

RADIO PERFORMANCE TEST REPORT

Test Report No. : OT-226-RWD-046

Reception No. : 2205001480

Applicant : CERAGEM CO., LTD.

Address : 10, Jeongja-1-gil, Seonggeo-eup, Seobuk-gu, Cheonan-si, Chungcheongnam-do,
Republic of Korea

Manufacturer : CERAGEM CO., LTD.

Address : 10, Jeongja-1-gil, Seonggeo-eup, Seobuk-gu, Cheonan-si, Chungcheongnam-do,
Republic of Korea

Type of Equipment : Bluetooth module

FCC ID. : 2A3VY-SQ410

Model Name : BCM-SQ410

Serial number : N/A

Total page of Report : 79 pages (including this page)

Date of Incoming : June 14, 2022

Date of issue : June 29, 2022

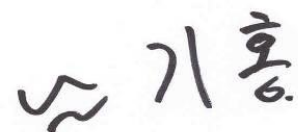
SUMMARY

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.

This report is not correlated with the "KS Q ISO/IEC 17025 and KOLAS accreditation" of Korean Laboratory Accreditation Scheme.



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Revision History

Rev. No.	Issue Report No.	Issued Date	Revisions	Section Affected
0	OT-226-RWD-046	June 29, 2022	Initial Release	All

1. VERIFICATION OF COMPLIANCE

Applicant : CERAGEM CO., LTD.

Address : 10, Jeongja-1-gil, Seonggeo-eup, Seobuk-gu, Cheonan-si, Chungcheongnam-do, Republic of Korea

Contact Person : HYEONGGEUN HWANG / Manager

Telephone No. : 041-529-4359

FCC ID : 2A3VY-SQ410

Model Name : BCM-SQ410

Brand Name : N/A

Serial Number : N/A

Date : June 29, 2022

EQUIPMENT CLASS	DSS – PART 15 SPREAD SPECTRUM TRANSMITTER
E.U.T. DESCRIPTION	Bluetooth module
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

3. GENERAL INFORMATION

3.1 Product Description

The CERAGEM CO., LTD., Model BCM-SQ410 (referred to as the EUT in this report) is a Bluetooth module. The product specification described herein was obtained from product data sheet or user's manual.

Device Type	Bluetooth module	
Temperature Range	-20 °C ~ 70 °C	
Operating Frequency	2 402 MHz ~ 2 480 MHz	
MAX. RF OUTPUT POWER	1 Mbps	5.74 dBm
	2 Mbps	8.00 dBm
	3 Mbps	8.59 dBm
Number of Channel	79 Channels	
Modulation Type	GFSK for 1 Mbps, $\pi/4$ -DQPSK for 2 Mbps, 8-DPSK for 3 Mbps	
Antenna Type	PCB Pattern Antenna	
Antenna Gain	2.10 dBi	
List of each Osc. or crystal Freq.(Freq. $\geq$ 1 MHz)	32 MHz	
Rated Supply Voltage	DC 5.0 V	

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

-. None

4. EUT MODIFICATIONS

-. None

5. SYSTEM TEST CONFIGURATION

5.1 Justification

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

DEVICE TYPE	MANUFACTURER	MODEL/PART NUMBER	FCC ID
Main Board	CERAGEM CO., LTD.	N/A	N/A

5.2 Peripheral equipment

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

Model	Manufacturer	Description	Connected to
BCM-SQ410	CERAGEM CO., LTD.	Bluetooth module (EUT)	-
Ideapad 320	LENOVO	Notebook PC	EUT

5.3 Mode of operation during the test

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

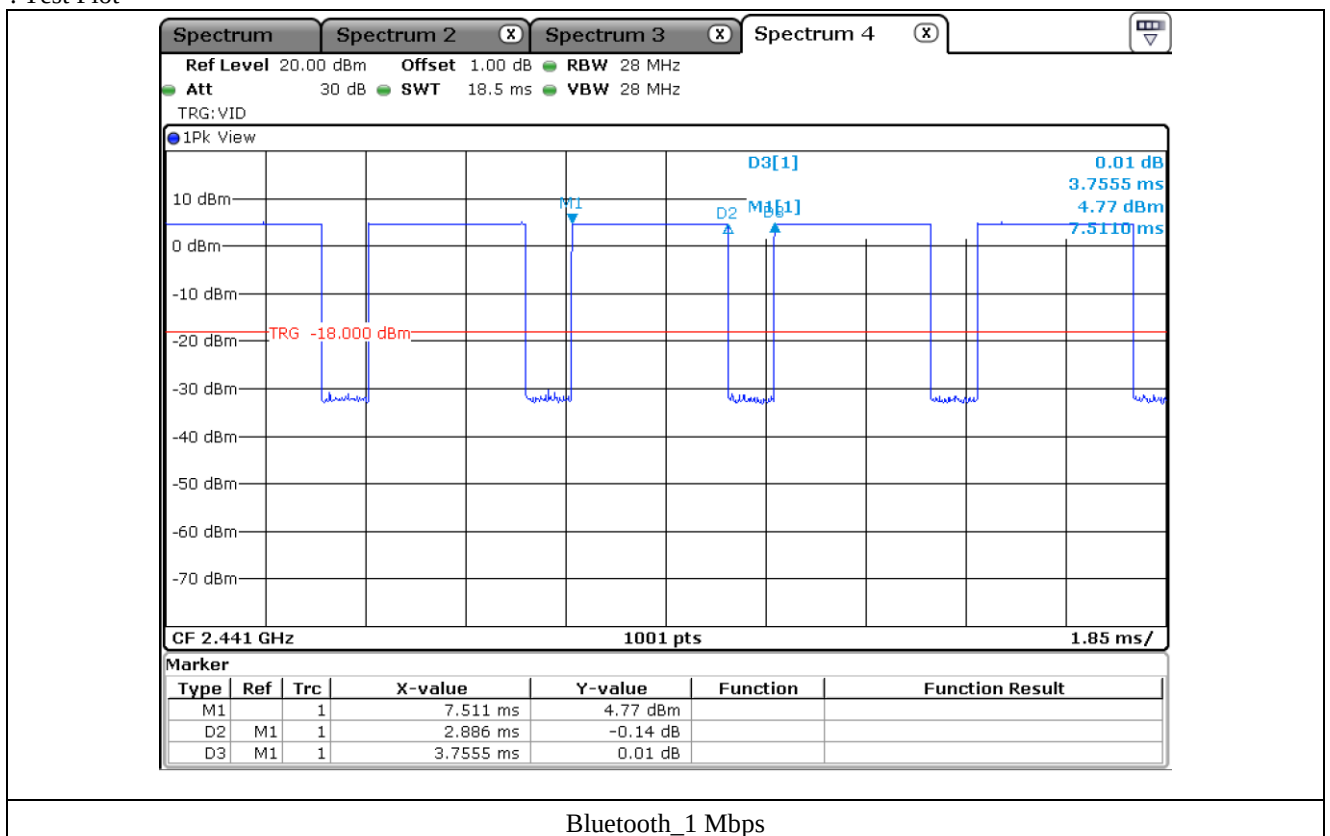
-. Duty Cycle

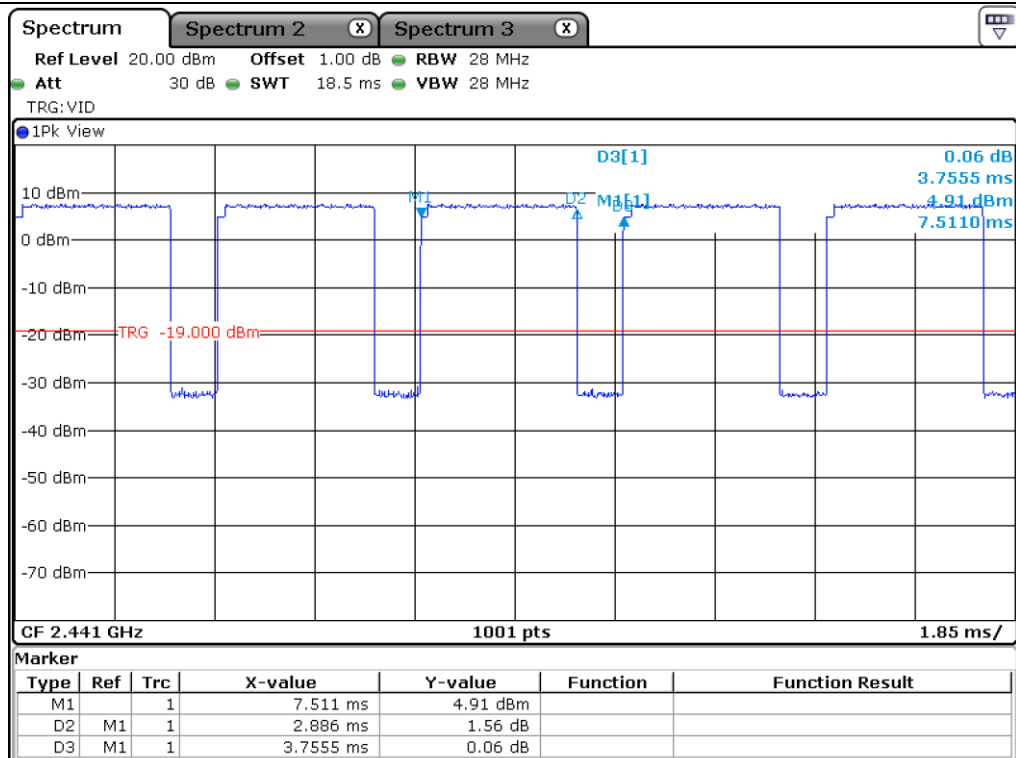
Mode	Tx On Time [ms]	Tx Off Time [ms]	Duty Cycle [%]	Correction Factor [dB]
Bluetooth [1 Mbps]	2.886	0.869	76.86	1.14
Bluetooth [2 Mbps]	2.886	0.869	76.86	1.14
Bluetooth [3 Mbps]	2.883	0.868	76.86	1.14

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

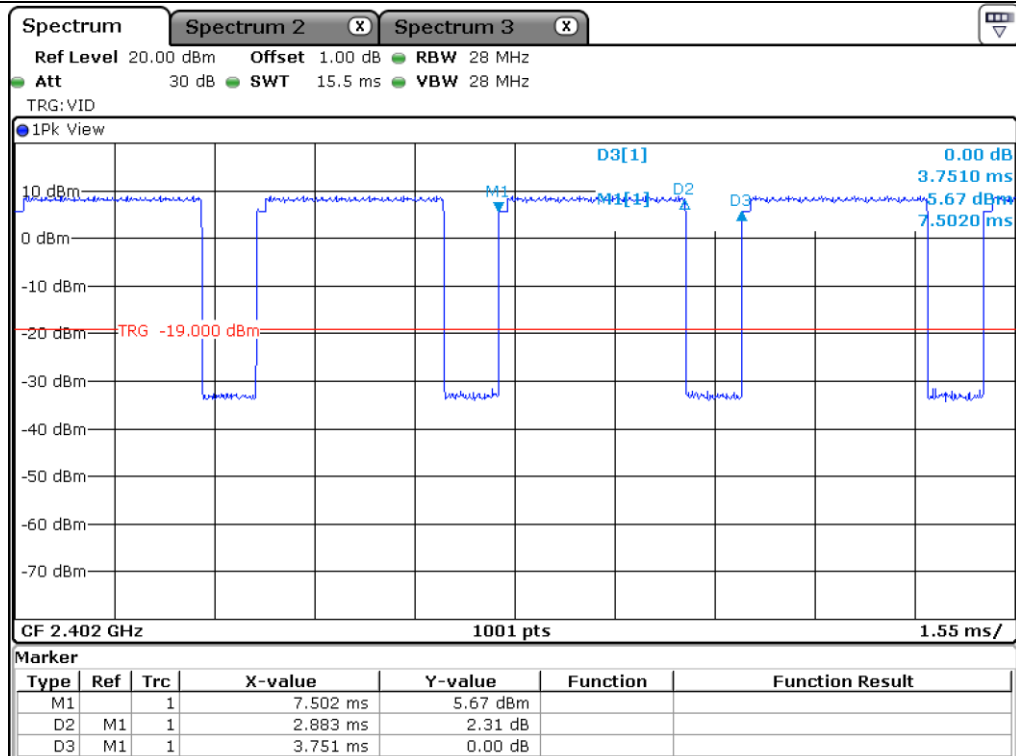
Correction Factor : 10 * Log(1 / (Duty Cycle / 100))

-. Test Plot





Bluetooth_2 Mbps



Bluetooth_3 Mbps

5.4 Configuration of Test System

Line Conducted Test: 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 Pattern Antenna of the EUT is located on the EUT, so no consideration of replacement by the user.

6. PRELIMINARY TEST

6.1 AC Power line Conducted Emissions Tests

During Preliminary Test, the following operating mode was investigated.

Operation Mode	The Worse operating condition (Please check one only)
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

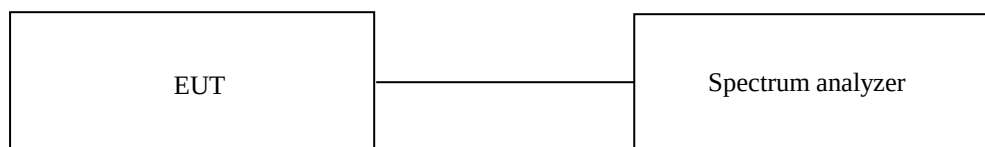
7. MINIMUM 20 dB BANDWIDTH

7.1 Operating environment

Temperature : 23 °C
Relative humidity : 48 % 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 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.



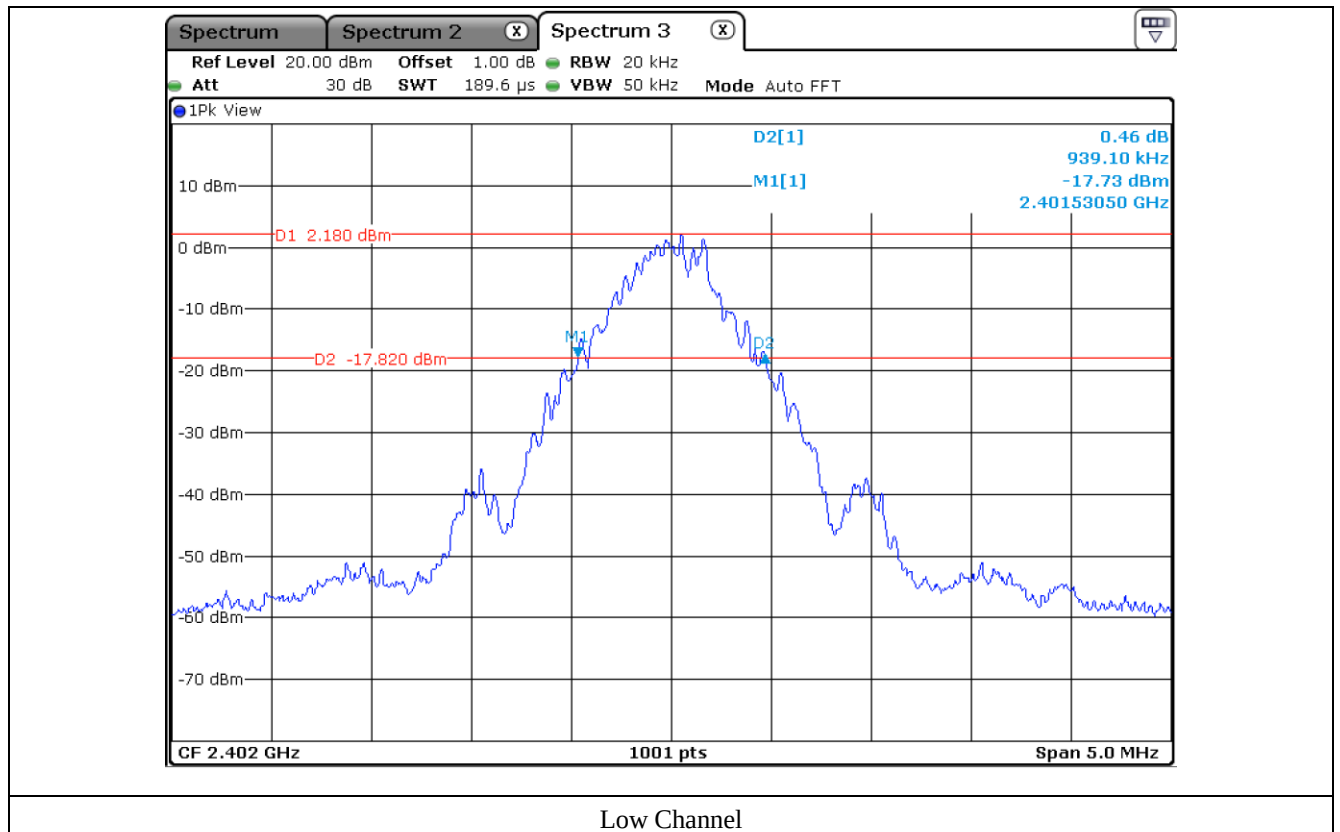
7.3 Test Date

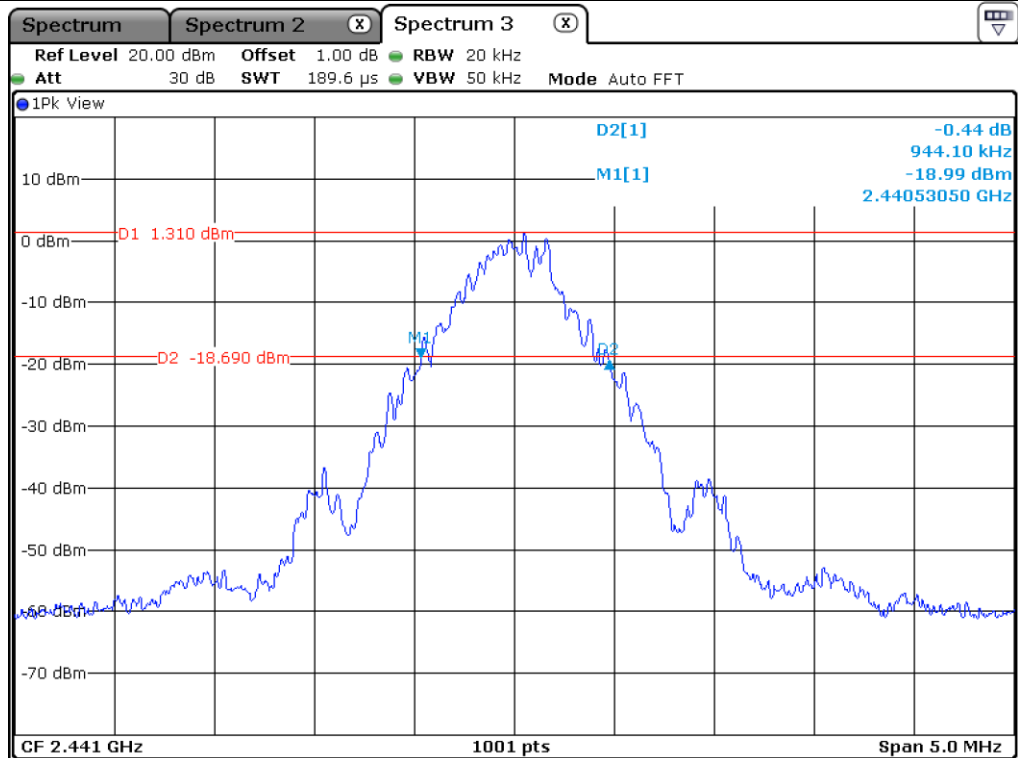
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7.4 Test Data

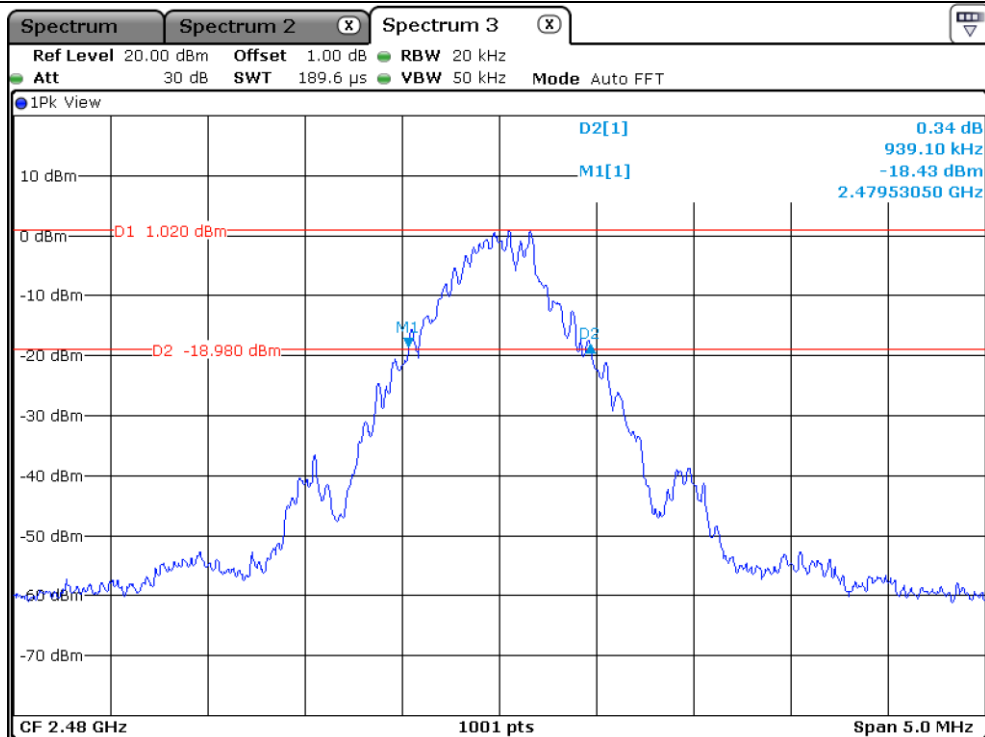
7.4.1 Test data for 1 Mbps

Channel	Frequency (MHz)	20 dB Bandwidth (kHz)
Low	2 402.00	939.10
Middle	2 441.00	944.10
High	2 480.00	939.10





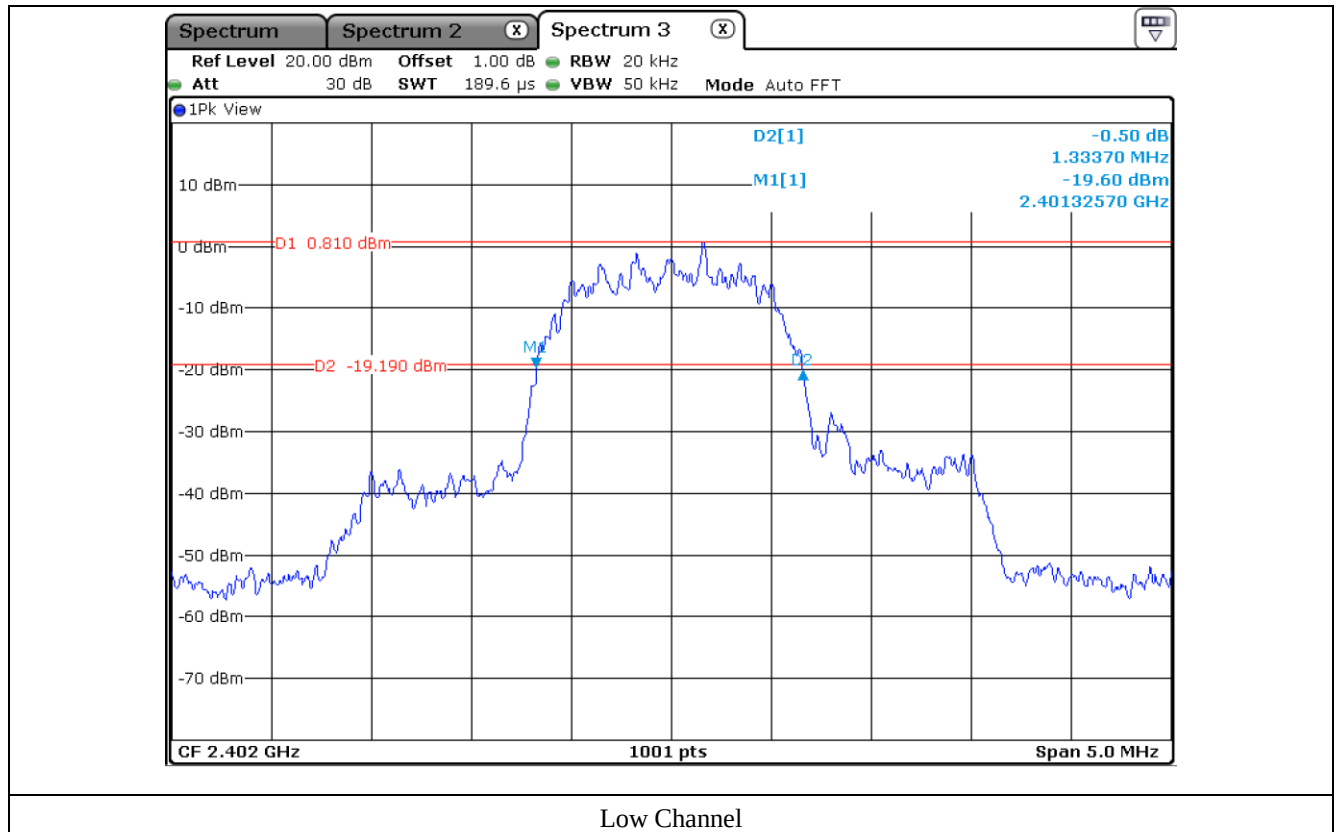
Middle Channel

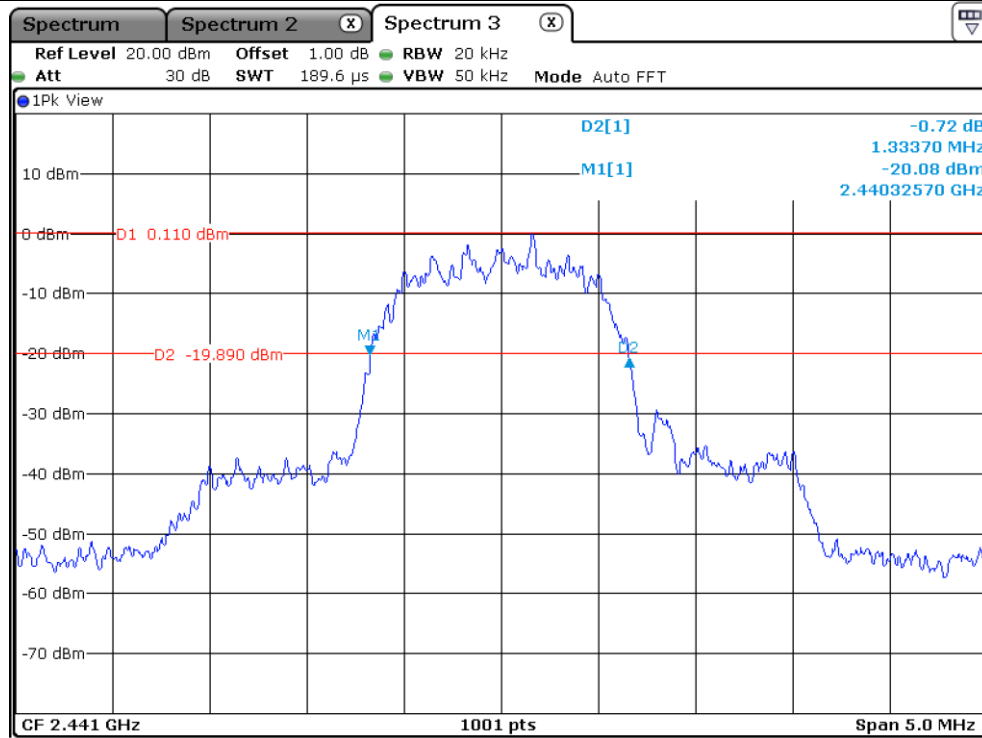


High Channel

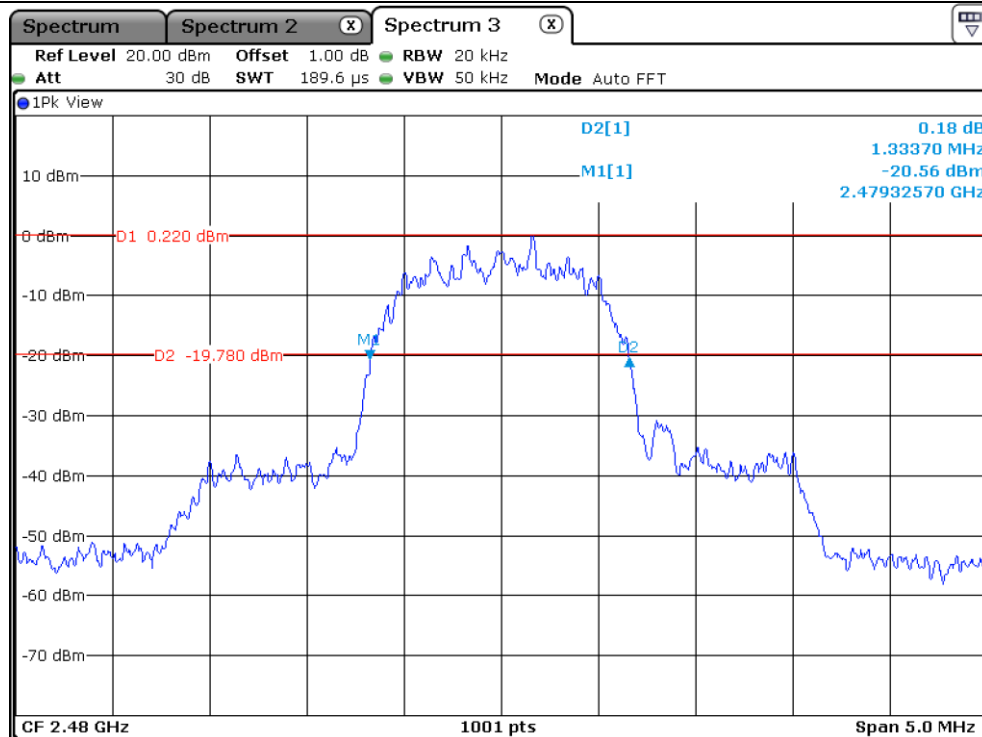
7.4.2 Test data for 2 Mbps

Channel	Frequency (MHz)	20 dB Bandwidth (kHz)
Low	2 402.00	1 333.70
Middle	2 441.00	1 333.70
High	2 480.00	1 333.70





