Certification Test Report

FCC ID: HSW-500M
IC: 4492A-500M

FCC Rule Part: 15.247
ISED Canada Radio Standards Specification: RSS-247

Report Number: AT72170058-1C0

Manufacturer: Murata Electronics North America
Model: 500M

Test Begin Date: May 28, 2021
Test End Date: August 04, 2021

Report Issue Date: August 17, 2021

FOR THE SCOPE OF ACCREDITATION UNDER Certificate Number: 2955.09

This report must not be used by the client to claim product certification, approval, or endorsement by A2LA, NIST, or any agency of the Federal Government.

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This report contains 59 pages

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1 GENERAL

Purpose

The purpose of this report is to demonstrate compliance with Part 15 Subpart C of the FCC's Code of Federal Regulations and Innovation, Science and Economic Development Canada's Radio Standards Specification RSS-247 for the tests documented herein.

Product description

The Murata 500M is a Wireless communications radio module optimized for battery-powered devices enabling the Internet of Things. The 500M leverages Itron's proven, self-forming, self-healing networking capabilities to bring connectivity to a new class of IoT devices. The small form factor and power-optimized design brings secure, reliable two-way integrated IPv6 connectivity to critical infrastructure.

Technical Information:
The model 500M provides 9 distinct proprietary modes of operation using both FHSS and hybrid classifications as outlined below.

Mode of Operation	Frequency Range (MHz)	Number of Channels	Channel Separation (kHz)	Modulation	Data Rates Supported (kbps)	Classification
1	903-926.8	120	200	OOK	16.384	FHSS
2	903-926.8	120	200	OOK	16.384	FHSS
3	902.2-927.75	512	50	GFSK	10	FHSS
4	902.4-927.6	64	400	GFSK	150	FHSS
5	902.3-926.9	83	300	GFSK	100	FHSS
6	902.4-927.6	64/3	400	GFSK	300	Hybrid
7	902.4-927.6	64	400	GFSK	300	FHSS
8	902.2-927.75	512	50	GFSK	25	FHSS
9	902.2-927.8	129	200	GFSK	50	FHSS

Antenna Type / Gain: WP WPANT30182-R1A-OMNI / 2 dBi (Host antenna trace design to host MMCX connector)
Voltage: 6.0 VDC

Manufacturer Information:
Murata Electronics North America.
2200 Lake Park Dr, Smyrna, GA 30080

EUT Serial Numbers 59B47D36 (Radiated Emission)
59B47D4B (RF Antenna Port Measurements)

Test Sample Condition: The test samples were provided in good working order with no visible defects.

Test Methodology and Considerations

All modes of operation, including all available data rates, were evaluated. The data presented in this report represents the worst case where applicable. The worst-case data rate for the radiated emission measurements was 50kbps (mode 9), which also represents the widest frequency range.

For radiated emissions, the EUT was evaluated in three orthogonal orientations. The worst-case orientation was X-position. See test setup photos for more information. The EUT was programmed to generate a continuously modulated signal on each channel evaluated.

For RF Conducted measurements, the EUT was connected to the test equipment with a MMCX to SMA connector. The EUT was programmed to generate a continuously modulated signal on each channel evaluated.

Software power setting during test:	Mode 1	0x200C8977
	Mode 2	0x1F0C014D
	Mode 6	0x1F0C0123
	Mode 6	0x1F0C0119 (Only for AVG Power & AVG PSD)
	All other modes	0x1F0C0355

2 TEST FACILITIES

Location

The radiated and conducted emissions test sites are located at the following addresses:

TÜV SÜD America, Inc.
5945 Cabot Pkwy, Suite 100
Alpharetta, GA 30005
Phone: (678) 341-5900

Laboratory Accreditations/Recognitions/Certifications

TÜV SÜD America, Inc. is accredited to ISO/IEC 17025 by the American Association for Laboratory Accreditation/A2LA accreditation program and has been issued certificate number 2955.09 in recognition of this accreditation.

Unless otherwise specified, all test methods described within this report are covered under the ISO/IEC 17025 scopes of accreditation.

The Semi-Anechoic Chamber Test Sites and Conducted Emissions Sites have been fully described, submitted to, and accepted by the FCC, ISED Canada and the Japanese Voluntary Control Council for Interference by information technology equipment.

FCC Designation Accreditation Number:	US1233
FCC Test Site Registration Number:	967699
ISED Canada Lab Code:	23932
VCCI Member Number:	1831
• VCCI Registration Number	A-0295

Radiated Emissions Test Site Description

2.1.1 Semi-Anechoic Chamber Test Site – Chamber A

The Semi-Anechoic Chamber Test Site consists of a 20’ x 30’ x 18’ shielded enclosure. The chamber is lined with Toyo Ferrite Grid Absorber, model number FFG-1000. The ferrite tile grid is 101 x 101 x 19mm thick and weighs approximately 550 grams. These tiles are mounted on steel panels and installed directly on the inner walls of the chamber.

The turntable is 5’ in diameter and is located 5’6” from the back wall of the chamber. The chamber is grounded via 1 - 8’ copper ground rod, installed at the center of the back wall, it is bound to the ground plane using 3/4" stainless steel braided cable.

The turntable is all steel, flush mounted EMCO Model 1060 installed in an all-steel frame. The table is remotely operated from inside the control room located 25’ from the range. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane during operation.

Behind the turntable is a 3’ x 6’ x 4’ deep shielded pit used for support equipment if necessary. The pit is equipped with 1 - 4” PVC chase from the turntable to the pit that allows for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit.

The chamber rear wall is covered with a mixture of Siepel pyramidal absorber. The side walls of the chamber are partially covered with Siepel pyramidal absorber.

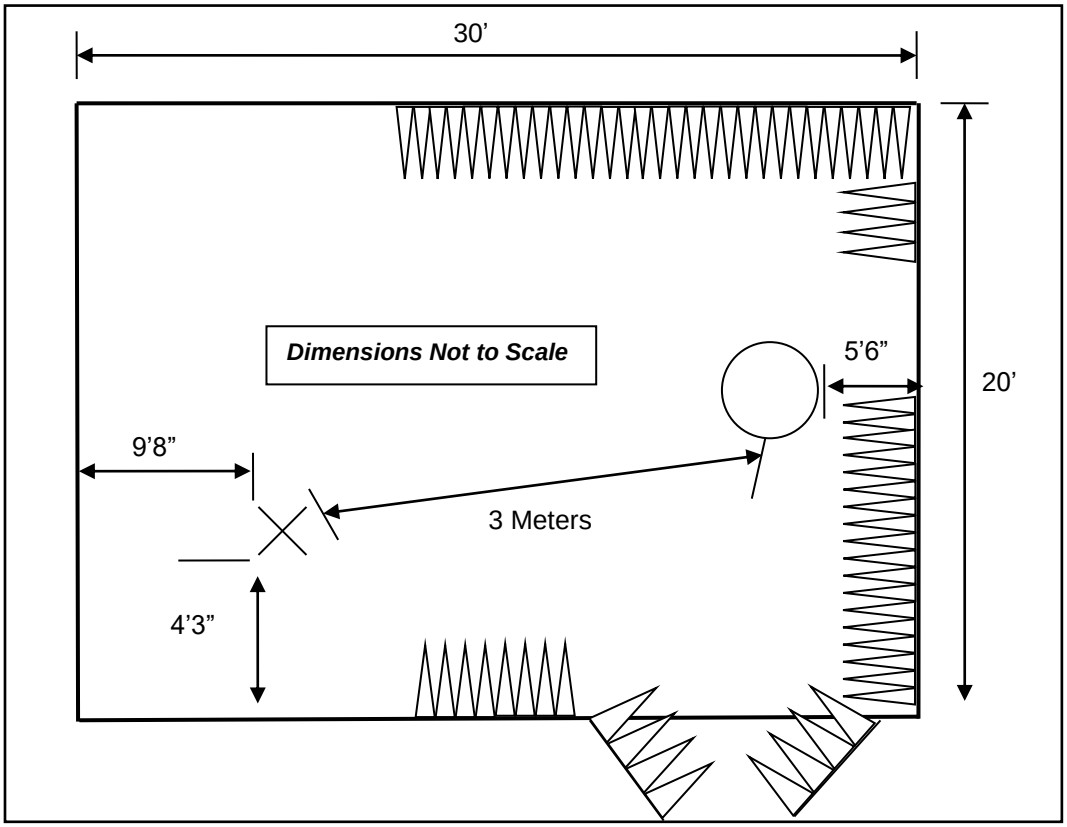


Figure 2.3.1-1: Semi-Anechoic Chamber Test Site – Chamber A

2.1.2 Semi-Anechoic Chamber Test Site – Chamber B

The Semi-Anechoic Chamber Test Site consists of a 20'W x 30'L x 20'H shielded enclosure. The chamber is lined with ETS-Lindgren Ferrite Absorber, model number FT-1500. The ferrite tile 600 mm x 600 mm (2.62 in x 23.62 in) panels and are mounted directly on the inner walls of the chamber shield.

The specular regions of the chamber are lined with additional ETS-Lindgren PS-600 hybrid absorber to extend its frequency range up to 18GHz and beyond.

The turntable is a 2m ETS-Lindgren Model 2170 and installed off the center axis is located 5'6" from the back wall of the chamber. The chamber is grounded via 1 - 8' copper ground rod, installed at the center of the back wall, it is bound to the shield using #8 solid copper wire.

The antenna mast is an EMCO 1060 and is remotely controlled from the control room for both antenna height and polarization.

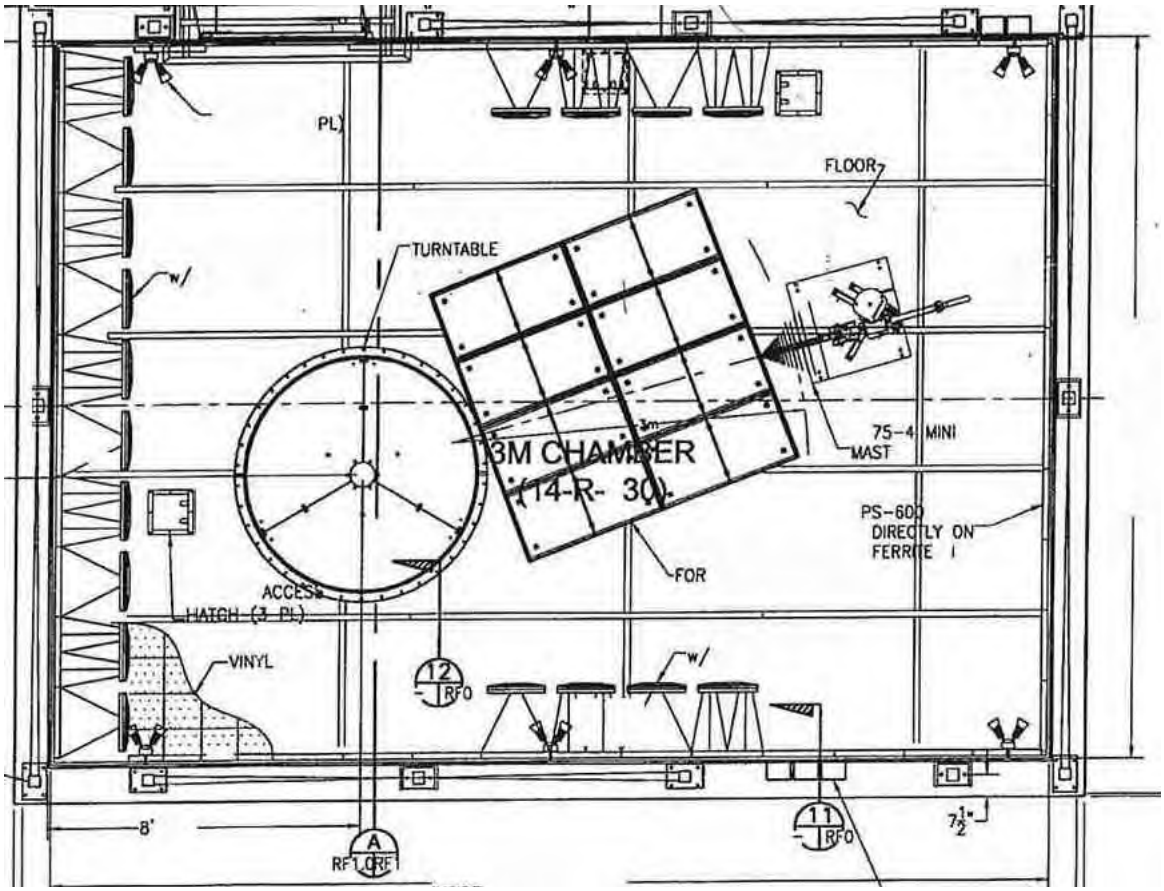


Figure 2.3.2-1: Semi-Anechoic Chamber Test Site – Chamber B

Conducted Emissions Test Site Description

2.1.3 Conducted Emissions Test Site

The AC mains conducted EMI site is located in the main EMC lab. It consists of a 12' x 10' horizontal coupling plane (HCP) as well as a 12'x8' vertical coupling plane (VCP). The HGP is constructed of 4' x 10' sheets of particle board sandwiched by galvanized steel sheets. These panels are bonded using 11AWG 1/8" x 2" by 10' galvanized sheet steel secured to the panels via by screws. The VCP is constructed of three 4'x8' sheets of 11AWG solid aluminum.

The HCP and VCP are electrically bonded together using 1"x1" angled aluminum secured with screws.

The site is of sufficient size to test tabletop and floor standing equipment in accordance with section 6.1.4 of ANSI C63.10.

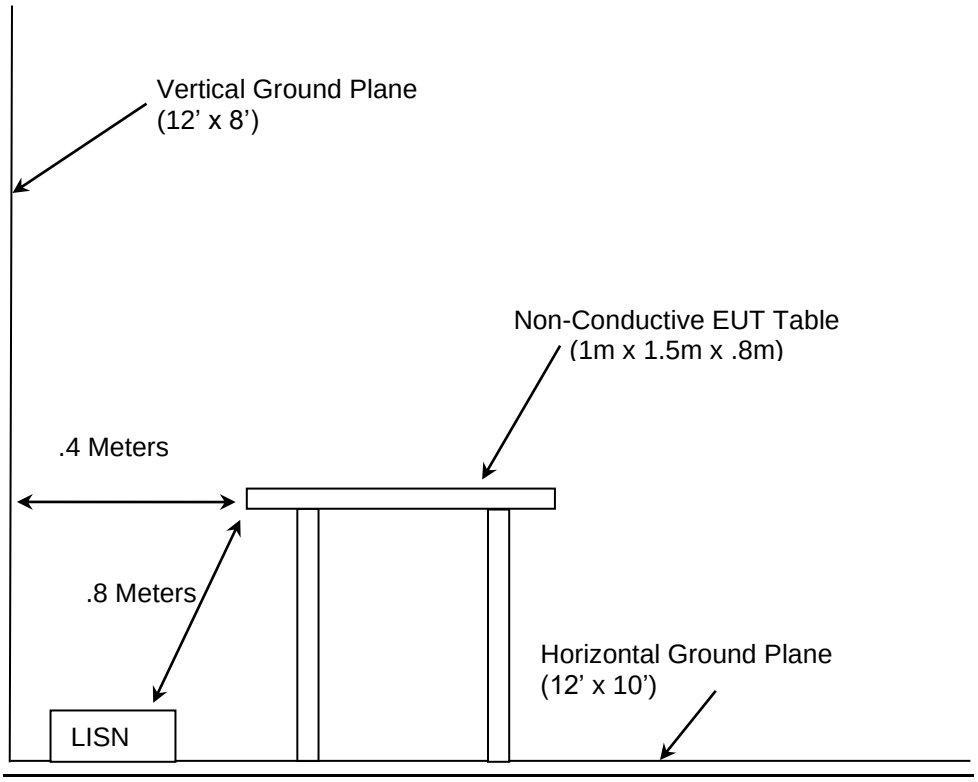


Figure 2.4.1-1: AC Mains Conducted EMI Site

3 APPLICABLE STANDARD REFERENCES

The following standards were used:

- ANSI C63.10-2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- US Code of Federal Regulations (CFR): Title 47, Part 2, Subpart J: Equipment Authorization Procedures, 2021
- US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators, 2021
- FCC KDB 558074 D01 15.247 Meas Guidance v05r02 – Guidance for Compliance Measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid System Devices Operating Under Section 15.247 of the FCC Rules, April 2, 2019
- ISED Canada Radio Standards Specification: RSS-247 – Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices, Issue 2, February 2017.
- ISED Canada Radio Standards Specification: RSS-GEN – General Requirements for Compliance of Radio Apparatus, Issue 5, Amendment 1 (March 2019), Amendment 2 (February 2021)

4 LIST OF TEST EQUIPMENT

The calibration interval of test equipment is annually or the manufacturer's recommendations. Where the calibration interval deviates from the annual cycle based on the instrument manufacturer's recommendations, it shall be stated below.

Table 4-1: Test Equipment

Asset ID	Manufacturer	Model	Equipment Type	Serial Number	Last Calibration Date	Calibration Due Date
628	EMCO	6502	Active Loop Antenna 10kHz-30MHz	9407-2877	2/7/2019	6/11/2021
628	EMCO	6502	Active Loop Antenna 10kHz-30MHz	9407-2877	6/8/2021	6/8/2023
852	Teseq; Huber+suhner	CBL 6112D;6804-17-A	Bilog Antenna	51617	10/13/2020	10/13/2021
857	ETS Lindgren	3117	Horn Antenna 1-18GHz	153608	11/12/2019	11/12/2021
213	TEC	PA 102	Amplifier	44927	7/30/2020	7/30/2021
338	Hewlett Packard	8449B	High Frequency Pre-Amp	3008A01111	7/15/2019	7/15/2021
338	Hewlett Packard	8449B	High Frequency Pre-Amp	3008A01111	6/22/2021	6/22/2023
337	Hewlett Packard	H1G513G1	Microwave Bandpass filter	282706	6/9/2020	6/9/2021
337	Hewlett Packard	H1G513G1	Microwave Bandpass filter	282706	6/9/2021	6/9/2022
819	Rohde & Schwarz	ESR26	EMI Test Receiver	101345	4/7/2021	4/7/2022
827	Rohde & Schwarz	TS8997 Rack Cable Set	TS8997 Rack Cable Set	N/A	9/4/2020	9/4/2021
267	Hewlett Packard	N1911A	Power Meter	MY45100129	7/26/2019	7/26/2021
622	Rohde & Schwarz	FSV40	FSV Signal Analyzer 10Hz to 40 GHz	101338	8/24/2020	8/24/2021

NOTE: All test equipment was used only during active calibration cycles as reported above.

5 SUPPORT EQUIPMENT

Table 5-1: Support Equipment

Item	Equipment Type	Manufacturer	Model Number	Serial Number
1	Module	Itron	500M	KM0128ES2
2	Representative Host Board	Itron	N/A	1721501561
3	Programming board	Itron	N/A	N/A
4	Laptop for configuration	DELL	N/A	N/A
5	AC/DC Adapter	CUI INC	SWI10-5-N	N/A

Table 5-2: Cable Description

Item	Cable Type	Length	Shield
A	AC/DC Power Cable	2m	Yes
B	USB Cable	1m	Yes
C	Data Cable	0.2m	Yes

6 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

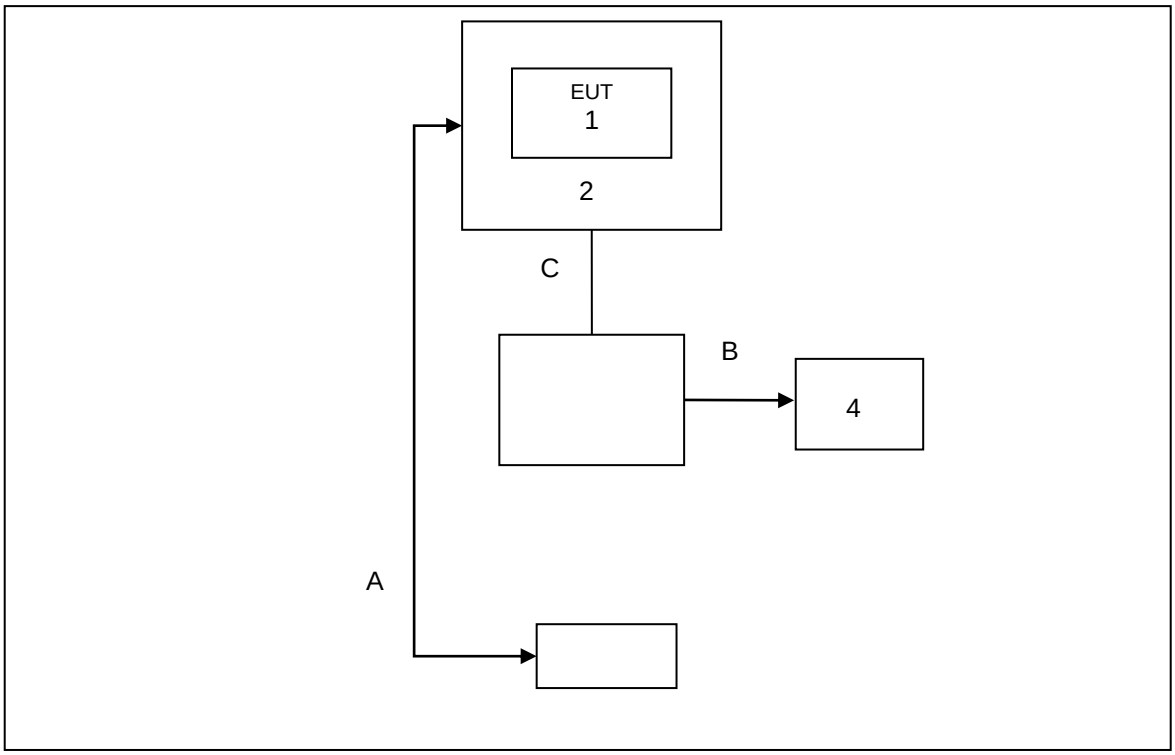


Figure 6-1: Test Setup Block Diagram

7 SUMMARY OF TESTS

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

Antenna Requirement – FCC: 15.203

The EUT utilizes WP WPANT30182-R1A-OMNI antenna with 2 dBi gain (Host antenna trace design to host MMCX connector), therefore satisfying the requirements of Section 15.203.

