.87	45.14	-	49.53	74.00	24.47
2 491 139	49.19	Average	V	27.70	6.87	45.14	1.13	39.75	54.00	14.25

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 – AMP Gain + Duty Factor

12.6.3 Spurious & Harmonic Radiated Emission above 1 GHz

12.6.3.1 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 : 77.00 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	AMP Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
4 804.00	49.51	Peak	H	31.30	9.39	45.10	-	45.10	74.00	28.90
4 804.00	39.39	Average	H	31.30	9.39	45.10	1.13	36.11	54.00	17.89
4 804.00	49.78	Peak	V	31.30	9.39	45.10	-	45.37	74.00	28.63
4 804.00	39.11	Average	V	31.30	9.39	45.10	1.13	35.83	54.00	18.17
Test Data for Middle Channel										
4 882.00	49.55	Peak	H	31.20	9.39	45.10	-	45.04	74.00	28.96
4 882.00	39.31	Average	H	31.20	9.39	45.10	1.13	35.93	54.00	18.07
4 882.00	49.41	Peak	V	31.20	9.39	45.10	-	44.90	74.00	29.10
4 882.00	39.21	Average	V	31.20	9.39	45.10	1.13	35.83	54.00	18.17
Test Data for High Channel										
4 960.00	49.57	Peak	H	31.20	9.39	45.10	-	45.06	74.00	28.94
4 960.00	39.23	Average	H	31.20	9.39	45.10	1.13	35.85	54.00	18.15
4 960.00	49.31	Peak	V	31.20	9.39	45.10	-	44.80	74.00	29.20
4 960.00	39.30	Average	V	31.20	9.39	45.10	1.13	35.92	54.00	18.08

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

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

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

12.6.3.2 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 : 77.00 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	AMP Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
4 804.00	49.33	Peak	H	31.30	9.39	45.10	-	44.92	74.00	29.08
4 804.00	39.35	Average	H	31.30	9.39	45.10	1.13	36.07	54.00	17.93
4 804.00	50.01	Peak	V	31.30	9.39	45.10	-	45.60	74.00	28.40
4 804.00	39.87	Average	V	31.30	9.39	45.10	1.13	36.59	54.00	17.41
Test Data for Middle Channel										
4 882.00	49.45	Peak	H	31.20	9.39	45.10		44.94	74.00	29.06
4 882.00	39.45	Average	H	31.20	9.39	45.10	1.13	36.07	54.00	17.93
4 882.00	49.32	Peak	V	31.20	9.39	45.10		44.81	74.00	29.19
4 882.00	39.33	Average	V	31.20	9.39	45.10	1.13	35.95	54.00	18.05
Test Data for High Channel										
4 960.00	49.35	Peak	H	31.20	9.39	45.03		44.91	74.00	29.09
4 960.00	39.45	Average	H	31.20	9.39	45.03	1.13	36.14	54.00	17.86
4 960.00	49.63	Peak	V	31.20	9.39	45.03		45.19	74.00	28.81
4 960.00	39.17	Average	V	31.20	9.39	45.03	1.13	35.86	54.00	18.14

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

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

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

12.6.3.3 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 : 77.00 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	AMP Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel										
4 804.00	49.66	Peak	H	31.30	9.39	45.10	-	45.25	74.00	28.75
4 804.00	39.43	Average	H	31.30	9.39	45.10	1.13	36.15	54.00	17.85
4 804.00	49.59	Peak	V	31.30	9.39	45.10	-	45.18	74.00	28.82
4 804.00	39.26	Average	V	31.30	9.39	45.10	1.13	35.98	54.00	18.02
Test Data for Middle Channel										
4 882.00	49.40	Peak	H	31.20	9.39	45.10	-	44.89	74.00	29.11
4 882.00	39.45	Average	H	31.20	9.39	45.10	1.13	36.07	54.00	17.93
4 882.00	49.55	Peak	V	31.20	9.39	45.10	-	45.04	74.00	28.96
4 882.00	39.33	Average	V	31.20	9.39	45.10	1.13	35.95	54.00	18.05
Test Data for High Channel										
4 960.00	49.60	Peak	H	31.20	9.39	45.03	-	45.16	74.00	28.84
4 960.00	39.37	Average	H	31.20	9.39	45.03	1.13	36.06	54.00	17.94
4 960.00	49.65	Peak	V	31.20	9.39	45.03	-	45.21	74.00	28.79
4 960.00	39.31	Average	V	31.20	9.39	45.03	1.13	36.00	54.00	18.00

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

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

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

13. RADIATED EMISSION TEST

13.1 Operating environment

Temperature : 22.5 °C
Relative humidity : 53.5 % R.H.