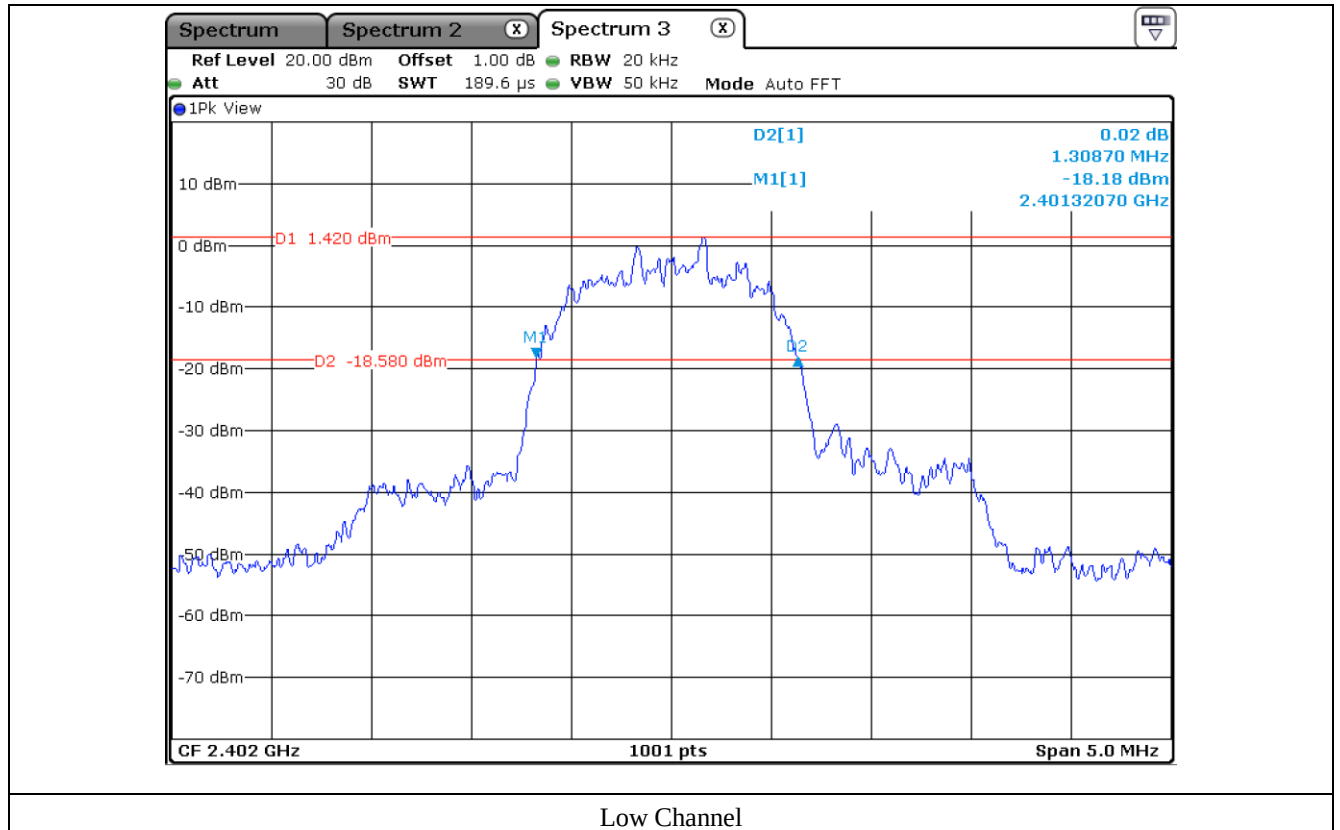
Middle Channel

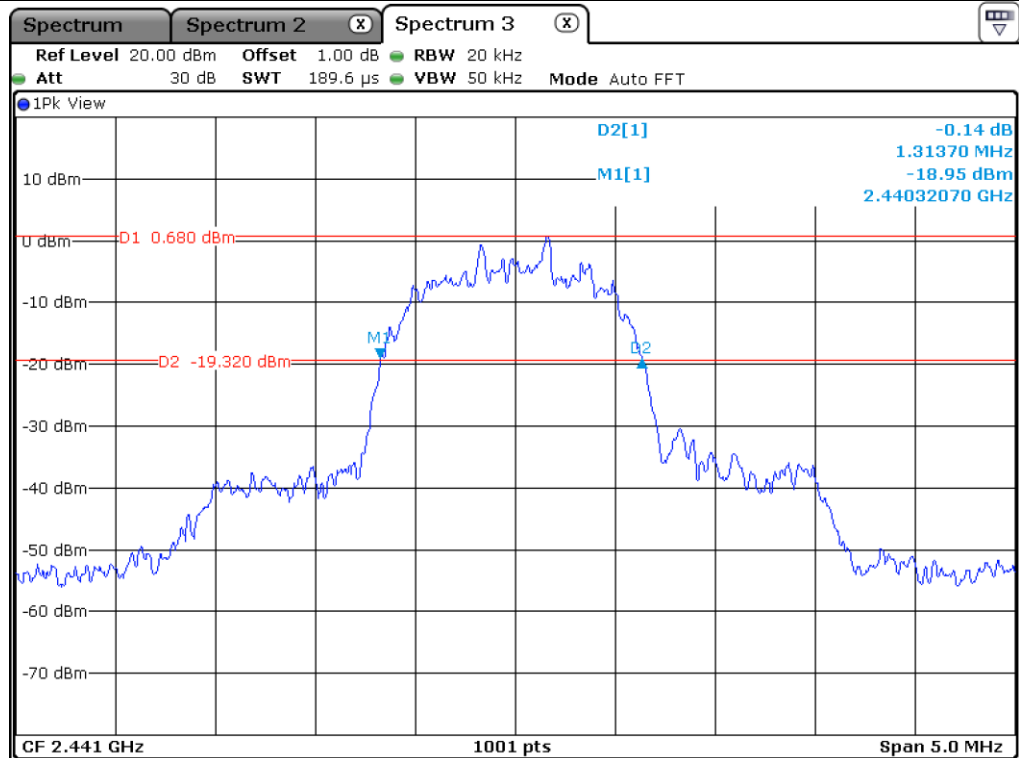


High Channel

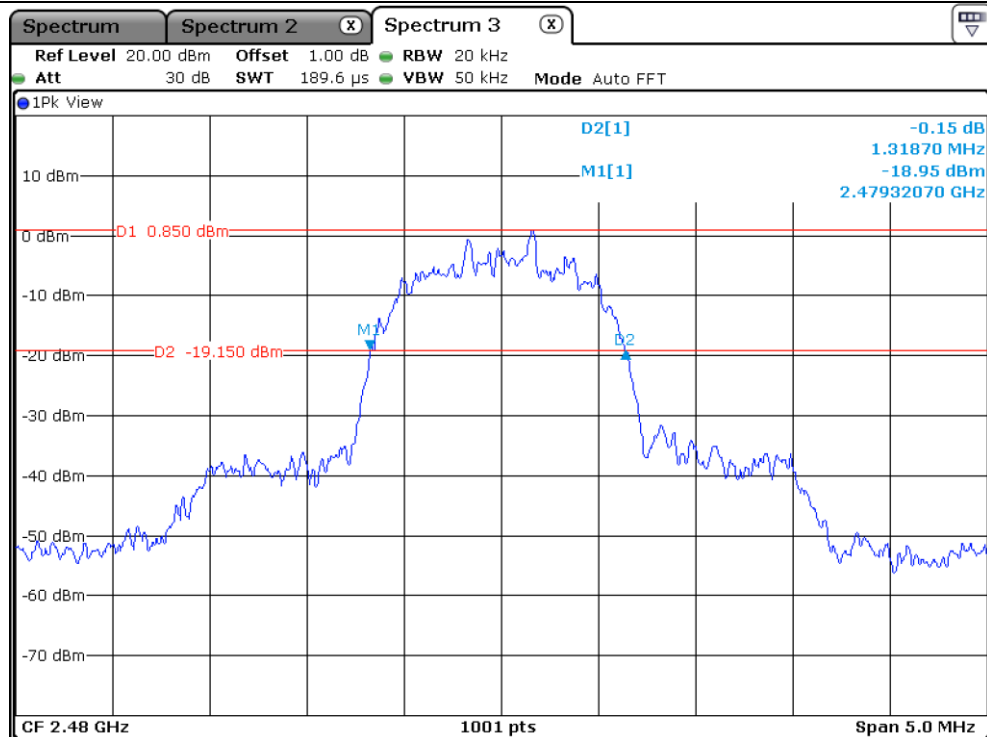
7.4.3 Test data for 3 Mbps

Channel	Frequency (MHz)	20 dB Bandwidth (kHz)
Low	2 402.00	1 308.70
Middle	2 441.00	1 313.70
High	2 480.00	1 318.70





Middle Channel



High Channel

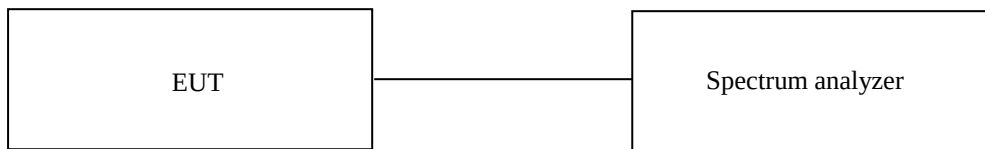
8. HOPPING FREQUENCY SEPARATION

8.1 Operating environment

Temperature : 23 °C
Relative humidity : 48 % 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

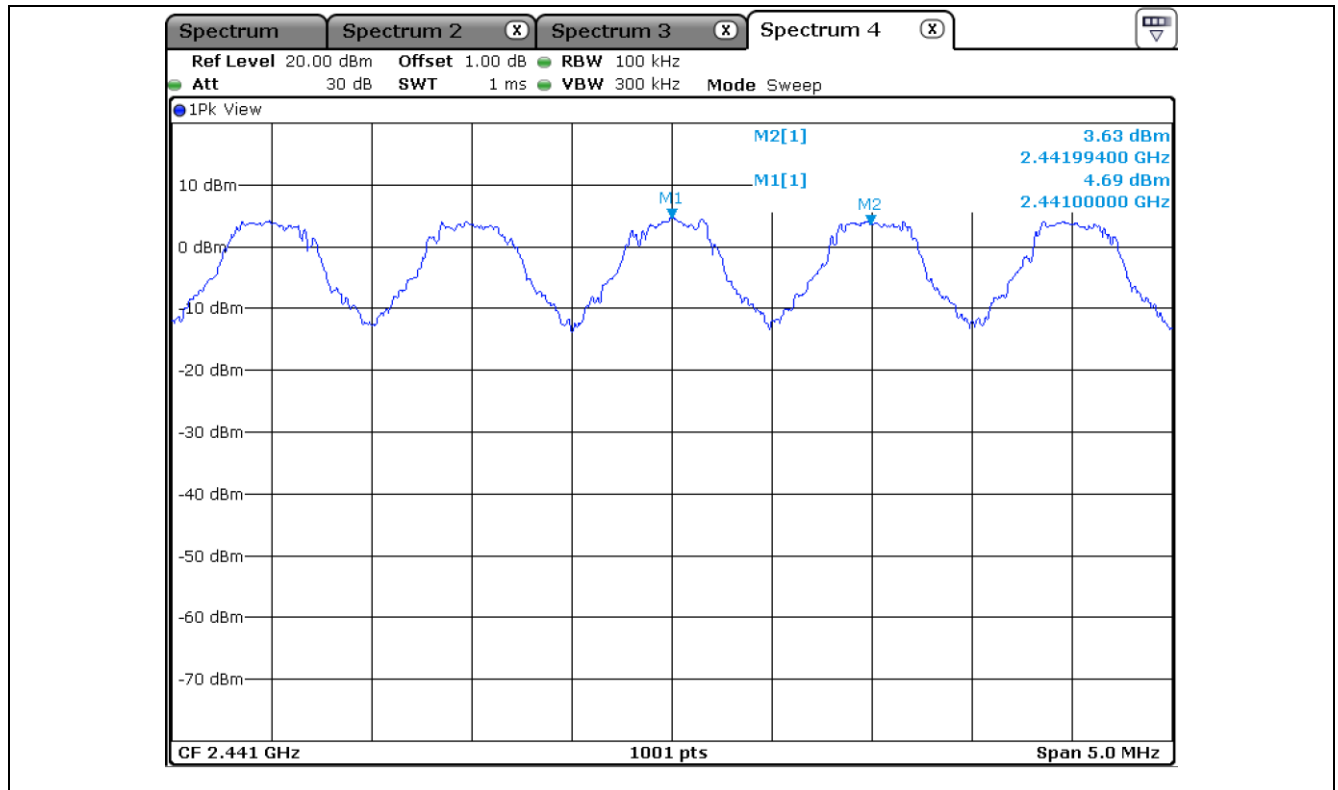
June 14, 2022 ~ June 20, 2022

8.4 Test Data

8.4.1 Test data for 1 Mbps

-. Test Result : Pass

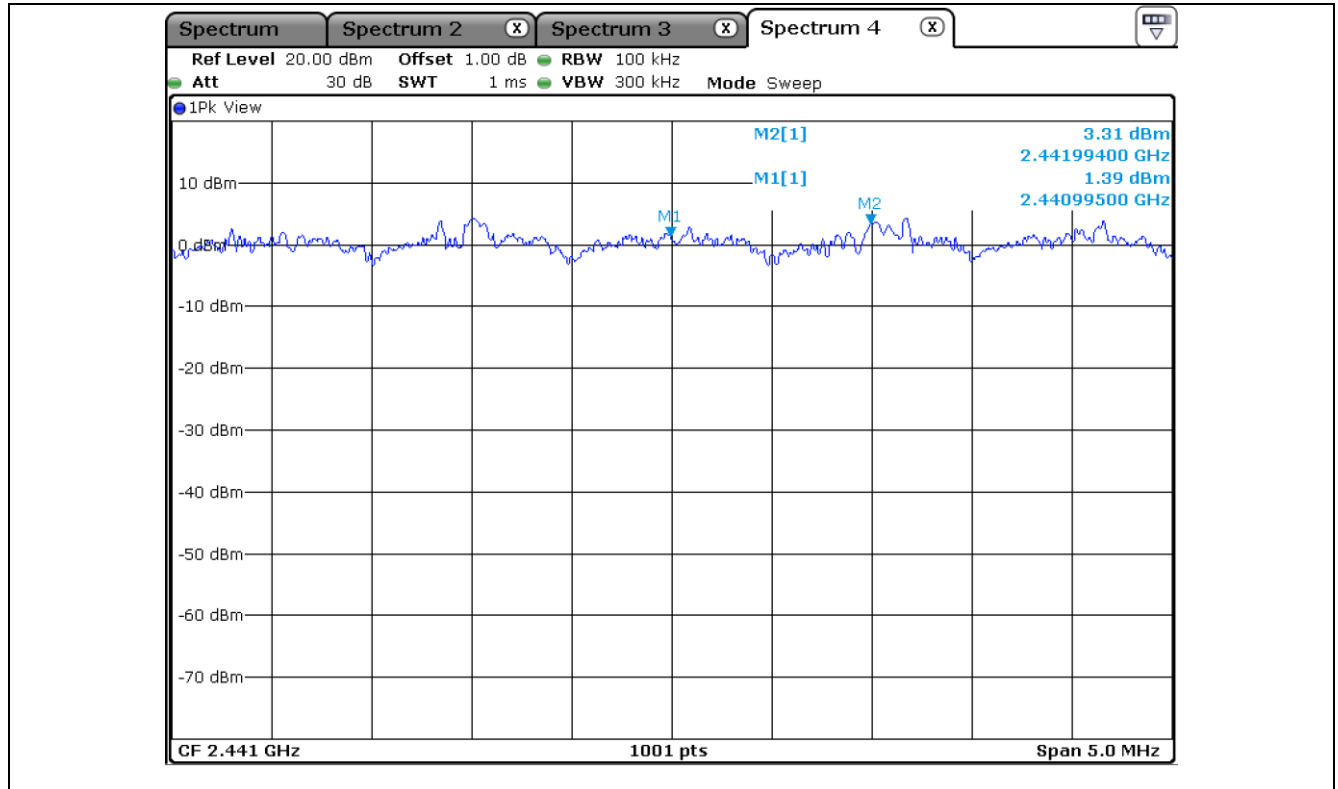
Measured Value (kHz)	Two-third of 20 dB Bandwidth (kHz)	Limit
994.00	629.40	Separated by a minimum of 629.40 kHz



8.4.2 Test data for 2 Mbps

-. Test Result : Pass

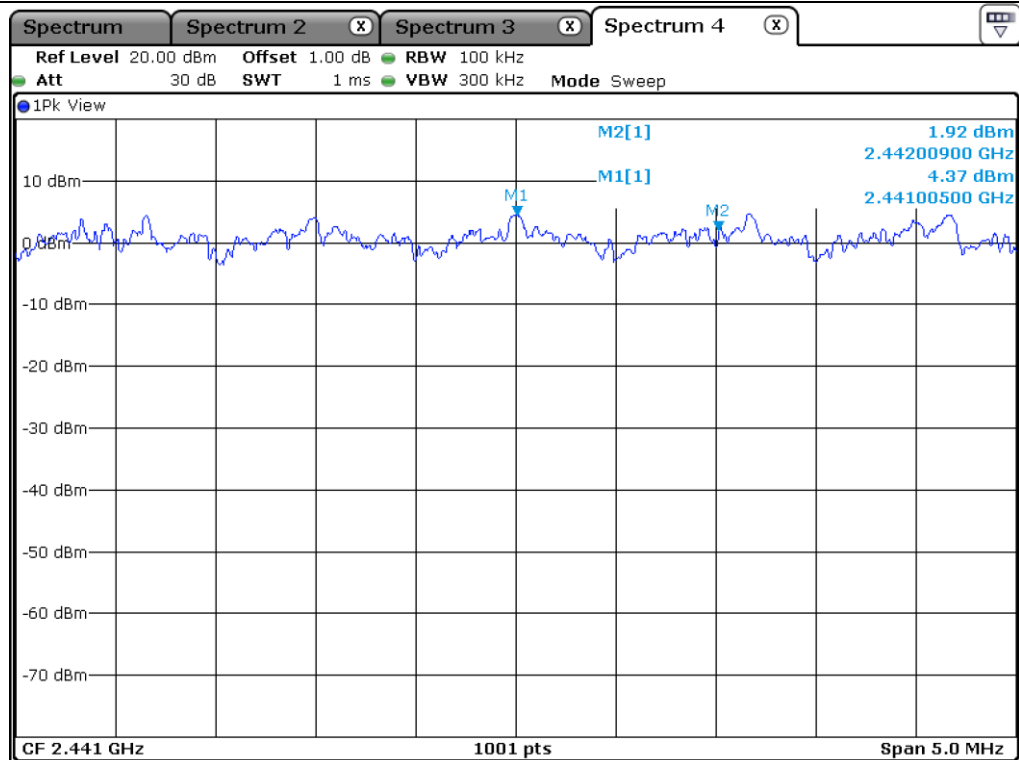
Measured Value (kHz)	Two-third of 20 dB Bandwidth (kHz)	Limit
999.00	889.13	Separated by a minimum of 889.13 kHz



8.4.3 Test data for 3 Mbps

-. Test Result : Pass

Measured Value (kHz)	Two-third of 20 dB Bandwidth (kHz)	Limit
1 004.00	875.80	Separated by a minimum of 875.80 kHz



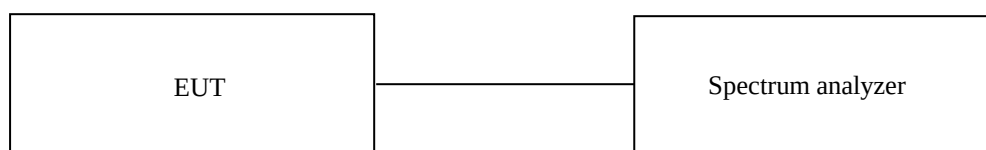
9. NUMBER OF HOPPING CHANNELS

9.1 Operating environment

Temperature : 23 °C
Relative humidity : 48 % 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

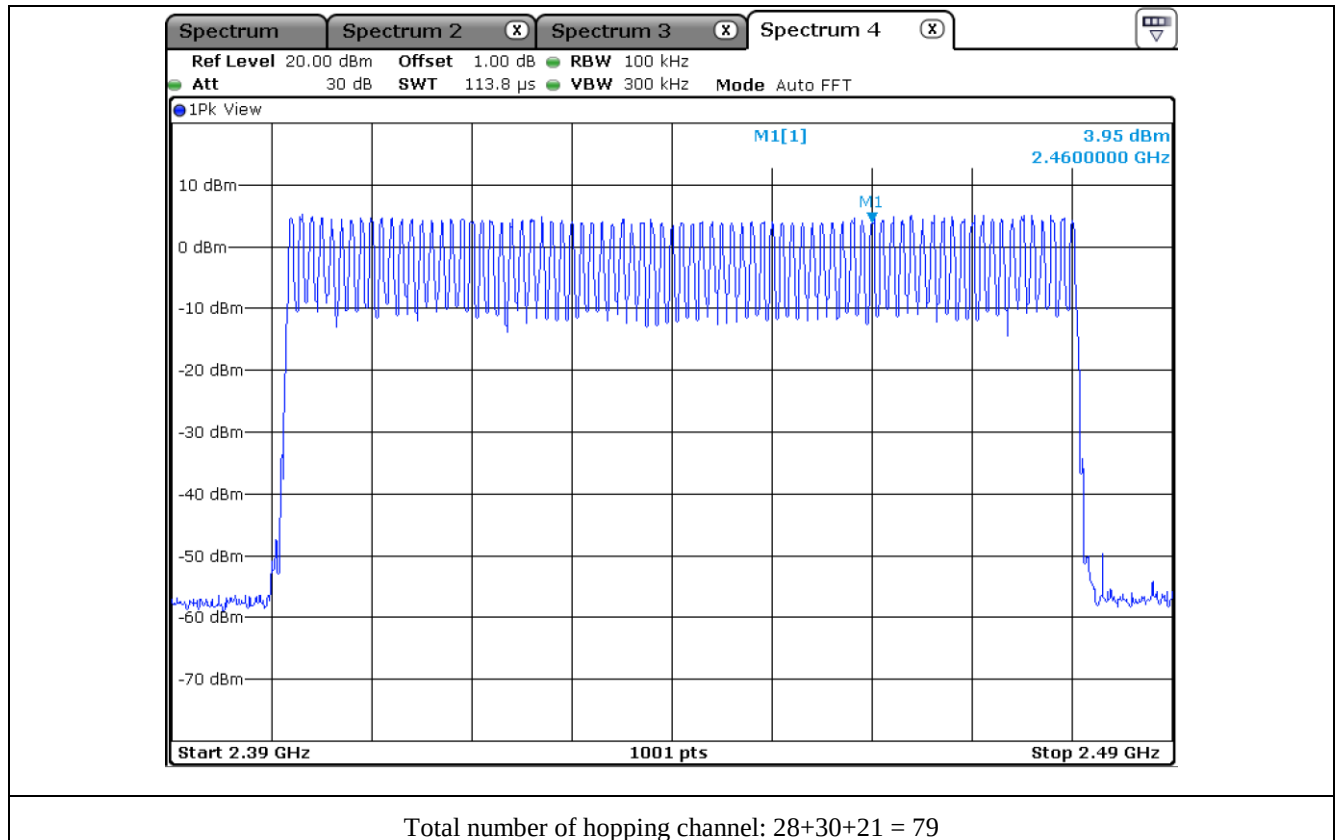
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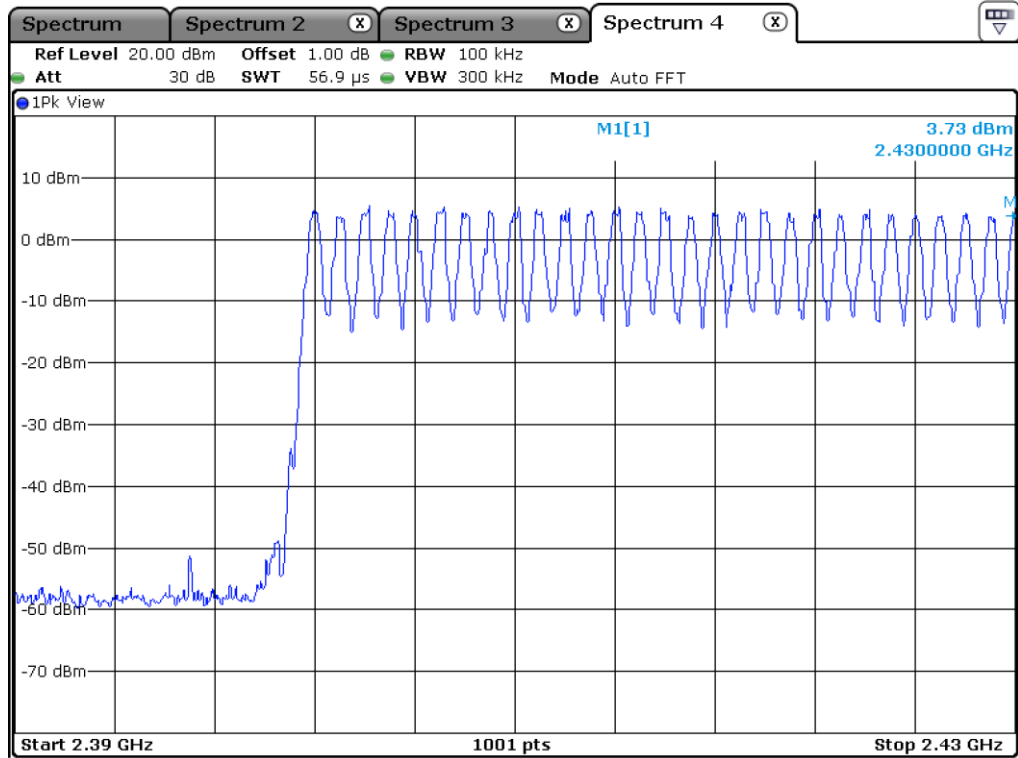
9.4 Test Data