Power Line Conducted Emissions – FCC: 15.207, ISED Canada: RSS-Gen 8.8

7.1.1 Measurement Procedure

ANSI C63.10 section 6 was the guiding documents for this evaluation. Conducted emissions were performed from 150kHz to 30MHz with the spectrum analyzer's resolution bandwidth set to 9kHz and the video bandwidth set to 30kHz. The calculation for the conducted emissions is as follows:

Corrected Reading = Analyzer Reading + LISN Loss + Cable Loss
Margin = Corrected Reading - Applicable Limit

7.1.2 Measurement Results

Performed by: Sean Vick

Table 7.2.2-1: Conducted EMI Results-Avg – Line 1

Frequency (MHz)	Avg Limit	Avg Level Corrected	Avg Level	Correction Fact.	Avg Margin	Result
0.15	56.0	34.5	24.8	9.682	-21.5	PASS
0.36	50.1	36.4	26.8	9.657	-13.7	PASS
0.90	46.0	31.0	21.3	9.674	-15.0	PASS
1.19	46.0.	30.0	20.3	9.673	-16.0	PASS
2.32	46.0	30.1	20.4	9.683	-15.9	PASS
3.01	46.0	29.7	20.0	9.690	-16.3	PASS

Table 7.2.2-2: Conducted EMI Results-QP – Line 1

Frequency (MHz)	QP Limit	QP Level Corrected	QP Level	Correction Fact.	QP Margin	Result
0.15	66.0	42.8	33.1	9.682	-23.2	PASS
0.36	60.1	43.2	33.6	9.657	-16.8	PASS
0.90	56.0	38.1	28.4	9.674	-17.9	PASS
1.19	56.0	35.8	26.2	9.673	-20.2	PASS
2.32	56.0	35.6	25.9	9.683	-20.4	PASS
3.01	56.0	35.6	25.9	9.690	-20.4	PASS

Table 7.2.2-3: Conducted EMI Results-Avg – Line 2

Frequency (MHz)	Avg Limit	Avg Level Corrected	Avg Level	Correction Fact.	Avg Margin	Result
0.19	55.0	24.0	14.3	9.671	-31.0	PASS
0.93	46.0	25.4	15.7	9.656	-20.6	PASS
2.05	46.0	24.5	14.8	9.661	-21.5	PASS
2.34	46.0	26.1	16.5	9.667	-19.9	PASS
3.73	46.0	25.9	16.2	9.700	-20.1	PASS
4.16	46.0	26.2	16.5	9.700	-19.8	PASS

Table 7.2.2-4: Conducted EMI Results-QP – Line 2

Frequency (MHz)	QP Limit	QP Level Corrected	QP Level	Correction Fact.	QP Margin	Result
0.19	65.0	33.1	23.4	9.671	-31.9	PASS
0.93	56.0	31.5	21.8	9.656	-24.5	PASS
2.05	56.0	30.9	21.2	9.661	-25.1	PASS
2.34	56.0	32.1	22.5	9.667	-23.9	PASS
3.73	56.0	31.5	21.8	9.700	-24.5	PASS
4.16	56.0	32.0	22.3	9.700	-24.0	PASS

Peak Output Power – FCC: Section 15.247(b)(2); ISED Canada: RSS-247

7.1.3 Measurement Procedure - FHSS

The maximum conducted peak output power was measured in accordance with ANSI C63.10 Subclause 7.8.5 Method PKPM (Peak Power meter). The RF output port of the EUT was directly connected to the input of a peak power meter. All data rates were evaluated.

Note: This measurement method was evaluated for FHSS Classification.

7.1.4 Measurement Results - FHSS

Performed by: Bhagyashree Chaudhary

Table 7.3.2-1: RF Output Power - FHSS

Frequency [MHz]	Peak Output Power (dBm)	Data Rate (kbps)	Mode(s)
903.00	10.07	16.384	1
903.00	22.96	16.384	2
902.20	27.46	10	3
902.40	27.42	150	4
902.30	27.47	100	5
902.40	27.33	300	7
902.20	27.42	25	8
902.20	27.41	50	9
916.00	9.68	16.384	1
916.00	22.92	16.384	2
915.25	27.50	10	3
915.60	27.45	150	4
915.20	27.53	100	5
915.60	27.45	300	7
915.25	27.42	25	8
915.20	27.47	50	9
926.80	9.69	16.384	1
926.80	22.82	16.384	2
927.75	27.46	10	3
927.60	27.51	150	4
926.90	27.45	100	5
927.60	27.43	300	7
927.75	27.45	25	8
927.80	27.46	50	9

7.1.5 Measurement Procedure - Hybrid

The Average conducted output power was measured in accordance with ANSI C63.10 Subclause 11.9.2.3.1 Method AVGPM (Average Power Meter). The RF output port of the EUT was directly connected to the input of an Average power meter. The resulting average value was recorded.

Note: This measurement method was evaluated for Hybrid Classification.

7.1.6 Measurement Results - Hybrid

Performed by: Bhagyashree Chaudhary

Table 7.3.4-1: RF Output Power - Hybrid

Frequency [MHz]	AVG Output Power (dBm)	Data Rate (kbps)	Mode(s)
902.40	11.76	300.0	6
915.60	11.70	300.0	6
927.60	11.61	300.0	6

Channel Usage Requirements

7.1.7 Carrier Frequency Separation – FCC Section 15.247(a)(1); ISED Canada: RSS-2475.1(b)

7.1.7.1 Measurement Procedure

The RF output port of the EUT was directly connected to the input of the spectrum analyzer with suitable attenuation. The span of the spectrum analyzer was set wide enough to capture two adjacent peaks and the RBW started at approximately 30% of the channel spacing and adjusted as necessary to best identify the center of each individual channel. The VBW was set to ≥ RBW.

Carrier frequency separation was measured for all Modes and data presented in section 7.4.1.2 below.

7.1.7.2 Measurement Results

Performed by: Bhagyashree Chaudhary

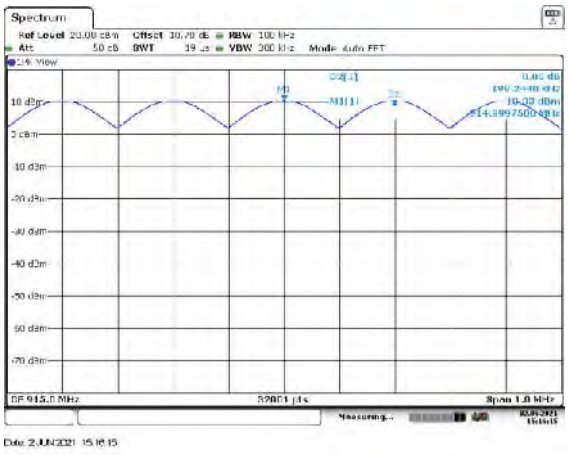


Figure 7.4.1.2-1: Channel Separation – Mode 1

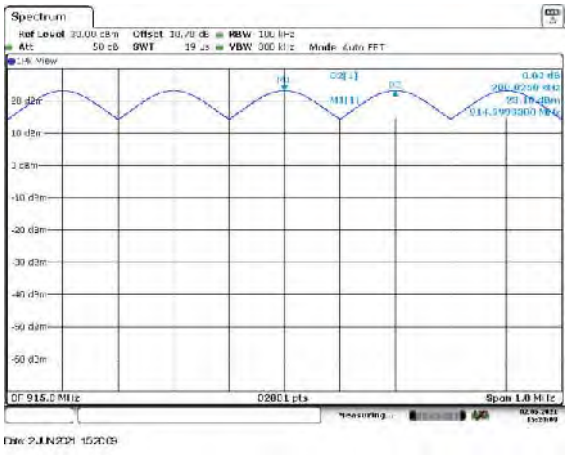


Figure 7.4.1.2-2: Channel Separation – Mode 2

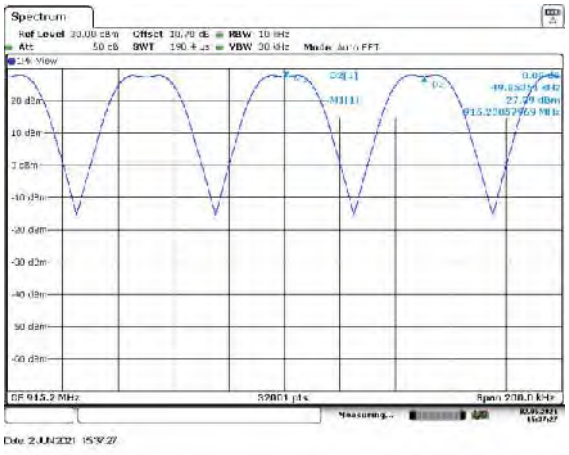


Figure 7.4.1.2-3: Channel Separation – Mode 3

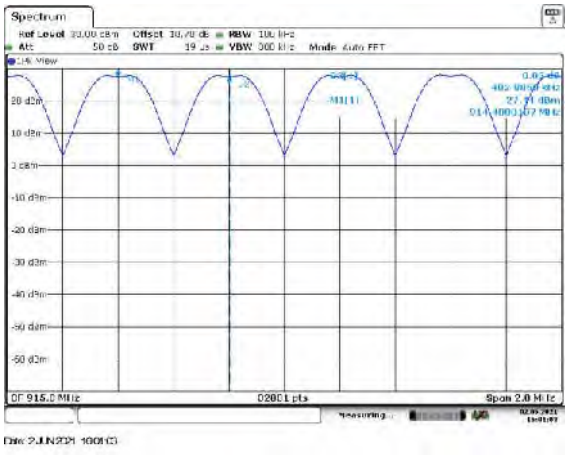


Figure 7.4.1.2-4: Channel Separation – Mode 4

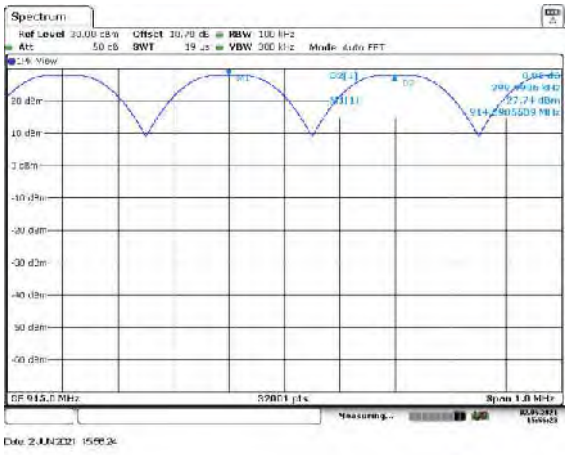


Figure 7.4.1.2-5: Channel Separation – Mode 5

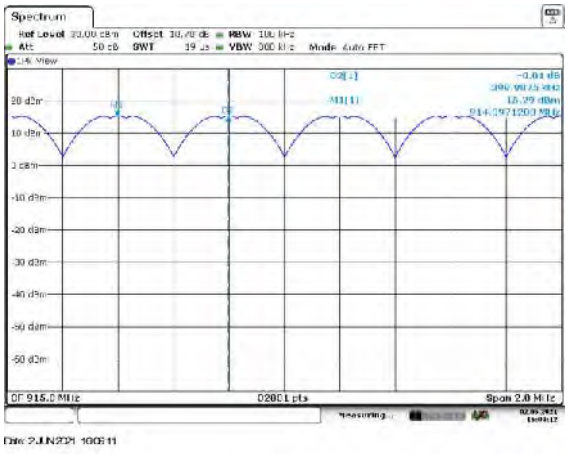


Figure 7.4.1.2-6: Channel Separation – Mode 6

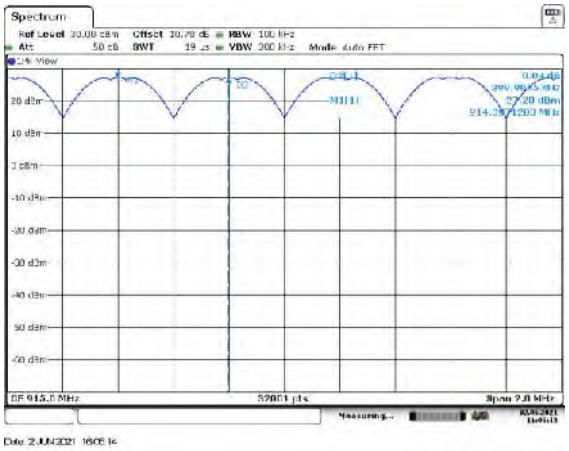


Figure 7.4.1.2-7: Channel Separation – Mode 7

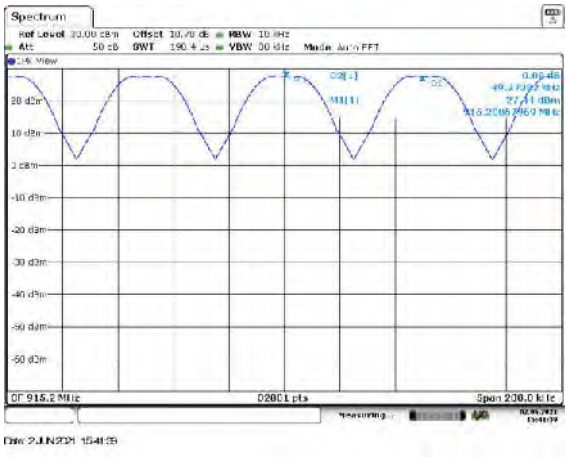


Figure 7.4.1.2-8: Channel Separation – Mode 8

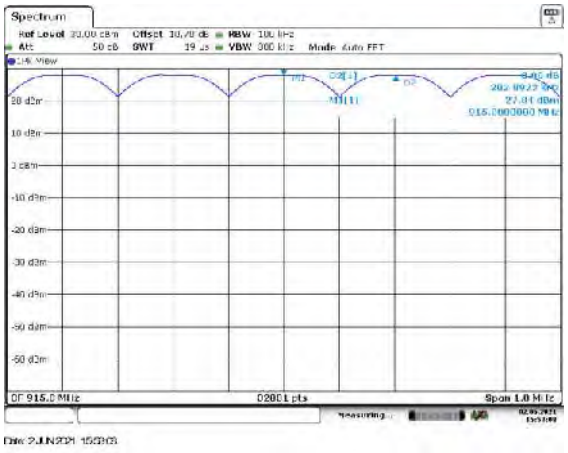


Figure 7.4.1.2-9: Channel Separation – Mode 9

7.1.8 Number of Hopping Channels – FCC Section 15.247(a)(1)(i); ISED Canada: RSS 247 5.1 (c)

7.1.8.1 Measurement Procedure

The RF output port of the EUT was directly connected to the input of the spectrum analyzer with suitable attenuation. The span of the spectrum analyzer was set wide enough to capture the frequency band of operation. The RBW was set to less than 30% of the channel spacing or the 20dB bandwidth, whichever is smaller. The VBW was set to ≥ RBW.

The number of hopping channels was evaluated for all Modes except Mode 6 Hybrid mode.

7.1.8.2 Measurement Results

Performed by: Divya Adusumilli

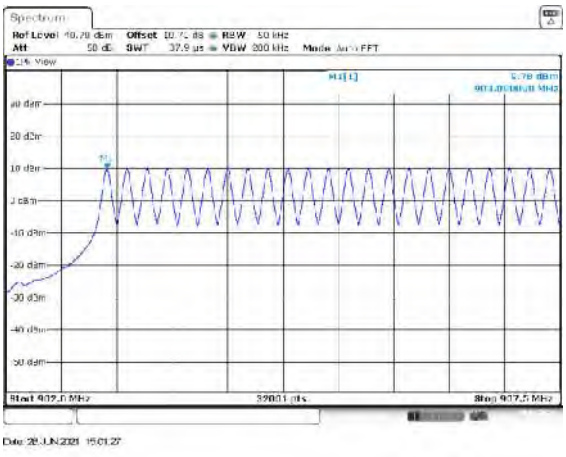


Figure 7.4.2.2-1: Mode 1 (120 Channels)

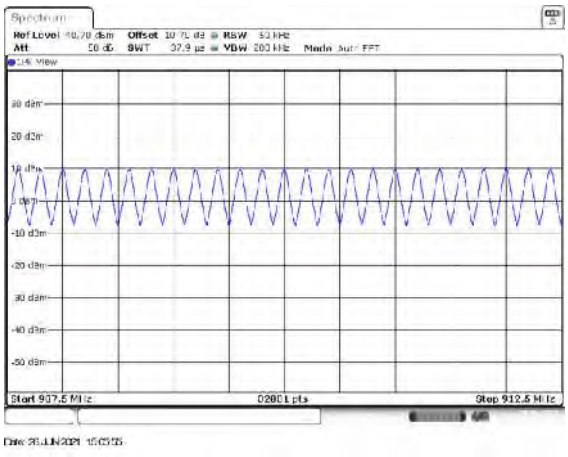


Figure 7.4.2.2-2: Mode 1 (120 Channels)

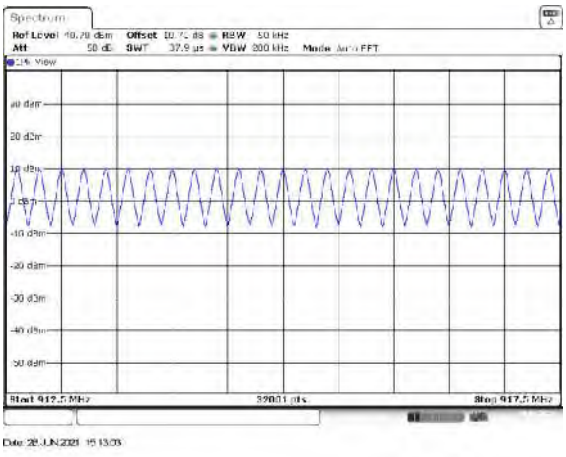


Figure 7.4.2.2-3: Mode 1 (120 Channels)

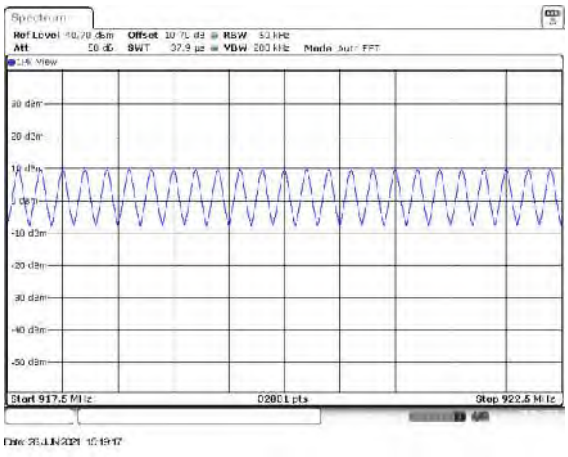


Figure 7.4.2.2-4: Mode 1 (120 Channels)

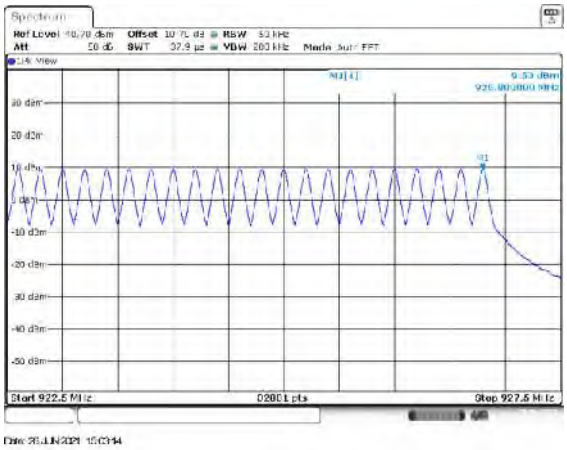


Figure 7.4.2.2-5: Mode 1 (120 Channels)

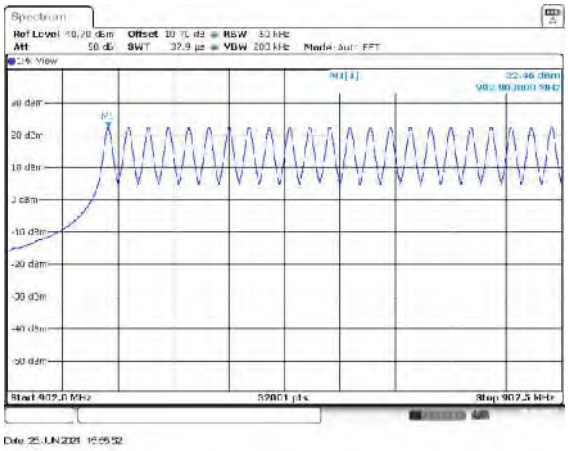


Figure 7.4.2.2-6: Mode 2 (120 Channels)

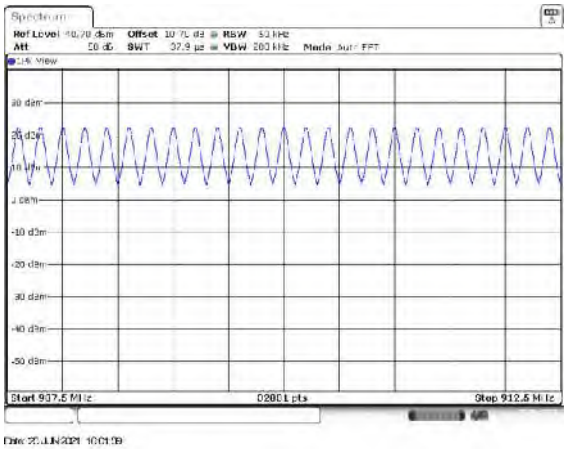


Figure 7.4.2.2-7: Mode 2 (120 Channels)

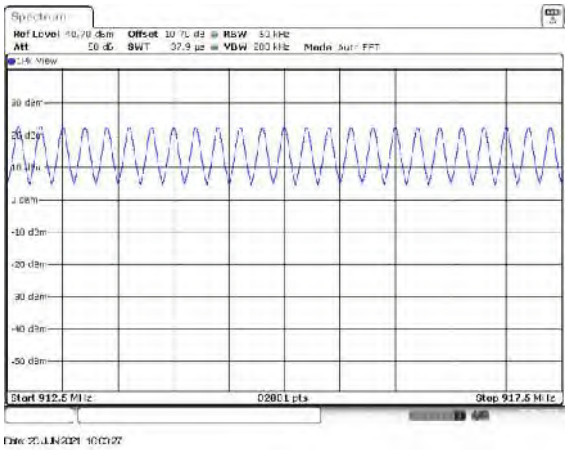


Figure 7.4.2.2-8: Mode 2 (120 Channels)

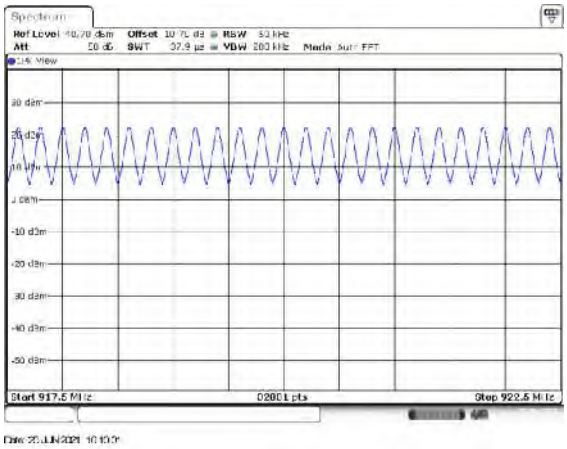


Figure 7.4.2.2-9: Mode 2 (120 Channels)

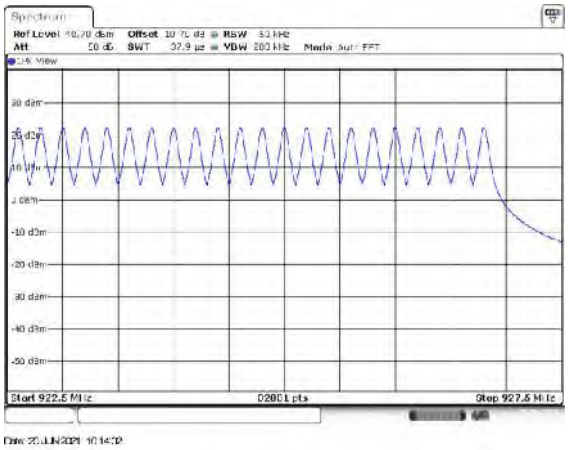


Figure 7.4.2.2-10: Mode 2 (120 Channels)

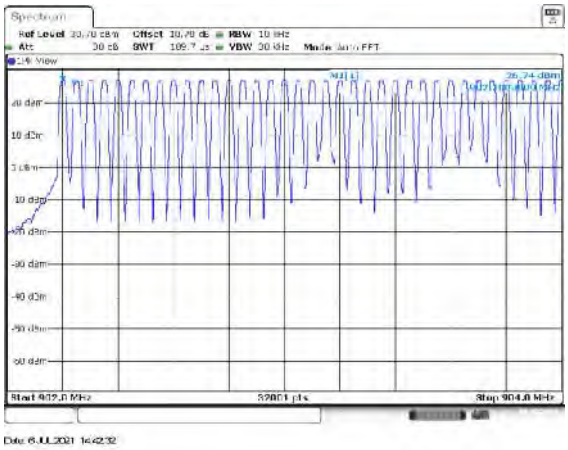


Figure 7.4.2.2-11: Mode 3 (512 Channels)

