Report on the Testing of the

Landis + Gyr Technology, Inc.
T1651 Series-6 Mesh IP & T1661 Series-6 WiSUN

America

Add value.
Inspire trust.

In accordance with:
FCC 47 CFR part 15.247
ISED RSS-247 Issue 2, February 2017

Prepared for: Landis + Gyr Technology, Inc.
30000 Mill Creek Ave., Suite 100
Alpharetta, GA 30022

COMMERCIAL-IN-CONFIDENCE

Document Number: AT72172744.2C0

SIGNATURE			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Kirby Munroe	**Wireless / EMC Technical and Certification Manager, NA** **TUV SUD America Inc.**	**Authorized Signatory**	2021-November-16

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD America, Inc. document control rules.

FCC Accreditation Designation Number US1233
FCC Test Site Registration Number 967699
Innovation, Science, and Economic Development Canada Lab Code 23932

EXECUTIVE SUMMARY

A sample of this product was tested and found to be compliant with the standards listed above.

A2LA Cert. No. 2955.09

ACCREDITATION

Our A2LA Accreditation does not cover opinions and interpretations and any expressed are outside the scope of our A2LA Accreditation.

TÜV SÜD America
5945 Cabot Parkway, Suite 100
Alpharetta, GA 3005

Phone: 678-341-5900
www.tuv-sud-america.com

Contents

1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Table 1.1-1 – Modification Record

Issue	Description of Change	Date of Issue
0	First Issue	2021-November-10

1.2 Introduction

The purpose of this report is to demonstrate compliance with Part 15 Subpart C of the FCC's Code of Federal Regulations Section 15.247 and Innovation Science and Economic Development Canada's Radio Standards Specification RSS-247 for the tests documented herein.

Applicant	Tim Walters
Manufacturer	Landis + Gyr Technology, Inc
Applicant's Email Address	Tim.walters@landisgyr.com
Model Number(s)	T1651 Series-6 Mesh IP & T1661 Series-6 WiSUN
Serial Number(s)	LAN ID: 612949B1(Conducted measurement) LAN ID: 61294A0C(Radiated measurement)
FCC ID	R7PNG0R1S4LP
ISED Certification Number	5294A-NG0R1S4LP
Hardware Version(s)	N/A
Software Version(s)	N/A
Number of Samples Tested	1
Test Specification/Issue/Date	US Code of Federal Regulation (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators, 2021 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.
Order Number	72172744
Date of Receipt of EUT	2021-September-10
Start of Test	2021-September-10
Finish of Test	2021-October-04

Related Document(s)	ANSI C63.10-2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Device. FCC OET 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 US Code of Federal Regulations (CFR): Title 47, Part 2, Subpart J: Equipment Authorization Procedures, 2021. ISED Canada Radio Standards Specification: RSS-GEN – General Requirements for Compliance of Radio Apparatus, Issue 5, Amendment 1 (March 2019), Amendment 2 (February 2021)

1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC Part 15.247 and ISED Canada's RSS-247 is shown below.

Table 1.3-1: Test Result Summary

Test Parameter	Test Plan (Yes/No)	Test Result	FCC 47 CFR Rule Part	ISED Canada's RSS	Test Report Page No
Antenna Requirement	Yes	Pass	15.203	-------	11
6 dB Bandwidth	Yes	Pass	15.247(a)(2)	RSS-247 5.2(a)	17
99% Bandwidth	Yes	Pass	-------	RSS-GEN 6.7	17
Avg Output Power	Yes	Pass	15.247(b)(3)	RSS-247 5.4(d)	15
Band-Edge Compliance of RF Conducted Emissions	Yes	Pass	15.247(d)	RSS-247 5.5	29
RF Conducted Spurious Emissions	Yes	Pass	15.247(d)	RSS-247 5.5	32
Radiated Spurious Emissions into Restricted Frequency Bands	Yes	Pass	15.205, 15.209	RSS-GEN 8.9, 8.10	36
Power Spectral Density	Yes	Pass	15.247(e)	RSS-247 5.2(b)	25
Power Line Conducted Emissions	Yes	Pass	15.207	RSS-GEN 8.8	12
Duty Cycle	No	--------			-------

1.4 Product Information

1.4.1 Technical Description

The Series-6 RF Mesh platform supports half-duplex operation in both the Sub-GHz and 2.4-GHz bands. There are 2 types of RF Mesh Communication Stacks supported by the Series-6 platform: Mesh IP and Wi-SUN.

Table 1.4-1 – Wireless Technical Information

Detail	Description
FCC ID	R7PNG0R1S4LP
Transceiver Model #	T1651 Series-6 Mesh IP & T1661 Series-6 WiSUN
Modulation Format	IEEE 802.15.4 SUN OFDM
Antenna Type / Description:	Monopole Chip antenna / 1 dBi Gain

A full description and detailed product specification details are available from the manufacturer.