9.4.1 Test data for 1 Mbps

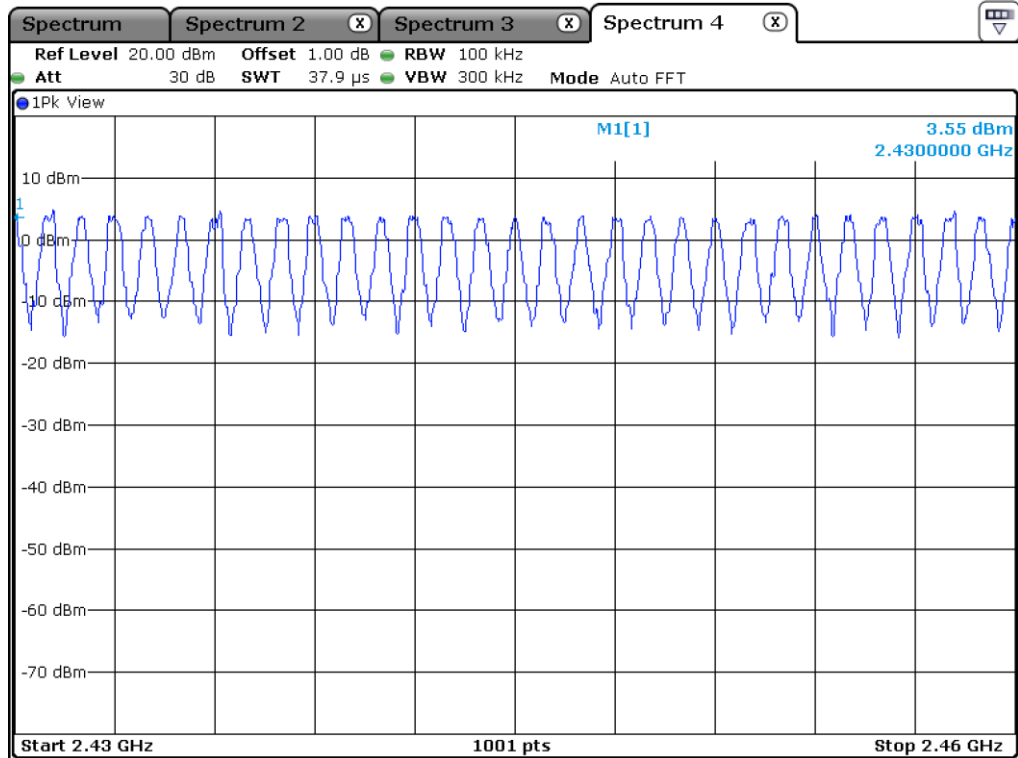
-. Test Result : Pass

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

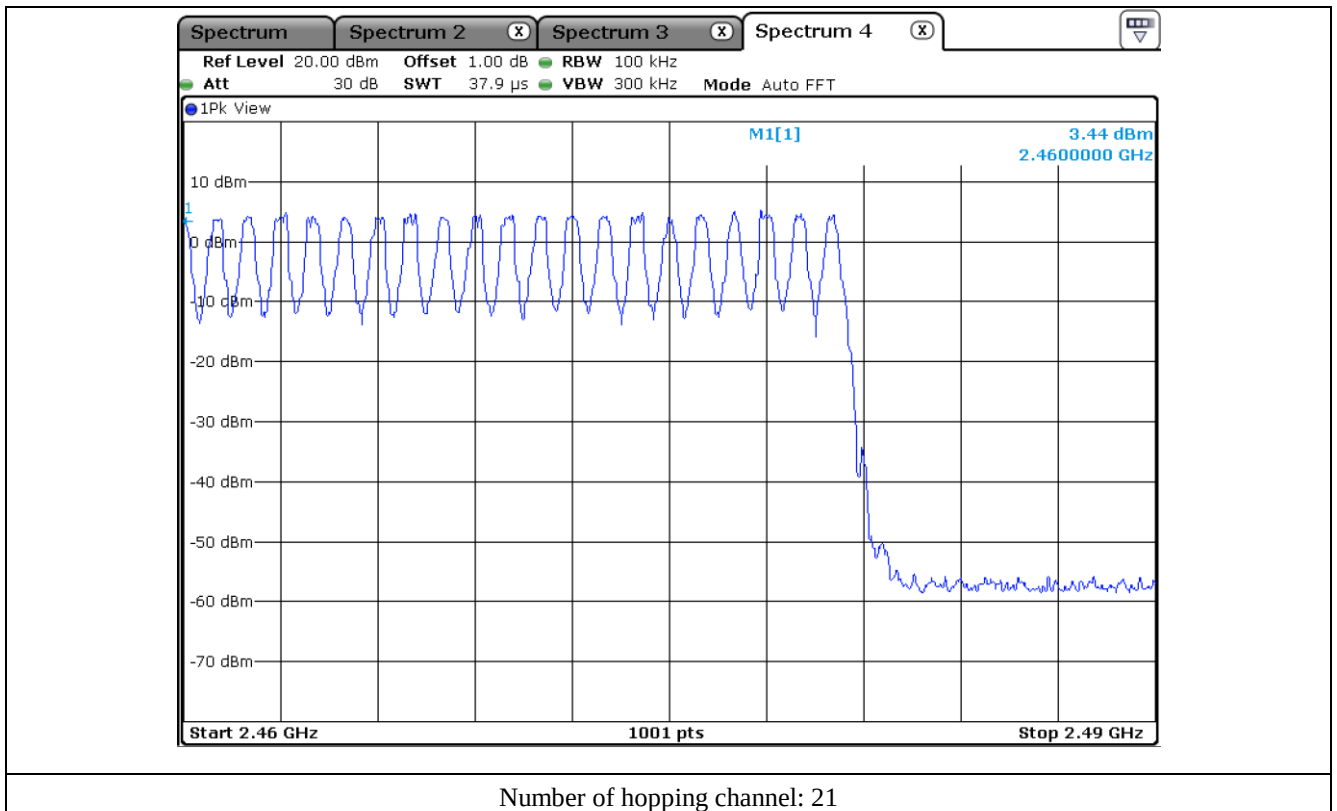




Number of hopping channel: 28



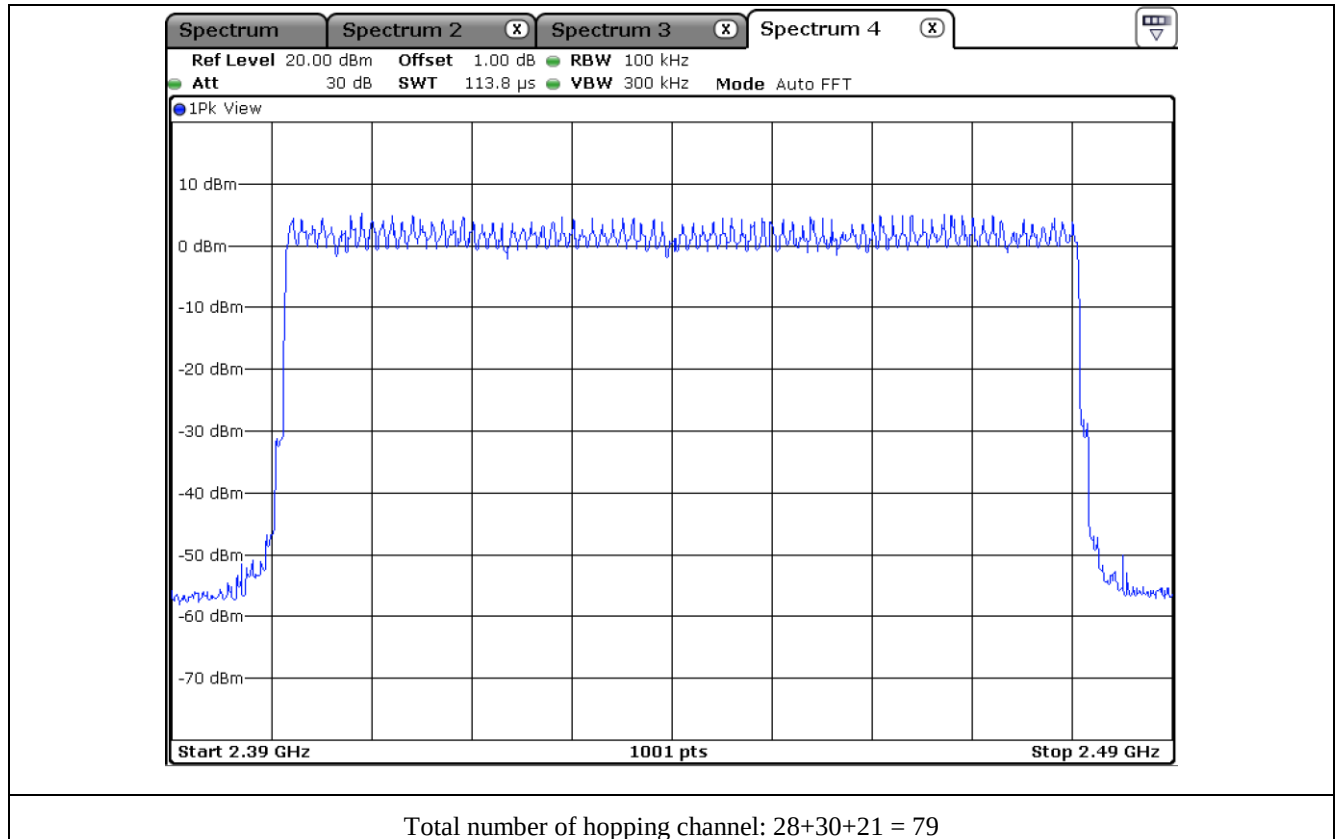
Number of hopping channel: 30

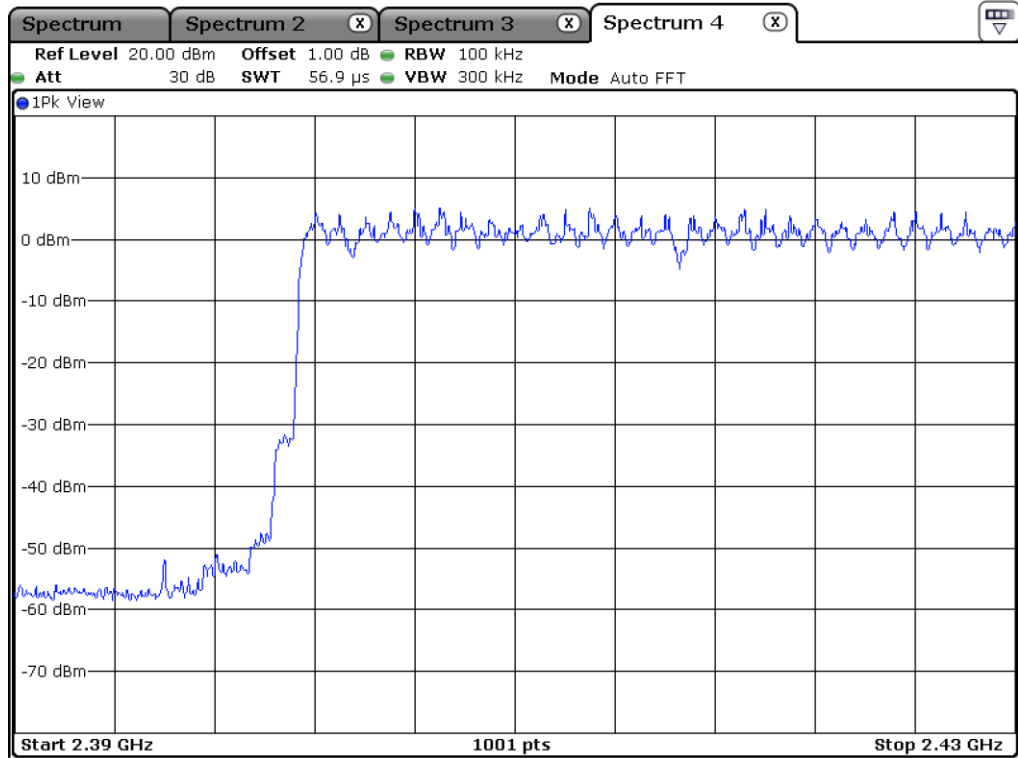


9.4.2 Test data for 2 Mbps

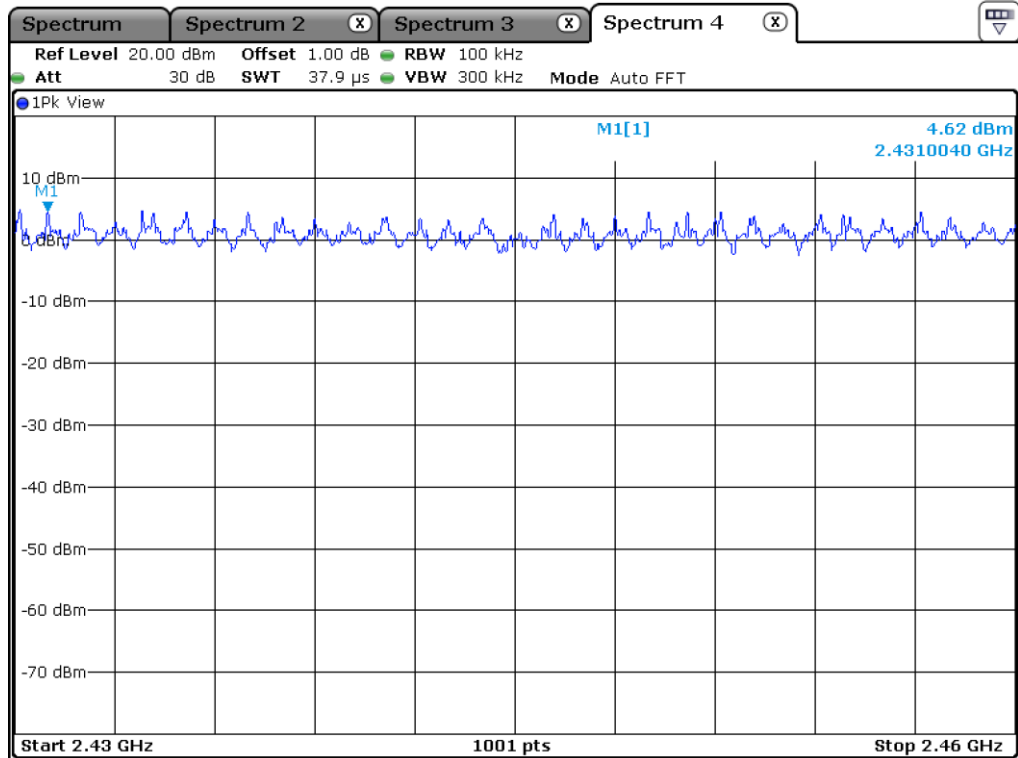
-. Test Result : Pass

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

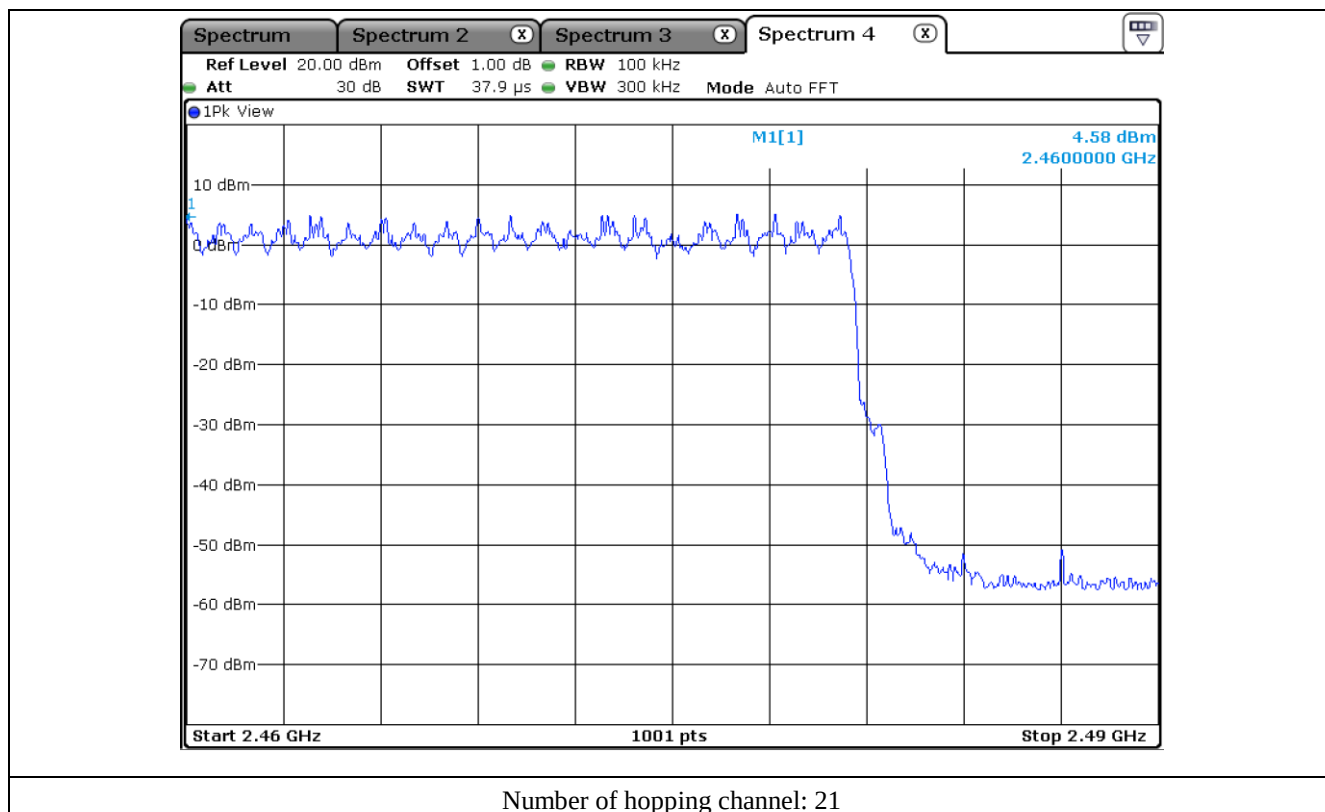




Number of hopping channel: 28



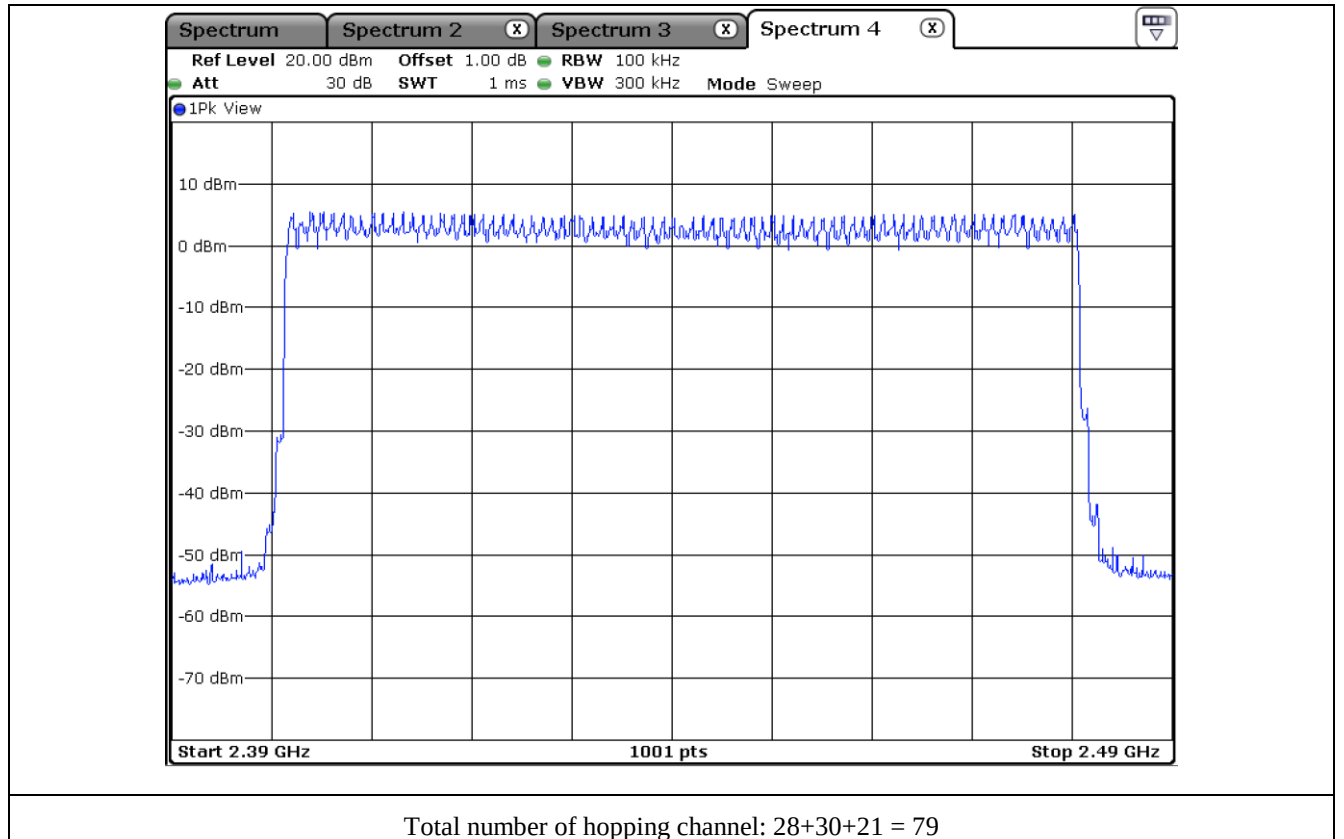
Number of hopping channel: 30

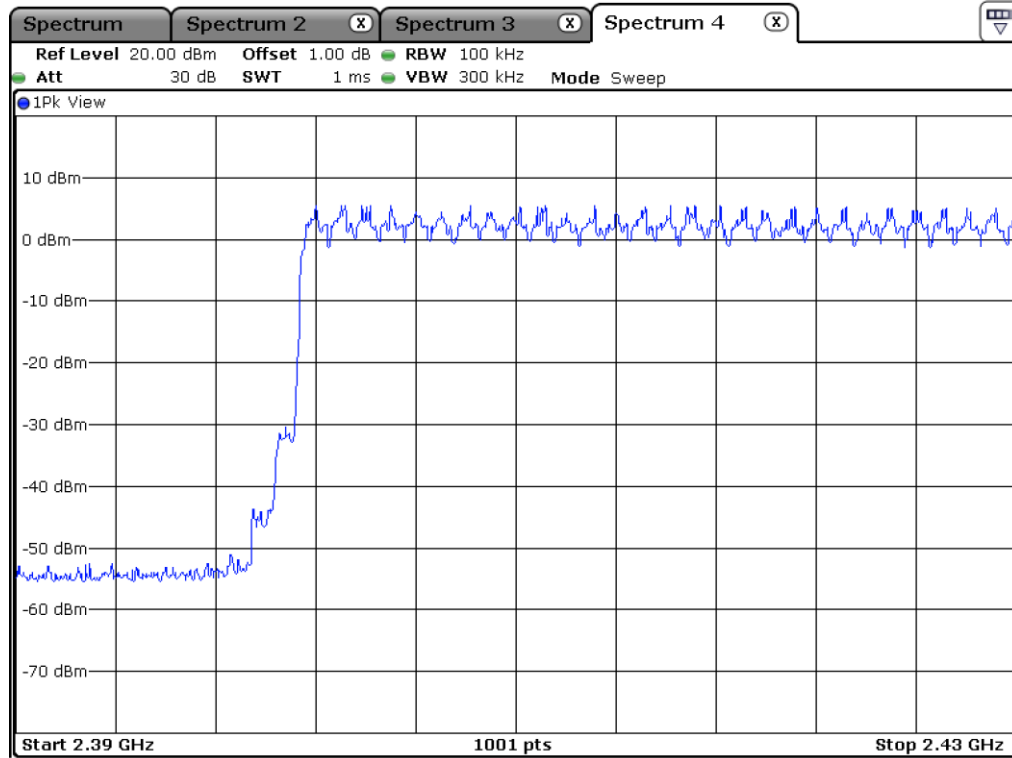


9.4.3 Test data for 3 Mbps

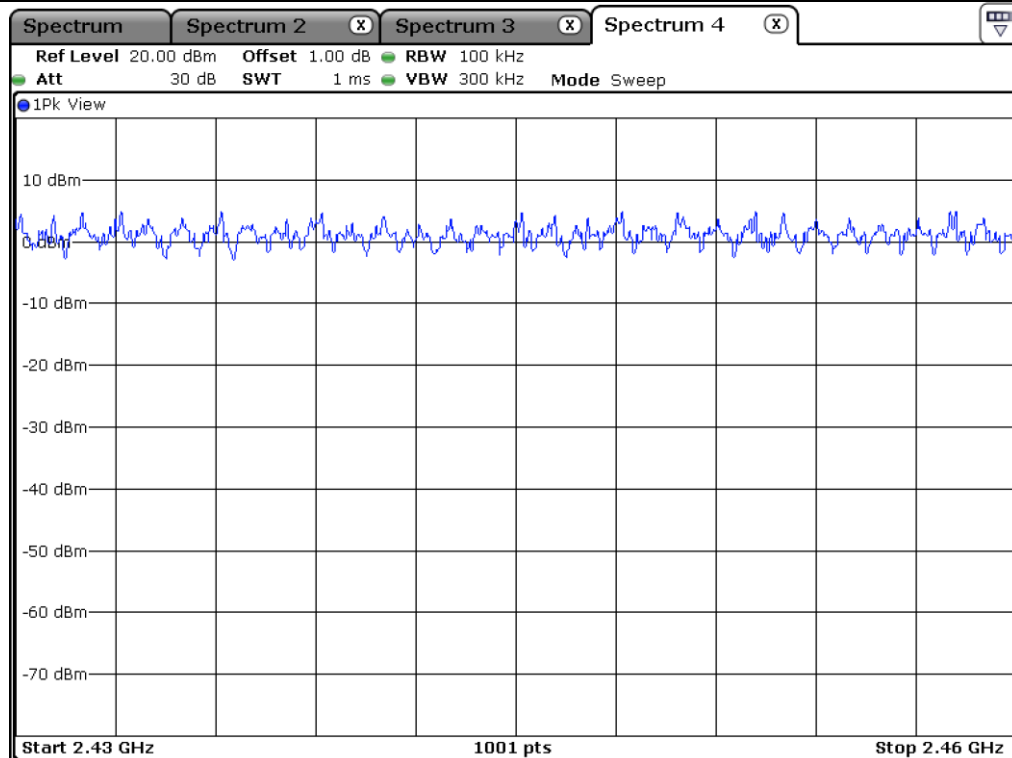
-. Test Result : Pass

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

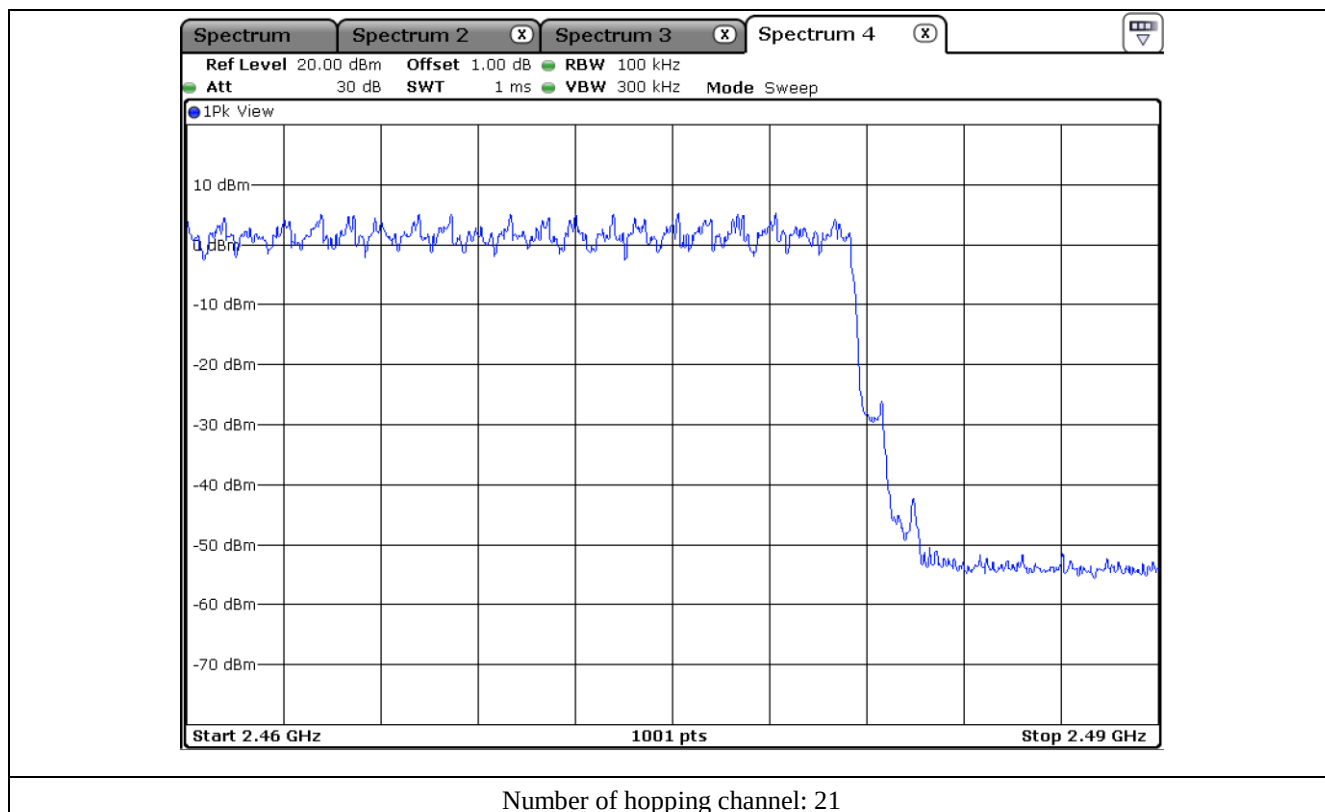




Number of hopping channel: 28



Number of hopping channel: 30



10. TIME OF OCCUPANCY

10.1 Operating environment

Temperature : 22 °C
Relative humidity : 46 % 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

June 14, 2022 ~ June 20, 2022

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.

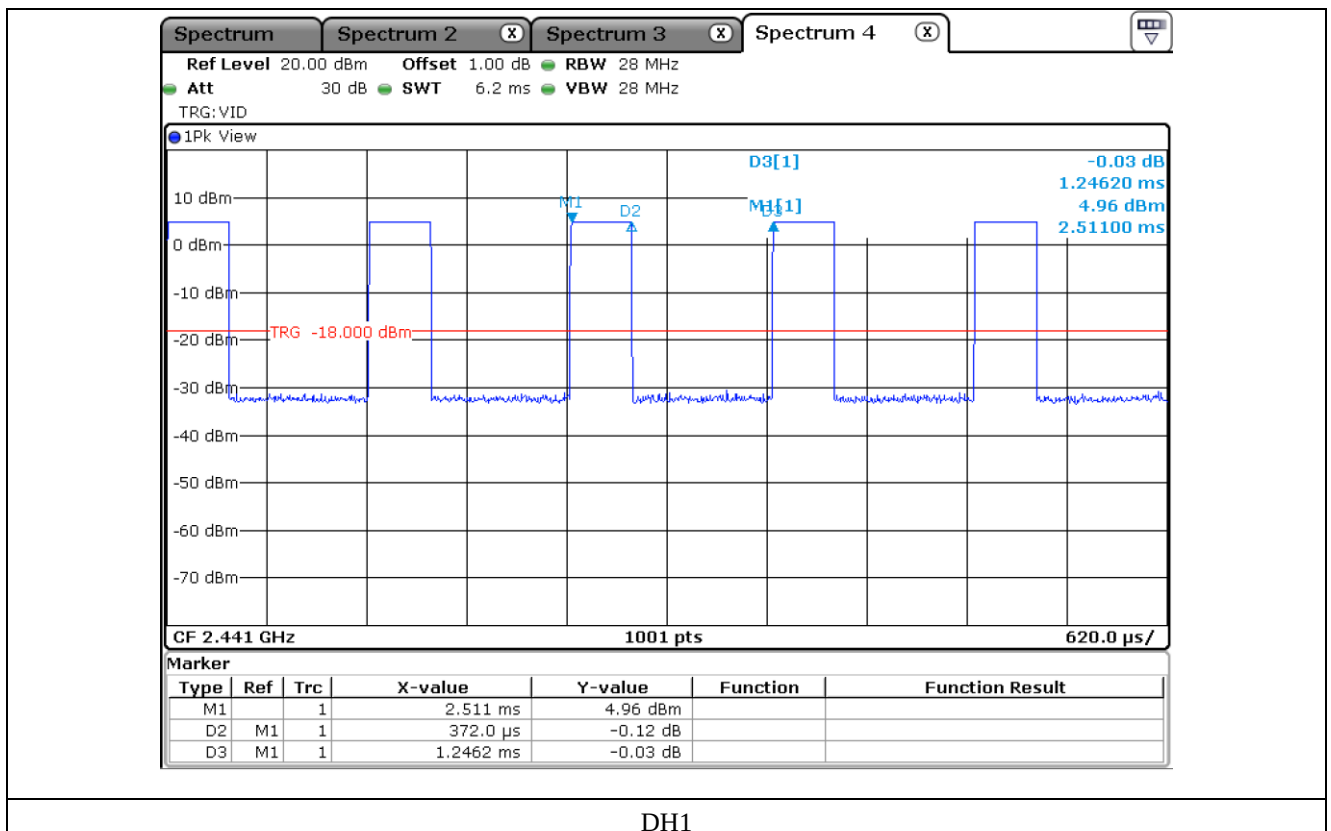
For DH1 packet type, the EUT needs 1 time slot for transmitting and 1 time slot for receiving and for DH3 packet type, the EUT needs 3 times slots for transmitting and 1 time slot for receiving, and DH5 packet needs 5 times slots for transmitting and 1 time slot for receiving. So The EUT has each channel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

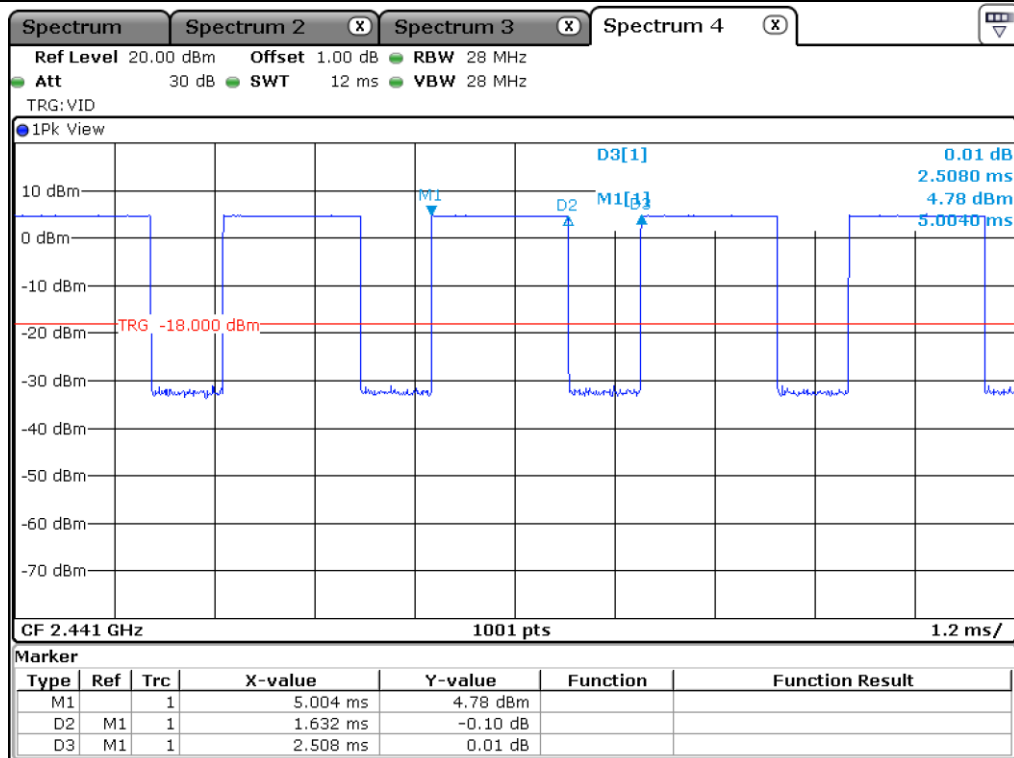
Packet Type	Pulse Time (ms)	Hops per second with channels	Period Time (ms)	Total Dwell Time (ms)	Limit (ms)	Test Result
DH1	0.372	10.13	31.60	119.08	400.00	PASS
DH3	1.632	5.06	31.60	260.95	400.00	
DH5	2.886	3.38	31.60	308.25	400.00	

Total dwell time is calculated as following.

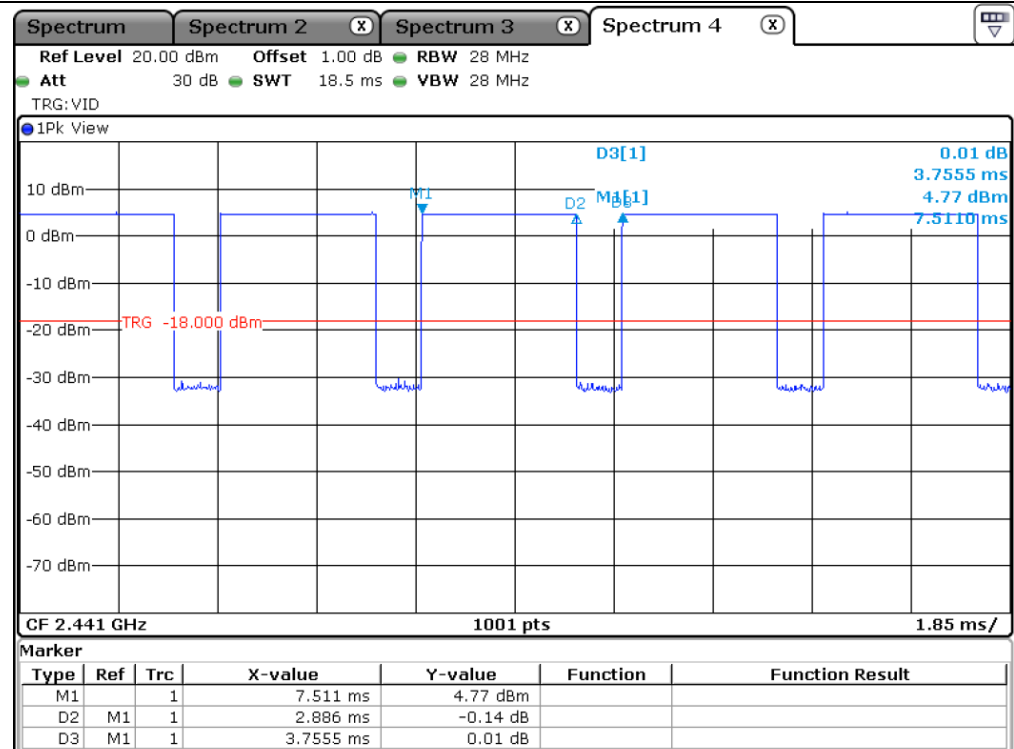
Total Dwell Time = Pulse time * Hops per second with channels * period time

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.