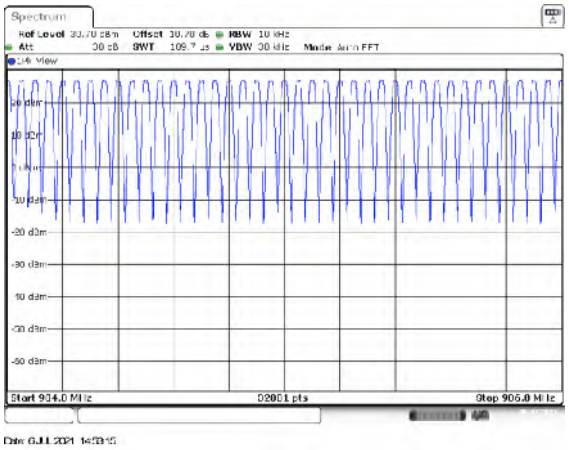


Figure 7.4.2.2-12: Mode 3 (512 Channels)

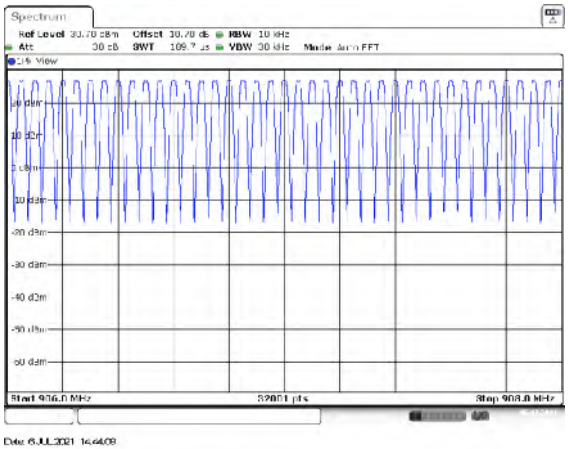


Figure 7.4.2.2-13: Mode 3 (512 Channels)

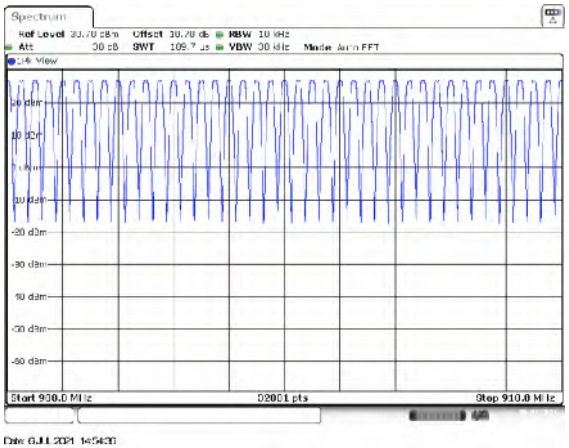


Figure 7.4.2.2-14: Mode 3 (512 Channels)

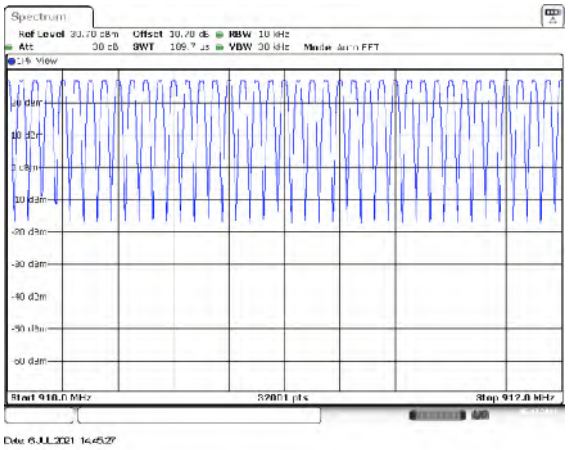


Figure 7.4.2.2-15: Mode 3 (512 Channels)

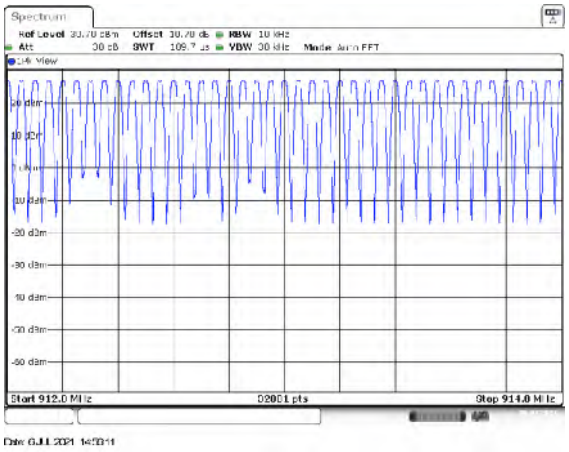


Figure 7.4.2.2-16: Mode 3 (512 Channels)

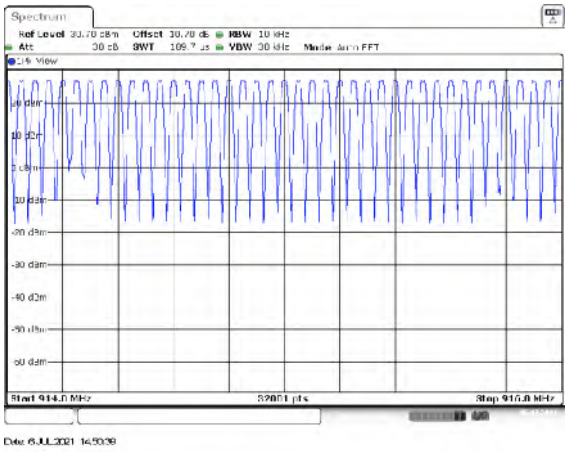


Figure 7.4.2.2-17: Mode 3 (512 Channels)

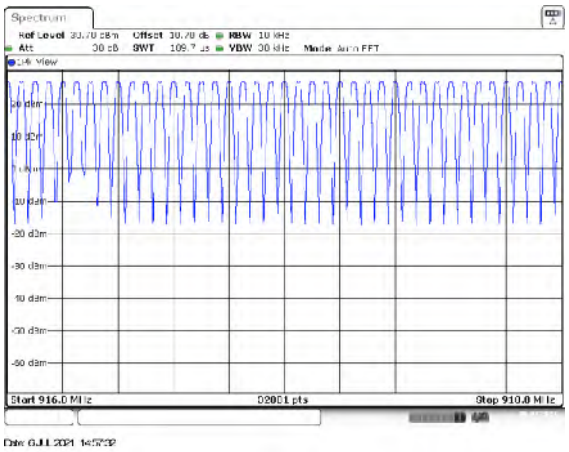


Figure 7.4.2.2-18: Mode 3 (512 Channels)

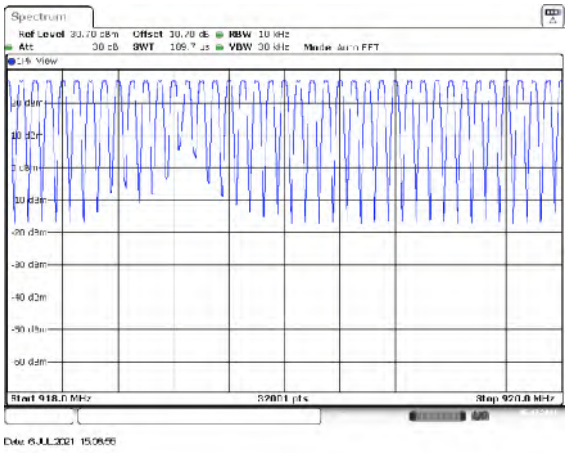


Figure 7.4.2.2-19: Mode 3 (512 Channels)

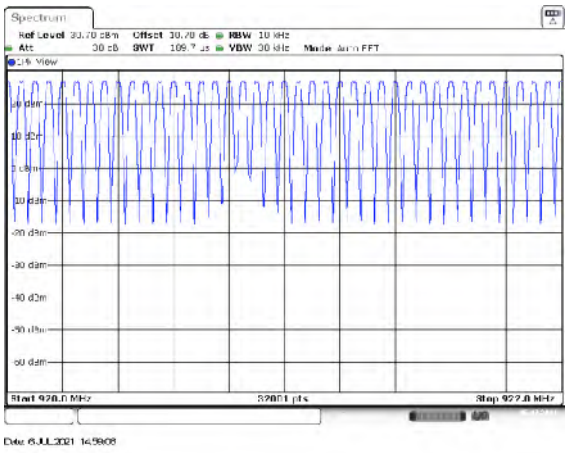


Figure 7.4.2.2-20: Mode 3 (512 Channels)

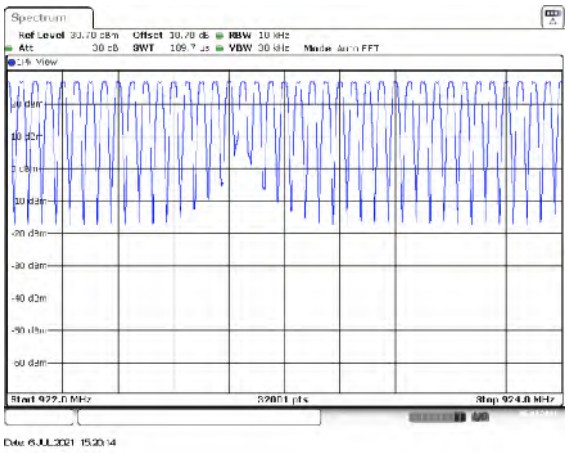


Figure 7.4.2.2-21: Mode 3 (512 Channels)

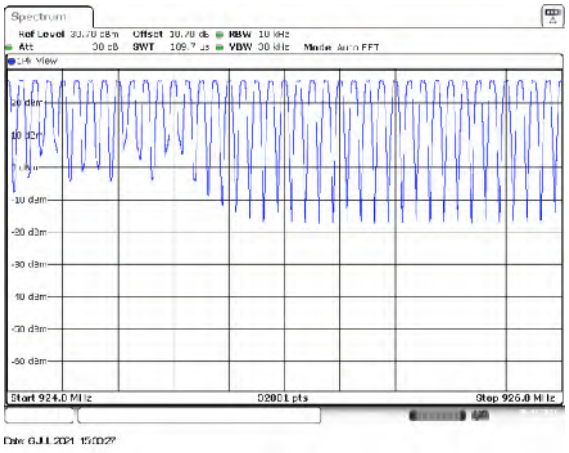


Figure 7.4.2.2-22: Mode 3 (512 Channels)

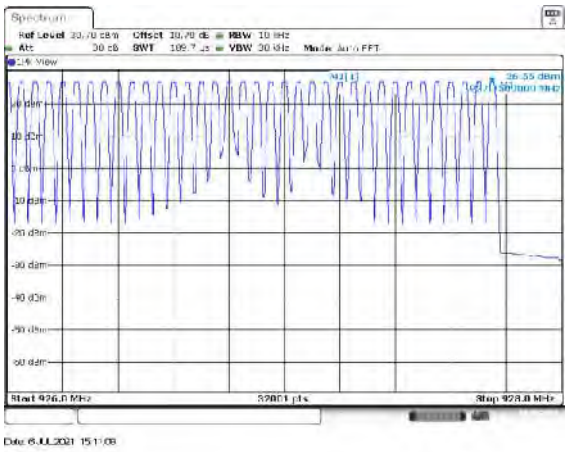


Figure 7.4.2.2-23: Mode 3 (512 Channels)

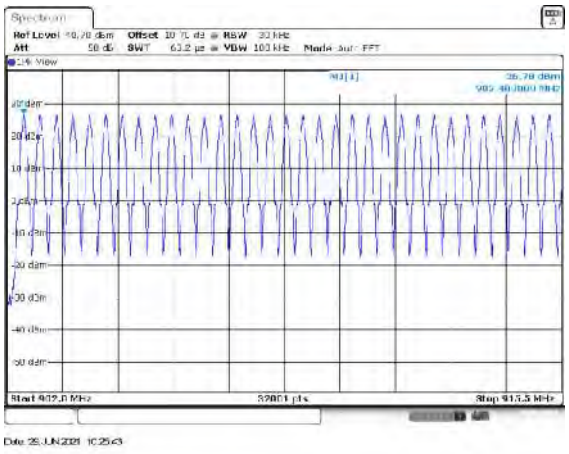


Figure 7.4.2.2-24: Mode 4 (64 Channels)

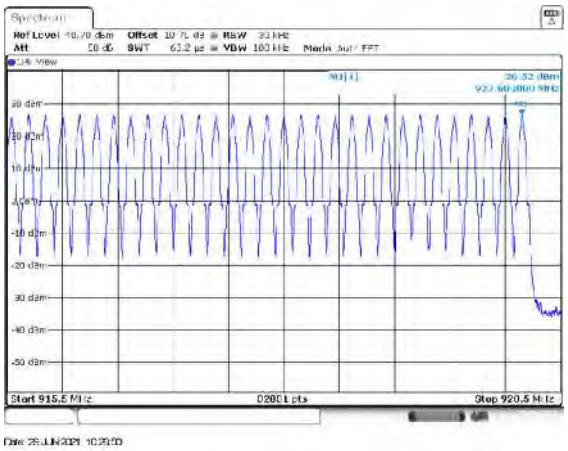


Figure 7.4.2.2-25: Mode 4 (64 Channels)

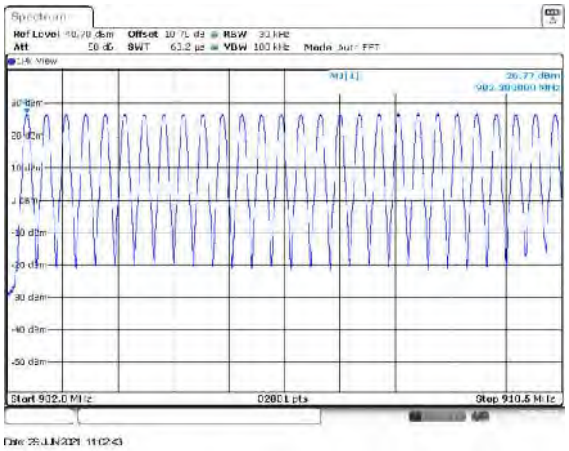


Figure 7.4.2.2-26: Mode 5 (83 Channels)

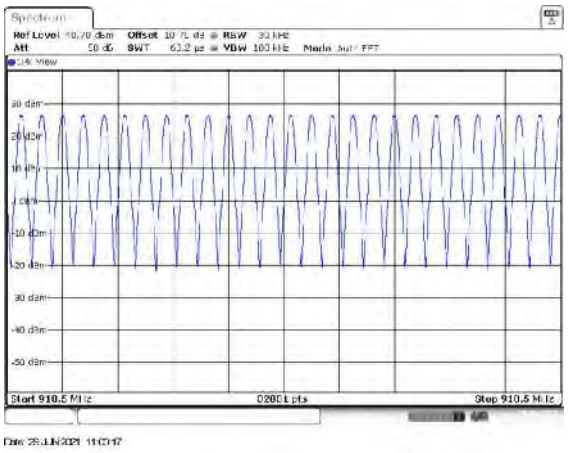


Figure 7.4.2.2-27: Mode 5 (83 Channels)

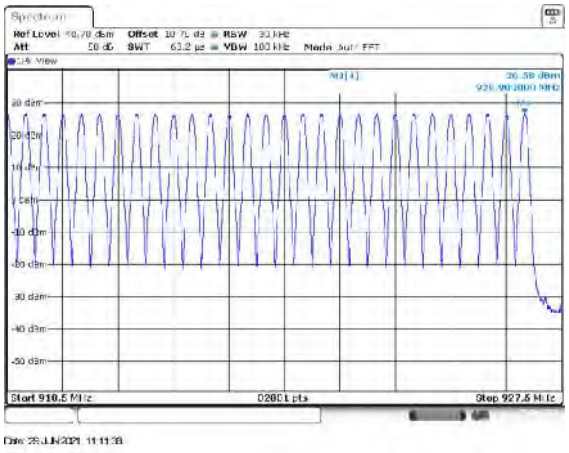


Figure 7.4.2.2-28: Mode 5 (83 Channels)

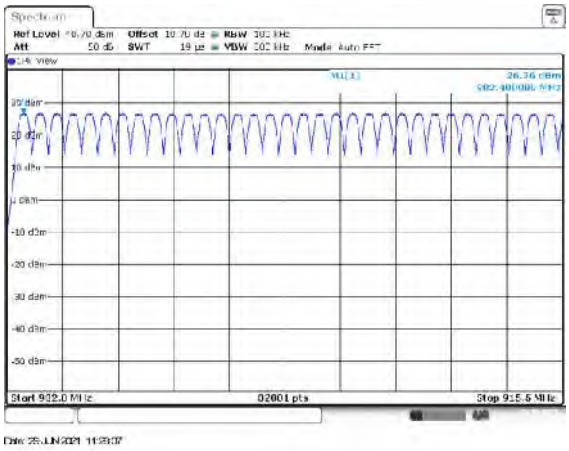


Figure 7.4.2.2-29: Mode 7 (64 Channels)

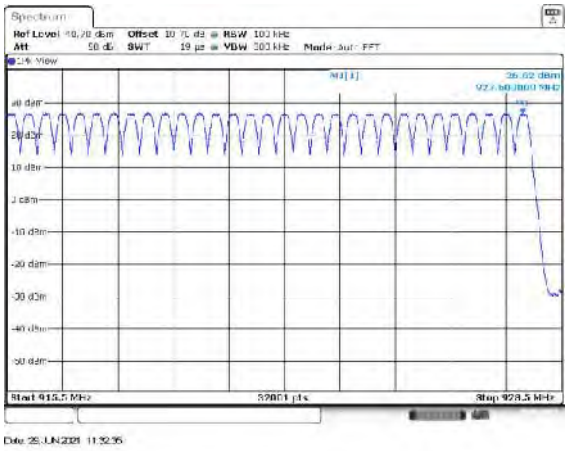


Figure 7.4.2.2-30: Mode 7 (64 Channels)

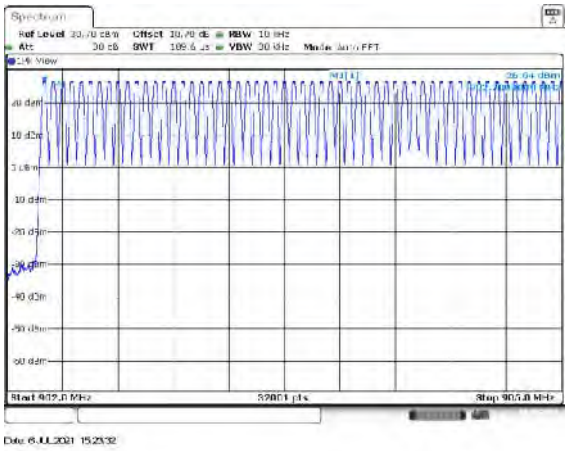


Figure 7.4.2.2-31: Mode 8 (512 Channels)

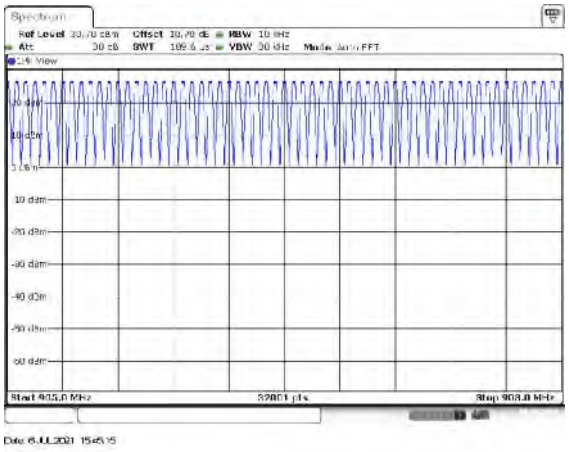


Figure 7.4.2.2-32: Mode 8 (512 Channels)

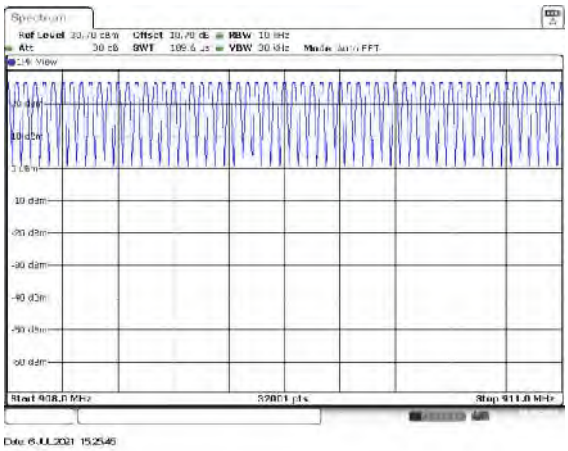


Figure 7.4.2.2-33: Mode 8 (512 Channels)

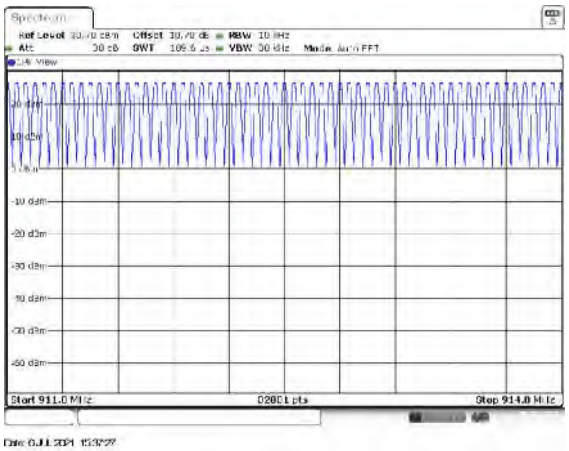


Figure 7.4.2.2-34: Mode 8 (512 Channels)

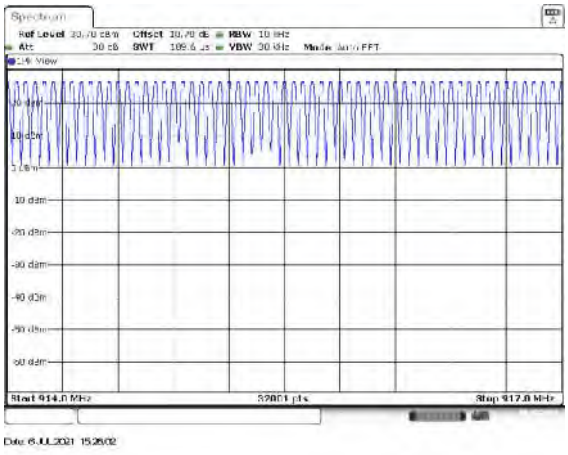


Figure 7.4.2.2-35: Mode 8 (512 Channels)

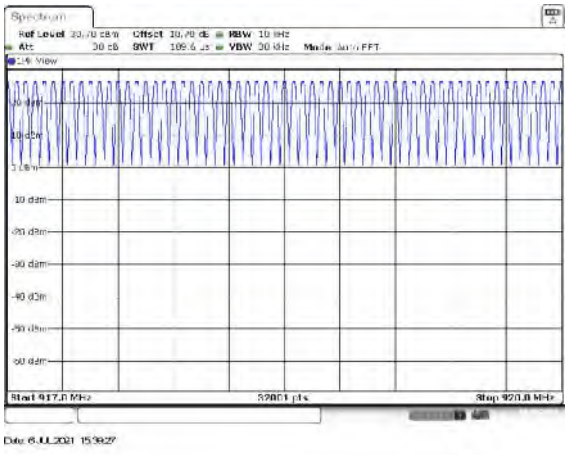


Figure 7.4.2.2-36: Mode 8 (512 Channels)