13.2 Test set-up

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

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

13.3 Test Date

November 26, 2021

13.4 Test data for 30 MHz ~ 1 000 MHz

Humidity Level : 53.5 % R.H.

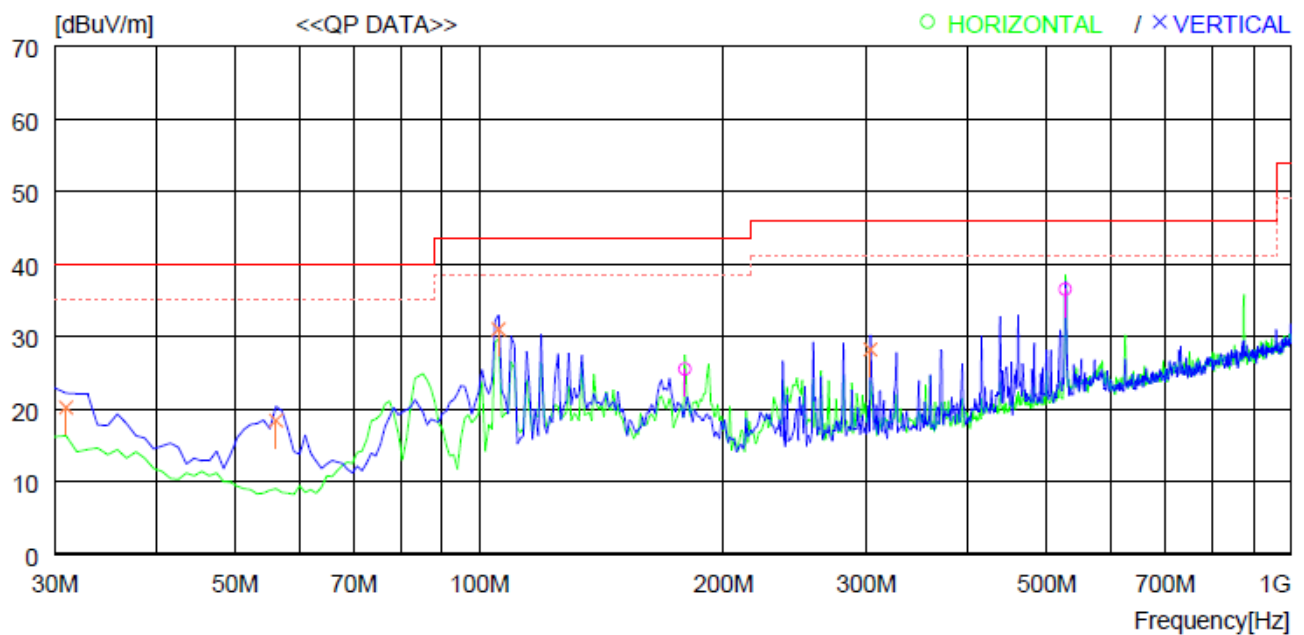
Temperature: 22.5 °C

Limits apply to : FCC CFR 47, PART 15, SUBPART C, SECTION 15.247

Result : PASSED

EUT : Thermal Sensing Terminal

Detector : CISPR Quasi-Peak (6 dB Bandwidth: 120 kHz)



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	179.380	38.7	16.6	3.2	33.0	25.5	43.5	18.0	100	347
2	527.610	40.7	23.5	5.5	33.2	36.5	46.0	9.5	200	359
----- Vertical -----										
3	30.970	31.4	20.6	1.3	33.1	20.2	40.0	19.8	100	64
4	56.190	37.6	12.1	1.8	33.1	18.4	40.0	21.6	100	197
5	105.660	45.4	16.3	2.4	33.1	31.0	43.5	12.5	100	96
6	303.540	37.7	19.3	4.2	33.0	28.2	46.0	17.8	200	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. CONDUCTED EMISSION TEST

14.1 Operating environment

Temperature : 22.5 °C
Relative humidity : 53.5 % R.H.