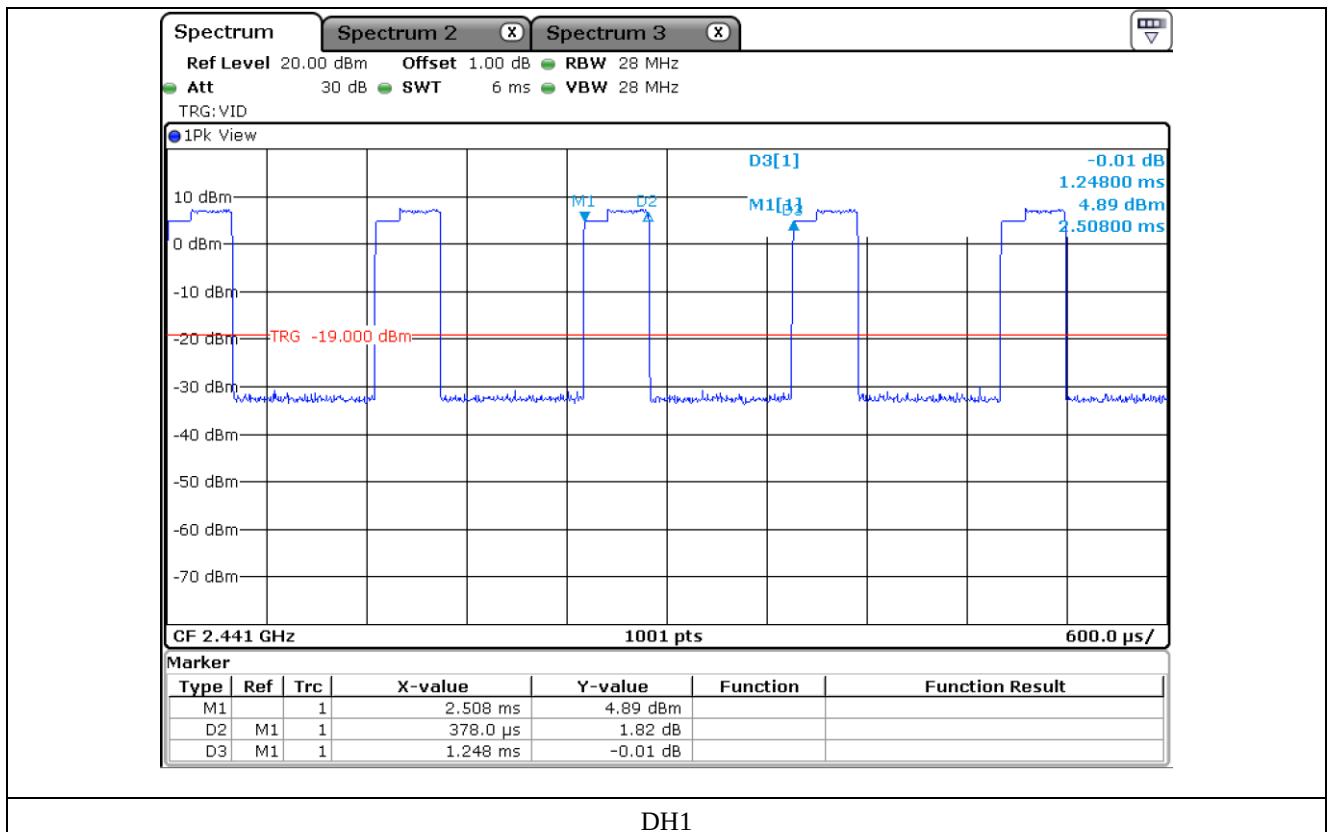
For DH1 packet type, the EUT needs 1 time slot for transmitting and 1 time slot for receiving and for DH3 packet type, the EUT needs 3 times slots for transmitting and 1 time slot for receiving, and DH5 packet needs 5 times slots for transmitting and 1 time slot for receiving. So The EUT has each channel 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	0.378	10.13	31.60	121.00	400.00	PASS
DH3	1.638	5.06	31.60	261.83	400.00	
DH5	2.886	3.38	31.60	308.25	400.00	

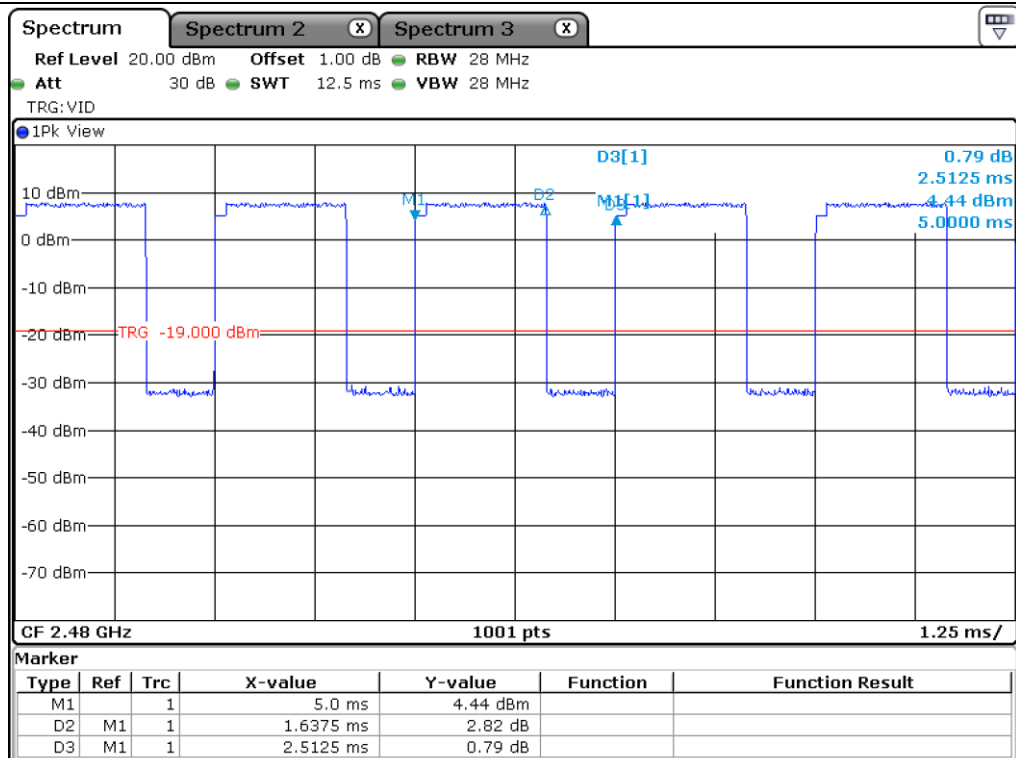
Total dwell time is calculated as following.

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

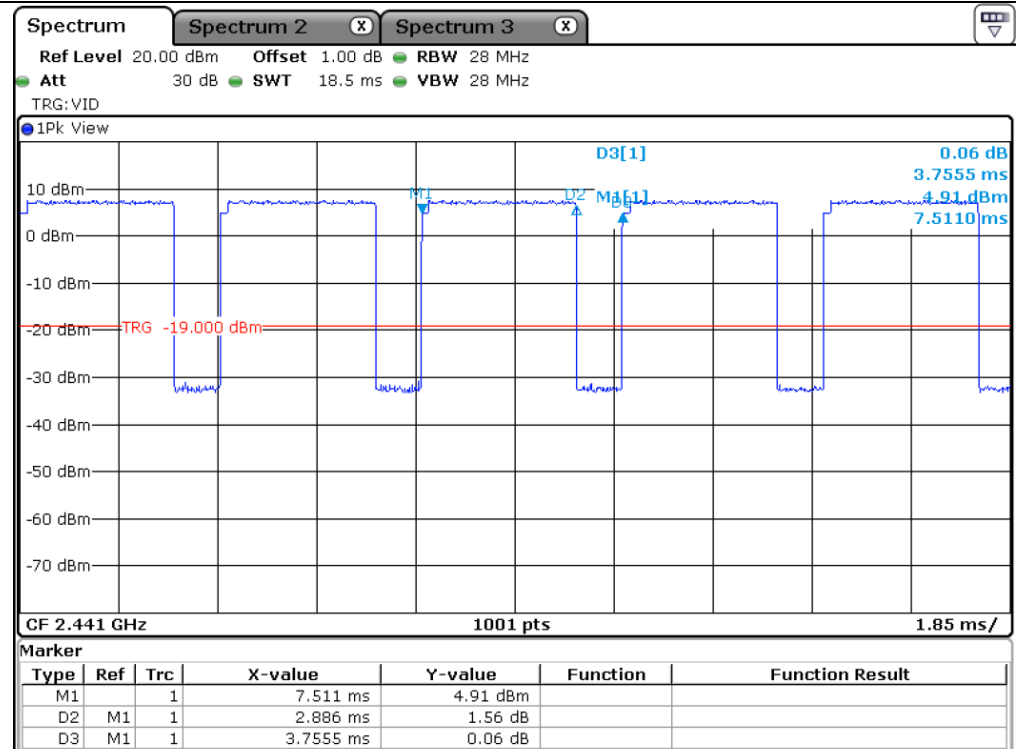
Remark: See next page for an overview sweep performed with peak detector.



DH1



DH3



DH5

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.

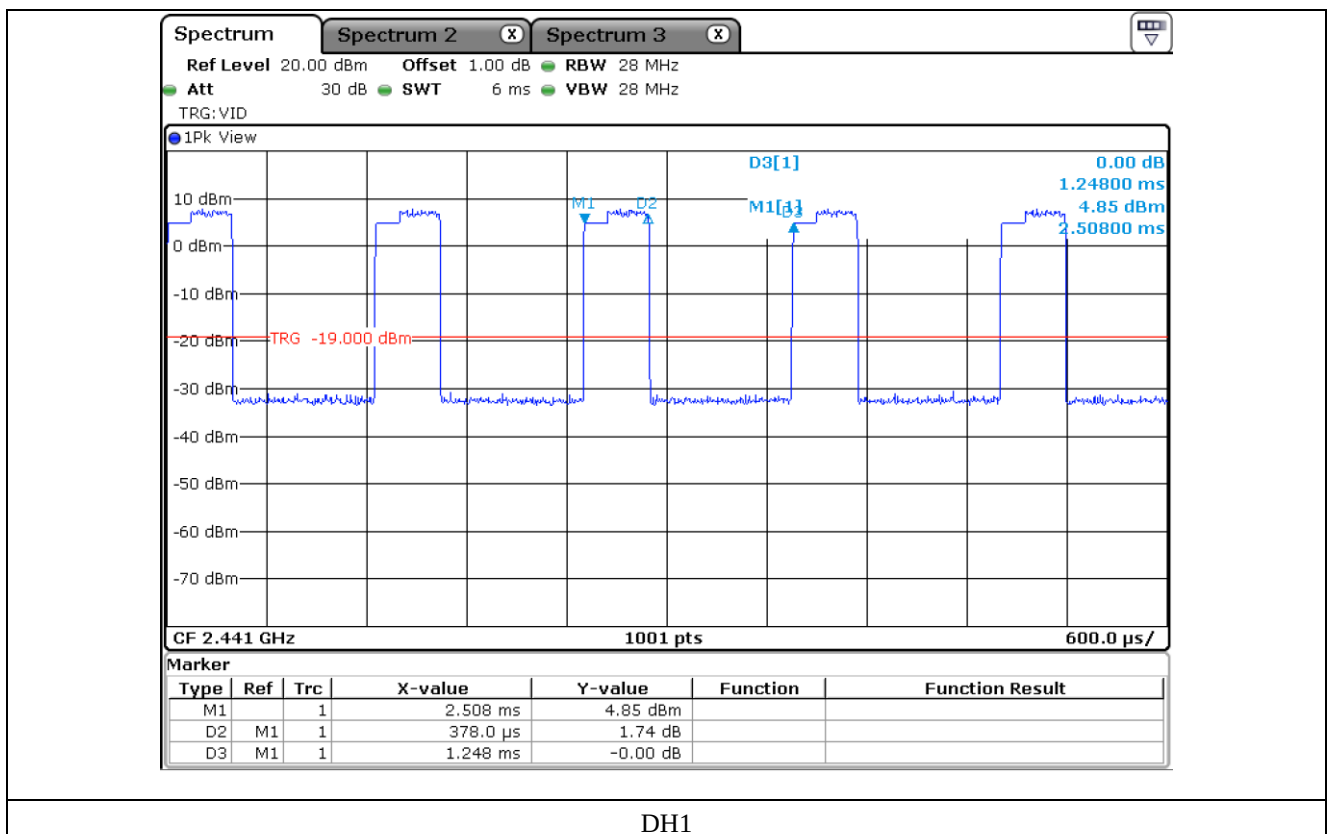
For DH1 packet type, the EUT needs 1 time slot for transmitting and 1 time slot for receiving and for DH3 packet type, the EUT needs 3 times slots for transmitting and 1 time slot for receiving, and DH5 packet needs 5 times slots for transmitting and 1 time slot for receiving. So The EUT has each channel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

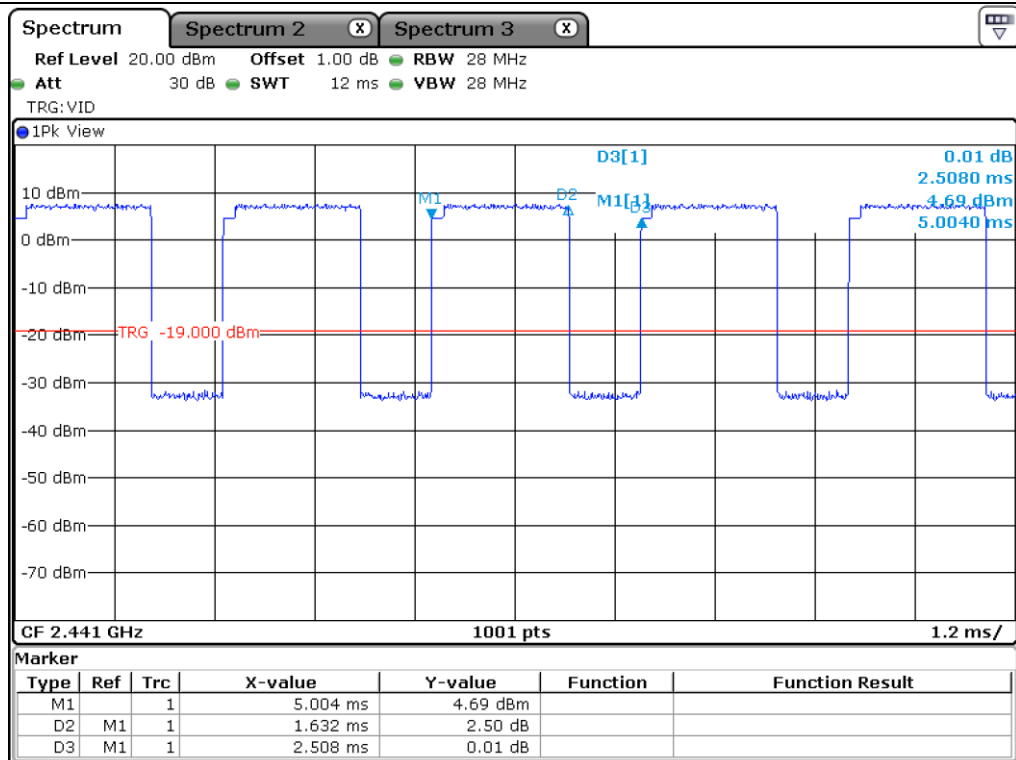
Packet Type	Pulse Time (ms)	Hops per second with channels	Period Time (ms)	Total Dwell Time (ms)	Limit (ms)	Test Result
DH1	0.378	10.13	31.60	121.00	400.00	PASS
DH3	1.632	5.06	31.60	260.95	400.00	
DH5	2.883	3.38	31.60	307.93	400.00	

Total dwell time is calculated as following.

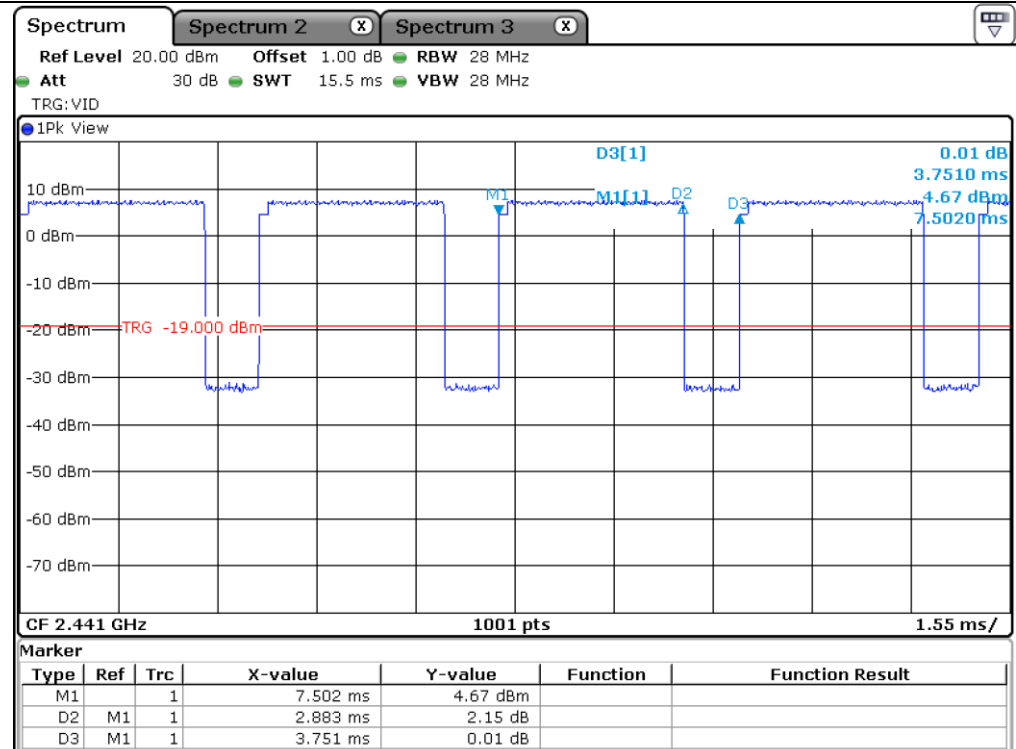
Total Dwell Time = Pulse time * Hops per second with channels * period time

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





DH3



DH5

11. MAXIMUM PEAK OUTPUT POWER

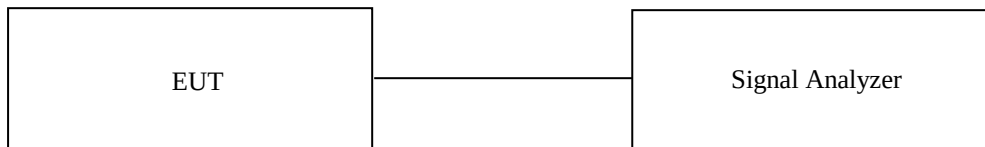
11.1 Operating environment

Temperature : 23 °C
Relative humidity : 48 % 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

June 14, 2022 ~ June 20, 2022

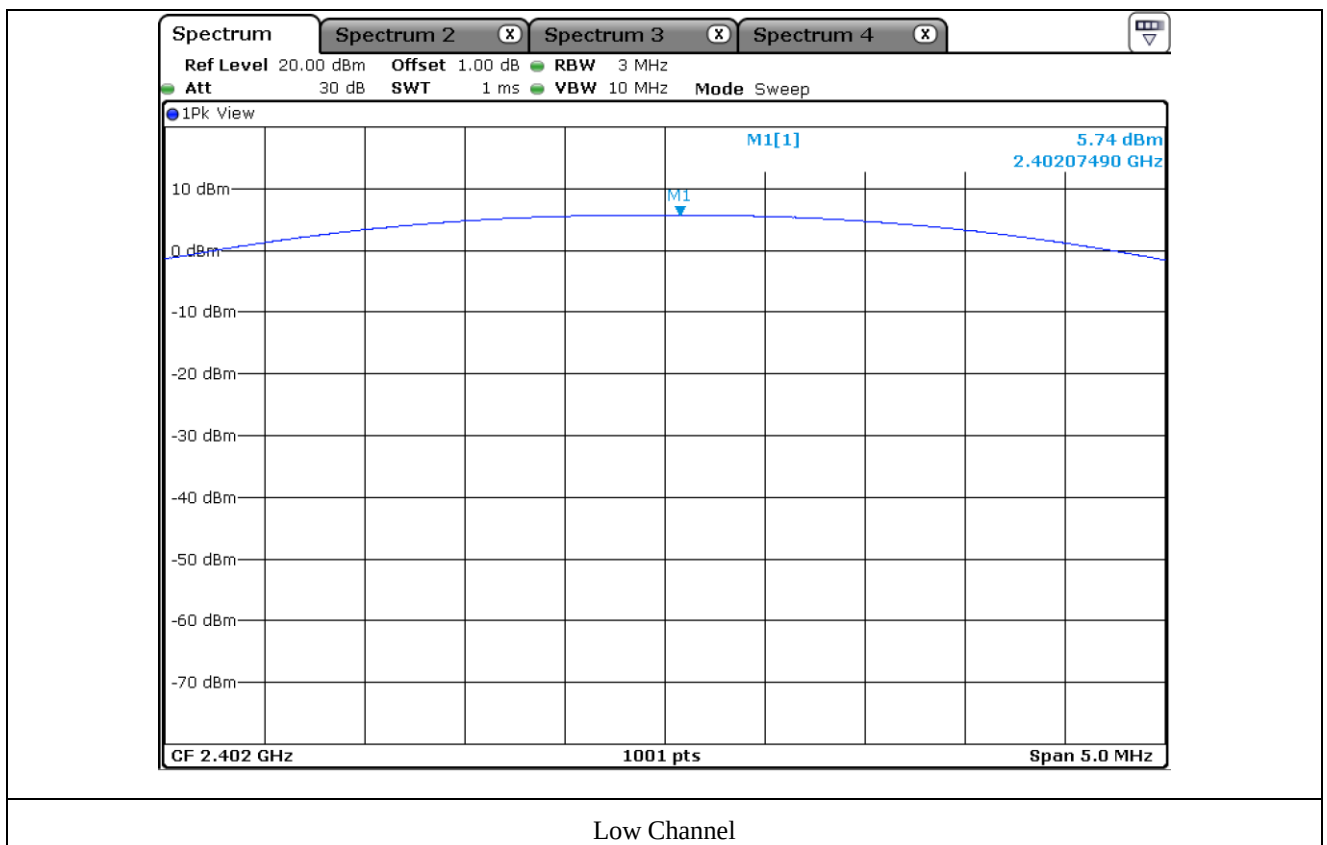
11.4 Test Data

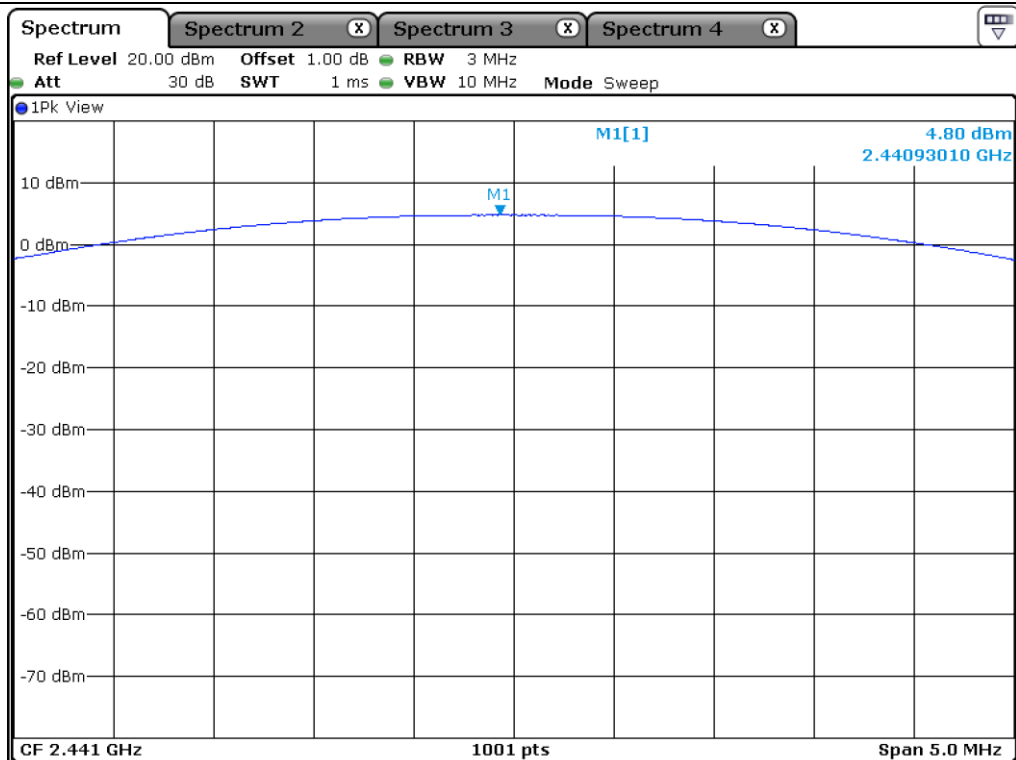
11.4.1 Test data for 1 Mbps

-. Test Result : Pass

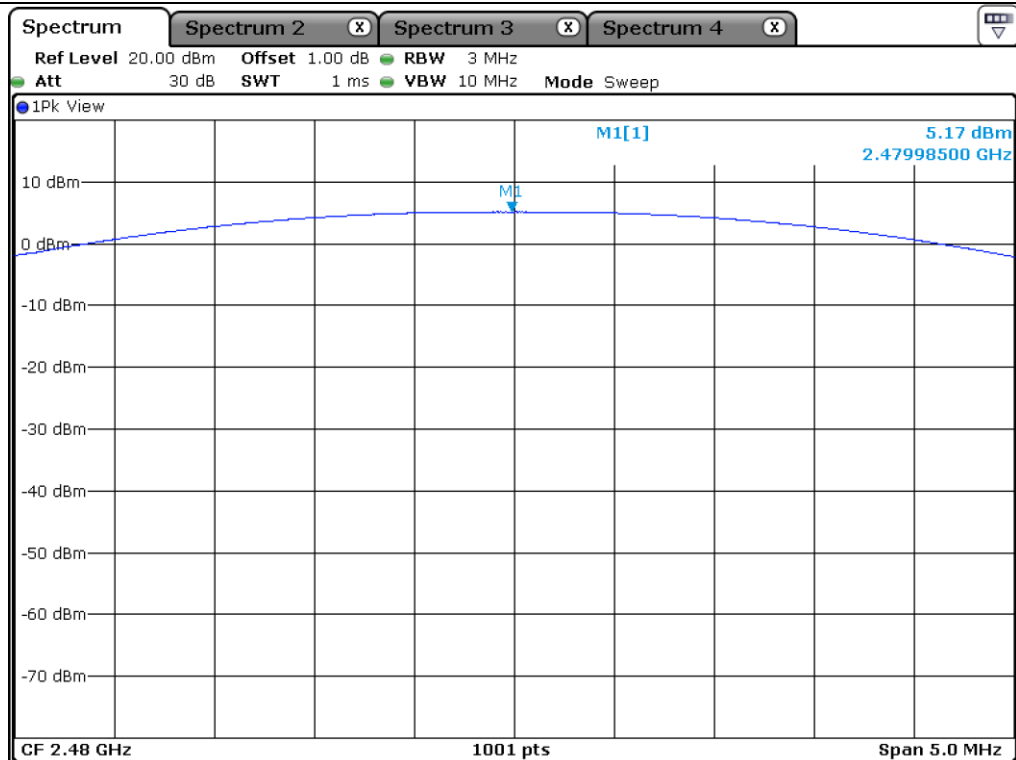
Channel	Frequency (MHz)	Measured Value (dBm)	Limit (dBm)	Margin (dB)
Low	2 402.00	5.74	21.00	15.26
Middle	2 441.00	4.80	21.00	16.20
High	2 480.00	5.17	21.00	15.83