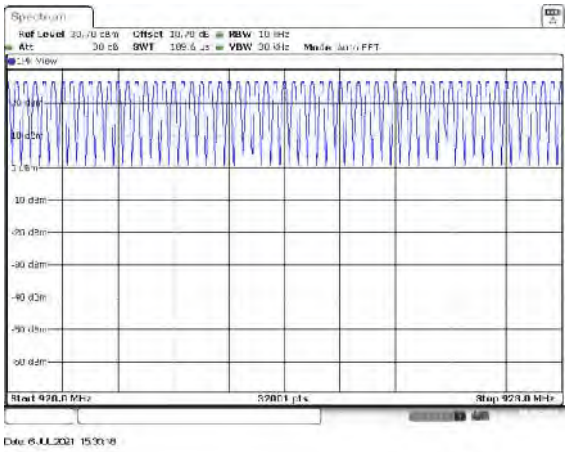


Figure 7.4.2.2-37: Mode 8 (512 Channels)

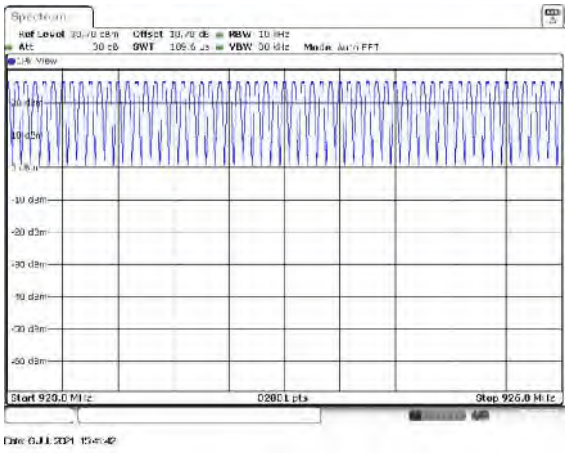


Figure 7.4.2.2-38: Mode 8 (512 Channels)

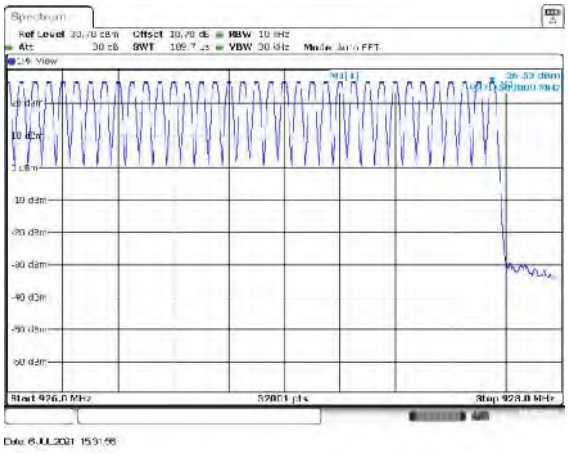


Figure 7.4.2.2-39: Mode 8 (512 Channels)

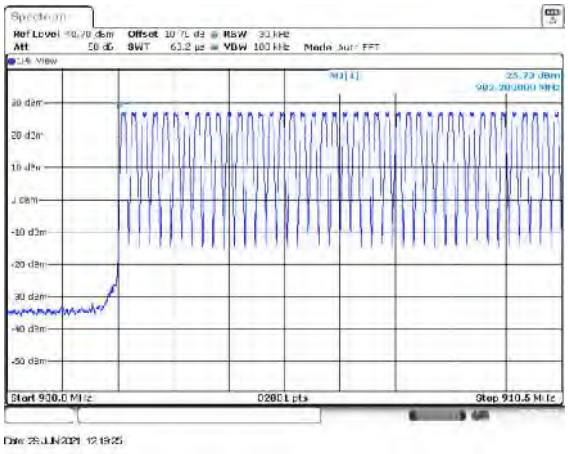


Figure 7.4.2.2-40: Mode 9 (129 Channels)

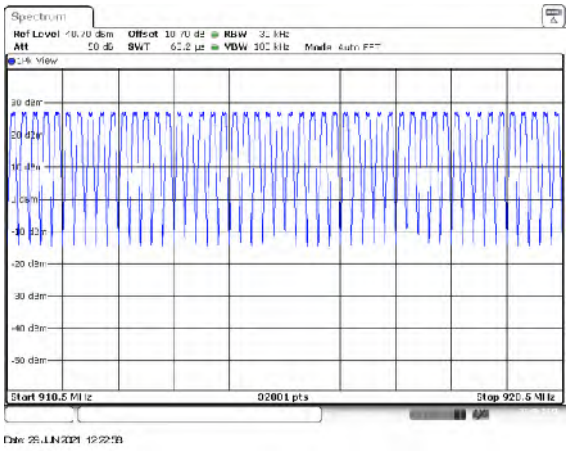


Figure 7.4.2.2-41: Mode 8 (129 Channels)

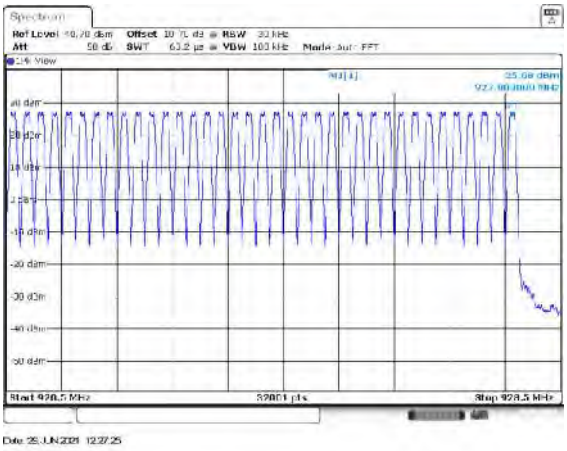


Figure 7.4.2.2-42: Mode 9 (129 Channels)

7.1.9 Channel Dwell Time - FCC Section 15.247(a)(1)(i); ISED: RSS-247 5.1(c)

7.1.9.1 Measurement Procedure

The EUT test mode does not generate a worst-case channel dwell time therefore a detailed engineering analysis is provided in the theory of operation.

7.1.10 20dB / 99% Bandwidth – FCC Section 15.247(a)(1)(i); ISED Canada: RSS-247 5.1(c)

7.1.10.1 Measurement Procedure

The RF output port of the EUT was directly connected to the input of the spectrum analyzer with suitable attenuation. The span of the spectrum analyzer display was set between two times and five times the occupied bandwidth (OBW) of the emission. The RBW of the spectrum analyzer was set to approximately 1 % to 5 % of the OBW. The trace was set to max hold with a peak detector active. The Delta and ndB down functions of the analyzer were utilized to determine the 20 dB bandwidth of the emission.

The occupied bandwidth measurement function of the spectrum analyzer was used to measure the 99% bandwidth. The span of the analyzer was set to capture all products of the modulation process, including the emission sidebands. The resolution bandwidth was set to 1% to 5% of the occupied bandwidth. The video bandwidth was set to 3 times the resolution bandwidth. A peak detector was used.

7.1.10.2 Measurement Results

Performed by: Bhagyashree Chaudhary

Table 7.4.4.2-1: 20dB / 99% Bandwidth

Frequency [MHz]	20dB Bandwidth [kHz]	99% Bandwidth [kHz]	Data Rate (kbps)	Mode(s)
903	110.555	321.937	16.384	1
903	109.469	299.344	16.384	2
902.2	20.724	18.476	10.000	3
902.4	158.214	157.073	150.000	4
902.3	107.078	105.016	100.000	5
902.4	312.553	312.146	300.000	6
902.4	312.303	312.303	300.000	7
902.2	27.105	26.074	25.000	8
902.2	103.100	97.550	50.000	9
916	112.094	320.989	16.384	1
916	108.844	298.771	16.384	2
915.25	20.742	18.482	10.000	3
915.6	157.823	157.401	150.000	4
915.2	107.078	105.078	100.000	5
915.6	312.553	312.146	300.000	6
915.6	312.584	311.896	300.000	7
915.25	27.048	26.038	25.000	8
915.2	103.081	97.462	50.000	9
926.8	110.031	320.989	16.384	1
926.8	109.906	299.772	16.384	2
927.75	20.741	18.479	10.000	3

927.6	157.792	157.323	150.000	4
926.9	107.219	105.140	100.000	5
927.6	312.437	311.719	300.000	6
927.6	312.521	311.928	300.000	7
927.75	27.129	26.085	25.000	8
927.8	103.125	97.612	50.000	9