14.2 Test set-up

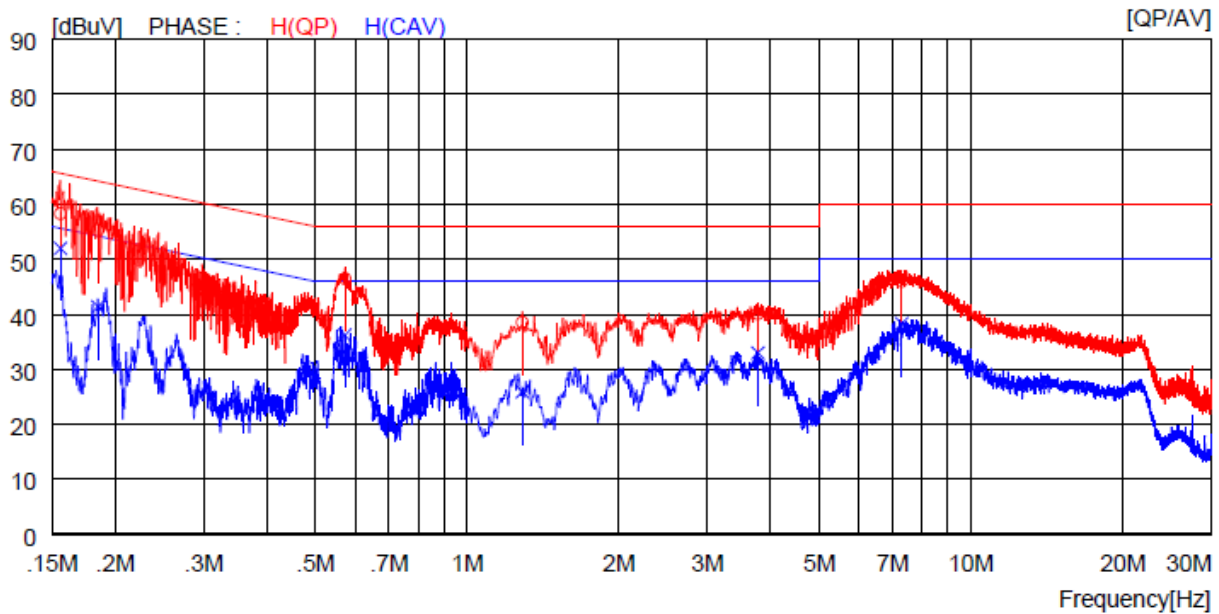
The EUT was placed on a wooden table, 0.8 m height above the floor. Power was fed to the EUT through a 50 Ω / 50 μ H + 5 Ω Artificial Mains Network (AMN). The ground plane was electrically bonded to the reference ground system and all power lines were filtered from ambient.

14.3 Test Date

November 26, 2021

14.4 Test data for Bluetooth

- Resolution bandwidth : 9 kHz
- Frequency range : 0.15 MHz ~ 30 MHz
- Tested Line : LIVE LINE



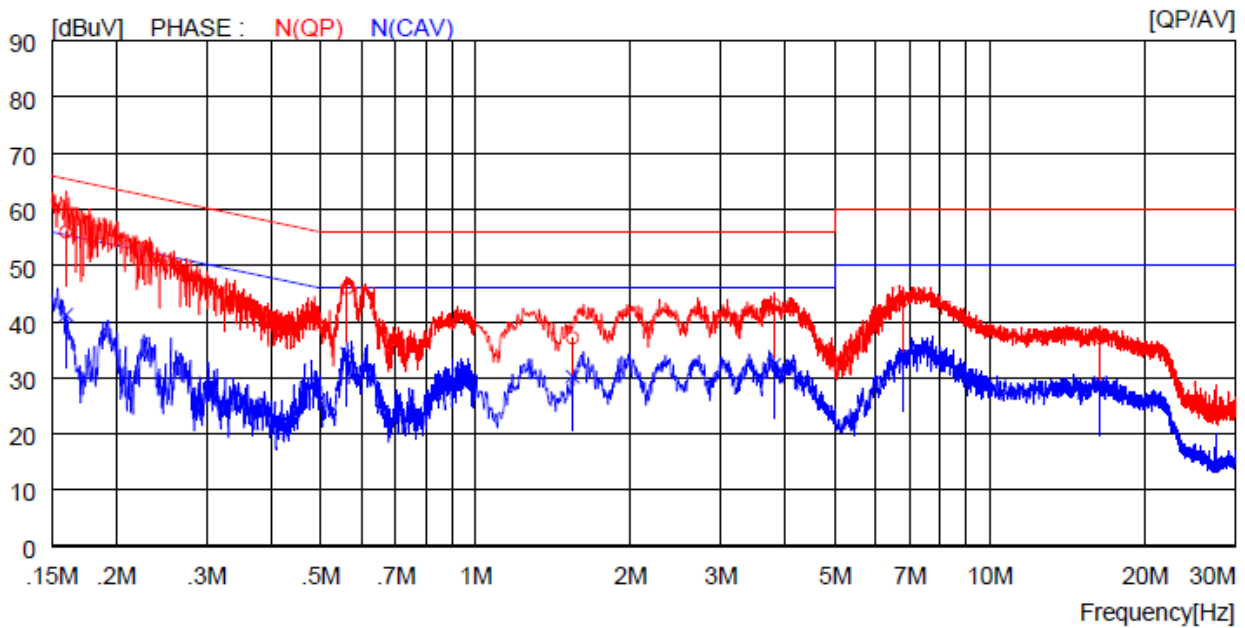
NO	FREQ [MHz]	READING		C. FACTOR [dB]	RESULT		LIMIT		MARGIN		PHASE
		QP [dBuV]	AV [dBuV]		QP [dBuV]	AV [dBuV]	QP [dBuV]	AV [dBuV]	QP [dBuV]	AV [dBuV]	
1	0.15600	48.3	----	10.0	58.3	----	65.7	----	7.4	----	H (QP)
2	0.18500	45.3	----	10.0	55.3	----	64.3	----	9.0	----	H (QP)
3	0.57200	36.5	----	10.0	46.5	----	56.0	----	9.5	----	H (QP)
4	1.28800	28.4	----	10.1	38.5	----	56.0	----	17.5	----	H (QP)
5	3.78000	30.0	----	10.1	40.1	----	56.0	----	15.9	----	H (QP)
6	7.29000	35.8	----	10.2	46.0	----	60.0	----	14.0	----	H (QP)
7	0.15600	----	42.0	10.0	----	52.0	----	55.7	----	3.7	H (CAV)
8	0.18500	----	31.4	10.0	----	41.4	----	54.3	----	12.9	H (CAV)
9	0.57200	----	26.2	10.0	----	36.2	----	46.0	----	9.8	H (CAV)
10	1.28800	----	15.8	10.1	----	25.9	----	46.0	----	20.1	H (CAV)
11	3.78000	----	22.9	10.1	----	33.0	----	46.0	----	13.0	H (CAV)
12	7.29000	----	28.1	10.2	----	38.3	----	50.0	----	11.7	H (CAV)