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





Middle Channel



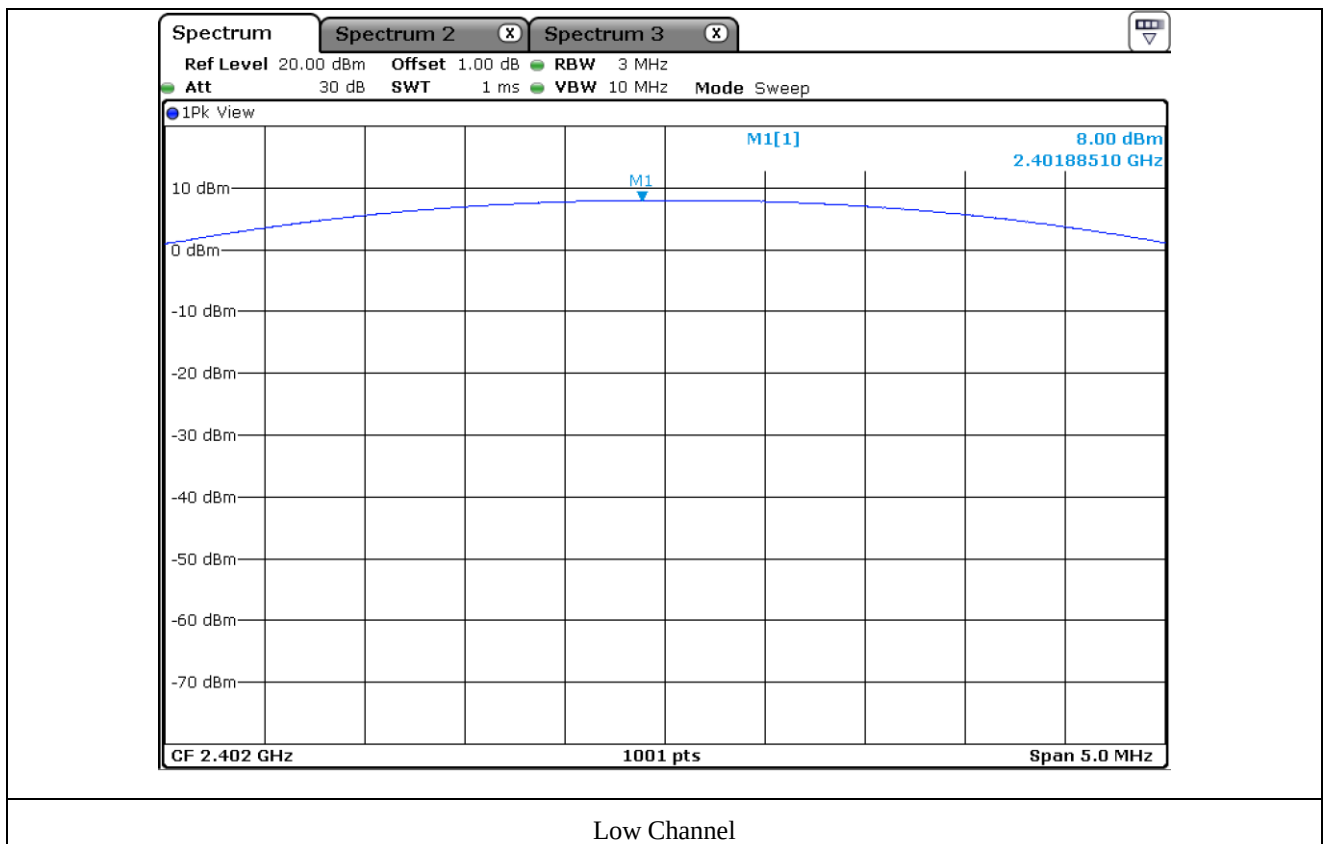
High Channel

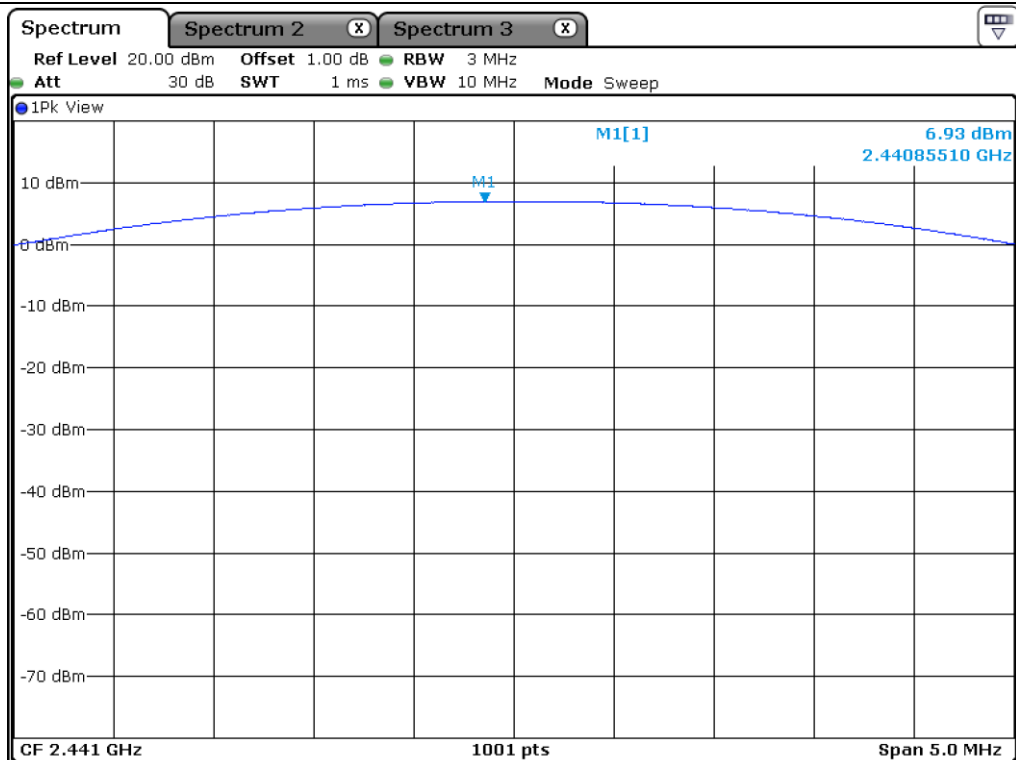
11.4.2 Test data for 2 Mbps

-. Test Result : Pass

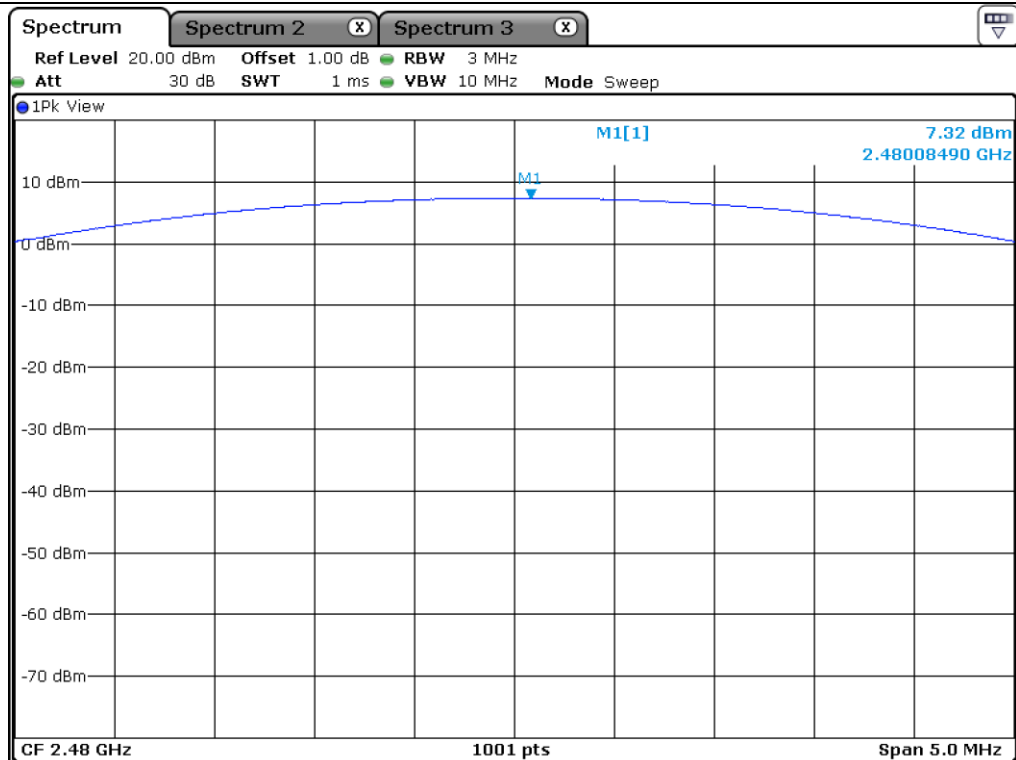
Channel	Frequency (MHz)	Measured Value (dBm)	Limit (dBm)	Margin (dB)
Low	2 402.00	8.00	21.00	13.00
Middle	2 441.00	6.93	21.00	14.07
High	2 480.00	7.32	21.00	13.68

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





Middle Channel



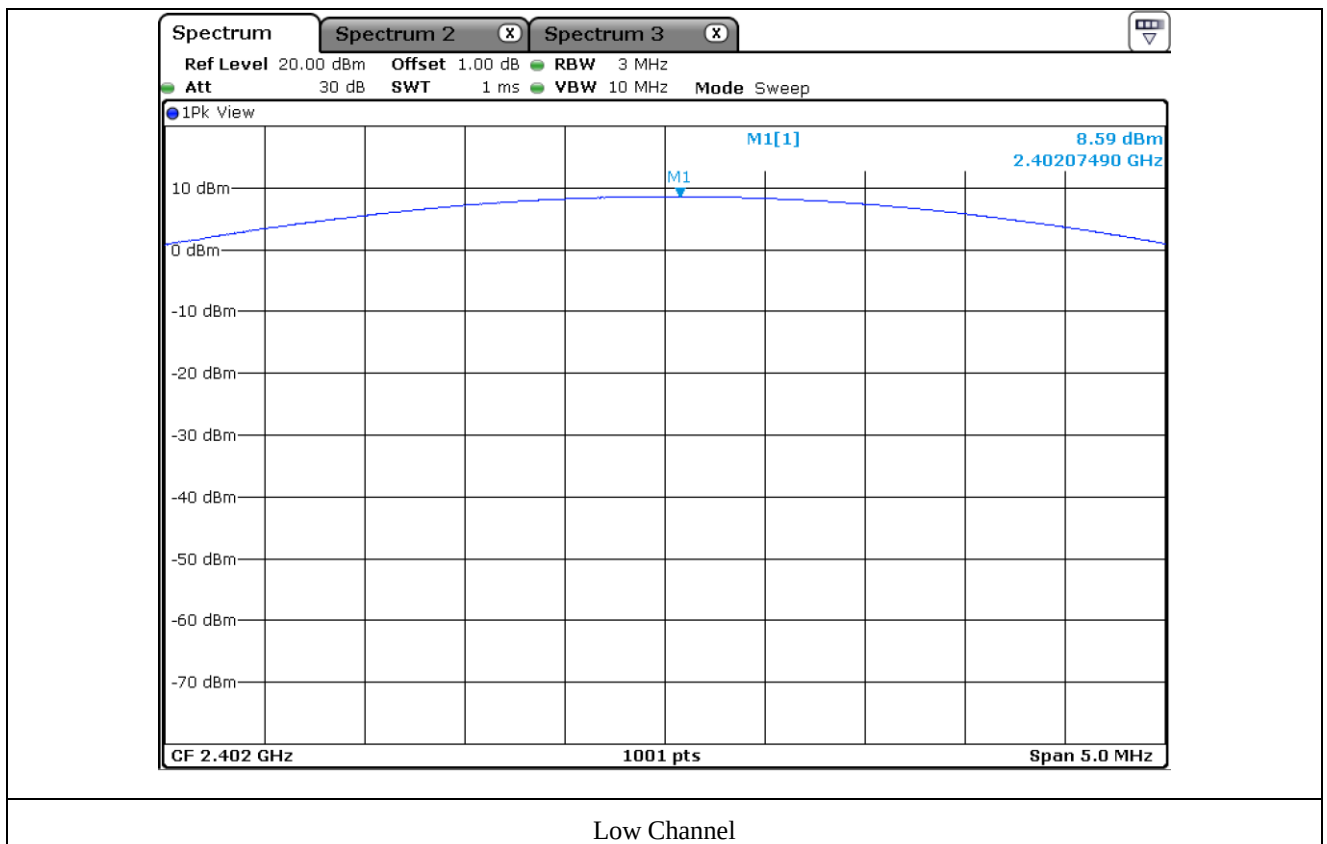
High Channel

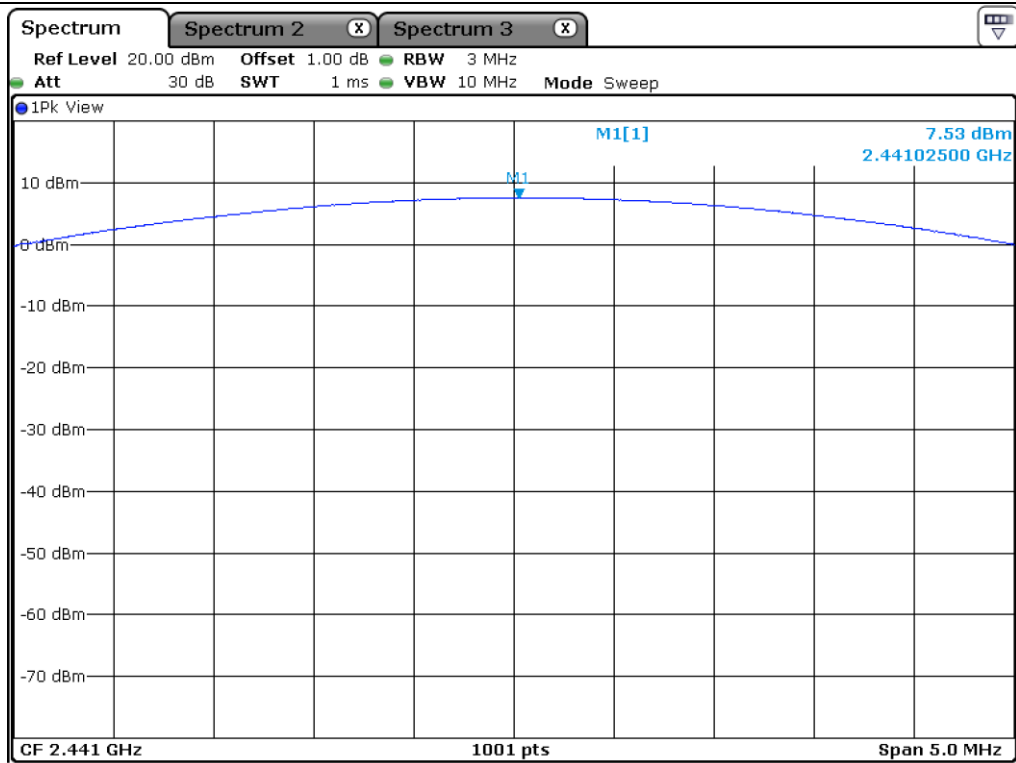
11.4.3 Test data for 3 Mbps

-. Test Result : Pass

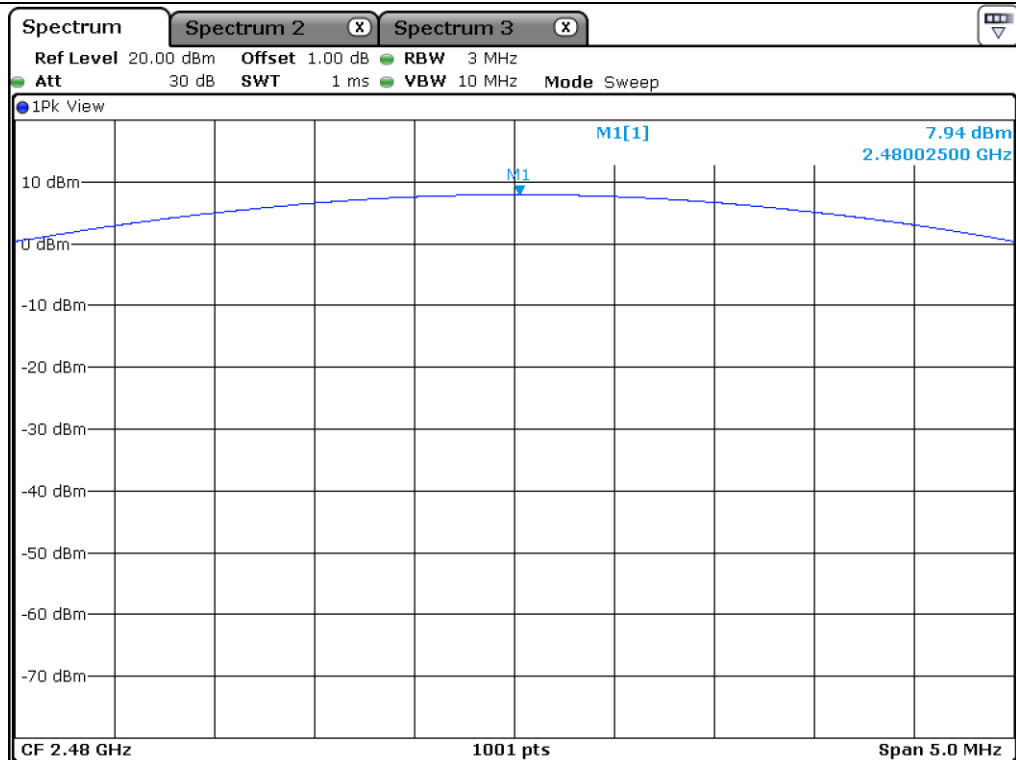
Channel	Frequency (MHz)	Measured Value (dBm)	Limit (dBm)	Margin (dB)
Low	2 402.00	8.59	21.00	12.41
Middle	2 441.00	7.53	21.00	13.47
High	2 480.00	7.94	21.00	13.03

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





Middle Channel



High Channel

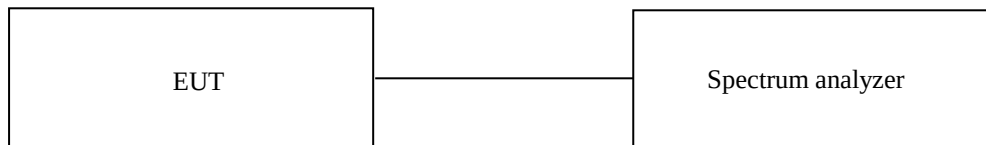
12. 100 kHz BANDWIDTH OUTSIDE THE FREQUENCY BAND

12.1 Operating environment

Temperature : 23 °C
Relative humidity : 48 % 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.

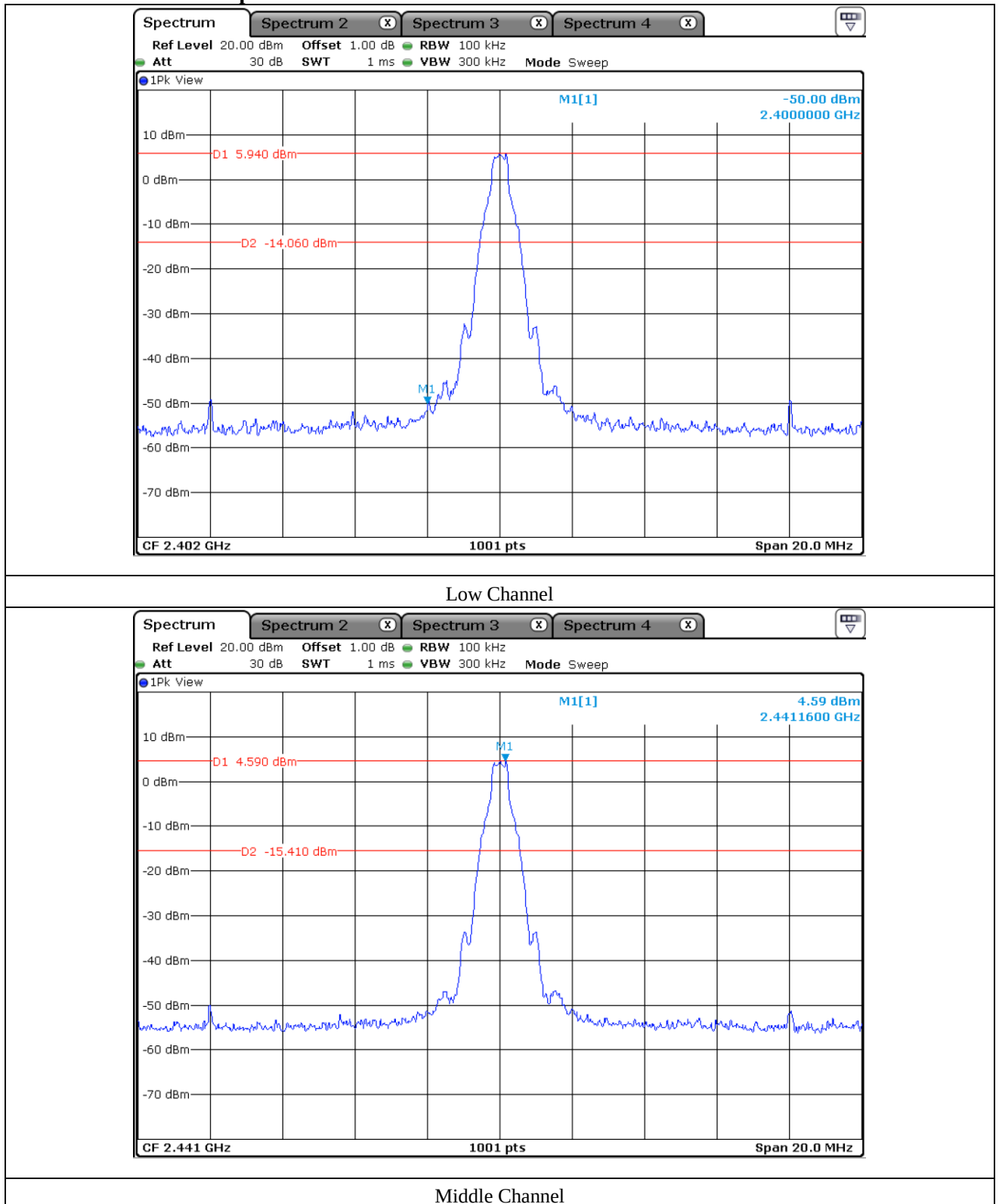
The frequency spectrum from 30 MHz to 26.5 GHz was scanned and maximum emission levels at each frequency recorded. The system was rotated 360°, and the antenna was varied in the height between 1.0 m and 4.0 m in order to determine the maximum emission levels. This procedure was performed for horizontal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