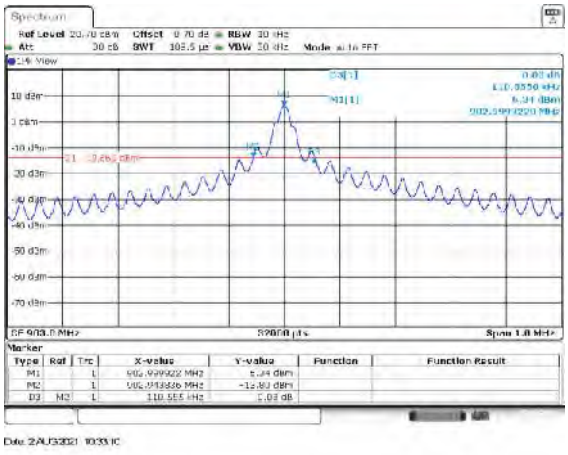


Figure 7.4.4.2-1: 20 dB BW Low Channel – Mode 1

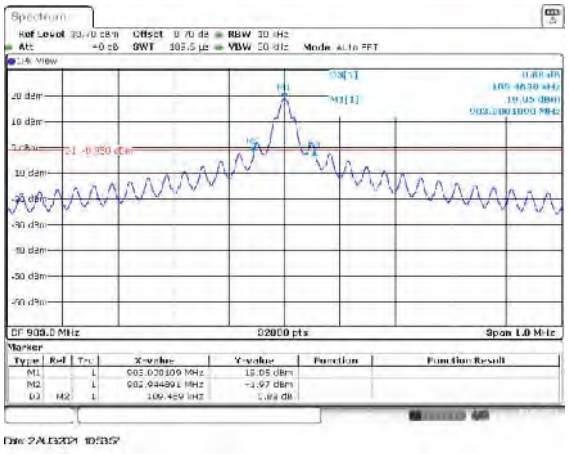


Figure 7.4.4.2-2: 20 dB BW Low Channel – Mode 2

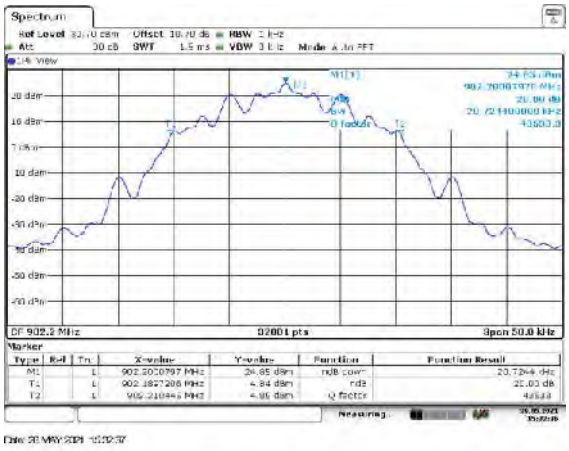


Figure 7.4.4.2-3: 20 dB BW Low Channel – Mode 3

Figure 7.4.4.2-4: 20 dB BW Low Channel – Mode 4

Figure 7.4.4.2-5: 20 dB BW Low Channel – Mode 5

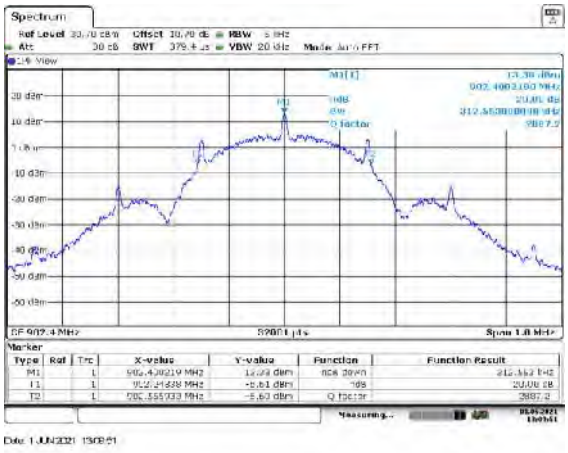


Figure 7.4.4.2-6: 20 dB BW Low Channel – Mode 6

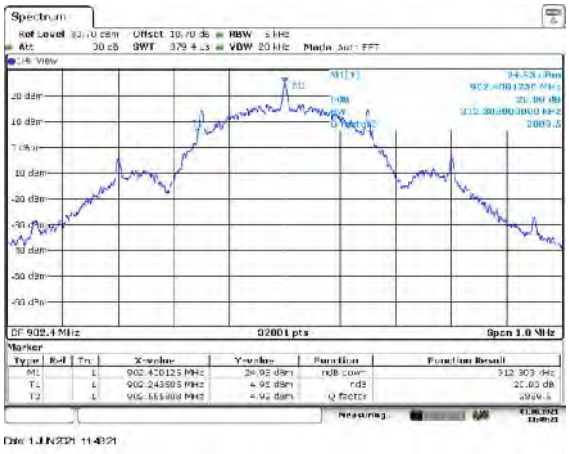


Figure 7.4.4.2-7: 20 dB BW Low Channel – Mode 7

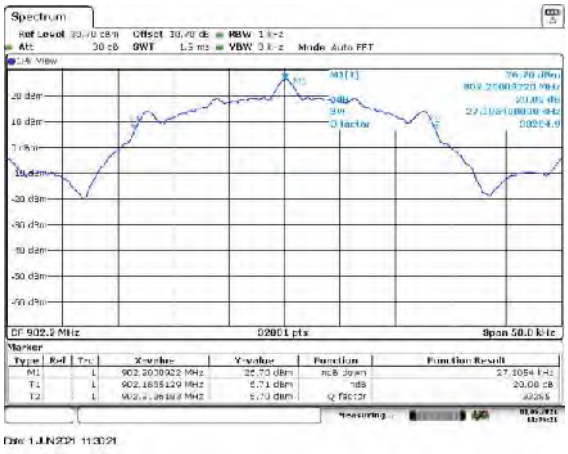


Figure 7.4.4.2-8: 20 dB BW Low Channel – Mode 8

Figure 7.4.4.2-9: 20 dB BW Low Channel – Mode 9

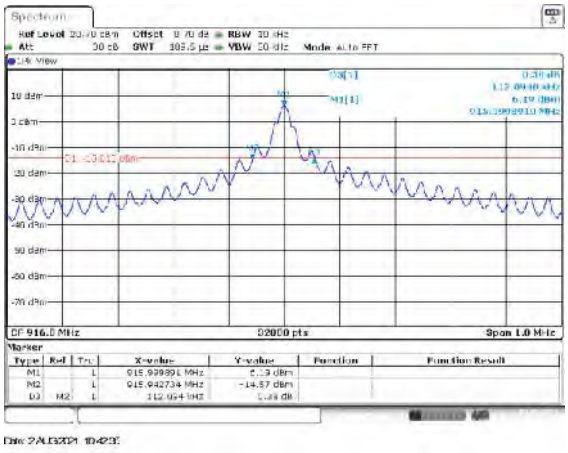


Figure 7.4.4.2-10: 20 dB BW Mid Channel – Mode 1

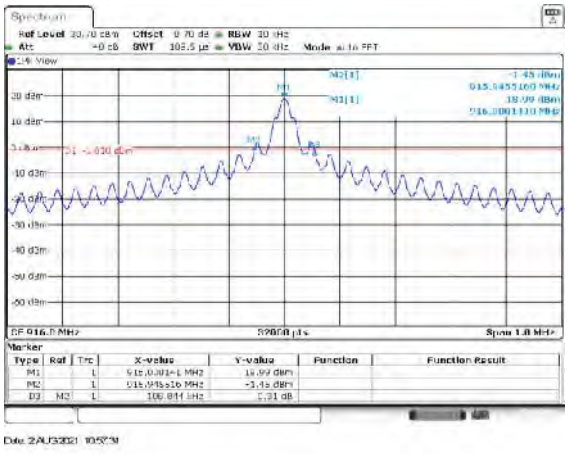


Figure 7.4.4.2-11: 20 dB BW Mid Channel – Mode 2

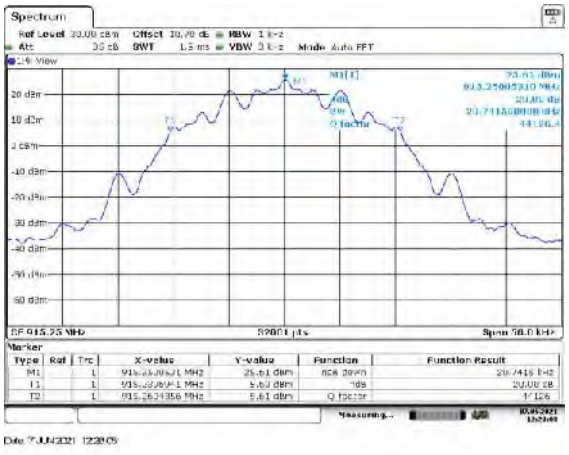


Figure 7.4.4.2-12: 20 dB BW Mid Channel – Mode 3

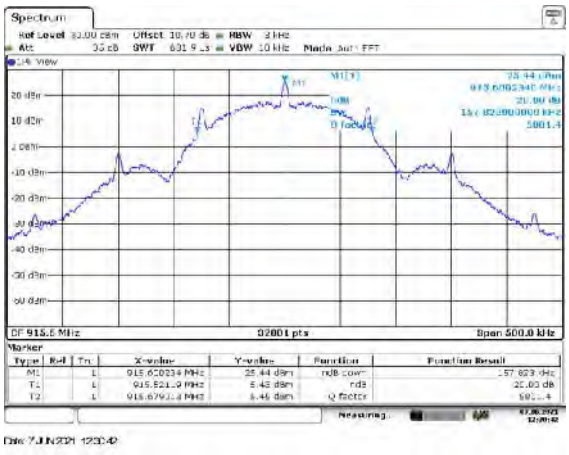


Figure 7.4.4.2-13: 20 dB BW Mid Channel – Mode 4

Figure 7.4.4.2-14: 20 dB BW Mid Channel – Mode 5

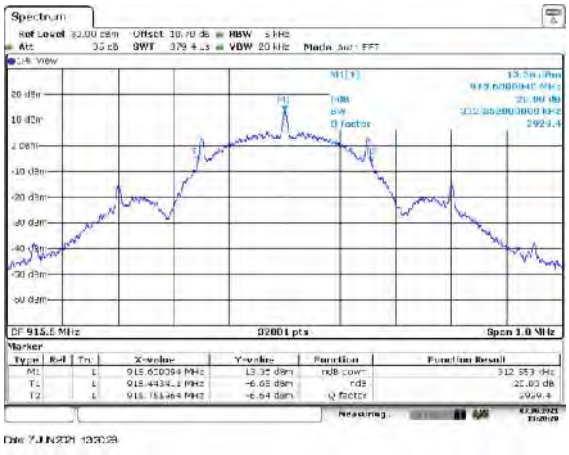


Figure 7.4.4.2-15: 20 dB BW Mid Channel – Mode 6

Figure 7.4.4.2-16: 20 dB BW Mid Channel –Mode 7

Figure 7.4.4.2-17: 20 dB BW Mid Channel – Mode 8

Figure 7.4.4.2-18: 20 dB BW Mid Channel –Mode 9

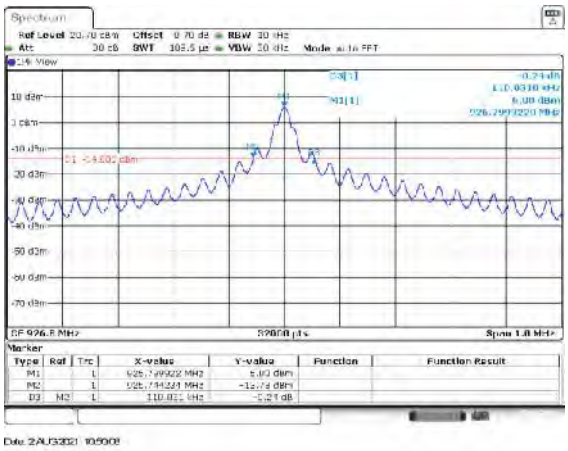


Figure 7.4.4.2-19: 20 dB BW High Channel – Mode 1

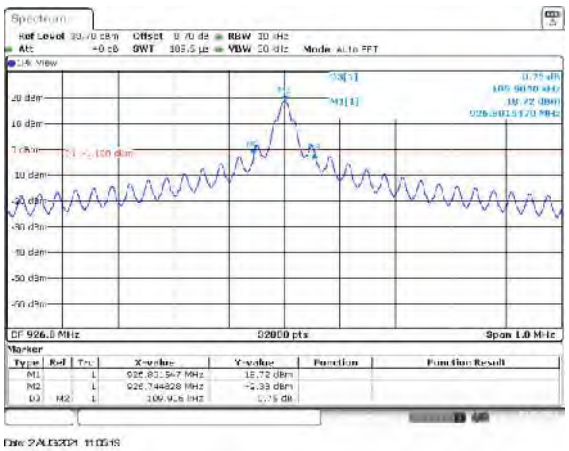


Figure 7.4.4.2-20: 20 dB BW High Channel – Mode 2

Figure 7.4.4.2-21: 20 dB BW High Channel – Mode 3

Figure 7.4.4.2-22: 20 dB BW High Channel – Mode 4

Figure 7.4.4.2-23: 20 dB BW High Channel – Mode 5

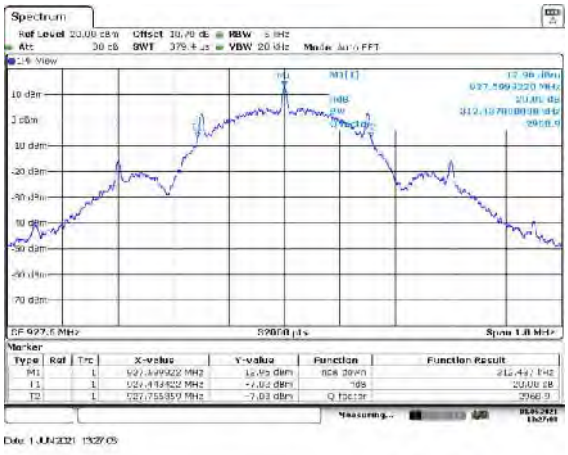


Figure 7.4.4.2-24: 20 dB BW High Channel – Mode 6

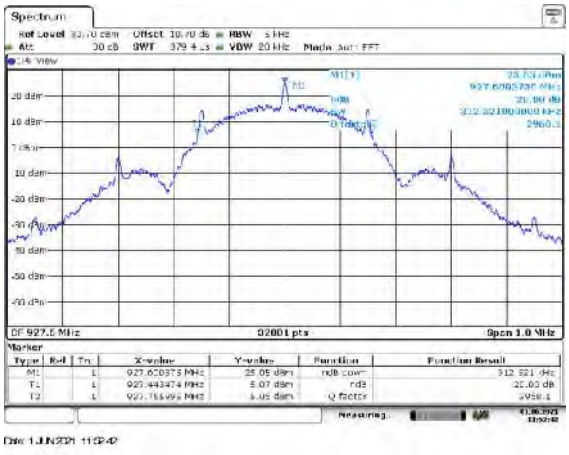


Figure 7.4.4.2-25: 20 dB BW High Channel – Mode 7

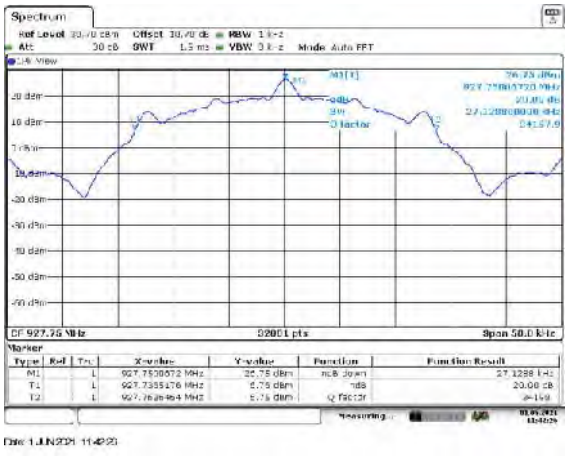


Figure 7.4.4.2-26: 99% BW Low Channel – Mode 8

Figure 7.4.4.2-27: 20 dB BW High Channel – Mode 9

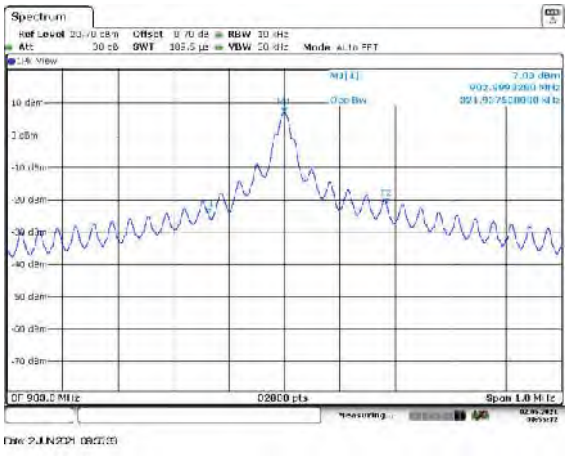


Figure 7.4.4.2-28: 99% BW Low Channel – Mode 1

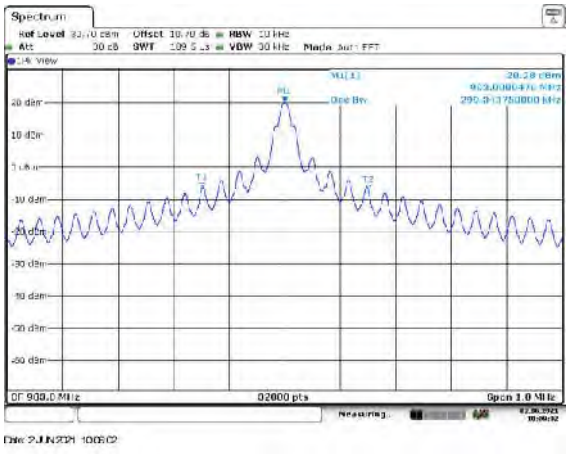


Figure 7.4.4.2-29: 99% BW Low Channel – Mode 2

Figure 7.4.4.2-30: 99% BW Low Channel – Mode 3

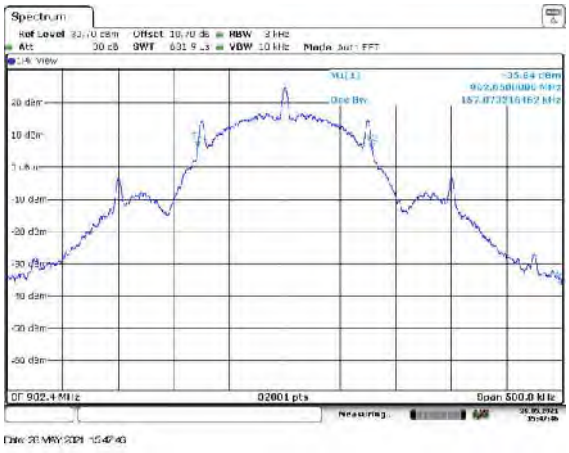


Figure 7.4.4.2-31: 99% BW Low Channel – mode 4

Figure 7.4.4.2-32: 99% BW Low Channel – Mode 5

Figure 7.4.4.2-33: 99% BW Low Channel – Mode 6

Figure 7.4.4.2-34: 99% BW Low Channel – Mode 7

Figure 7.4.4.2-35: 99% BW Low Channel – Mode 8

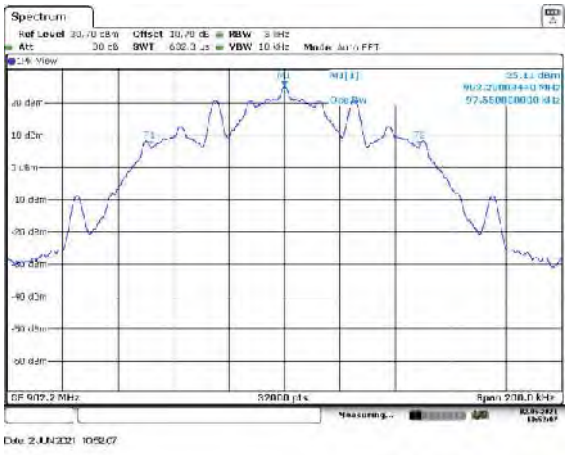


Figure 7.4.4.2-36: 99% BW Low Channel – Mode 9

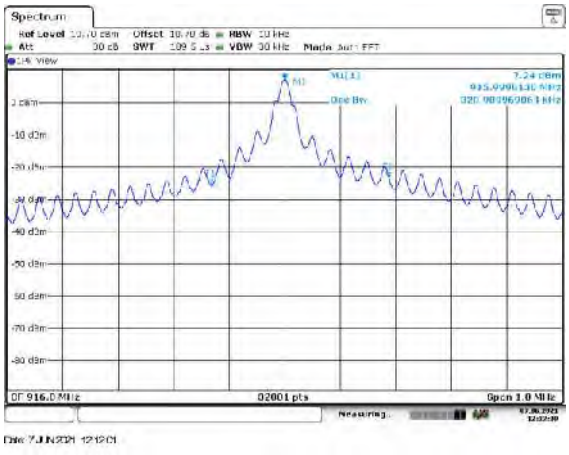


Figure 7.4.4.2-37: 99% BW Mid Channel – Mode 1

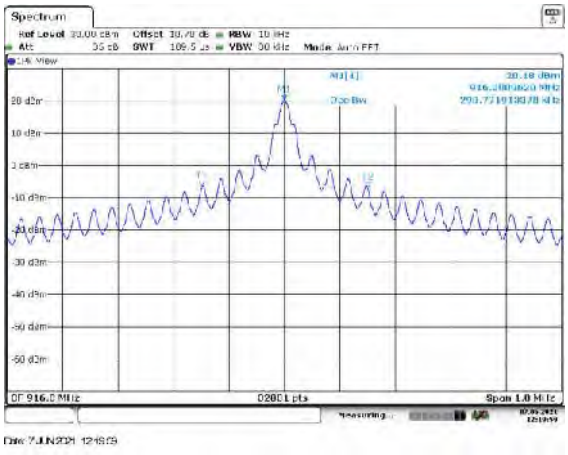


Figure 7.4.4.2-38: 99% BW Mid Channel – Mode 2

Figure 7.4.4.2-39: 99% BW Mid Channel – Mode 3

Figure 7.4.4.2-40 99% BW Mid Channel – Mode 4

Figure 7.4.4.2-41: 99% BW Mid Channel – Mode 5

Figure 7.4.4.2-42: 99% BW Mid Channel – Mode 6

Figure 7.4.4.2-43: 99% BW Mid Channel – Mode 7

Figure 7.4.4.2-44: 99% BW Mid Channel – Mode 8

Figure 7.4.4.2-45: 99% BW Mid Channel – Mode 9

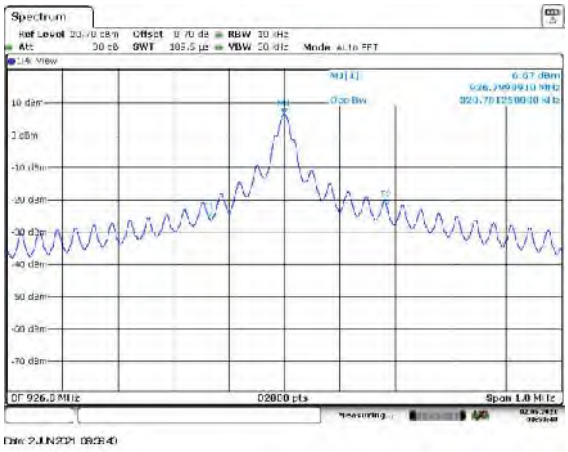


Figure 7.4.4.2-46: 99% BW High Channel – Mode 1

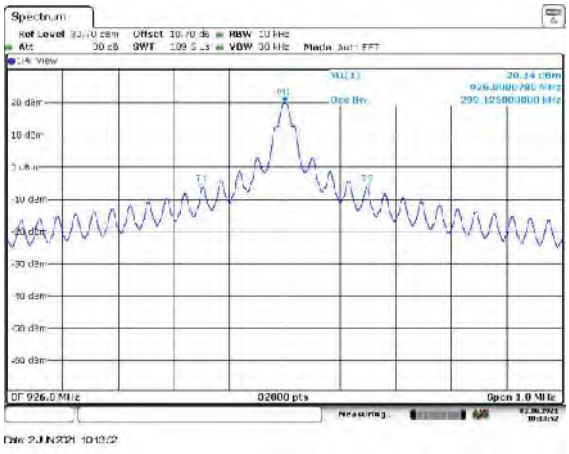
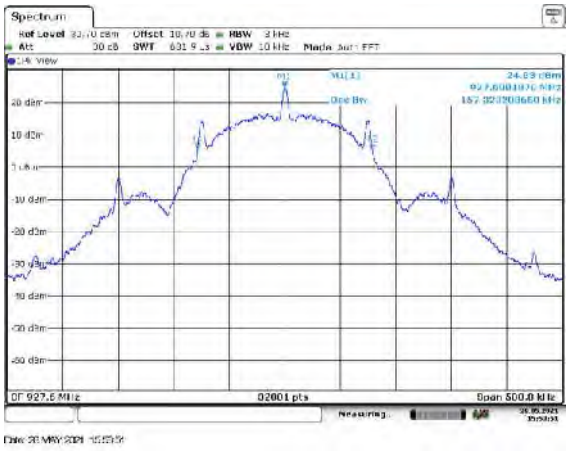


Figure 7.4.4.2-47: 99% BW High Channel – Mode 2

Figure 7.4.4.2-48: 99% BW High Channel – Mode 3



F Figure 7.4.4.2-49: 99% BW High Channel – Mode 4

Figure 7.4.4.2-50: 99% BW High Channel – Mode 5

Figure 7.4.4.2-51: 99% BW High Channel – Mode 6

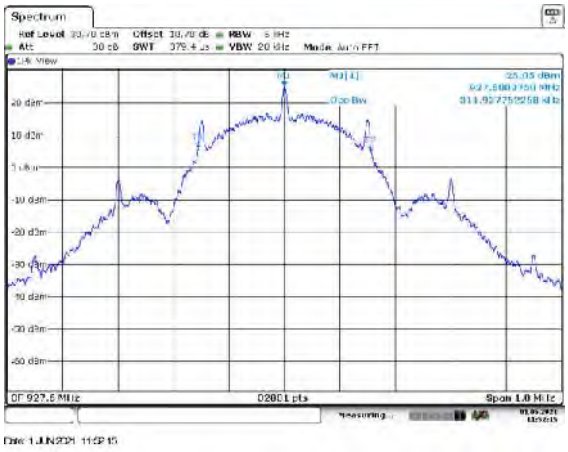


Figure 7.4.4.2-52: 99% BW High Channel – Mode 7

Figure 7.4.4.2-53: 99% BW High Channel – Mode 8

Figure 7.4.4.2-54: 99% BW High Channel – Mode 9

Band-Edge Compliance and Spurious Emissions

7.1.11 Band-Edge Compliance of RF Conducted Emissions – FCC Section 15.247(d); ISED Canada: RSS-247 5.5

7.1.11.1 Measurement Procedure

The RF output port of the EUT was directly connected to the input of the spectrum analyzer with suitable attenuation. The EUT was investigated at the lowest and highest channel available to determine band-edge compliance. For each measurement, the spectrum analyzer's RBW was set to 100kHz and the VBW was set to 300kHz.

Band-edge was measured for all Modes and data presented in section 7.5.1.2 below.

7.1.11.2 Measurement Results

Performed by: Divya Adusumilli

HOPPING MODE:

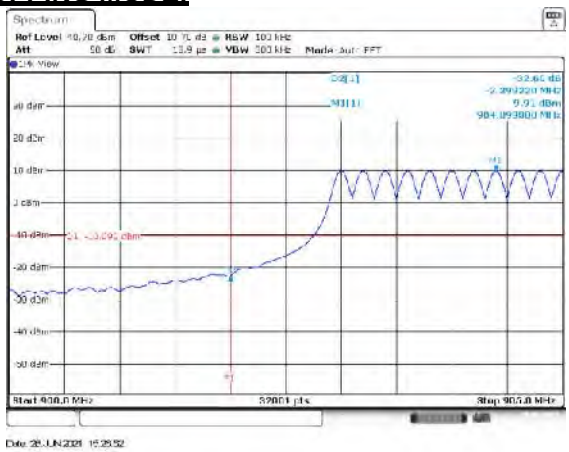


Figure 7.5.1.2-1: Lower Band edge – Mode 1

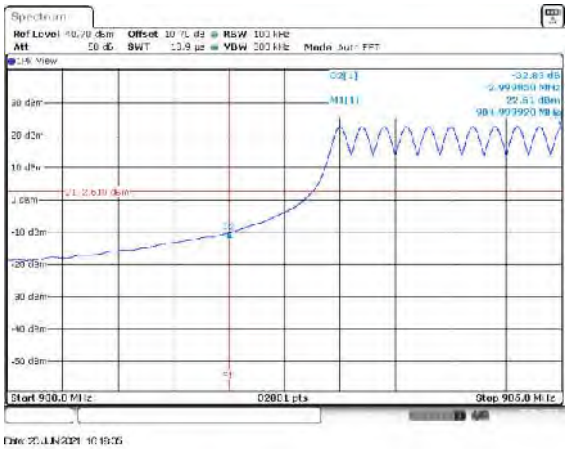


Figure 7.5.1.2-2: Lower Band edge – Mode 2

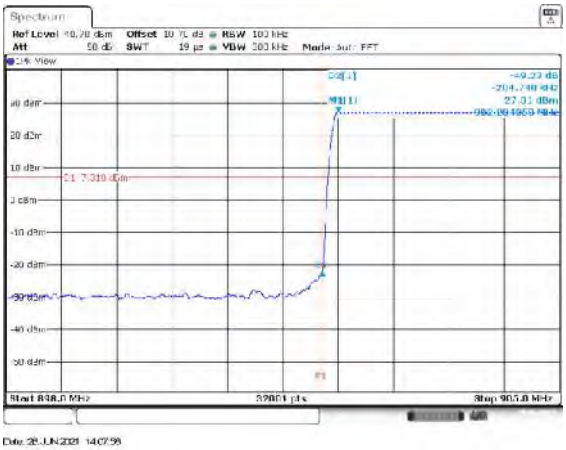


Figure 7.5.1.2-3: Lower Band edge – Mode 3

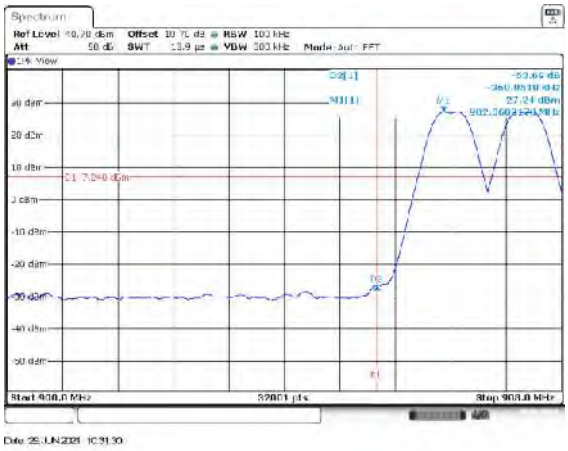


Figure 7.5.1.2-4: Lower Band edge – Mode 4

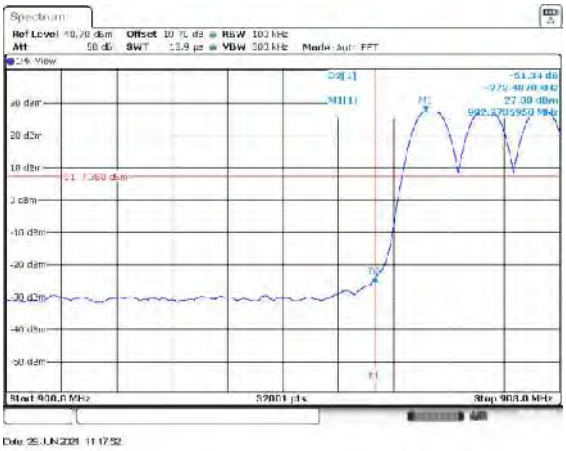


Figure 7.5.1.2-5: Lower Band edge – Mode 5

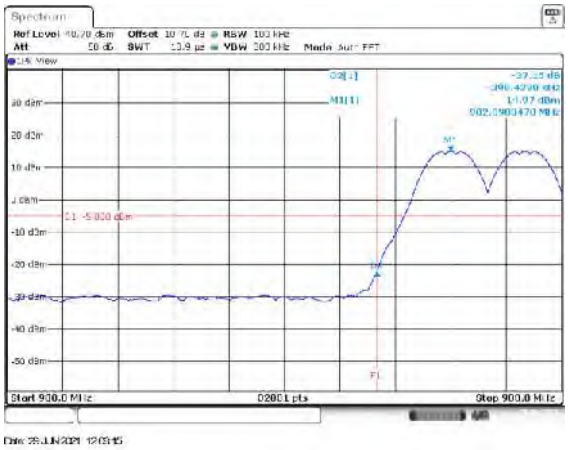


Figure 7.5.1.2-6: Lower Band edge – Mode 6

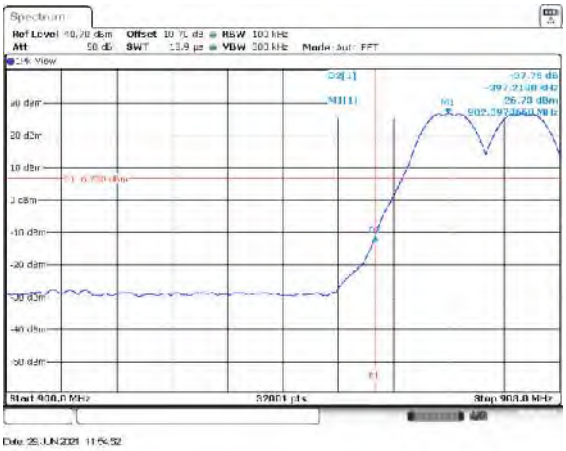


Figure 7.5.1.2-7: Lower Band edge – Mode 7

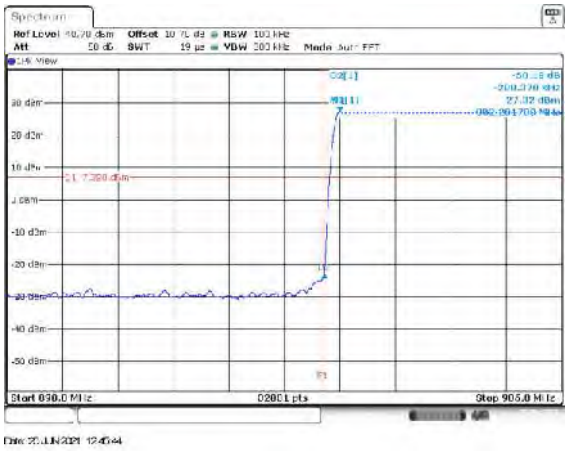


Figure 7.5.1.2-8: Lower Band edge – Mode 8

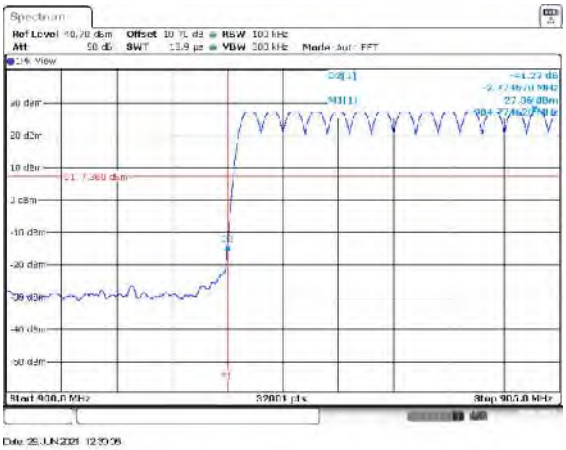


Figure 7.5.1.2-9: Lower Band edge – Mode 9

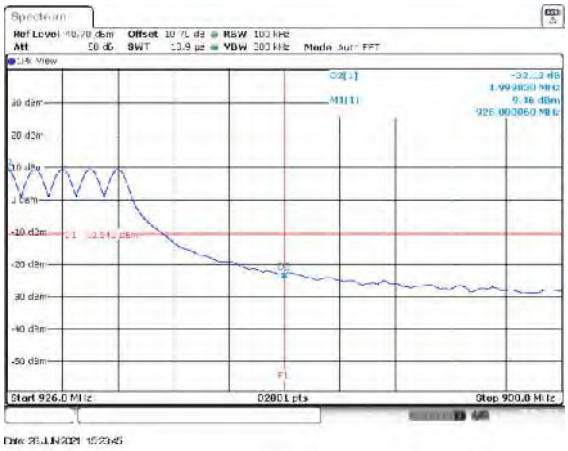


Figure 7.5.1.2-10: Upper Band edge – Mode 1

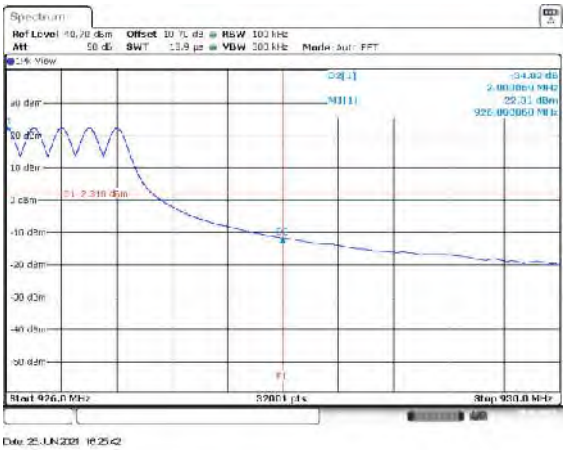


Figure 7.5.1.2-11: Upper Band edge – Mode 2

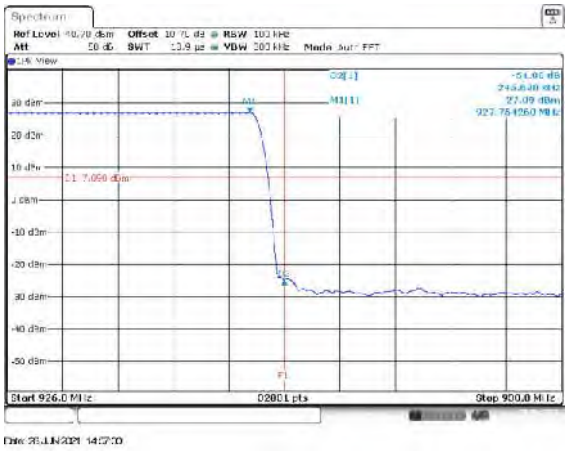


Figure 7.5.1.2-12: Upper Band edge – Mode 3

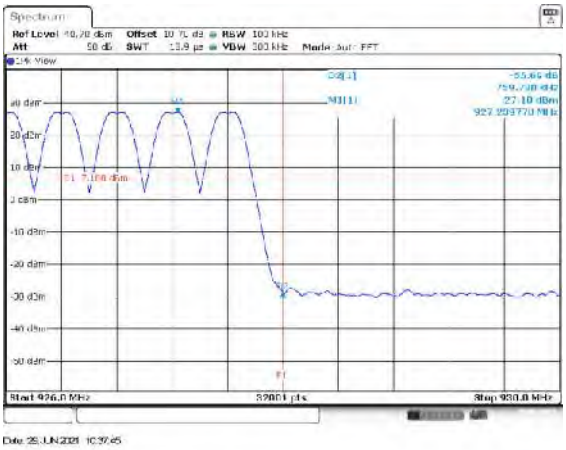


Figure 7.5.1.2-13: Upper Band edge – Mode 4

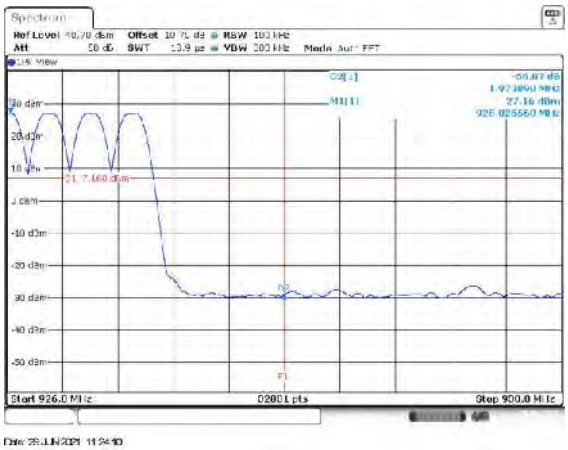


Figure 7.5.1.2-14: Upper Band edge – Mode 5

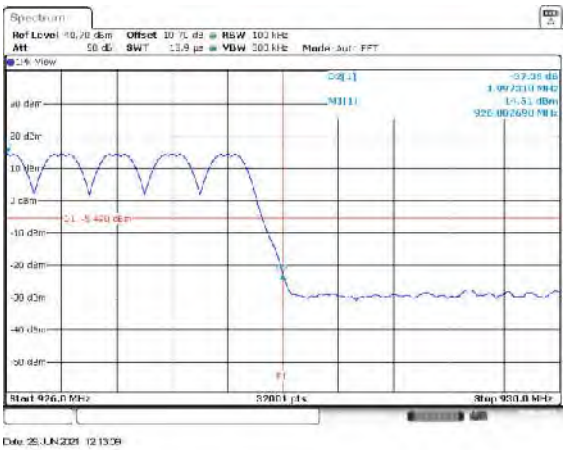


Figure 7.5.1.2-15: Upper Band edge – Mode 6

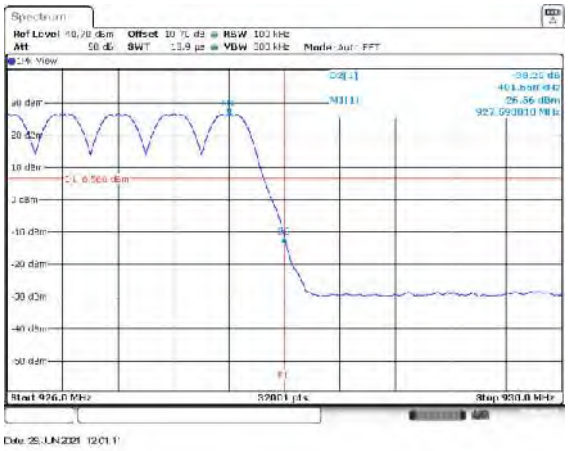


Figure 7.5.1.2-16: Upper Band edge – Mode 7

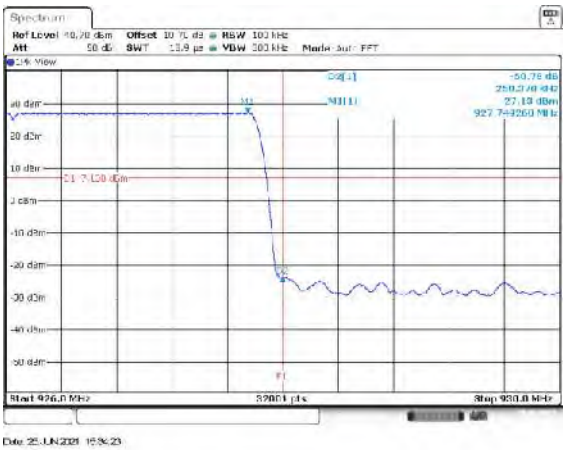


Figure 7.5.1.2-17: Upper Band edge – Mode 8

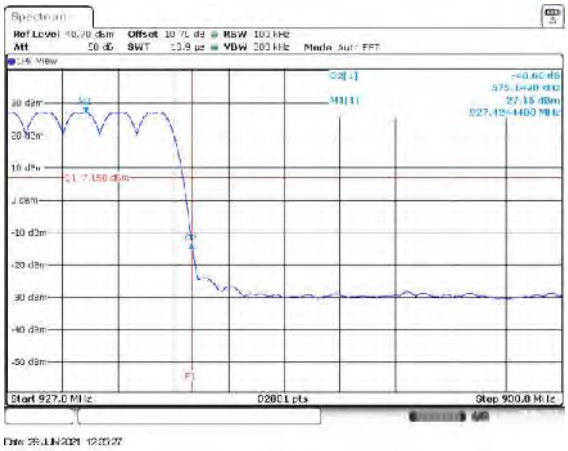


Figure 7.5.1.2-18: Upper Band edge – Mode 9

NON-HOPPING MODE:

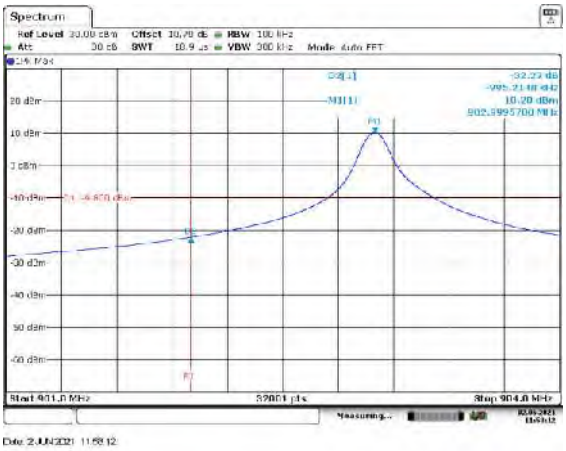


Figure 7.5.1.2-1: Lower Band edge – Mode 1

Figure 7.5.1.2-2: Lower Band edge – Mode 2

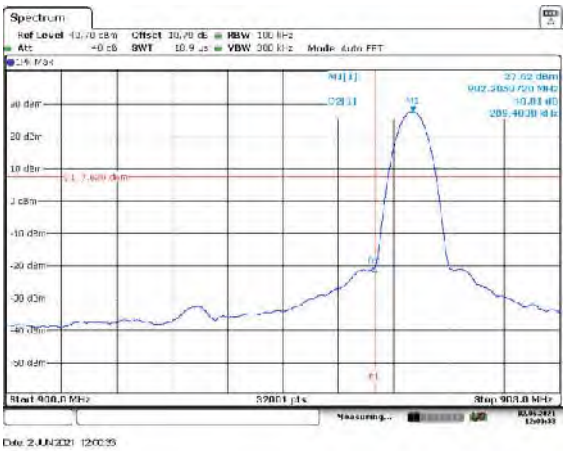


Figure 7.5.1.2-3: Lower Band edge – Mode 3

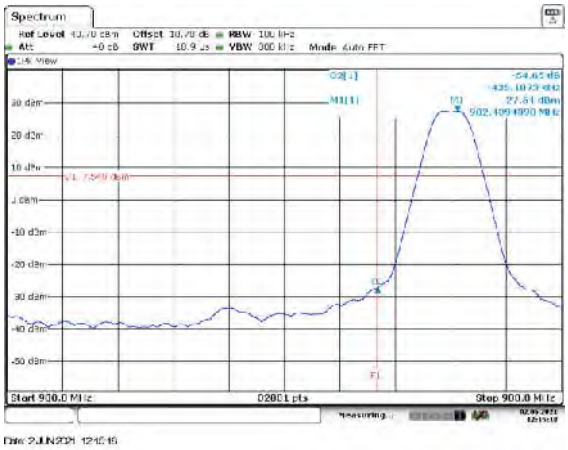


Figure 7.5.1.2-4: Lower Band edge – Mode 4

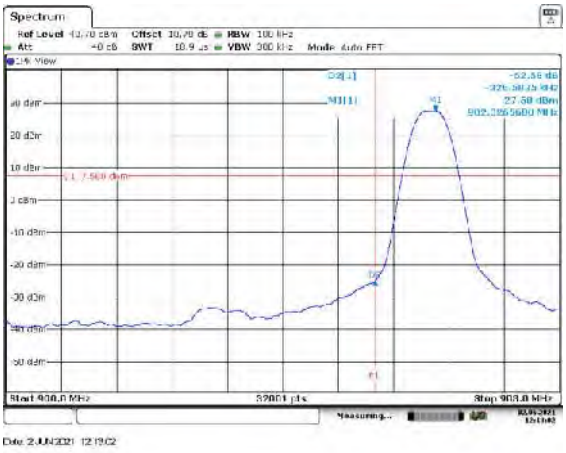


Figure 7.5.1.2-5: Lower Band edge – Mode 5

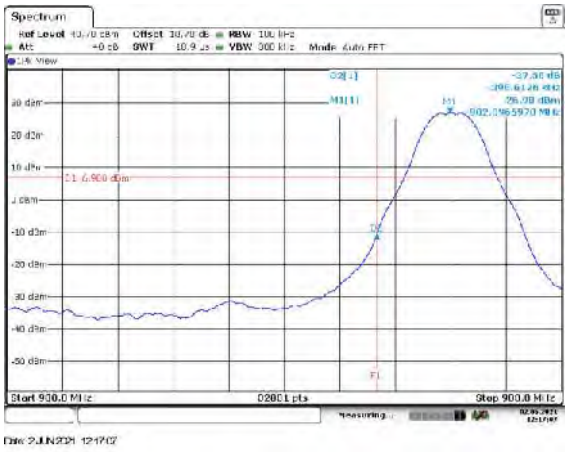


Figure 7.5.1.2-6: Lower Band edge – Mode 6

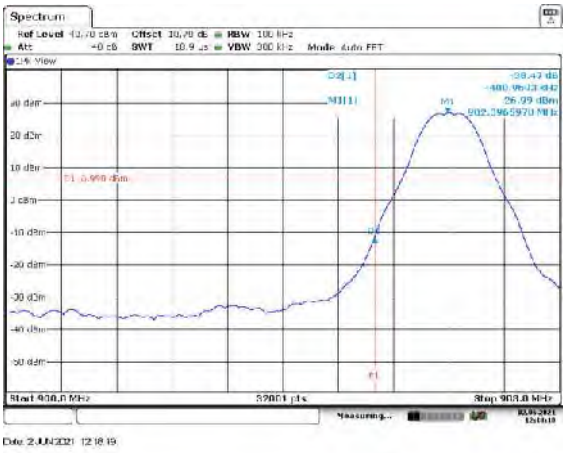


Figure 7.5.1.2-7: Lower Band edge – Mode 7

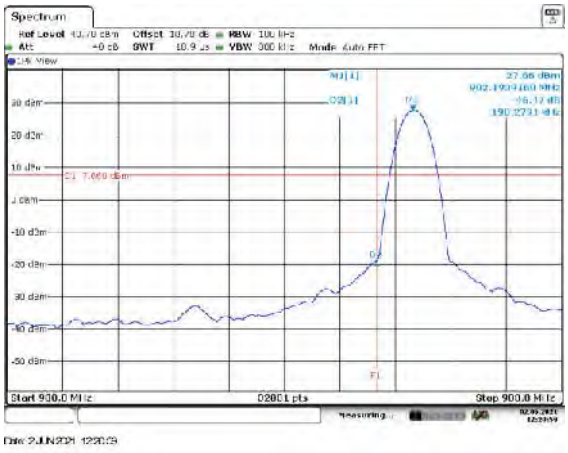


Figure 7.5.1.2-8: Lower Band edge – Mode 8

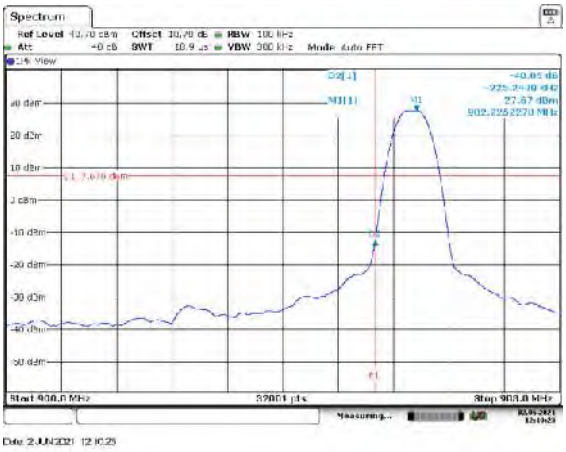


Figure 7.5.1.2-9: Lower Band edge – Mode 9

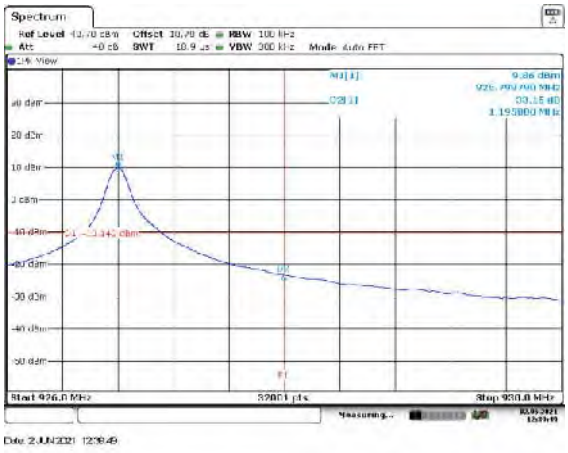


Figure 7.5.1.2-10: Upper Band edge – Mode 1

Figure 7.5.1.2-11: Upper Band edge – Mode 2

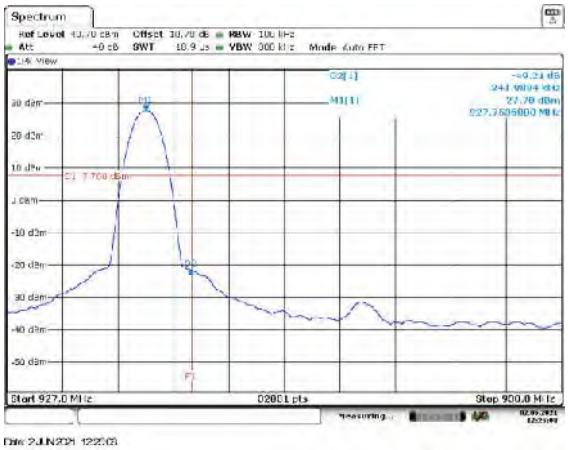


Figure 7.5.1.2-12: Upper Band edge – Mode 3

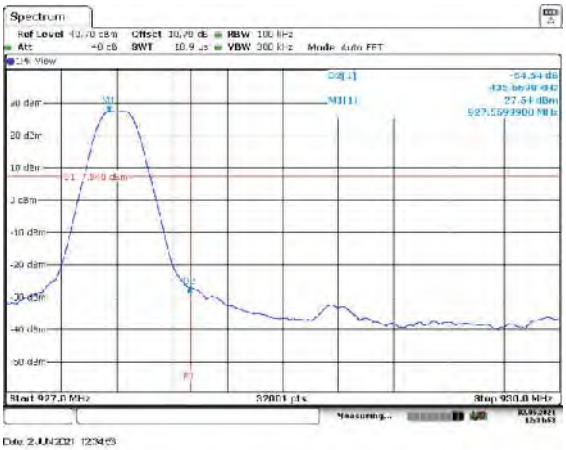


Figure 7.5.1.2-13: Upper Band edge – Mode 4

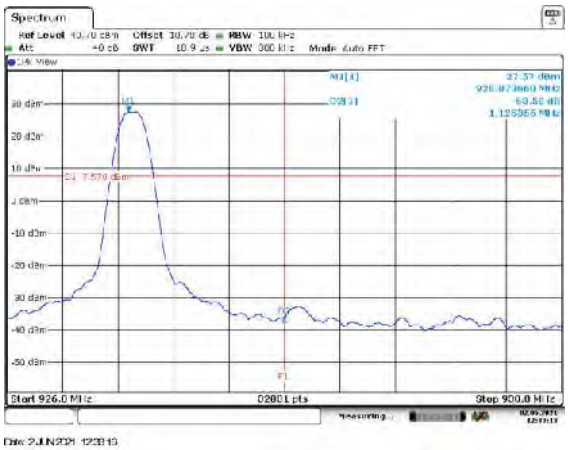


Figure 7.5.1.2-14: Upper Band edge – Mode 5

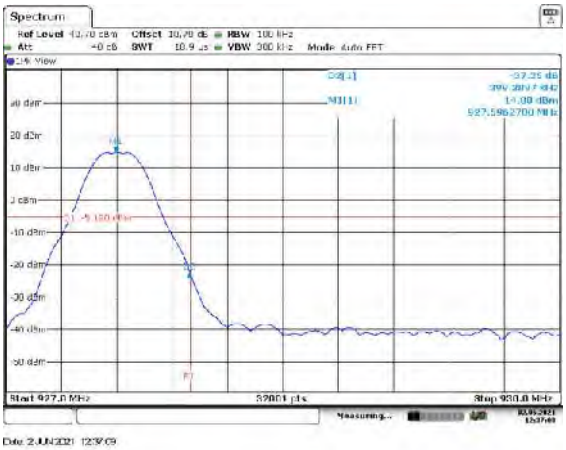


Figure 7.5.1.2-15: Upper Band edge – Mode 6

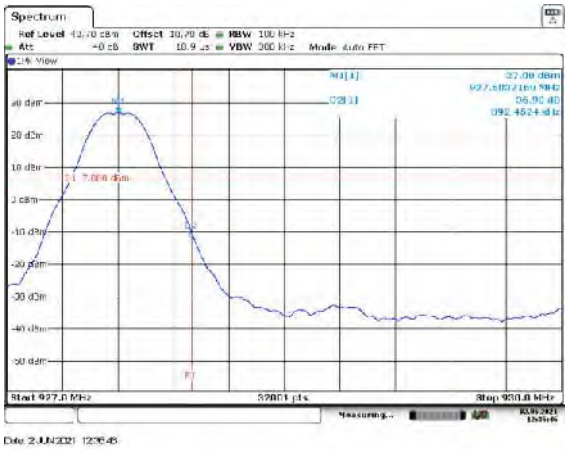


Figure 7.5.1.2-16: Upper Band edge – Mode 7

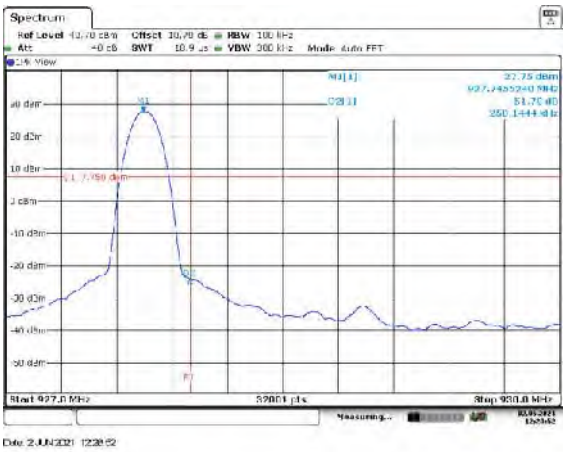


Figure 7.5.1.2-17: Upper Band edge – Mode 8

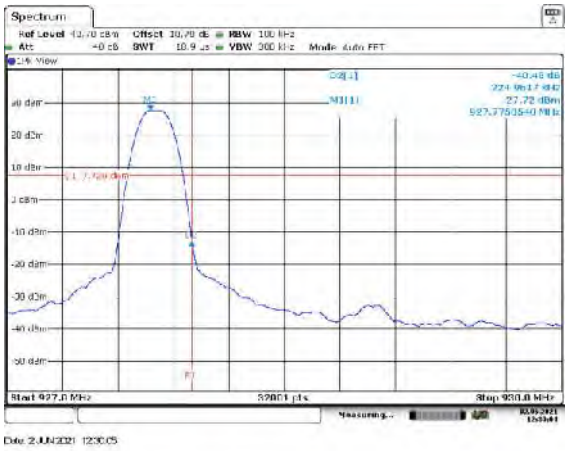


Figure 7.5.1.2-18: Upper Band edge – Mode 9

7.1.12 RF Conducted Spurious Emissions – FCC Section 15.247(d); ISED Canada RSS – 247 5.5

7.1.12.1 Measurement Procedure

The RF output port of the EUT was directly connected to the input of the spectrum analyzer. The EUT was investigated for conducted spurious emissions from 30MHz to 10 GHz, 10 times the highest fundamental frequency. Measurements were made at the low, center and high channels of the EUT. For each measurement, the spectrum analyzer's RBW was set to 100kHz. A peak detector function was used with the trace set to max hold.

Conducted spurious emissions were evaluated for all combinations of operating modes and data rates with worst case data provided.