-. Tested Line : NEUTRAL LINE

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.

LIMIT : EN.KN.FCC.VCCI CISPR Pub.22 Class B, Quasi-Peak Limits (Mains Ports)
EN.KN.FCC.VCCI CISPR Pub.22 Class B, Average Limits (Mains Ports)



NO	FREQ [MHz]	READING		C.FACTOR [dB]	RESULT		LIMIT		MARGIN		PHASE
		QP [dBuV]	AV [dBuV]		QP [dBuV]	AV [dBuV]	QP [dBuV]	AV [dBuV]	QP [dBuV]	AV [dBuV]	
1	0.16000	46.0	----	10.0	56.0	----	65.5	----	9.5	----	N (QP)
2	0.56300	36.0	----	10.0	46.0	----	56.0	----	10.0	----	N (QP)
3	1.54400	27.0	----	10.1	37.1	----	56.0	----	18.9	----	N (QP)
4	3.80800	32.9	----	10.1	43.0	----	56.0	----	13.0	----	N (QP)
5	6.79500	33.7	----	10.2	43.9	----	60.0	----	16.1	----	N (QP)
6	16.39000	26.8	----	10.3	37.1	----	60.0	----	22.9	----	N (QP)
7	0.16000	----	31.2	10.0	----	41.2	----	55.5	----	14.3	N (CAV)
8	0.56300	----	24.3	10.0	----	34.3	----	46.0	----	11.7	N (CAV)
9	1.54400	----	20.1	10.1	----	30.2	----	46.0	----	15.8	N (CAV)
10	3.80800	----	22.2	10.1	----	32.3	----	46.0	----	13.7	N (CAV)
11	6.79500	----	23.2	10.2	----	33.4	----	50.0	----	16.6	N (CAV)
12	16.39000	----	18.8	10.3	----	29.1	----	50.0	----	20.9	N (CAV)

15. LIST OF TEST EQUIPMENT

Model Number	Manufacturer	Description	Serial Number	Last Cal.(Interval)
FSV40-N	Rohde & Schwarz	Signal Analyzer	102177	Apr. 16, 2021 (1Y)
ESR	Rohde & Schwarz	EMI TEST RECEIVER	101470	Oct. 18, 2021 (1Y)
ESCI	Rohde & Schwarz	EMI Test RECEIVER	101012	Oct. 20, 2021 (1Y)
ESH3-Z2	Rohde & Schwarz	Pulse Limiter	100655	Mar. 15, 2021 (1Y)
NSLK8128	Schwarzbeck	V - LISN (4*32/50A)	8128216	Mar. 16, 2021 (1Y)
310N	Sonoma Instrument	Pre-Amplifier	312544	Mar. 16, 2021 (1Y)
DT3000-3t	Innco System	Turn Table	DT3000/093	N/A
MA-4000XPET	Innco System	Antenna Master	MA4000/509	N/A
BBHA9120D	Schwarzbeck	Horn Antenna	295	Mar. 04, 2021(1Y)
TC-3000C	TESCOM	BLUETOOTH TESTER	3000C000634	Feb. 09, 2021 (1Y)