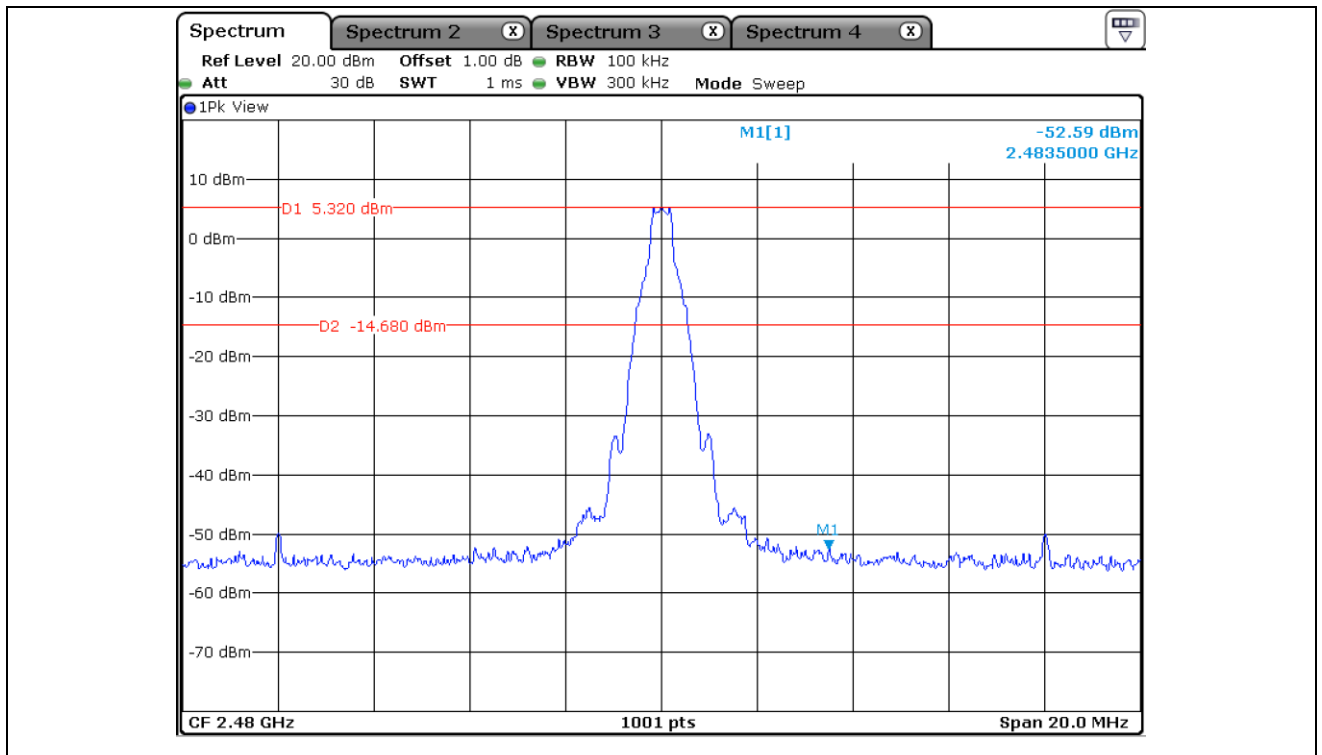
12.4 Test Date

June 14, 2022 ~ June 20, 2022

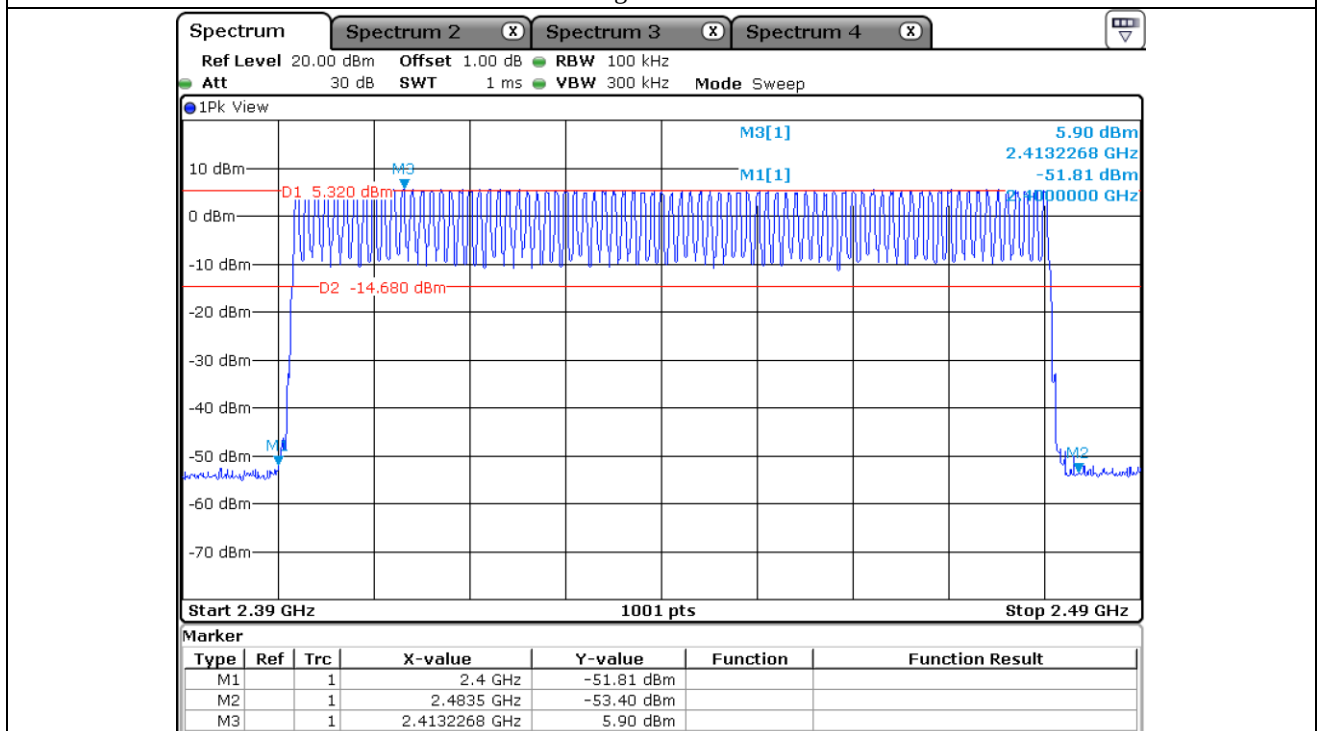
12.5 Test data for conducted emission

12.5.1 Test data for 1 Mbps

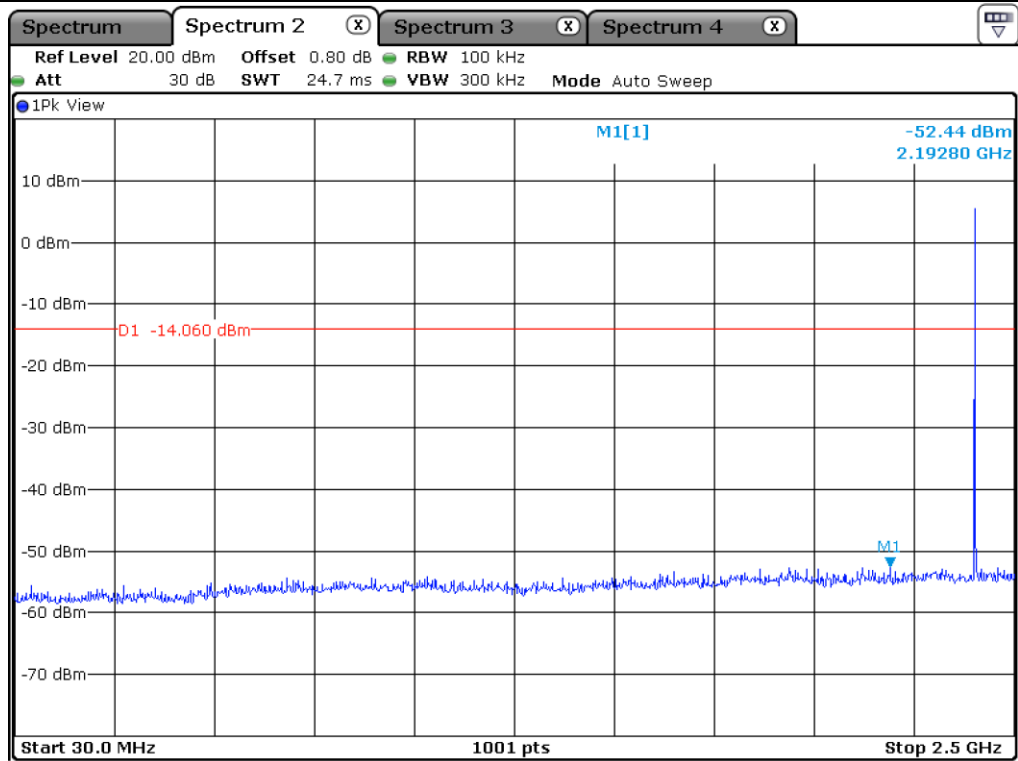




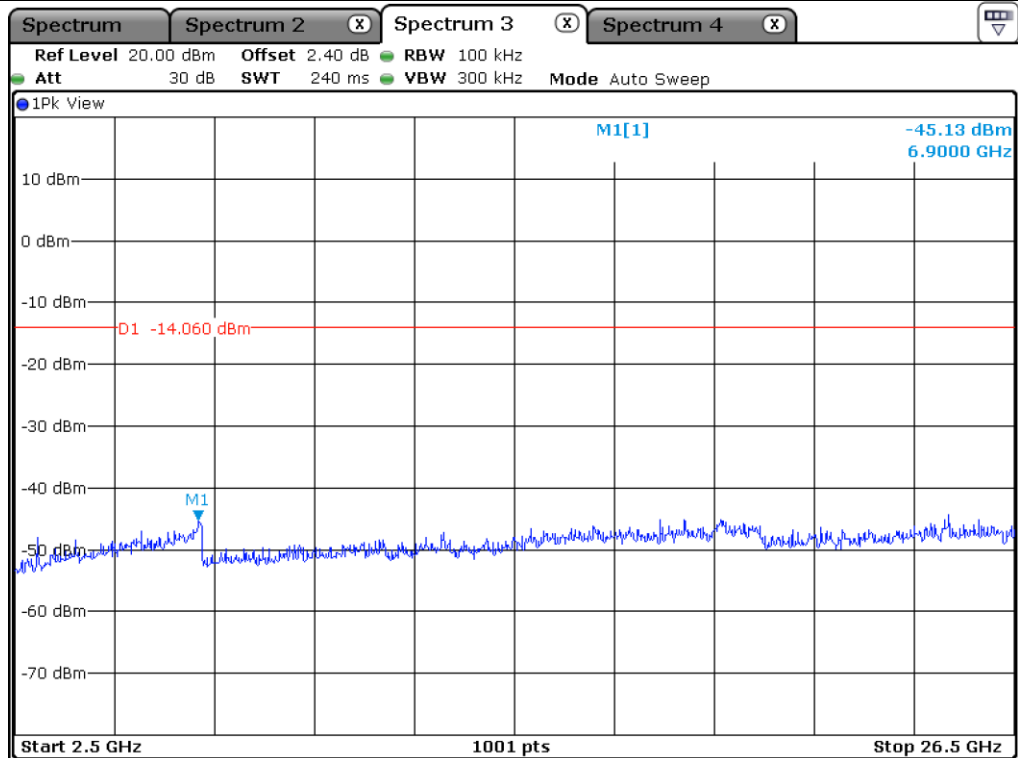
High Channel



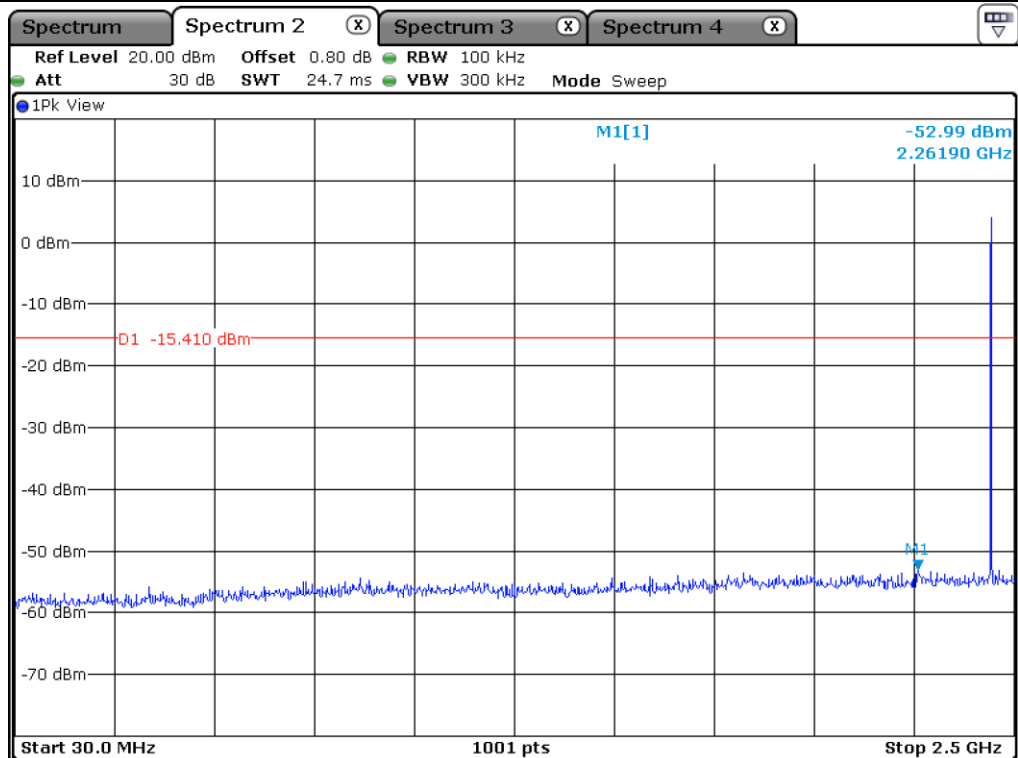
Hopping Mode



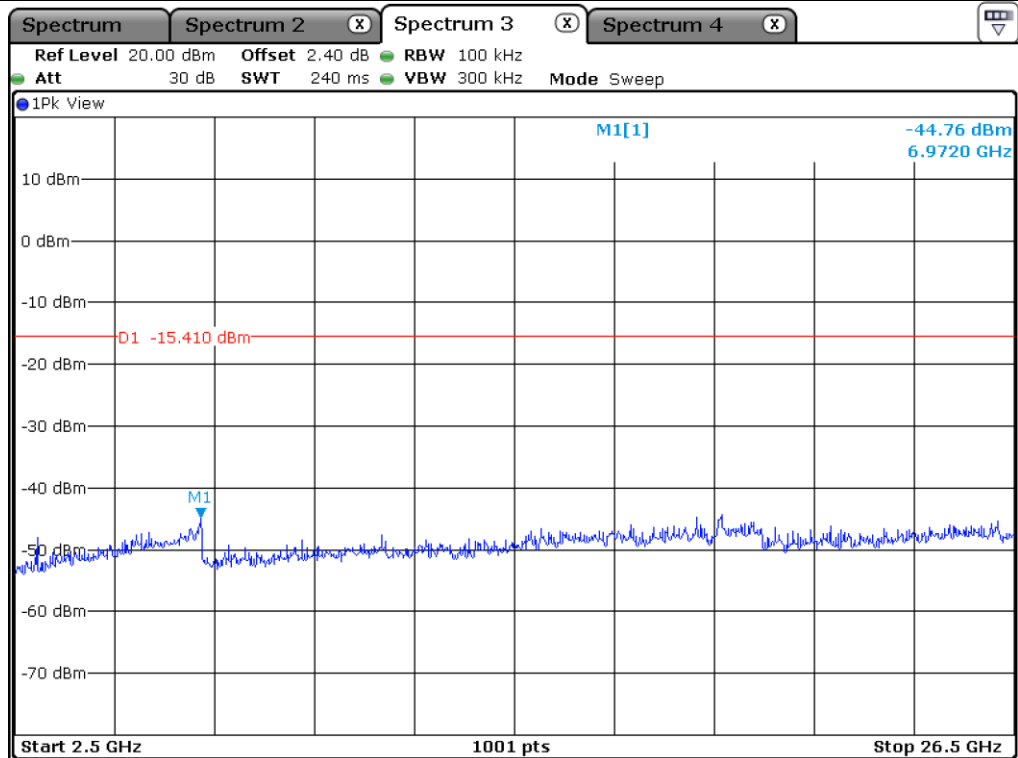
Low Channel



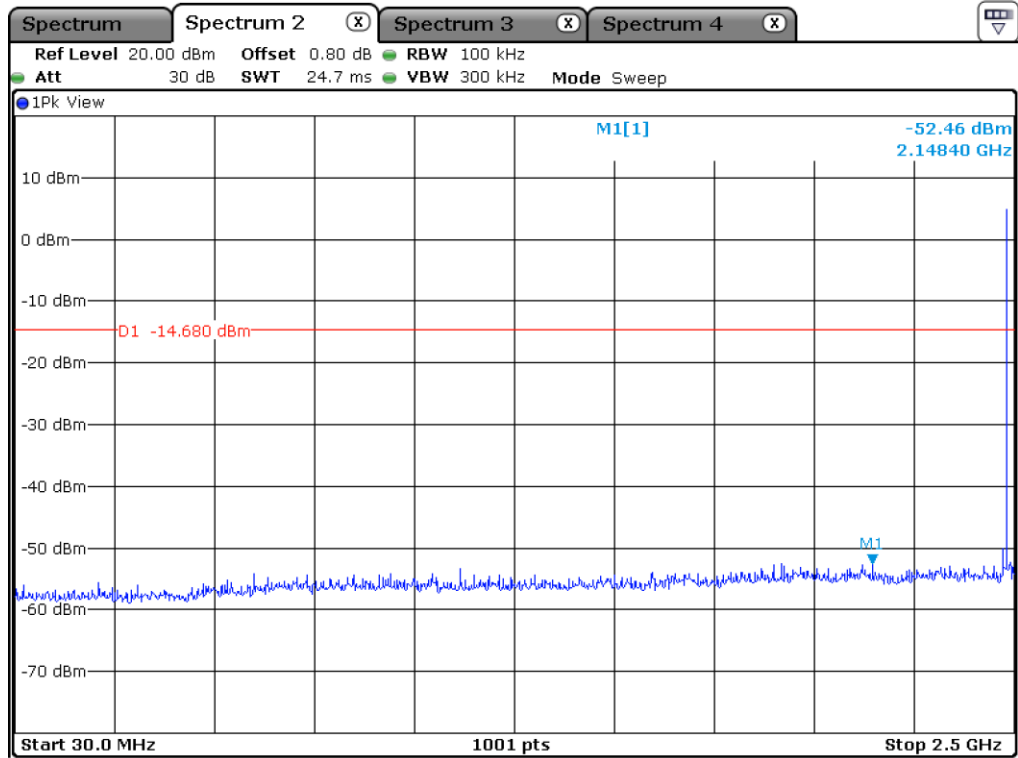
Low Channel



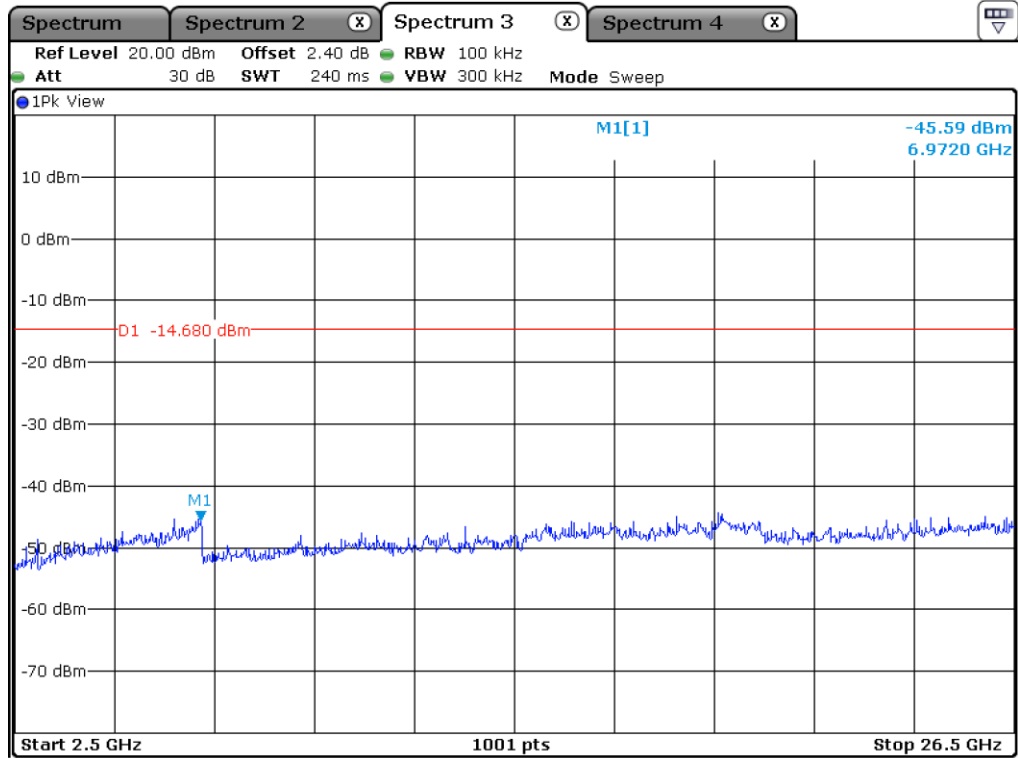
Middle Channel



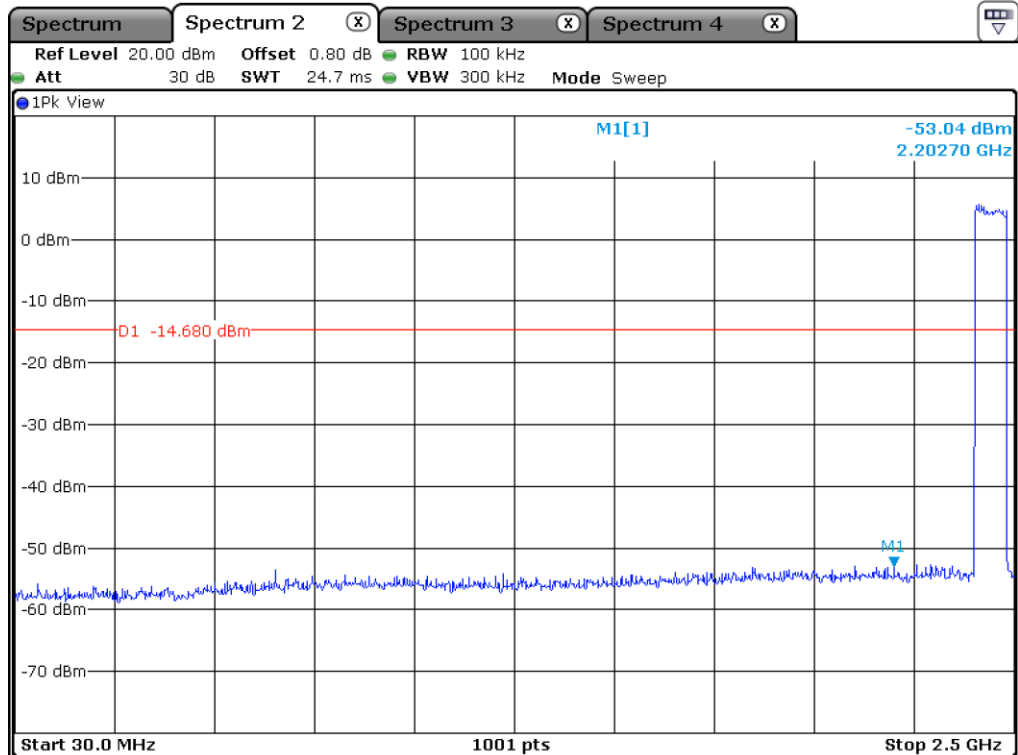
Middle Channel



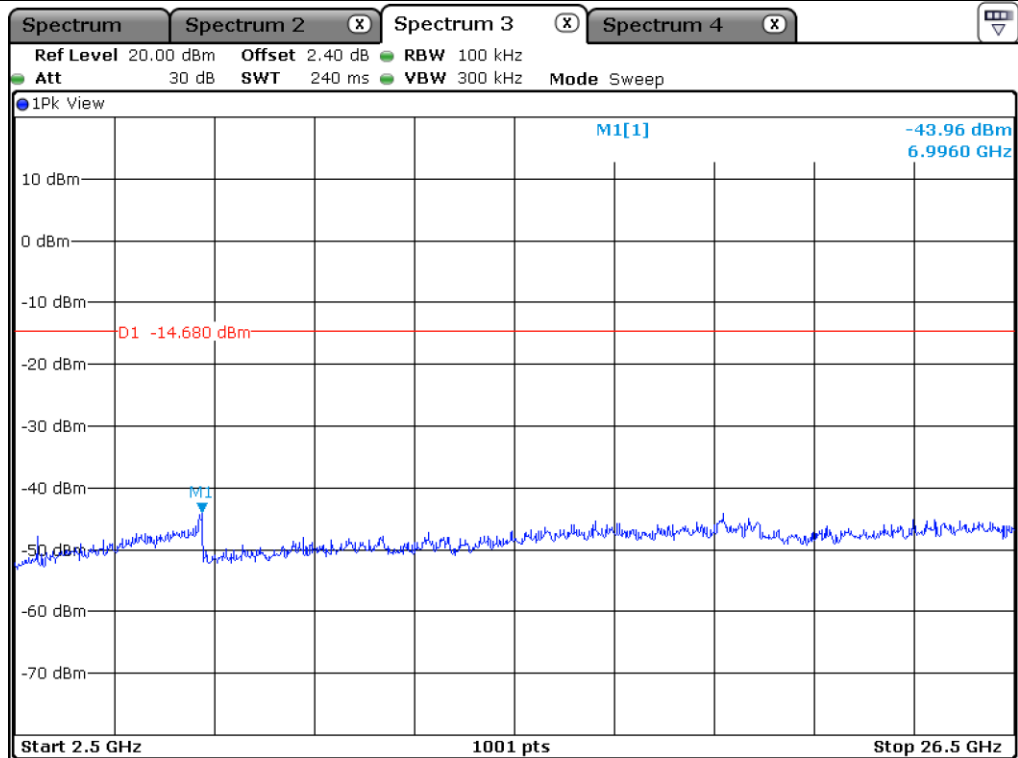
High Channel



High Channel

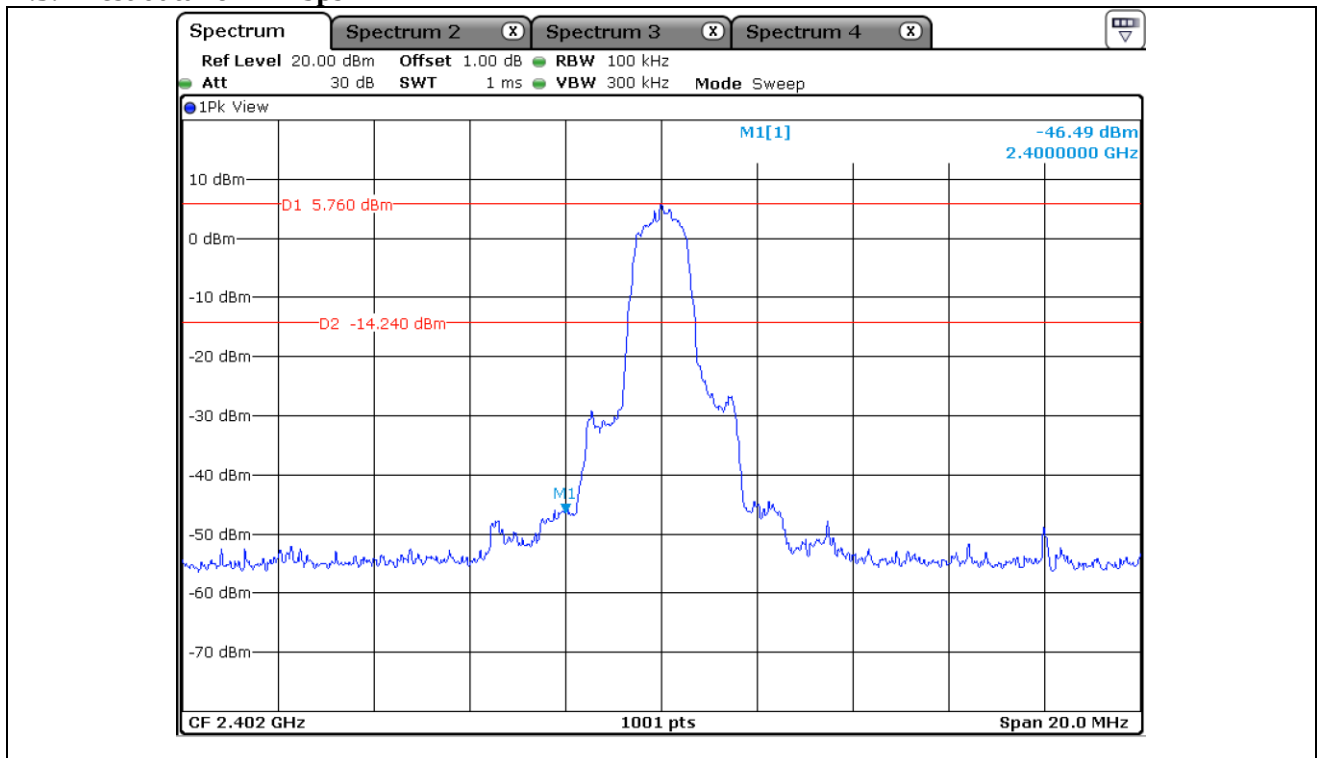


Hopping Mode

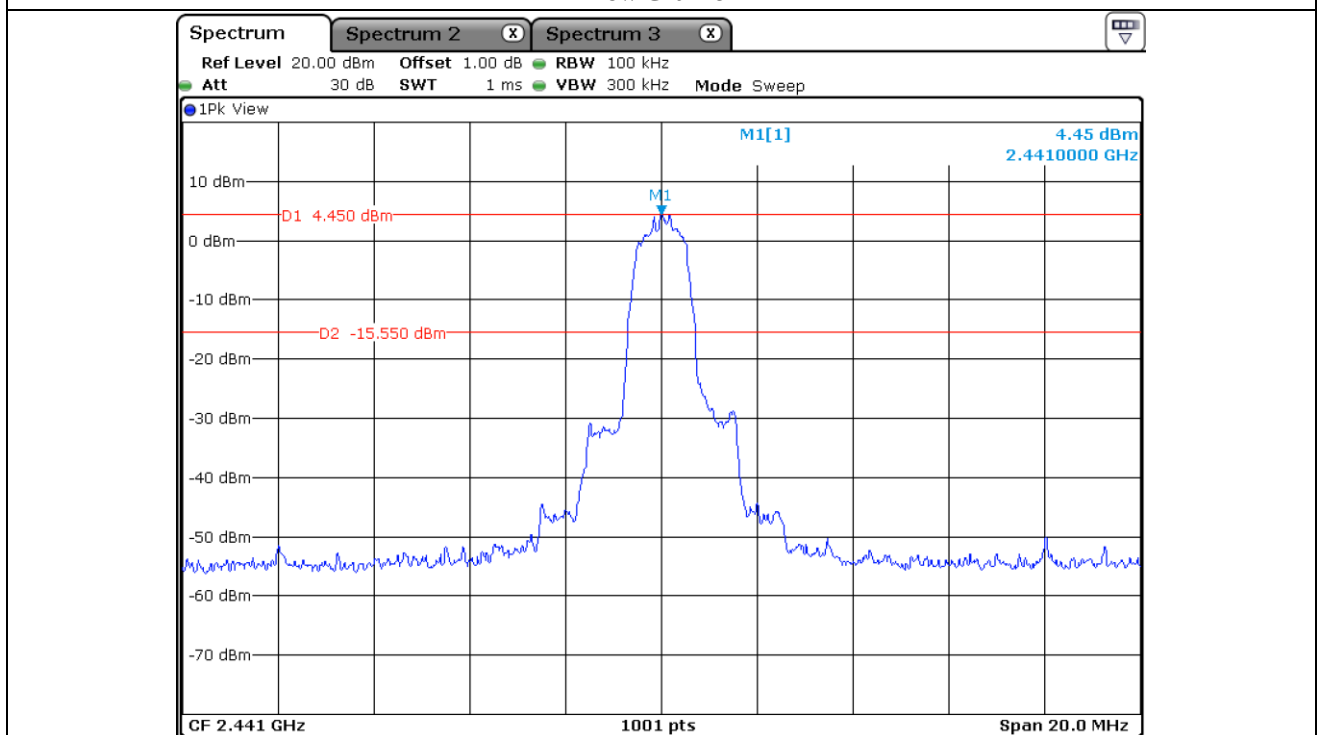


Hopping Mode

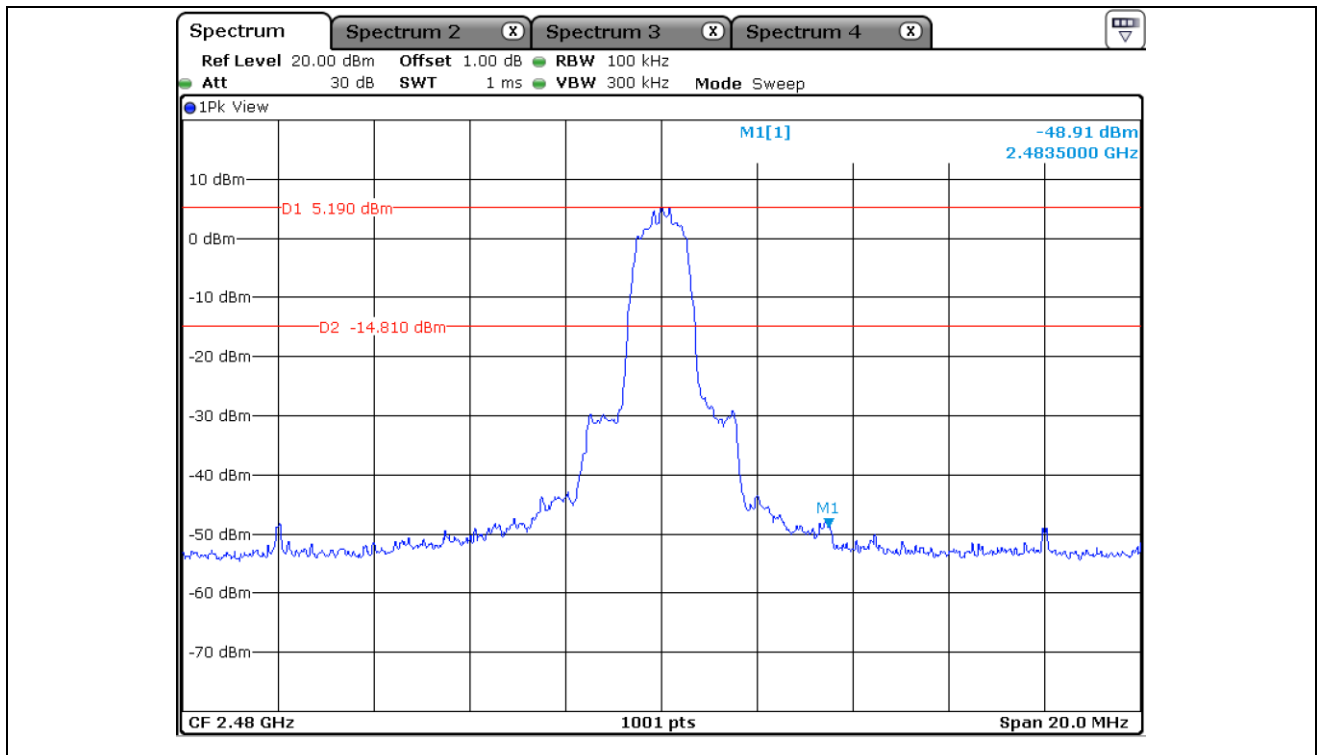
12.5.2 Test data for 2 Mbps



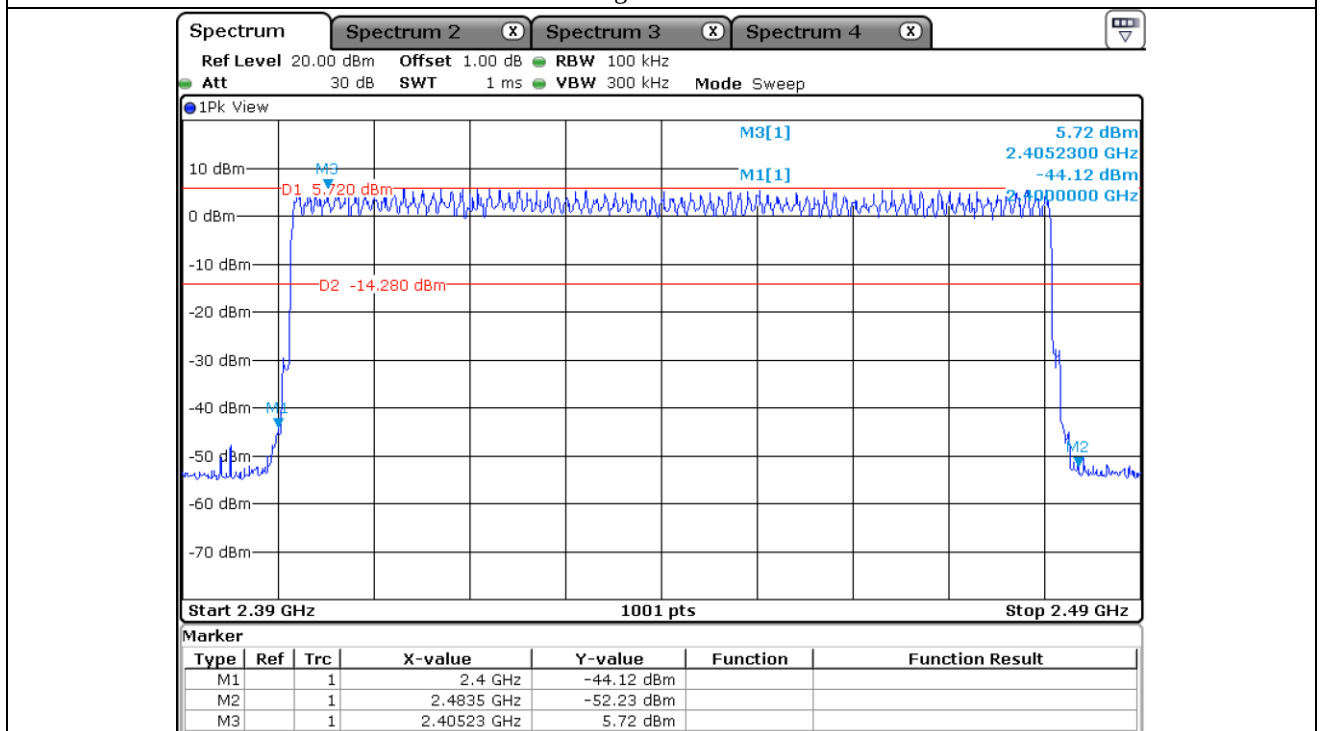
Low Channel



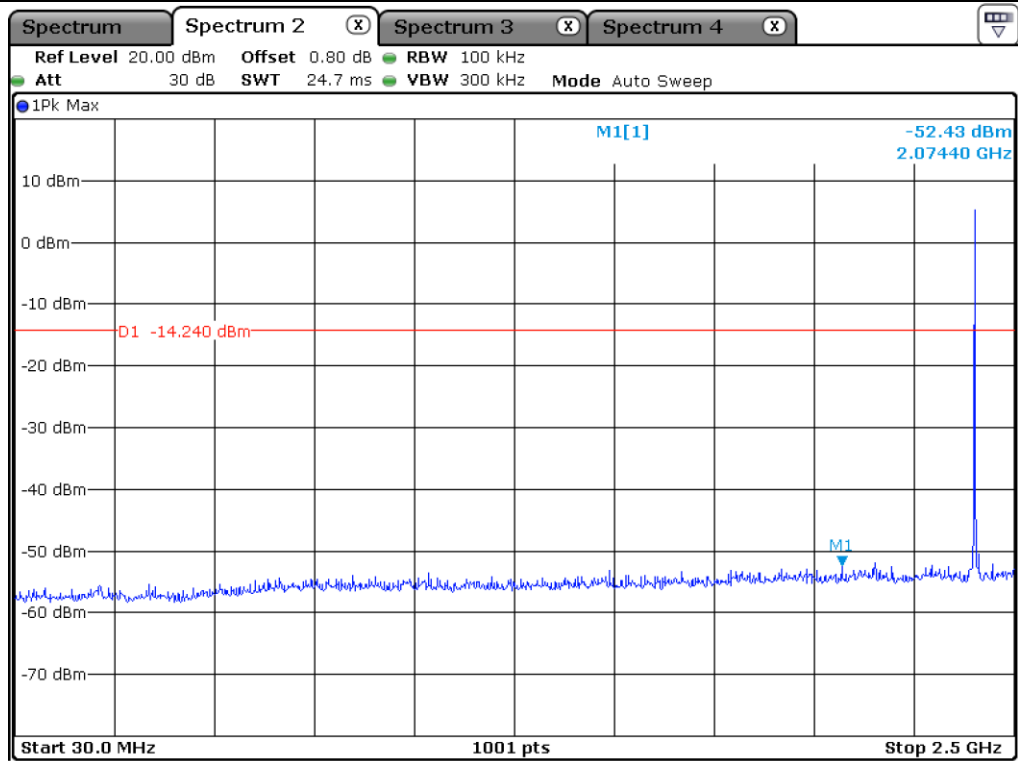
Middle Channel



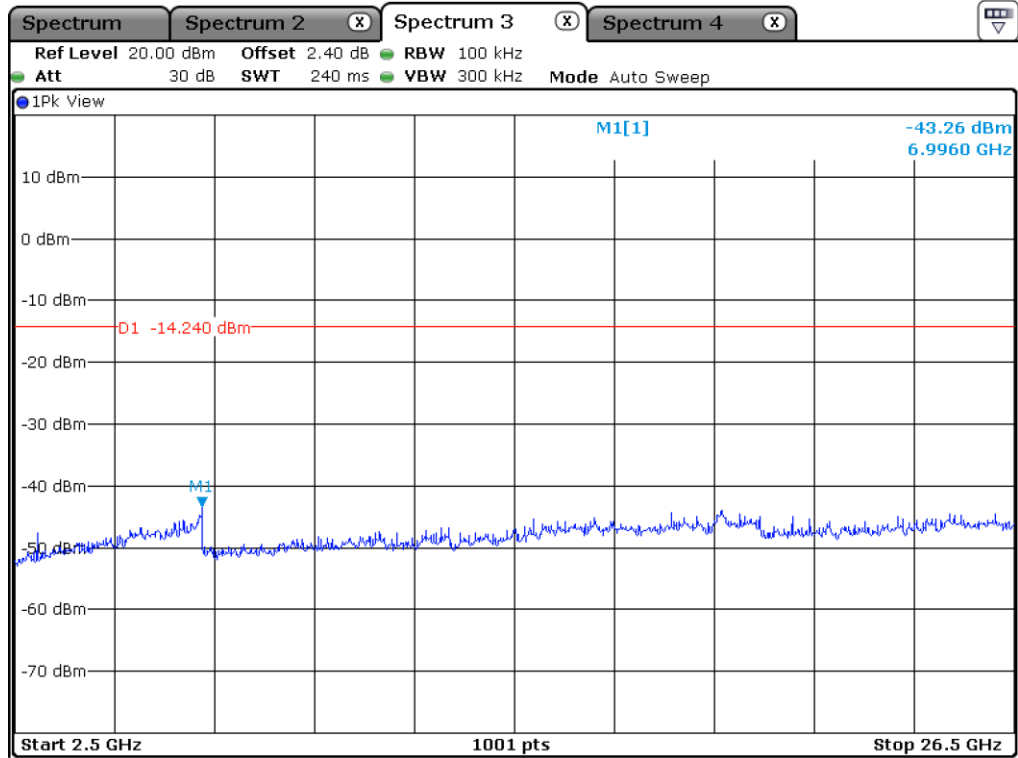
High Channel



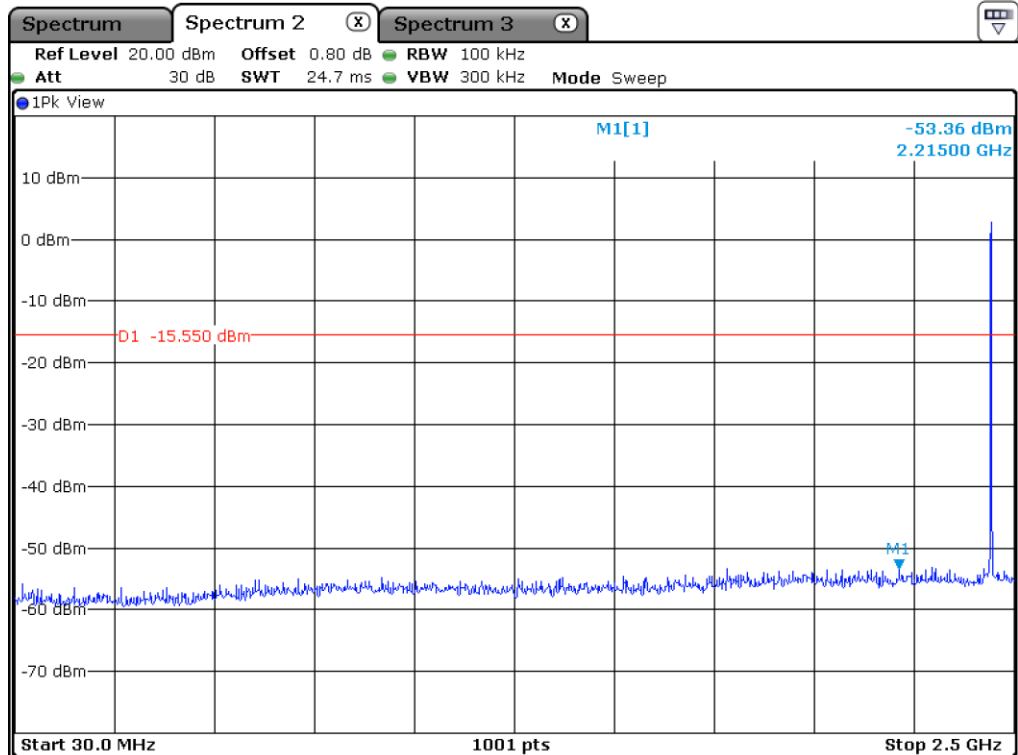
Hopping Mode



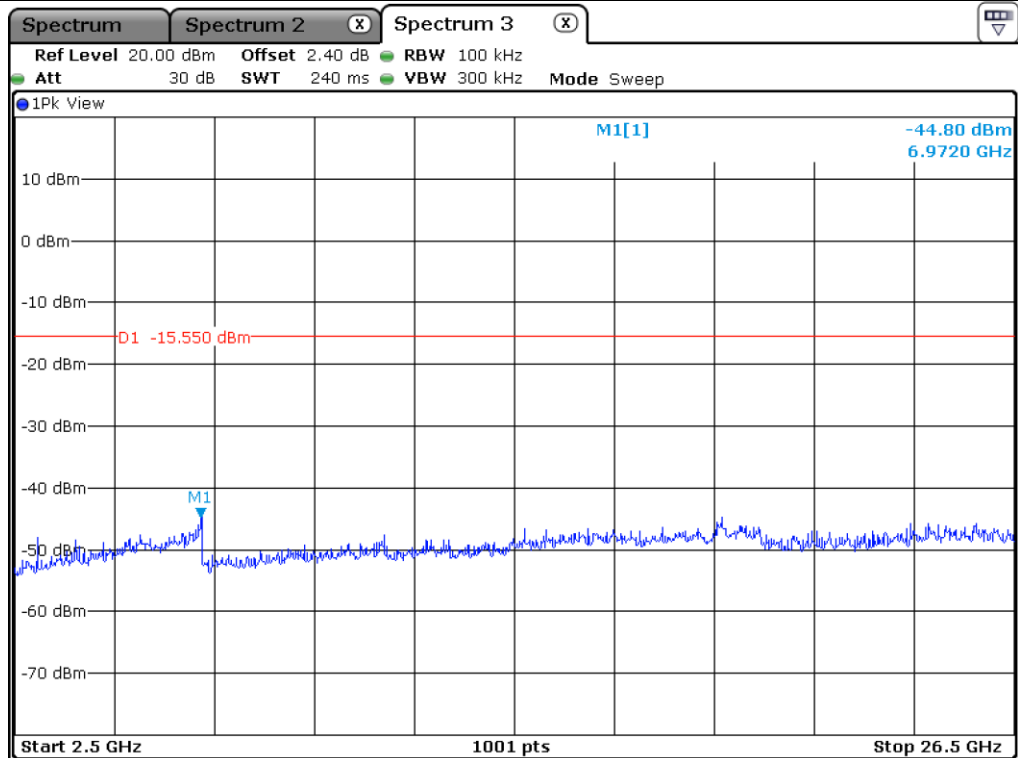
Low Channel



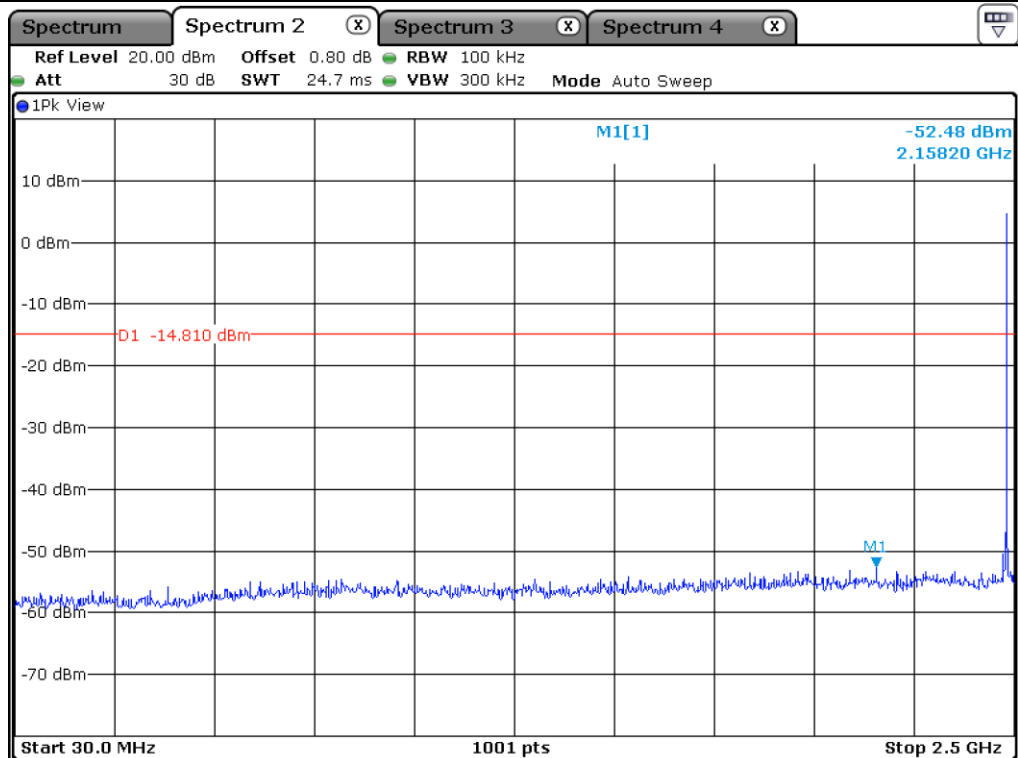
Low Channel



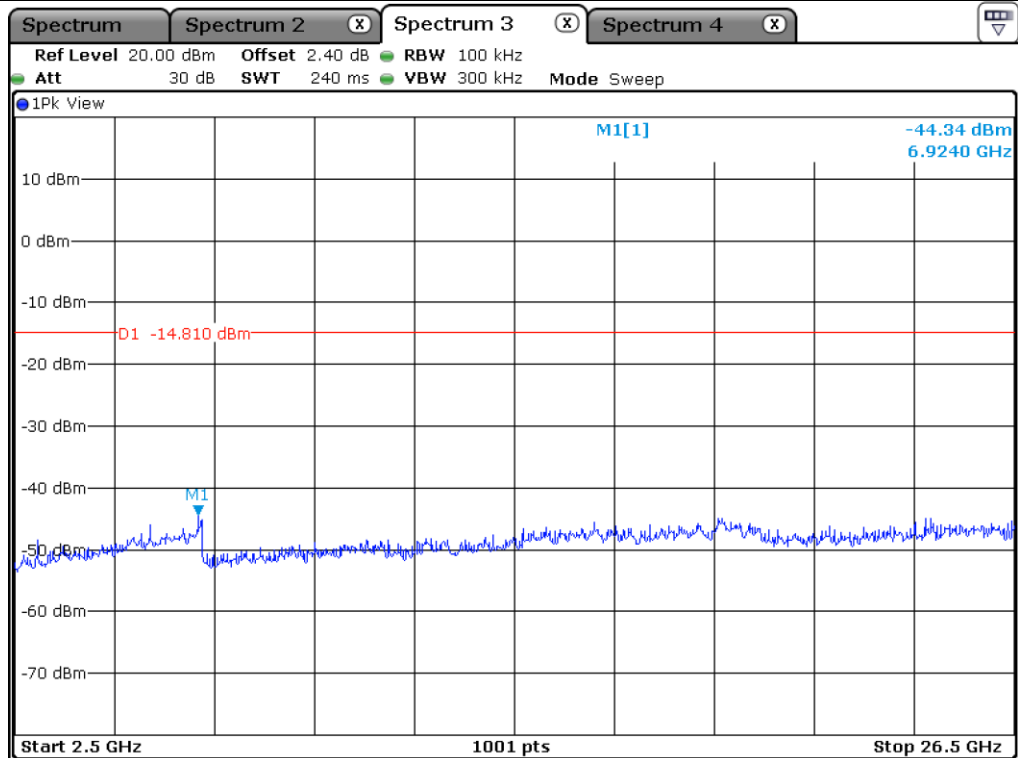
Middle Channel



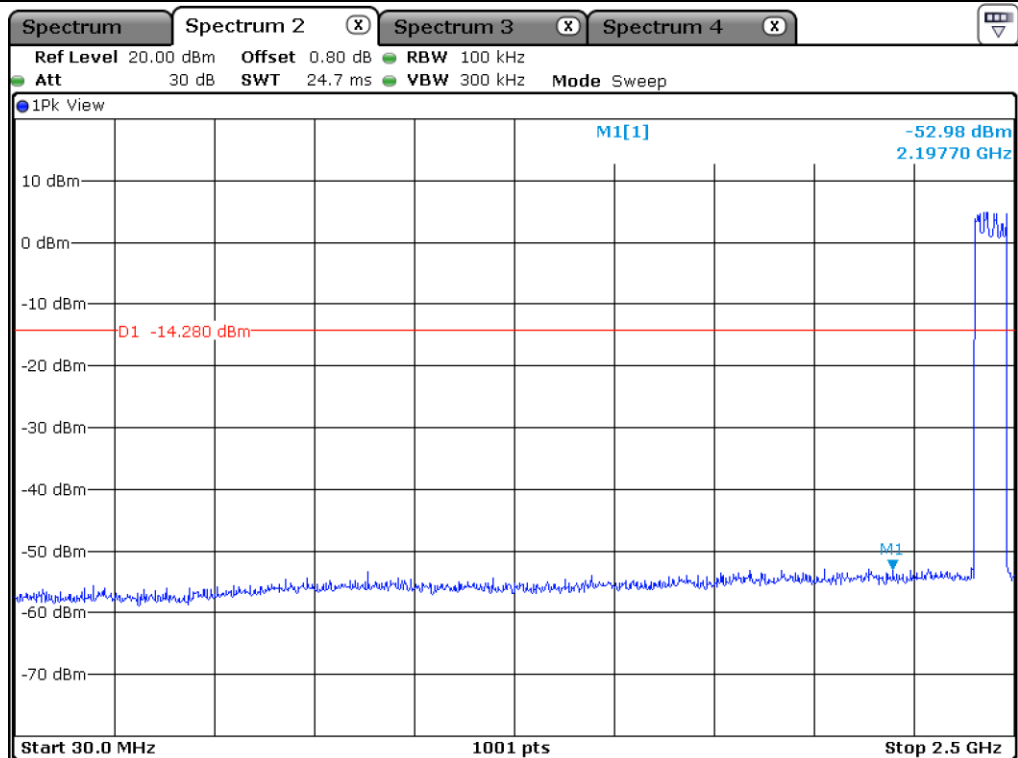
Middle Channel



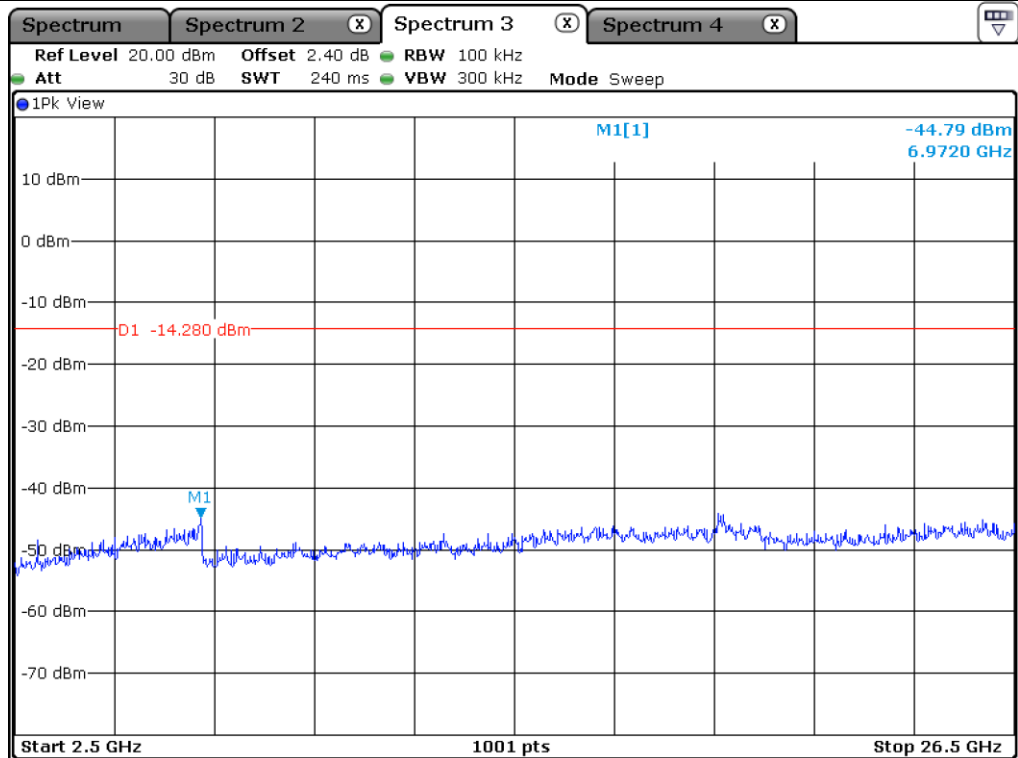
High Channel



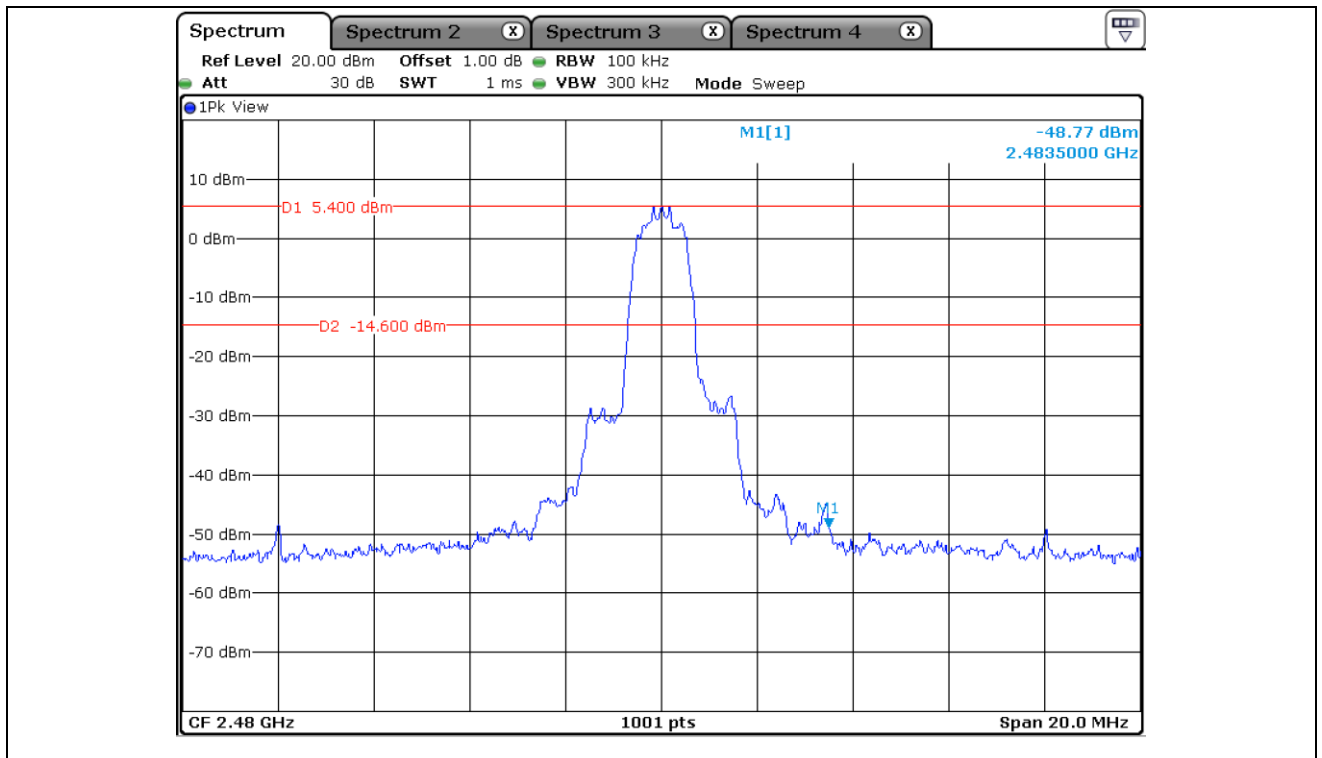
High Channel



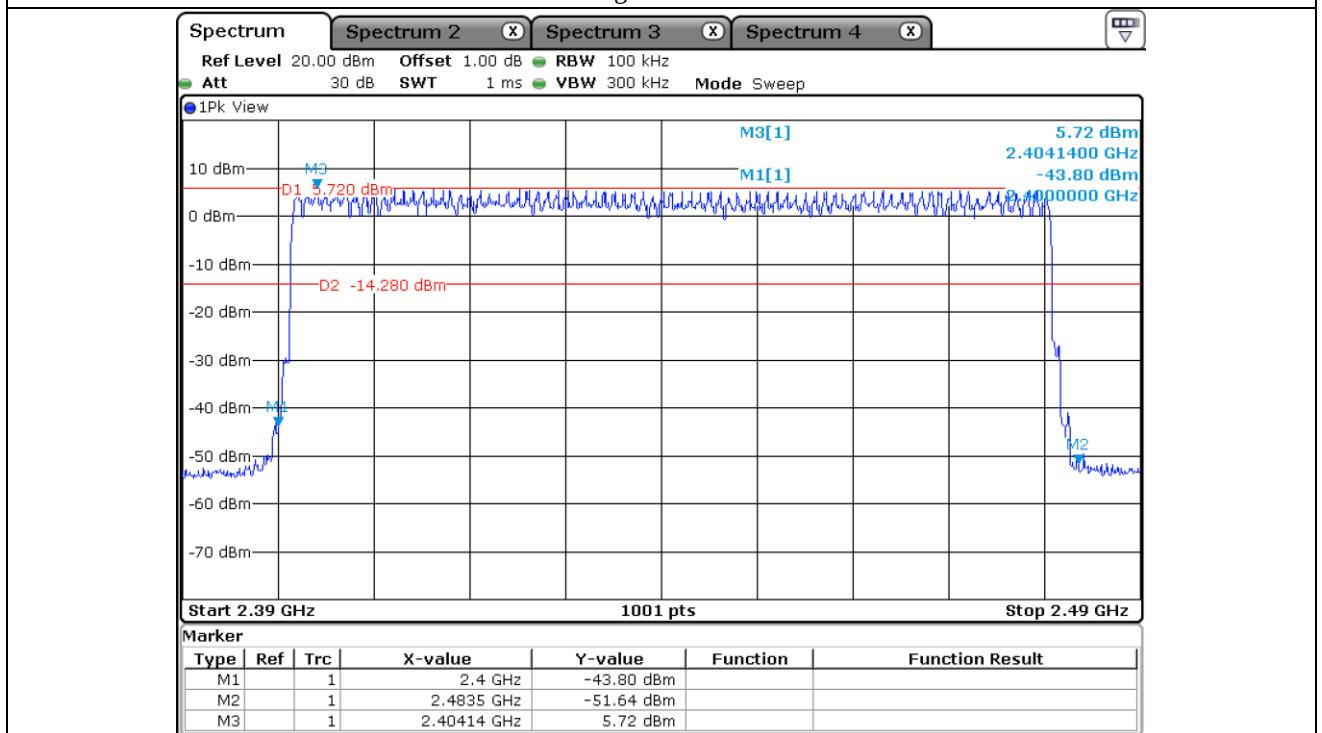
Hopping Mode



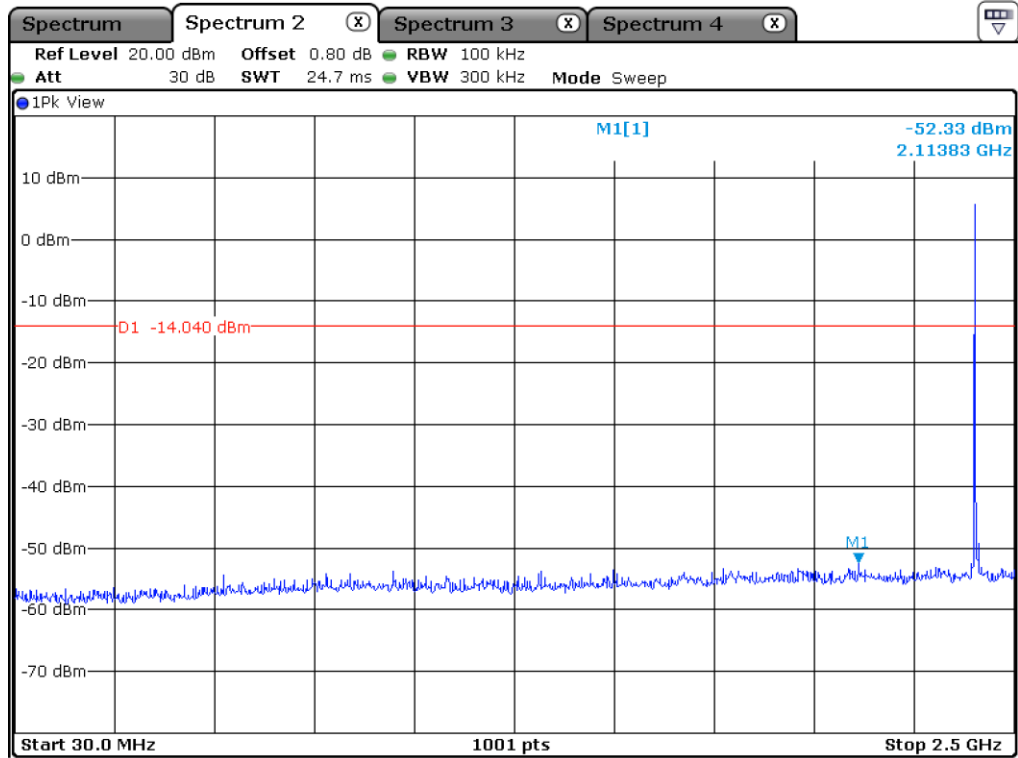
Hopping Mode



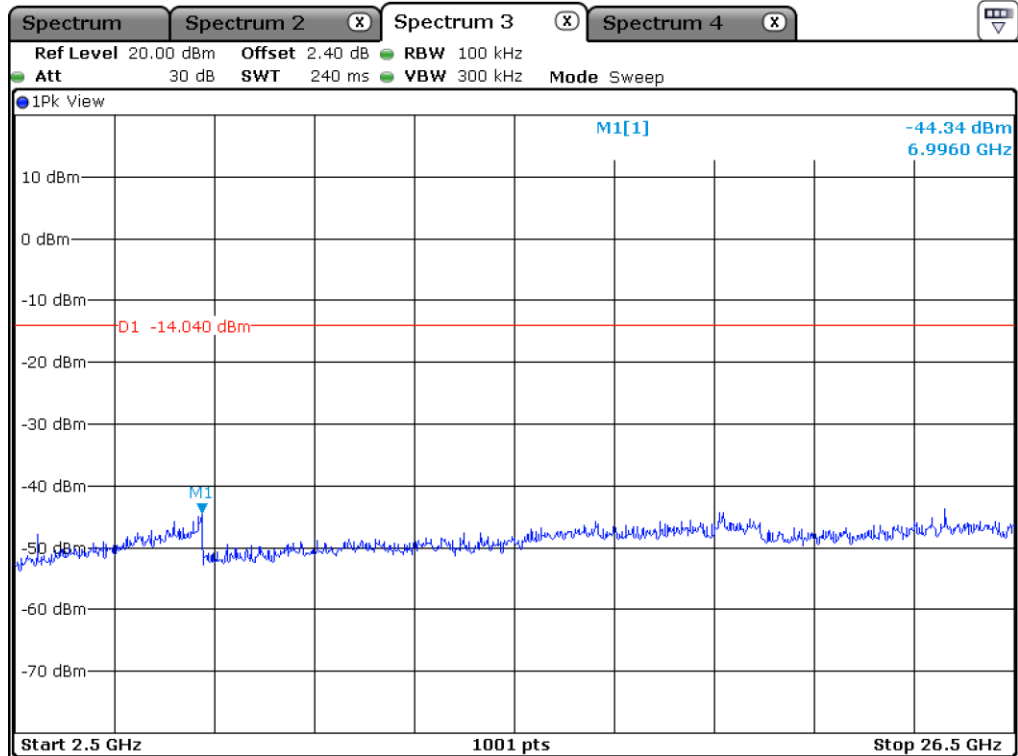
High Channel



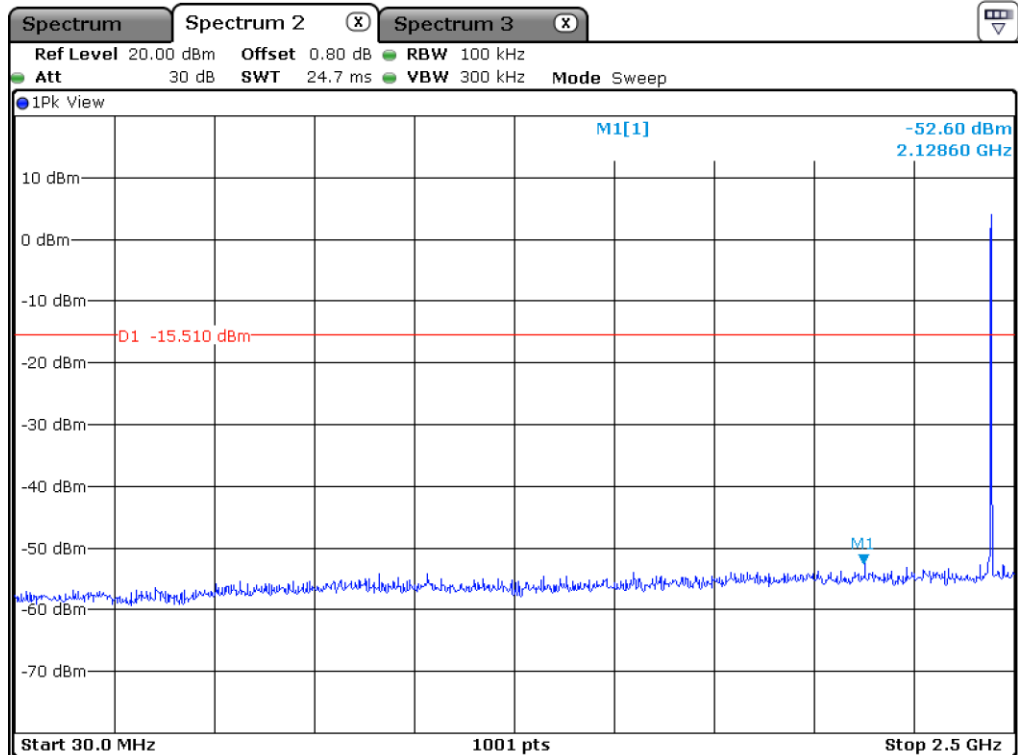
Hopping Mode



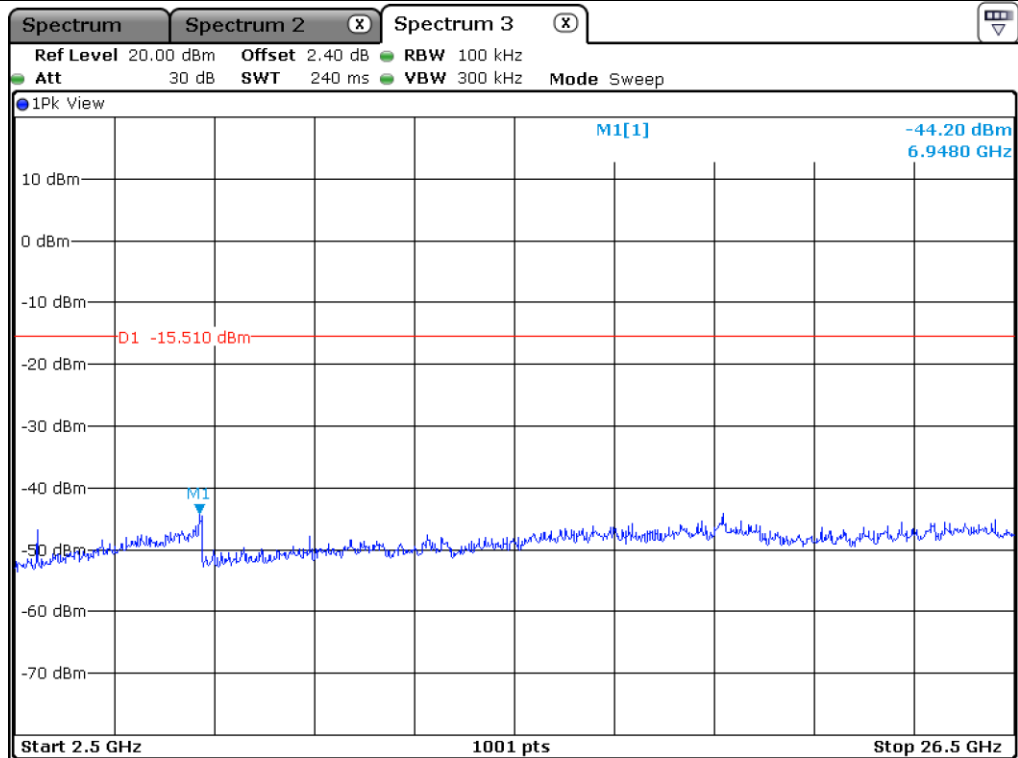
Low Channel



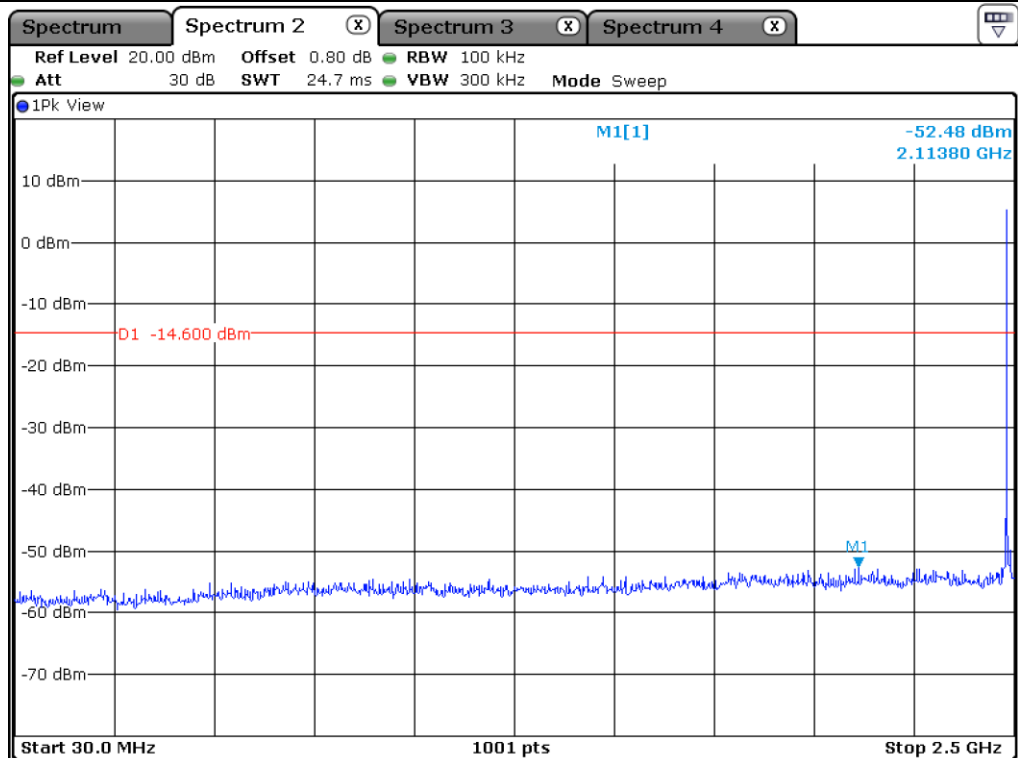
Low Channel



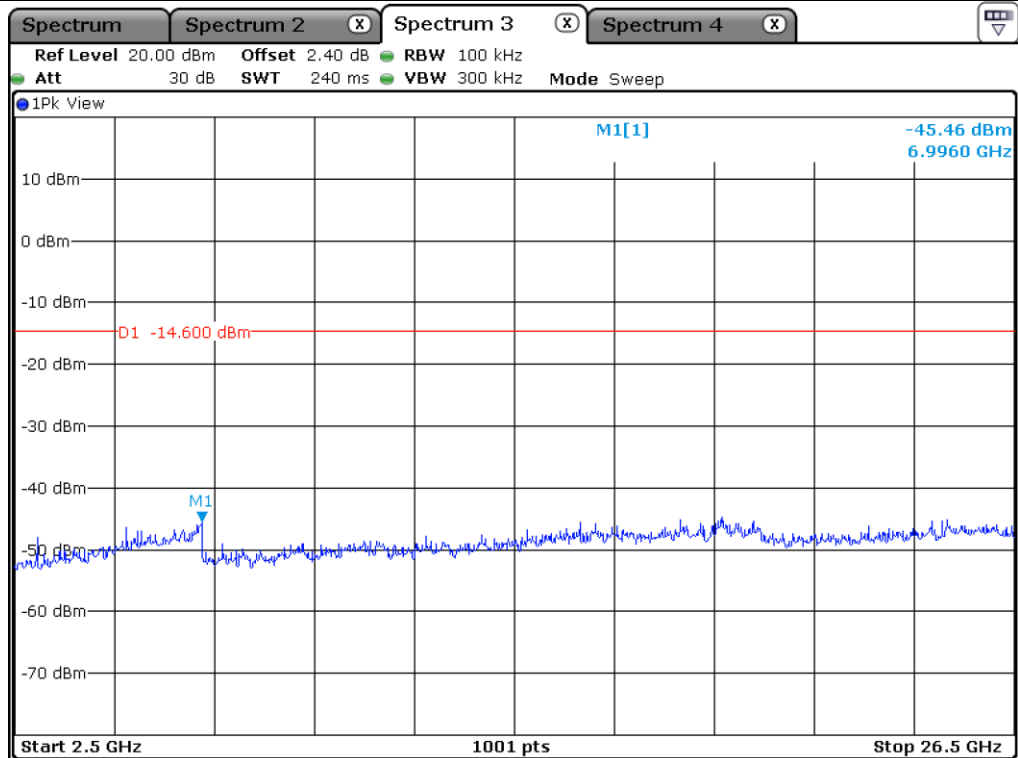
Middle Channel



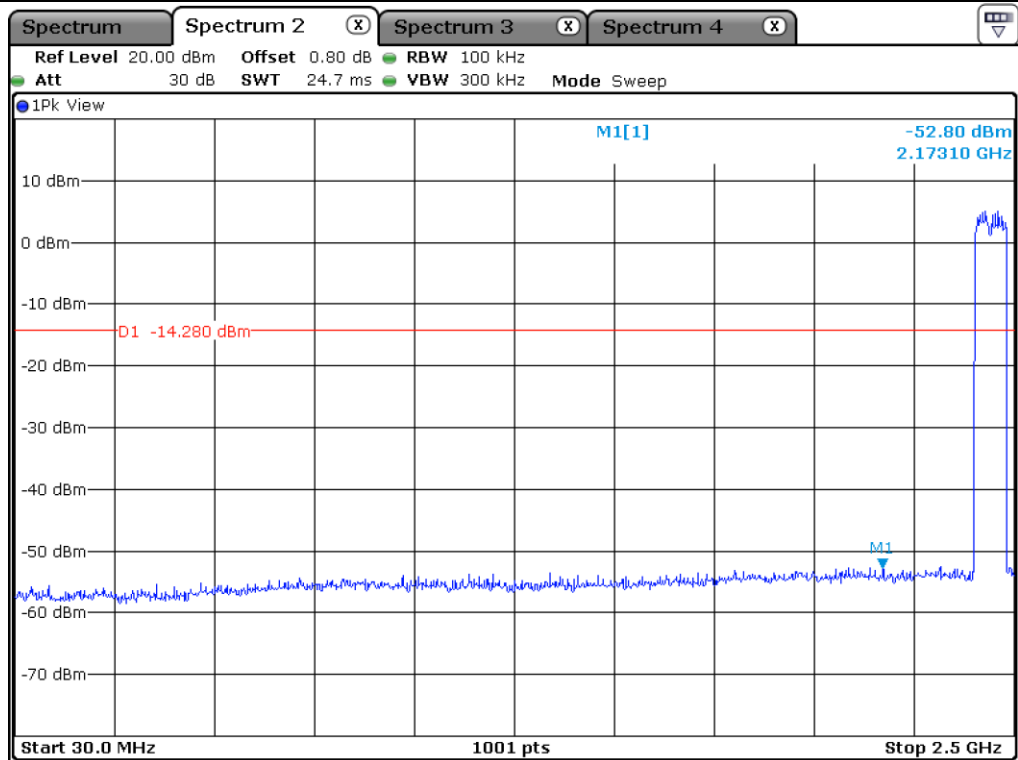
Middle Channel



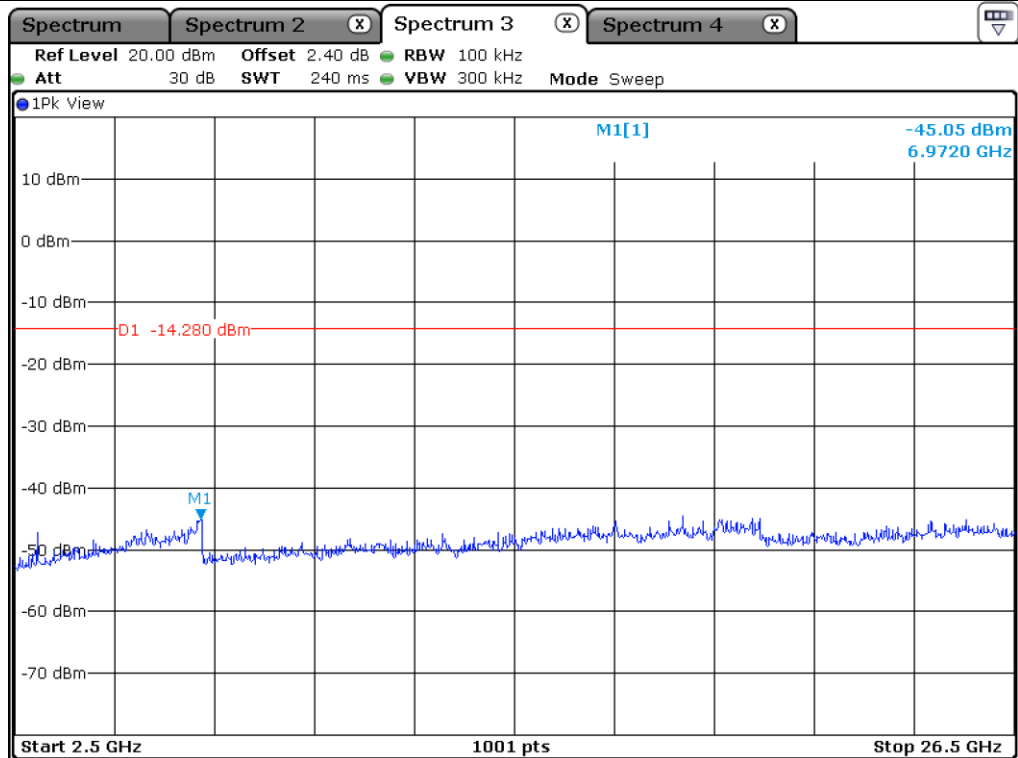
High Channel



High Channel



Hopping Mode



Hopping Mode

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 : 76.86 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Attenuat or Loss	Cable Loss	AMP Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel											
2 312.07	56.26	Peak	H	28.00	6.17	4.70	45.03	-	50.10	74.00	23.90
2 337.89	44.98	Average	H	28.00	6.17	4.70	45.03	1.14	39.96	54.00	14.04
2 350.58	56.35	Peak	V	28.00	6.17	4.70	45.03	-	50.19	74.00	23.81
2 389.82	44.77	Average	V	28.50	6.17	4.70	45.03	1.14	40.25	54.00	13.75
Test Data for High Channel											
2 483.51	57.52	Peak	H	28.80	6.17	4.70	45.03	-	52.16	52.16	21.84
2 483.51	45.30	Average	H	28.80	6.17	4.70	45.03	1.14	41.08	54.00	12.92
2 484.35	58.10	Peak	V	28.80	6.17	4.70	45.03	-	52.74	52.74	21.26
2 483.51	46.16	Average	V	28.80	6.17	4.70	45.03	1.14	41.94	54.00	12.06

Tabulated test data for Restricted Band

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

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

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

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 : 76.86 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Attenuat or Loss	Cable Loss	AMP Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel											
2 390.01	55.02	Peak	H	28.50	6.17	4.70	45.03	-	49.36	74.00	24.64
2 390.01	44.72	Average	H	28.50	6.17	4.70	45.03	1.14	40.20	54.00	13.80
2 389.91	56.63	Peak	V	28.50	6.17	4.70	45.03	-	50.97	74.00	23.03
2 384.03	45.76	Average	V	28.50	6.17	4.70	45.03	1.14	41.24	54.00	12.76
Test Data for High Channel											
2 483.51	61.04	Peak	H	28.80	6.17	4.70	45.03	-	55.68	74.00	18.32
2 483.51	49.72	Average	H	28.80	6.17	4.70	45.03	1.14	45.50	54.00	8.50
2 483.69	63.06	Peak	V	28.80	6.17	4.70	45.03	-	57.70	74.00	16.30
2 483.57	49.74	Average	V	28.80	6.17	4.70	45.03	1.14	45.52	54.00	8.48

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 + Attenuator Loss + Cable Loss + Duty Factor – AMP Gain

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 : 76.86 %
- Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Attenuat or Loss	Cable Loss	AMP Gain	Duty Factor (dB)	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel											