7.1.12.2 Measurement Results

Performed by: Bhagyashree Chaudhary

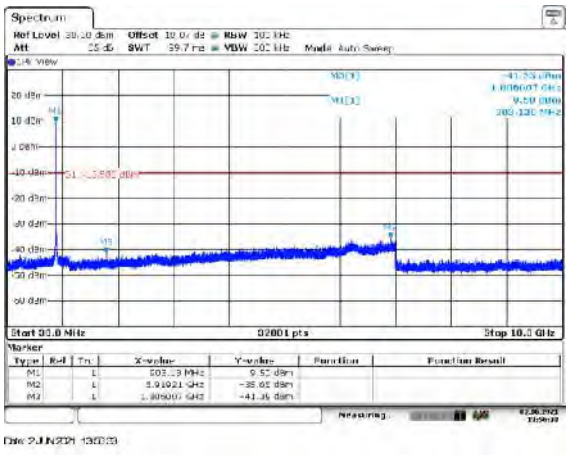


Figure 7.5.2.2-1: 30 MHz – 10 GHz – LCH-Mode 1

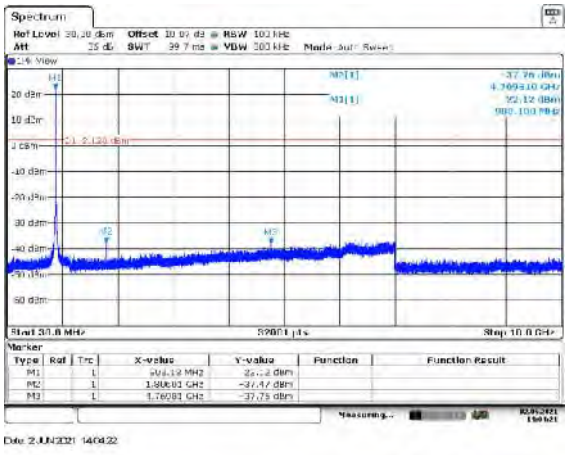


Figure 7.5.2.2-2: 30 MHz – 10 GHz – LCH-Mode 2

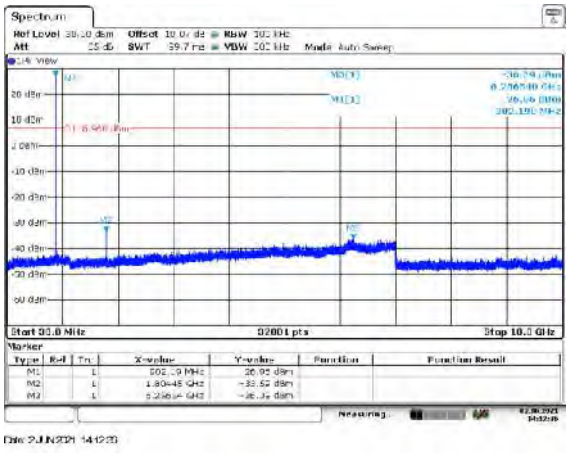


Figure 7.5.2.2-3: 30 MHz – 10 GHz – LCH-Mode 3

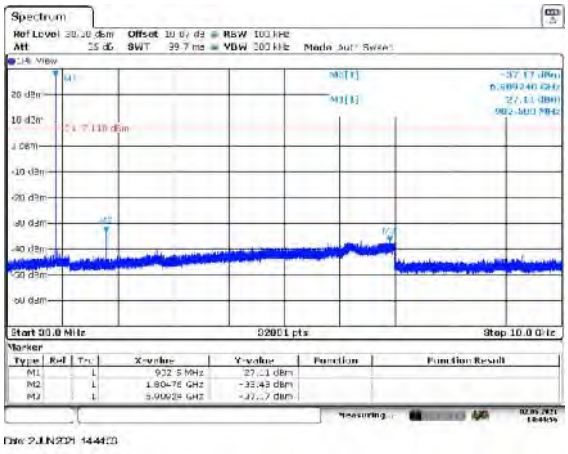


Figure 7.5.2.2-4: 30 MHz – 10 GHz – LCH-Mode 4

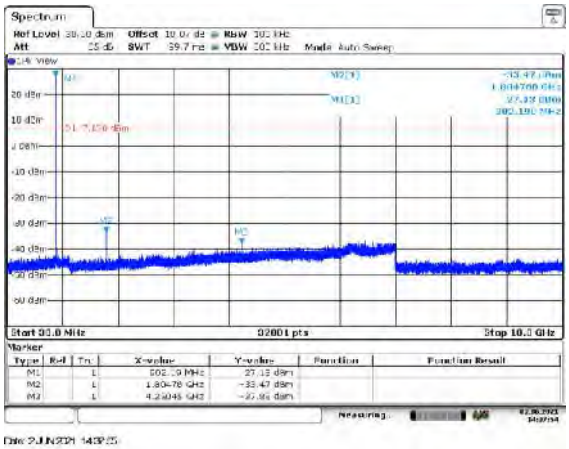


Figure 7.5.2.2-5: 30 MHz – 10 GHz – LCH-Mode 5

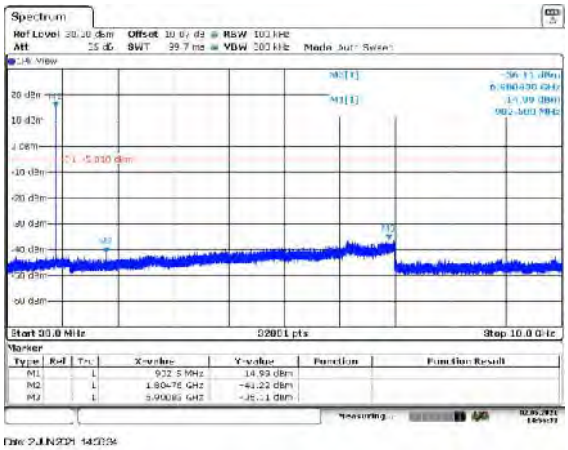


Figure 7.5.2.2-6: 30 MHz – 10 GHz – LCH-Mode 6

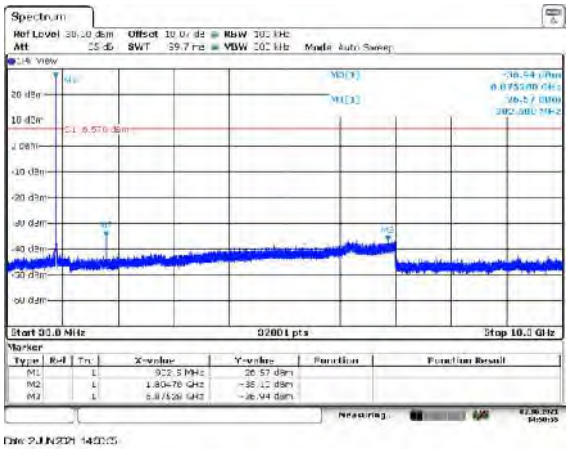


Figure 7.5.2.2-7: 30 MHz – 10 GHz – LCH-Mode 7

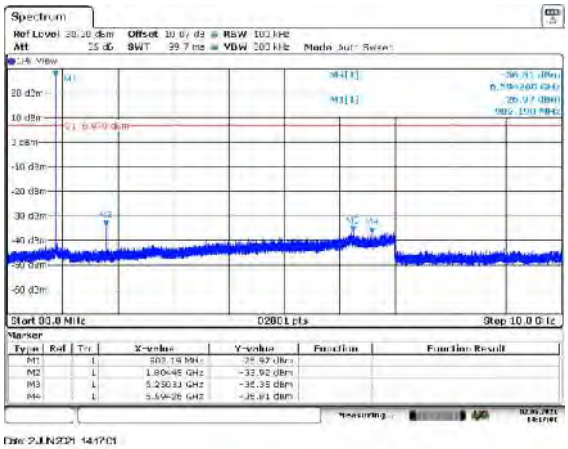


Figure 7.5.2.2-8: 30 MHz – 10 GHz – LCH-Mode 8

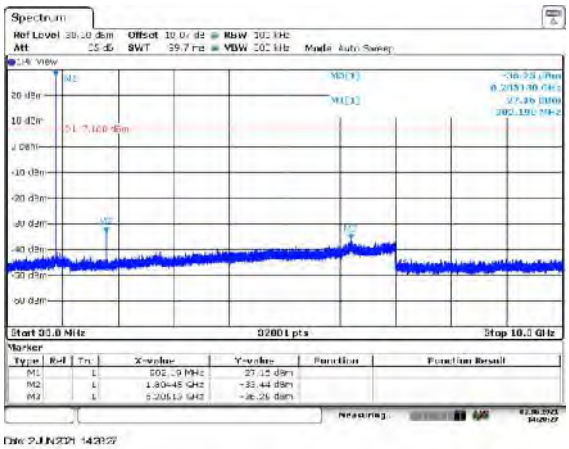


Figure 7.5.2.2-9: 30 MHz – 10 GHz – LCH-Mode 9

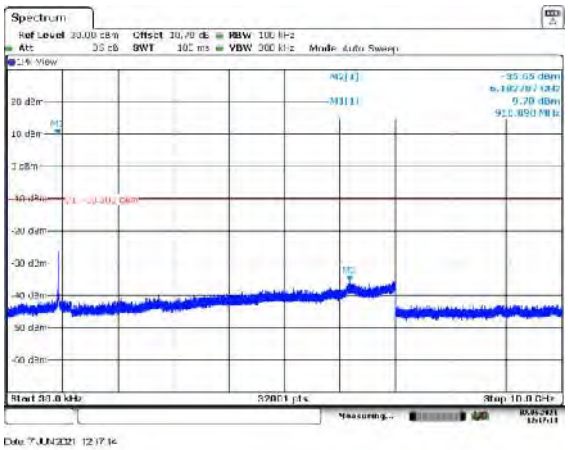


Figure 7.5.2.2-10: 30 MHz – 10 GHz – MCH-Mode 1

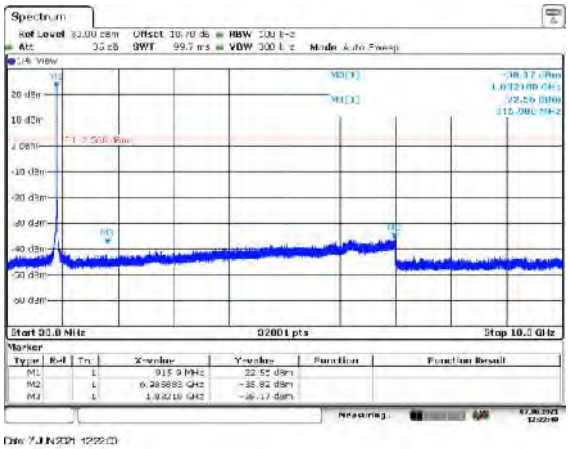


Figure 7.5.2.2-11: 30 MHz – 10 GHz – MCH-Mode 2

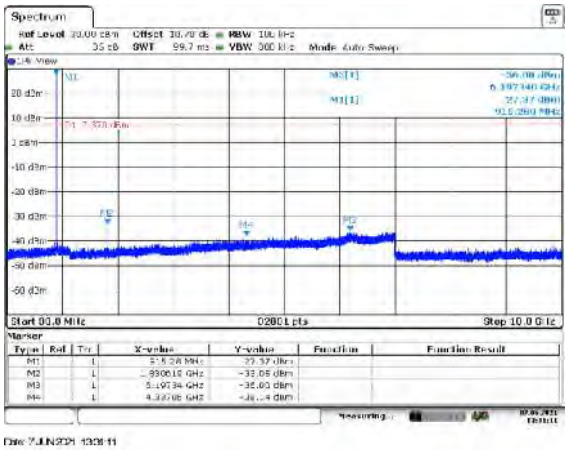


Figure 7.5.2.2-12: 30 MHz – 10 GHz – MCH-Mode 3

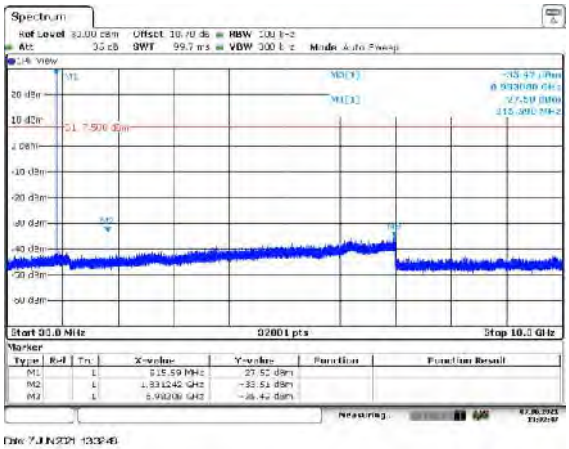


Figure 7.5.2.2-13: 30 MHz – 10 GHz – MCH-Mode 4

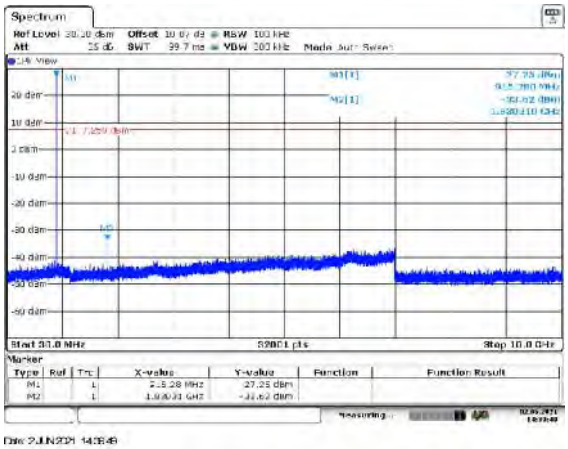


Figure 7.5.2.2-14: 30 MHz – 10 GHz – MCH-Mode 5

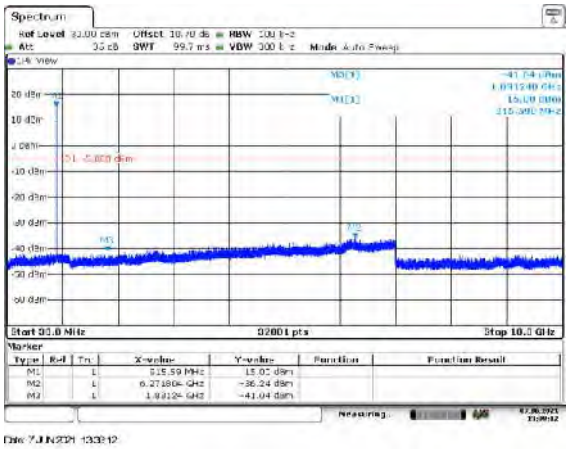


Figure 7.5.2.2-15: 30 MHz – 10 GHz – MCH-Mode 6

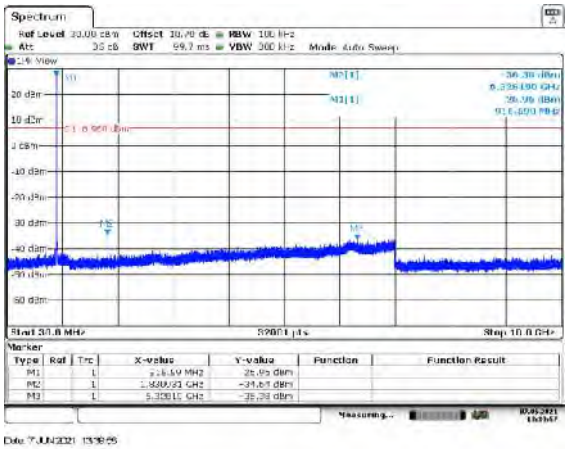


Figure 7.5.2.2-16: 30 MHz – 10 GHz – MCH-Mode 7

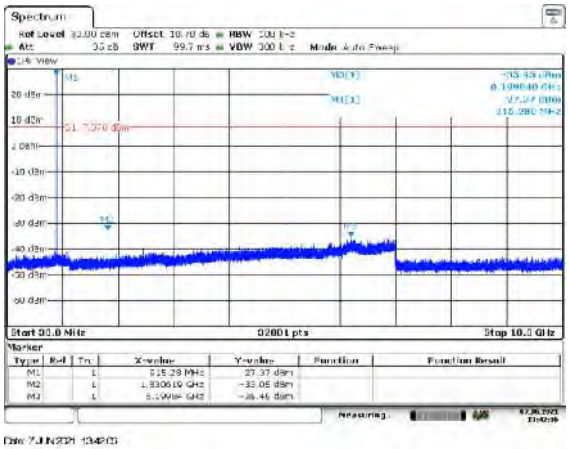


Figure 7.5.2.2-17: 30 MHz – 10 GHz – MCH-Mode 8

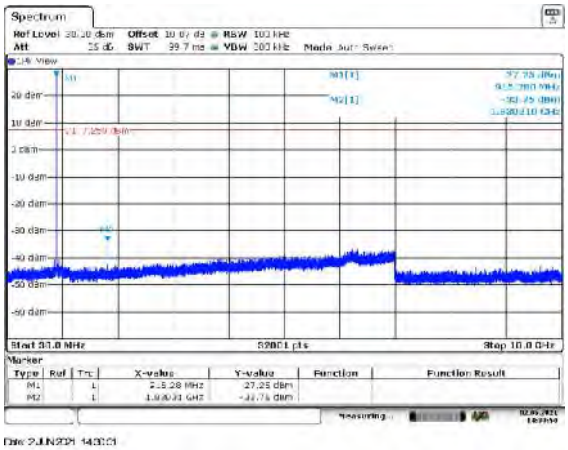


Figure 7.5.2.2-18: 30 MHz – 10 GHz – MCH-Mode 9

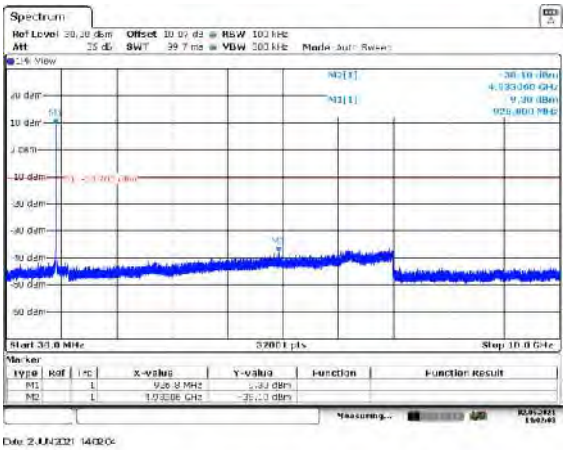


Figure 7.5.2.2-19: 30 MHz – 10 GHz – HCH-Mode 1

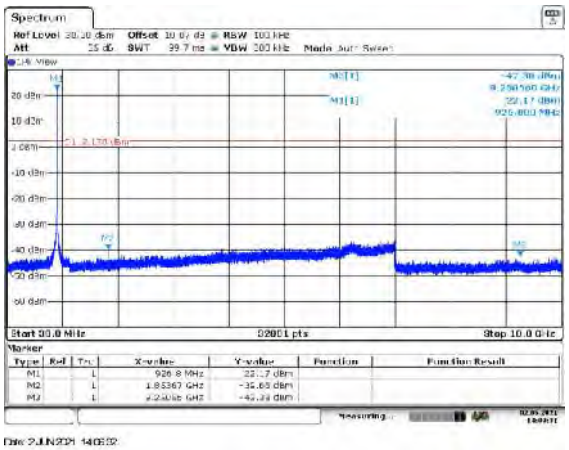


Figure 7.5.2.2-20: 30 MHz – 10 GHz – HCH-Mode 2

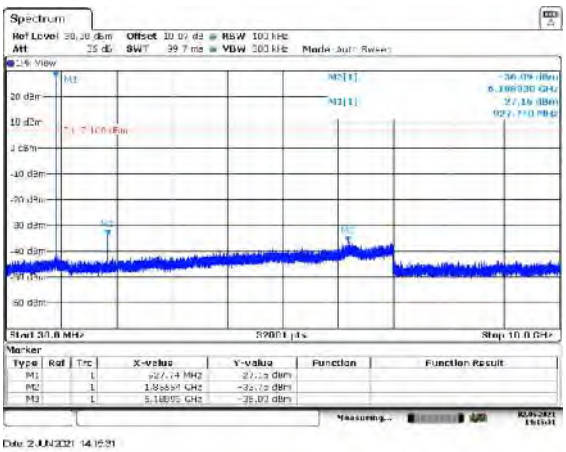


Figure 7.5.2.2-21: 30 MHz – 10 GHz – HCH-Mode 3

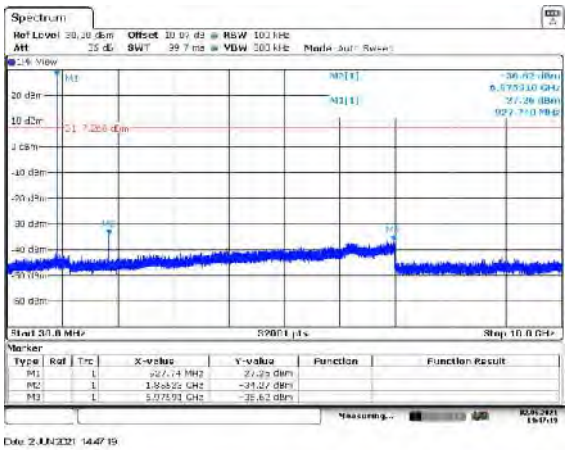


Figure 7.5.2.2-22: 30 MHz – 10 GHz – HCH-Mode 4

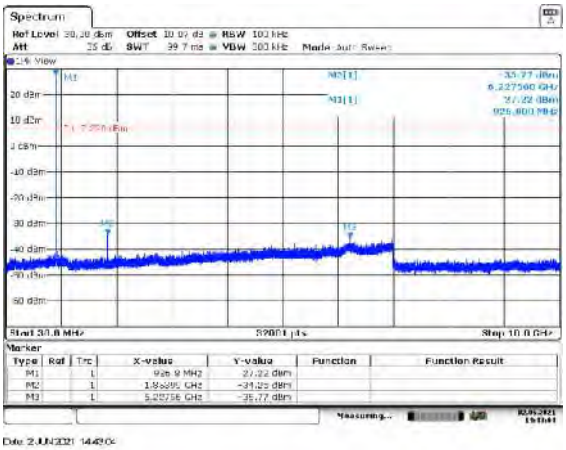


Figure 7.5.2.2-23: 30 MHz – 10 GHz – HCH-Mode 5

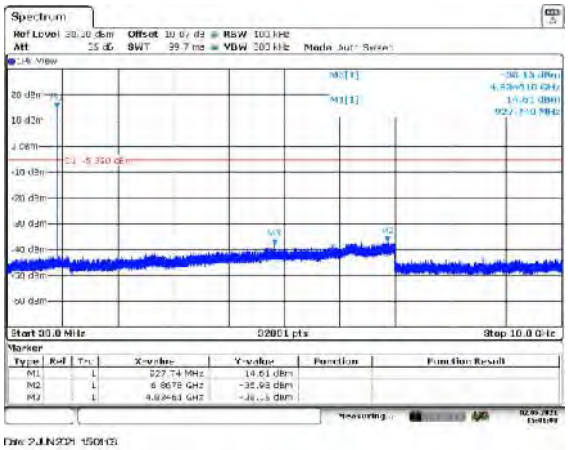


Figure 7.5.2.2-24: 30 MHz – 10 GHz – HCH-Mode 6

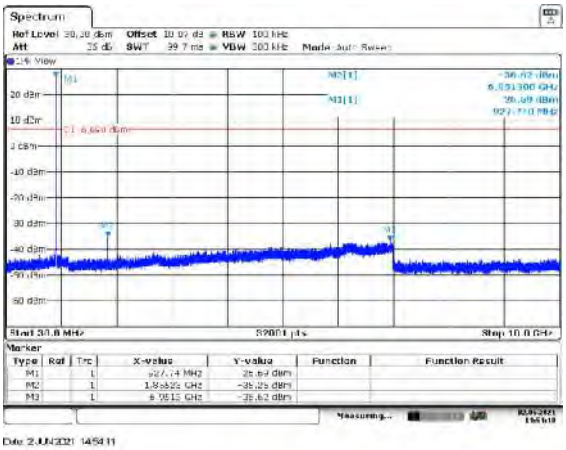


Figure 7.5.2.2-25: 30 MHz – 10 GHz – HCH-Mode 7

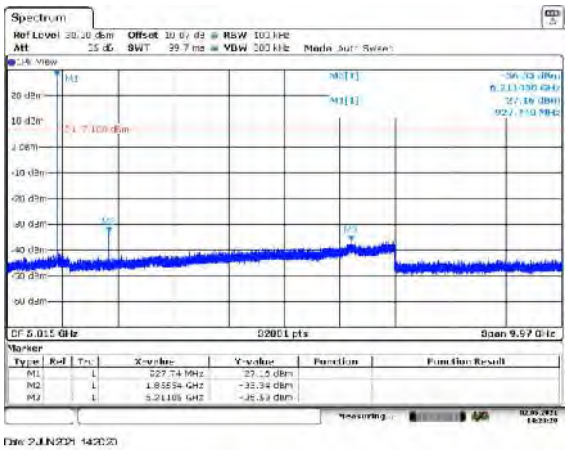


Figure 7.5.2.2-26: 30 MHz – 10 GHz – HCH-Mode 8

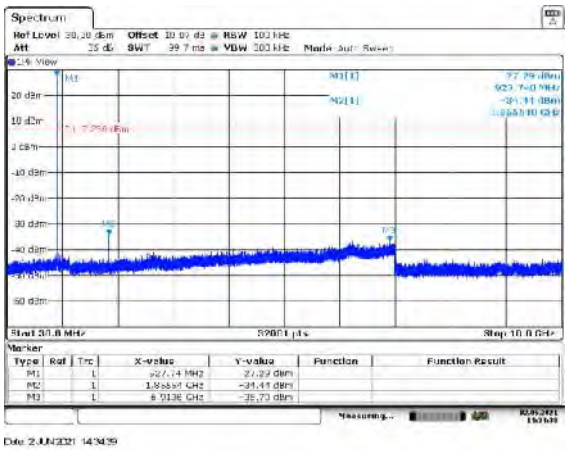


Figure 7.5.2.2-27: 30 MHz – 10 GHz – HCH-Mode 9

7.1.13 Radiated Spurious Emissions – FCC Section 15.205, 15.209, ISED Canada RSS – Gen 8.9/8.10

7.1.13.1 Measurement Procedure

Radiated emissions tests were made over the frequency range of 30MHz to 10GHz, 10 times the highest fundamental frequency.

The EUT was rotated through 360° and the receive antenna height was varied from 1 meter to 4 meters so that the maximum radiated emissions level would be detected. For frequencies below 1000 MHz, quasi-peak measurements were made using a resolution bandwidth RBW of 100 kHz and a video bandwidth VBW of 300 kHz. For frequencies above 1000 MHz, peak and average measurements were made with RBW and VBW of 1 MHz and 3 MHz respectively.