2 353.52	56.17	Peak	H	28.00	6.17	4.70	45.03	-	50.01	74.00	23.99
2 390.01	44.52	Average	H	28.50	6.17	4.70	45.03	1.14	40.00	54.00	14.00
2 340.74	56.77	Peak	V	28.00	6.17	4.70	45.03	-	50.61	74.00	23.39
2 389.91	45.35	Average	V	28.50	6.17	4.70	45.03	1.14	40.83	54.00	13.17
Test Data for High Channel											
2 483.51	65.96	Peak	H	28.80	6.17	4.70	45.03	-	60.60	74.00	13.40
2 483.51	50.70	Average	H	28.80	6.17	4.70	45.03	1.14	46.48	54.00	7.52
2 483.51	64.72	Peak	V	28.80	6.17	4.70	45.03	-	59.36	74.00	14.64
2 483.51	50.80	Average	V	28.80	6.17	4.70	45.03	1.14	46.58	54.00	7.42

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 +Attenuator Loss+ Duty Factor– AMP Gain

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 : 76.86 %
- . 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										
4 804.08	55.63	Peak	H	33.50	9.30	45.03	-	53.40	74.00	20.60
4 804.08	48.41	Average	H	33.50	9.30	45.03	1.14	47.32	54.00	6.68
4 803.44	54.19	Peak	V	33.50	9.30	45.03	-	51.96	74.00	22.04
4 804.16	46.47	Average	V	33.50	9.30	45.03	1.14	45.38	54.00	8.62
Test Data for Middle Channel										
4 881.96	55.84	Peak	H	33.50	9.30	45.03	-	53.61	74.00	20.39
4 881.68	49.70	Average	H	33.50	9.30	45.03	1.14	48.61	54.00	5.39
4 882.14	53.29	Peak	V	33.50	9.30	45.03	-	51.06	74.00	22.94
4 881.96	46.89	Average	V	33.50	9.30	45.03	1.14	45.80	54.00	8.20
Test Data for High Channel										
4 960.36	56.37	Peak	H	33.50	9.30	45.03	-	54.14	74.00	19.86
4 959.94	49.63	Average	H	33.50	9.30	45.03	1.14	48.54	54.00	5.46
4 960.14	55.46	Peak	V	33.50	9.30	45.03	-	53.23	74.00	20.77
4 959.96	46.37	Average	V	33.50	9.30	45.03	1.14	45.28	54.00	8.72

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

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

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

12.6.3.2 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 : 76.86 %
- 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										
4 803.92	56.28	Peak	H	33.50	9.30	45.03	-	54.05	74.00	19.95
4 803.90	48.28	Average	H	33.50	9.30	45.03	1.14	47.19	54.00	6.81
4 804.48	54.84	Peak	V	33.50	9.30	45.03	-	52.61	74.00	21.39
4 803.78	45.48	Average	V	33.50	9.30	45.03	1.14	44.39	54.00	9.61
Test Data for Middle Channel										
4 881.36	56.05	Peak	H	33.50	9.30	45.03	-	53.82	74.00	20.18
4 881.94	46.56	Average	H	33.50	9.30	45.03	1.14	45.47	54.00	8.53
4 882.30	54.06	Peak	V	33.50	9.30	45.03	-	51.83	74.00	22.17
4 882.18	45.82	Average	V	33.50	9.30	45.03	1.14	44.73	54.00	9.27
Test Data for High Channel										
4 960.24	54.35	Peak	H	33.50	9.30	45.03	-	52.12	74.00	21.88
4 959.92	47.92	Average	H	33.50	9.30	45.03	1.14	46.83	54.00	7.17
4 959.86	55.11	Peak	V	33.50	9.30	45.03	-	52.88	74.00	21.12
4 960.08	45.59	Average	V	33.50	9.30	45.03	1.14	44.50	54.00	9.50

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 : 76.86 %
- 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										
4 804.02	55.83	Peak	H	33.50	9.30	45.03	-	53.60	74.00	20.40
4 803.98	46.30	Average	H	33.50	9.30	45.03	1.14	45.21	54.00	8.79
4 804.00	54.63	Peak	V	33.50	9.30	45.03	-	52.40	74.00	21.60
4 804.02	46.24	Average	V	33.50	9.30	45.03	1.14	45.15	54.00	8.85
Test Data for Middle Channel										
4 882.34	56.03	Peak	H	33.50	9.30	45.03	-	53.80	74.00	20.20
4 882.10	48.75	Average	H	33.50	9.30	45.03	1.14	47.66	54.00	6.34
4 882.74	54.67	Peak	V	33.50	9.30	45.03	-	52.44	74.00	21.56
4 882.02	45.99	Average	V	33.50	9.30	45.03	1.14	44.90	54.00	9.10
Test Data for High Channel										
4 960.28	55.44	Peak	H	33.50	9.30	45.03	-	53.21	74.00	20.79
4 960.20	49.09	Average	H	33.50	9.30	45.03	1.14	48.00	54.00	6.00
4 959.66	53.93	Peak	V	33.50	9.30	45.03	-	51.70	74.00	22.30
4 959.94	45.29	Average	V	33.50	9.30	45.03	1.14	44.20	54.00	9.80

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 : 23 °C
Relative humidity : 48 % 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

June 14, 2022 ~ June 20, 2022

13.4 Test data for 30 MHz ~ 1 000 MHz

Humidity Level : 48 % R.H.

Temperature: 23 °C

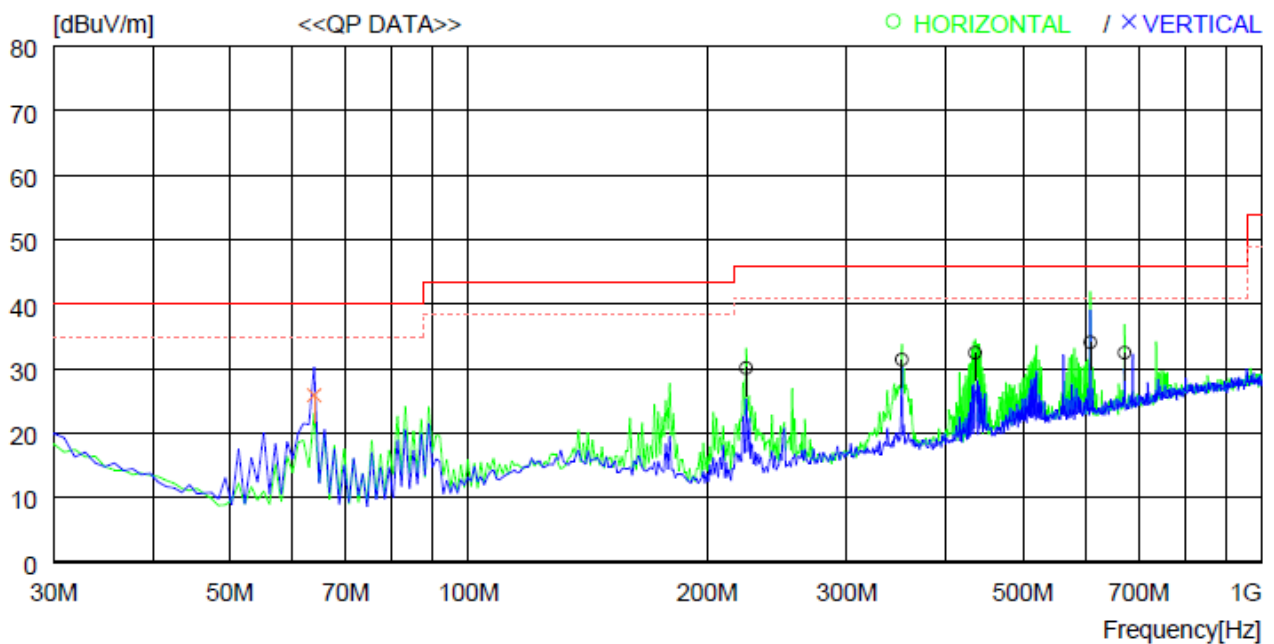
Limits apply to : FCC CFR 47, PART 15, SUBPART C, SECTION 15.247

Result : PASSED

EUT : Bluetooth module