The EUT was caused to generate a continuous modulated carrier on the hopping channel.

Each emission found to be in a restricted band was compared to the applicable radiated emission limits.

Radiated spurious emissions were evaluated for all combinations of operating modes and data rates with worst case data provided. The worst-case data rate was GFSK 50kbps (mode 9) for the lowest, middle and highest channels.

7.1.13.2 Measurement Results

Table 7.5.3.2-1: Radiated Spurious Emissions Tabulated Data

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	Qpk/Avg	(H/V)	(dB)	pk	Qpk/Avg	pk	Qpk/Avg	pk	Qpk/Avg
Low Channel										
2706.60	44.10	32.10	H	5.82	49.92	37.92	74.00	54.00	24.10	16.10
2706.60	47.20	40.00	V	5.82	53.02	45.82	74.00	54.00	21.00	8.20
117.66	32.50	26.00	H	-9.03	---------	16.97	---------	43.50	---------	26.50
117.66	40.10	35.90	V	-9.03	---------	26.87	---------	43.50	---------	16.60
980.24	43.50	41.70	H	2.33	---------	44.03	---------	54.00	---------	10.00
980.24	47.10	45.60	V	2.33	---------	47.93	---------	54.00	---------	6.10
Middle Channel										
118.04	30.40	22.90	H	-9.02	---------	13.88	--------	43.50	---------	29.60
118.04	37.74	33.28	V	-9.02	---------	24.26	--------	43.50	---------	19.20
967.20	44.26	43.00	H	2.01	---------	45.01	--------	54.00	---------	9.00
967.20	48.00	47.10	V	2.01	---------	49.11	--------	54.00	---------	4.90
993.20	43.80	42.40	H	2.44	---------	44.84	--------	54.00	---------	9.20
993.20	47.60	46.36	V	2.44	---------	48.80	--------	54.00	---------	5.20
High Channel										
113.20	34.10	28.60	H	-9.20	---------	19.40	--------	43.50	---------	24.10
113.20	39.60	35.30	V	-9.20	---------	26.10	--------	43.50	---------	17.40
979.80	46.10	44.80	H	2.32	---------	47.12	--------	54.00	---------	6.90
979.80	48.00	46.60	V	2.32	---------	48.92	--------	54.00	---------	5.10

7.1.13.3 Sample Calculation:

$R_C = R_U + CF_T$

Where:

CF_T	=	Total Correction Factor (AF+CA+AG)-DC (Average Measurements Only)
R_U	=	Uncorrected Reading
R_C	=	Corrected Level
AF	=	Antenna Factor
CA	=	Cable Attenuation
AG	=	Amplifier Gain
DC	=	Duty Cycle Correction Factor

Example Calculation: Peak

Corrected Level: 47.20 + 5.82 = 53.02 dBuV/m
Margin: 74dBuV/m – 53.02 dBuV/m = -21.00dB

Example Calculation: Average

Corrected Level: 47.10 + 2.01- 0 = 49.11dBuV
Margin: 54dBuV – 49.11dBuV = 4.90dB

Maximum Power Spectral Density in the Fundamental Emission – FCC 15.247(e) ISED Canada: RSS-247 5.2(b)

7.1.14 Measurement Procedure

The power spectral density was measured in accordance with the ANSI 63.10 Subclause 11.10.3 Method AVGPSD (peak PSD). The RF output of the equipment under test was directly connected to the input of the spectrum analyzer applying suitable attenuation. The Resolution Bandwidth (RBW) of the spectrum analyzer was set to 3 kHz. The Video Bandwidth (VBW) was set to 10 kHz. Span was set to 1.5 times the OBW. The RMS average detector is used, with the trace set to average hold. The marker is placed on the highest peak of the resulting trace.

Note: This test requirement is evaluated for only Hybrid Classification.

7.1.15 Measurement Results - Hybrid

Performed by: Bhagyashree Chaudhary

Table 7.6.2-1: Power Spectral Density - Hybrid

Frequency [MHz]	AVG PSD (dBm)	Data Rate (kbps)	Mode(s)
902.40	7.63	300.0	6
915.60	7.43	300.0	6
927.60	7.26	300.0	6

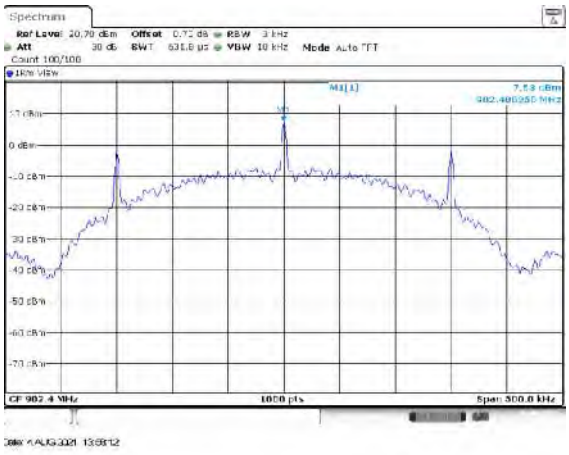


Figure 7.6.2.1-1: PSD – LCH-Mode 6

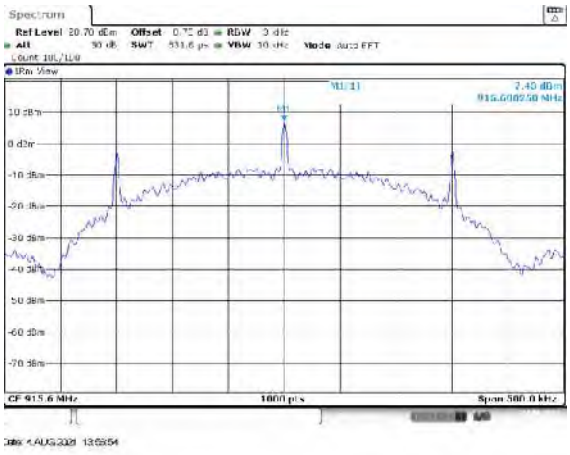


Figure 7.6.2.1-2: PSD – MCH-Mode 6

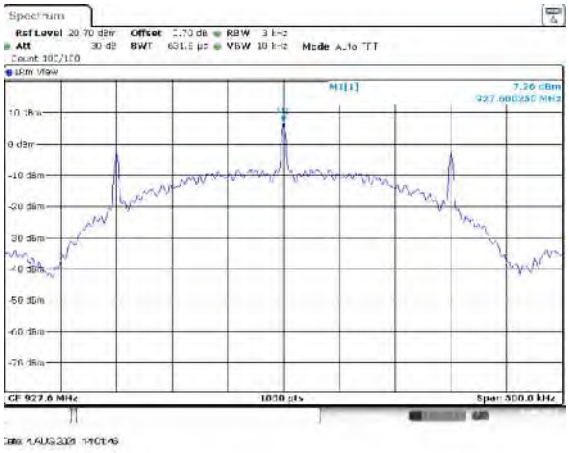


Figure 7.6.2.1-3: PSD – HCH-Mode 6

8 ESTIMATION OF MEASUREMENT UNCERTAINTY

The expanded laboratory measurement uncertainty figures (U_{Lab}) provided below correspond to an expansion factor (coverage factor) k = 1.96 which provide confidence levels of 95%.

Table 8-1: Estimation of Measurement Uncertainty

Parameter	U_{lab}
Occupied Channel Bandwidth	± 0.009 %
RF Conducted Output Power	± 0.349 dB
Power Spectral Density	± 0.372 dB
Antenna Port Conducted Emissions	± 1.264 dB
Radiated Emissions ≤ 1 GHz	± 5.814 dB
Radiated Emissions > 1 GHz	± 4.318 dB
Temperature	± 0.860 °C
Radio Frequency	± 2.832 x 10^{-8}
AC Power Line Conducted Emissions	± 3.360 dB

9 CONCLUSION

In the opinion of TÜV SÜD America, Inc. the 500M, manufactured by Murata Electronics North America. meets the requirements of FCC Part 15 subpart C and Innovation, Science and Economic Development Canada's Radio Standards Specification RSS-247.

Appendix A: Plots

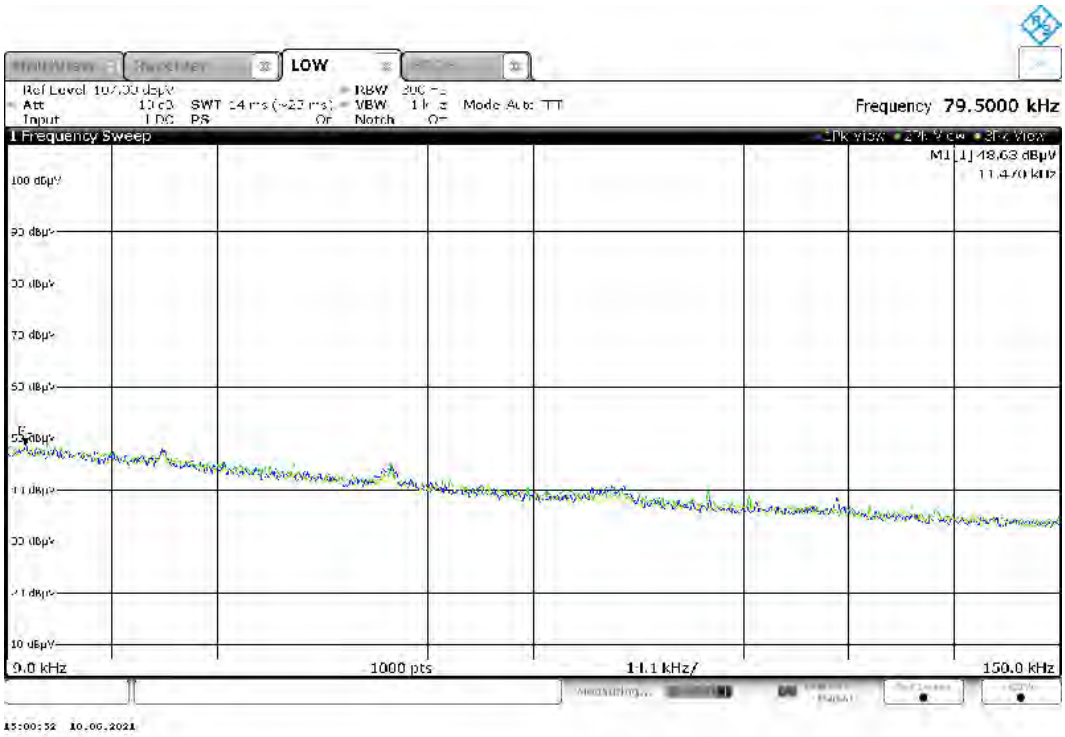


Figure A-1: Radiated Emissions – 9 kHz – 150 kHz

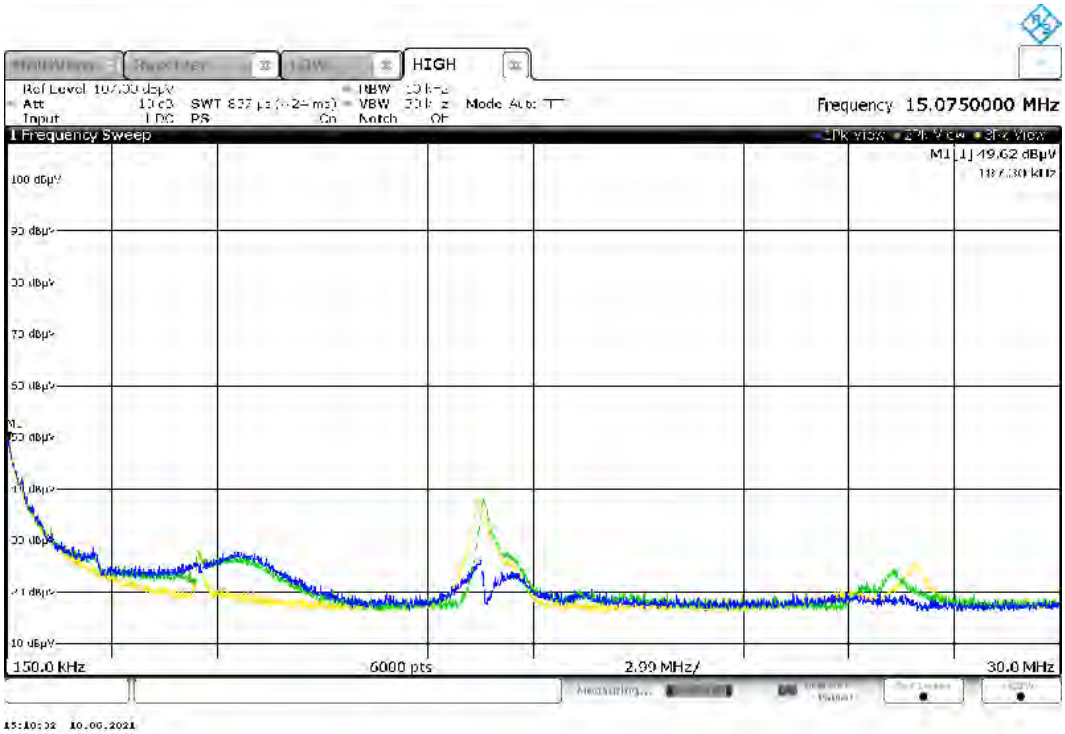
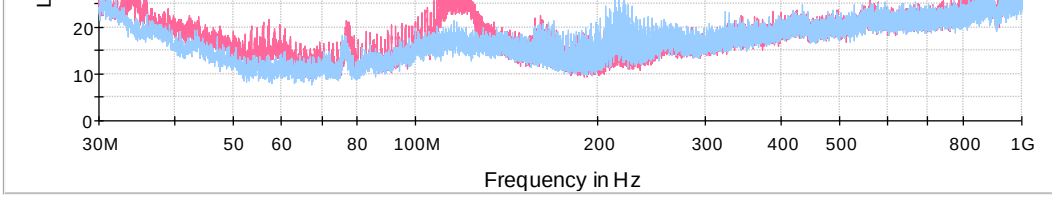


Figure A-2: Radiated Emissions – 150 kHz to 30 MHz

Note: Emissions above the noise floor are ambient noise and not associated with the DUT.



Full Spectrum

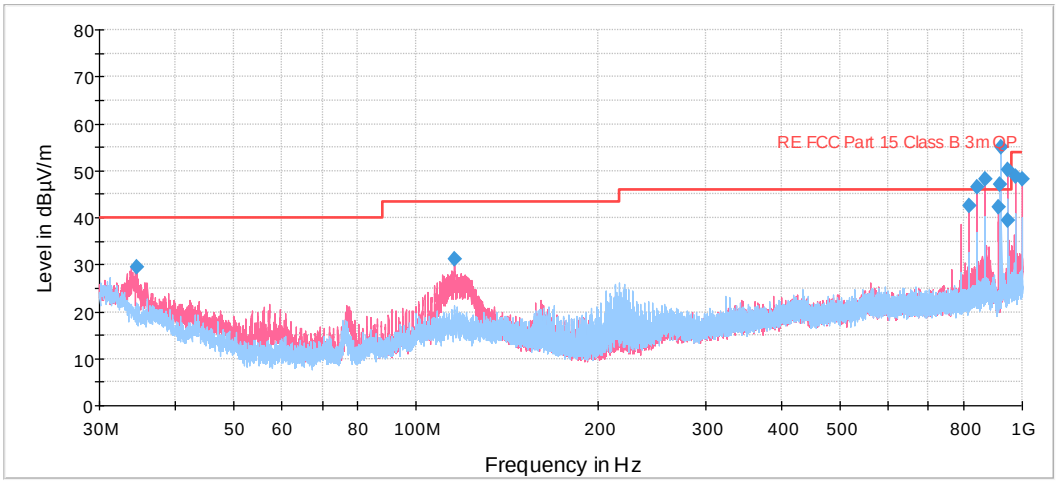


Figure A-3: Radiated Emissions – 30 MHz – 1 GHz
Note: Only emissions within restricted bands were evaluated.

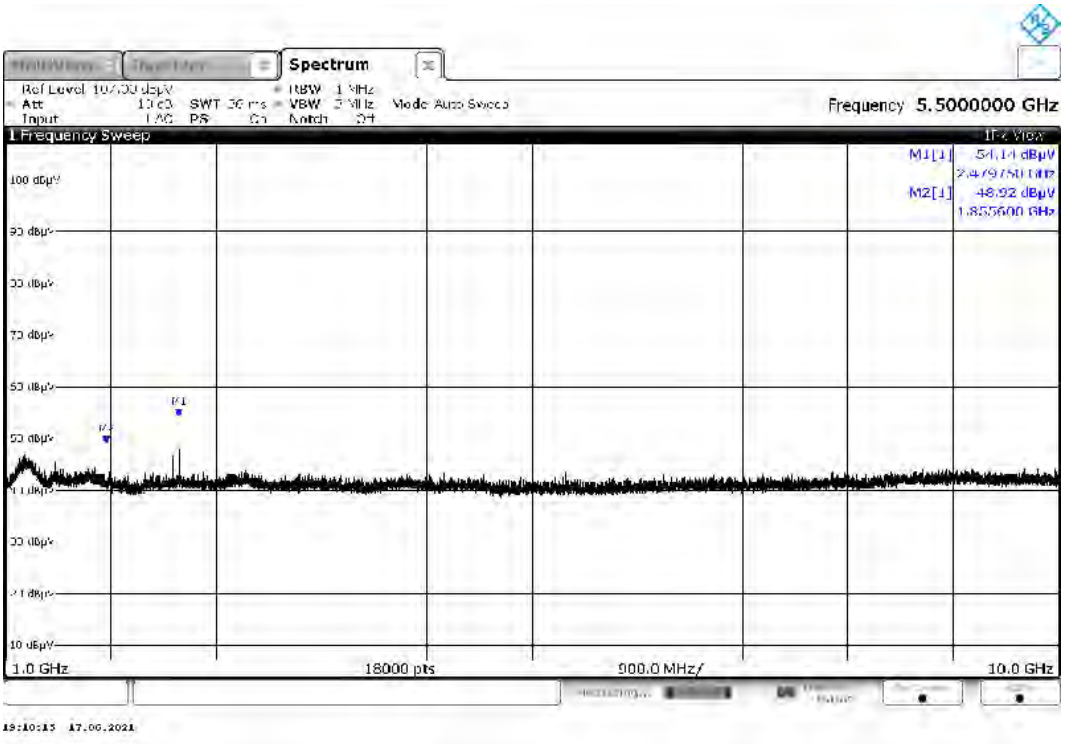


Figure A-4: Radiated Emissions – 1 GHz – 10 GHz
Note: Only emissions within restricted bands were evaluated. Emission within 2.4GHz is ambient noise and not associated with the EUT.

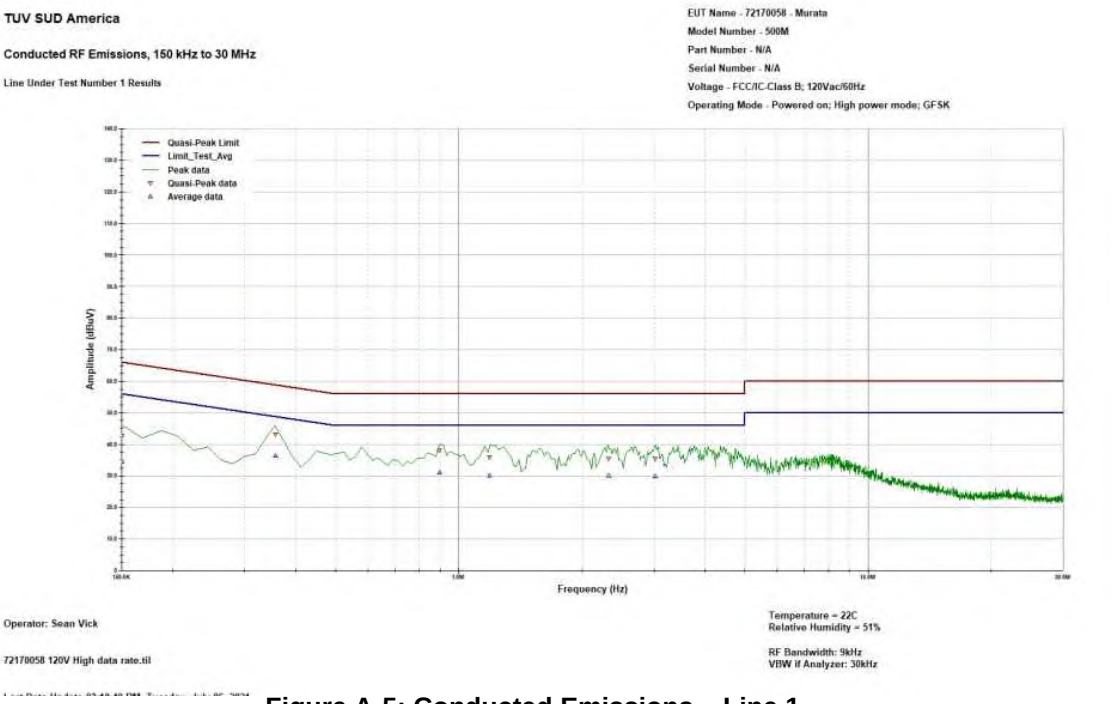


Figure A-5: Conducted Emissions – Line 1

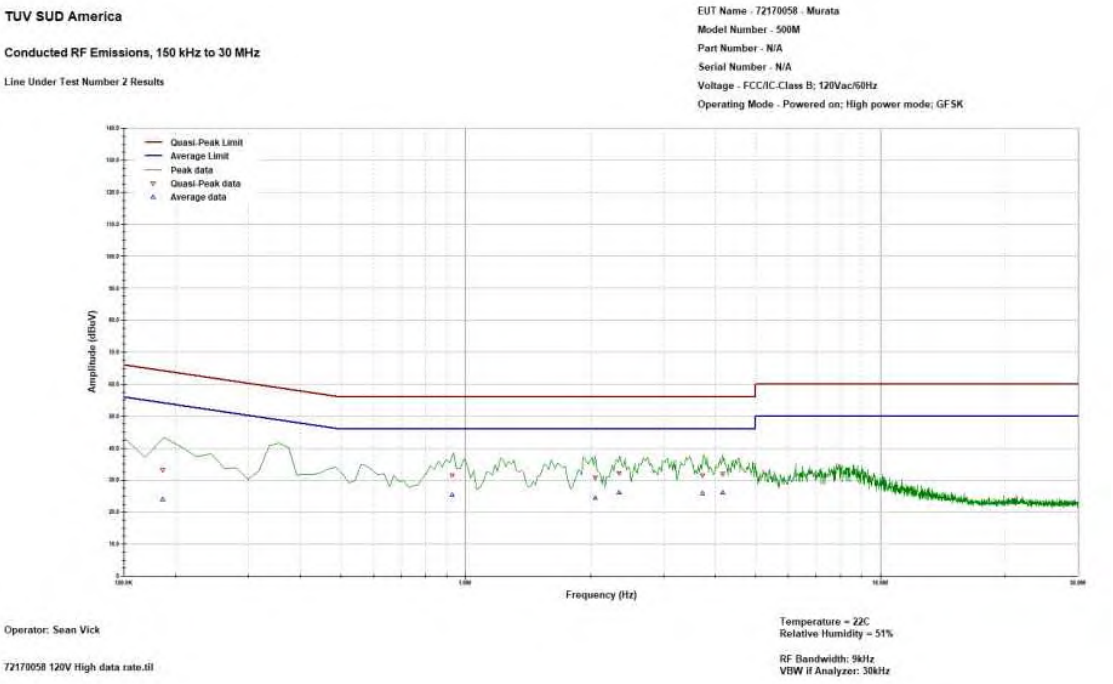


Figure A-6: Conducted Emissions – Neutral

END REPORT