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

LIMIT : FCC Part15 Subpart.B Class B (3m)
MARGIN: 5 dB



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	224.000	43.1	16.5	2.6	32.1	30.1	46.0	15.9	200	0
2	352.040	40.5	19.9	3.2	32.2	31.4	46.0	14.6	400	0
3	435.461	39.6	21.5	3.6	32.2	32.5	46.0	13.5	100	149
4	608.118	38.1	24.2	4.2	32.4	34.1	46.0	11.9	400	0
5	672.136	35.4	25.0	4.5	32.4	32.5	46.0	13.5	200	229
----- Vertical -----										
6	63.950	43.9	12.5	1.5	32.0	25.9	40.0	14.1	200	359

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 : 23 °C
Relative humidity : 48 % R.H.

14.2 Test set-up

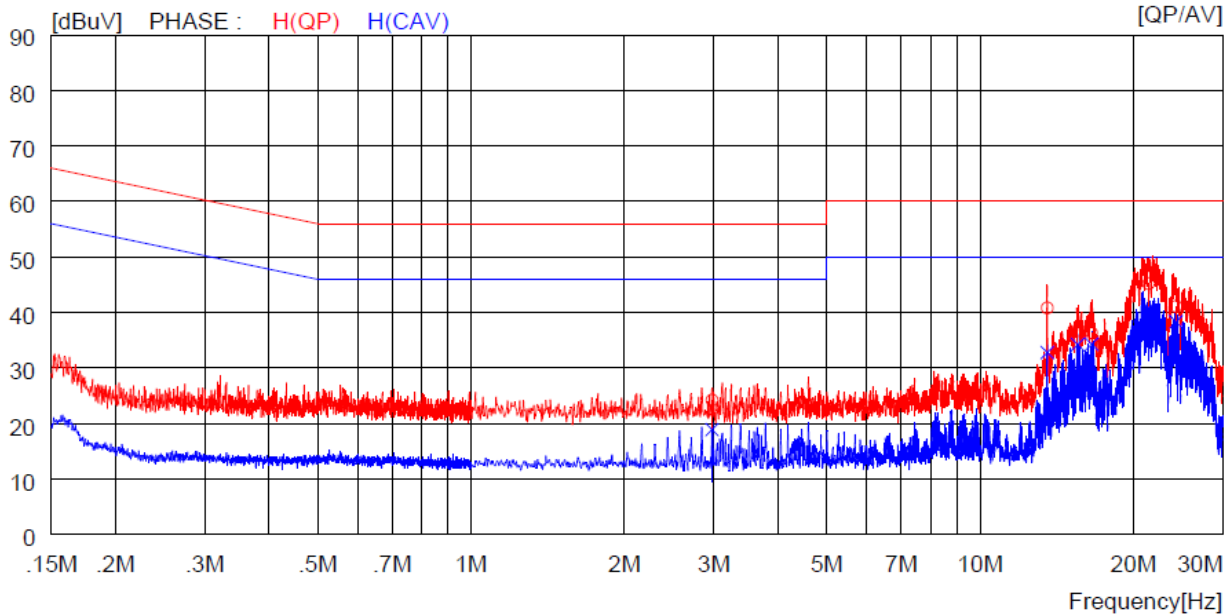
The EUT was placed on a wooden table, 0.8 m height above the floor. Power was fed to the EUT through a $50\ \Omega$ / $50\ \mu\text{H}$ + $5\ \Omega$ Artificial Mains Network (AMN). The ground plane was electrically bonded to the reference ground system and all power lines were filtered from ambient.

14.3 Test Date

June 14, 2022 ~ June 20, 2022

14.4 Test data for Bluetooth

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

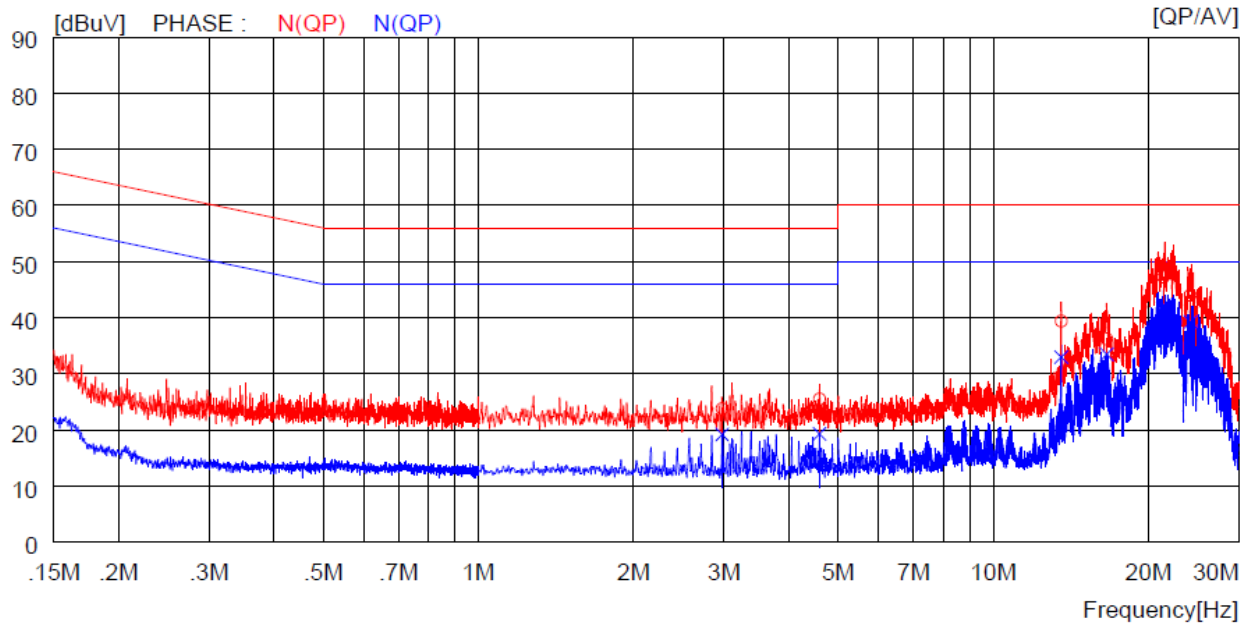


NO	FREQ [MHz]	READING		C.FACTOR [dB]	RESULT		LIMIT		MARGIN		PHASE
		QP [dBuV]	AV [dBuV]		QP [dBuV]	AV [dBuV]	QP [dBuV]	AV [dBuV]	QP [dBuV]	AV [dBuV]	
1	2.97600	14.1	----	10.1	24.2	----	56.0	----	31.8	----	H (QP)
2	13.56000	30.5	----	10.3	40.8	----	60.0	----	19.2	----	H (QP)
3	15.56000	26.4	----	10.3	36.7	----	60.0	----	23.3	----	H (QP)
4	16.56000	26.0	----	10.3	36.3	----	60.0	----	23.7	----	H (QP)
5	21.44000	34.7	----	10.5	45.2	----	60.0	----	14.8	----	H (QP)
6	24.28000	30.5	----	10.6	41.1	----	60.0	----	18.9	----	H (QP)
7	2.97600	----	8.8	10.1	----	18.9	----	46.0	----	27.1	H (CAV)
8	13.56000	----	22.5	10.3	----	32.8	----	50.0	----	17.2	H (CAV)
9	15.56000	----	23.9	10.3	----	34.2	----	50.0	----	15.8	H (CAV)
10	16.56000	----	24.0	10.3	----	34.3	----	50.0	----	15.7	H (CAV)
11	21.44000	----	30.3	10.5	----	40.8	----	50.0	----	9.2	H (CAV)
12	24.28000	----	27.7	10.6	----	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.



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	2.97600	13.5	----	10.3	23.8	----	56.0	----	32.2	----	N (QP)
2	4.60000	15.2	----	10.3	25.5	----	56.0	----	30.5	----	N (QP)
3	13.56000	28.9	----	10.5	39.4	----	60.0	----	20.6	----	N (QP)
4	16.60000	25.6	----	10.6	36.2	----	60.0	----	23.8	----	N (QP)
5	21.40000	36.5	----	10.7	47.2	----	60.0	----	12.8	----	N (QP)
6	24.16000	33.3	----	10.7	44.0	----	60.0	----	16.0	----	N (QP)
7	2.97600	----	8.9	10.3	----	19.2	----	46.0	----	26.8	N (CAV)
8	4.60000	----	9.0	10.3	----	19.3	----	46.0	----	26.7	N (CAV)
9	13.56000	----	22.5	10.5	----	33.0	----	50.0	----	17.0	N (CAV)
10	16.60000	----	22.9	10.6	----	33.5	----	50.0	----	16.5	N (CAV)
11	21.40000	----	31.5	10.7	----	42.2	----	50.0	----	7.8	N (CAV)
12	24.16000	----	28.5	10.7	----	39.2	----	50.0	----	10.8	N (CAV)

15. LIST OF TEST EQUIPMENT

Model Number	Manufacturer	Description	Serial Number	Last Cal.(Interval)
FSV30	Rohde & Schwarz	Signal Analyzer	101372	Jul. 14, 2021 (1Y)
ESR7	Rohde & Schwarz	EMI Test Receiver	102190	Oct. 12, 2021 (1Y)
ESH3-Z2	Rohde & Schwarz	Pulse Limiter	060117	Mar. 14, 2022 (1Y)
NSLK 8128	Schwarzbeck Mess-ELE	Artificial Main Networks	8128216	Mar. 14, 2022 (1Y)
310N	Sonoma Instrument	AMPLIFIER	392756	Oct. 14, 2021 (1Y)
SCU18	Rohde & Schwarz	Signal Conditioning unit	102266	Jul. 14, 2021 (1Y)
SCU40A	Rohde & Schwarz	Signal Conditioning unit	100436	Jan. 18, 2022 (1Y)
DT2000-2t	Innco Systems GmbH	Turn Table	N/A	N/A
CO3000	Innco Systems GmbH	Controller	1026/40960617/P	N/A
MA-4640-XPET	Innco Systems GmbH	Antenna Master	MA4640/652/43100318/P	N/A
HLP-2008	TDK RF Solutions	Hybrid Antenna	131316	Mar. 07, 2022 (2Y)
BBHA9170	Schwarzbeck	Horn Antenna	BBHA9170178	Jan. 06, 2022(1Y)
BBHA9120D	Schwarzbeck	Horn Antenna	9120D-1349	Jul. 26, 2021 (1Y)
AH-118	Com-Power	Horn Antenna	10050061	Oct. 15, 2021 (1Y)
FMZB 1513	Schwarzbeck	Loop Antenna	1513-235	Mar. 24, 2022(2Y)
HPF 3GHz	Rohde & Schwarz	High Pass Filter	N/A	Jan. 18, 2022 (1Y)
GP-4303D	LG Precision Co.,Ltd	DC POWER SUPPLY	5071069	Jan. 03, 2022 (1Y)