Photo 1.4.1-1 –Front view of the EUT

Photo 1.4.1-2 – Back view of the EUT

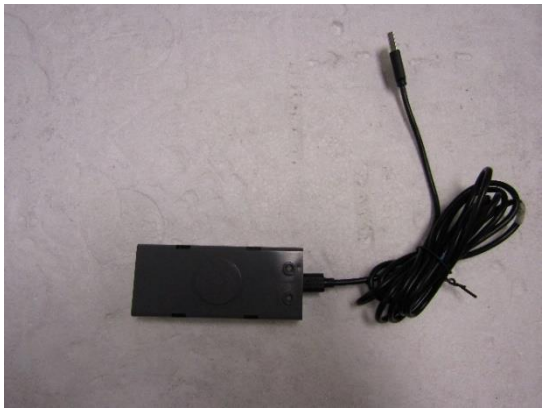

Photo 1.4.1-3 –EUT with USB cable

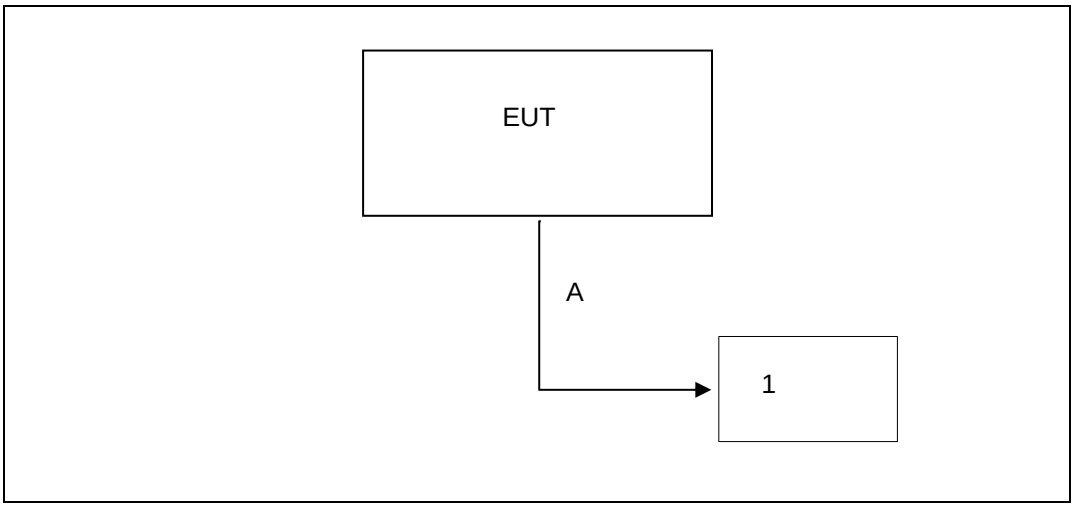

Figure 1.4.1-4 – Test Setup Block Diagram

Table 1.4.1-1 – Cable Descriptions

Item	Cable/Port	Description
A	USB	Power Cable

Table 1.4.1-2 – Support Equipment Descriptions

Item	Make/Model	Description
1	Lenovo	Laptop used for configuring wireless module – Landis + Gyr provided

1.4.2 Modes of Operation

T1651 Series-6 Mesh IP & T1661 Series-6 WiSUN model provides 4 distinct proprietary modes of operation using DTS classifications as outlined below.

Mode of Operation	Frequency Range (MHz)	Number of Channels	Channel Separation (kHz)	Stack / Mode	Data Rates Supported (kbps)	Classification
1	904 – 926.8	20	1200	Mesh IP (OFDM Option 1)	MCS0 – MCS6	DTS
2	903.2 – 927.2	21	1200	WiSUN (OFDM Option 1)	MCS5 – MCS6	DTS
3	902.8 – 926.8	31	800	WiSUN (OFDM Option 2)	MCS3 – MCS5	DTS
4	2410.8 – 2461.2	43	1200	Mesh IP (OFDM Option 1)	MCS0 – MCS6	DTS

1.4.3 Monitoring of Performance

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.

Worst case mode for all parameters measured listed below:

Mode	Classification	6dB/99% Bandwidth	Average Output Power	RF Conducted Spurious Emissions	Band-Edge RF Conducted Emissions	RSE into Restricted Frequency Bands	Band-Edge RF Radiated Emissions	Power Spectral Density
		Data Rate (kbps) / MCS						
1	DTS	MCS0	MCS0	MCS0	MCS0	MCS0	NA	MCS0
2	DTS	MCS5	MCS5	MCS5	MCS5	MCS5	NA	MCS5
3	DTS	MCS3	MCS3	MCS3	MCS3	MCS3	NA	MCS3
4	DTS	MCS0	MCS0	MCS0	MCS0	MCS0	MCS0	MCS0

Power setting during test: Mode of operation 1: 25 dBm
Mode of operation 2: 24.5 dBm
Mode of operation 3: 25 dBm
Mode of operation 4: 28 dBm

1.5 Deviations from the Standard

No deviations from the applicable test standard were made during testing.

1.6 EUT Modification Record

The table below details modifications made to the EUT during the test program. The modifications incorporated during each test are recorded on the appropriate test pages.

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
0	Initial State		

The equipment was tested as provided without any modifications.

1.7 Test Location

TÜV SÜD conducted the following tests at our Alpharetta, GA test laboratory.

Test Name	Name of Engineer(s)	Accreditation
DC Powered Operating		
Antenna Requirement	Divya Adusumilli	A2LA
Power Line Conducted Emissions	Divya Adusumilli	A2LA
Avg Output Power	Divya Adusumilli	A2LA
6dB / 99% Bandwidth	Divya Adusumilli	A2LA
Band-Edge Compliance of RF Conducted Emissions	Paul Villarreal	A2LA
RF Conducted Spurious Emissions	Divya Adusumilli	A2LA
Radiated Spurious Emissions into Restricted Frequency Bands	Divya Adusumilli	A2LA
Band-Edge Compliance of RF Radiated Emissions	Divya Adusumilli	A2LA
Power Spectral Density	Divya Adusumilli	A2LA

Office address:
TÜV SÜD America
5945 Cabot Parkway, Suite 100
Alpharetta, GA 30005, USA

2 Test Details

2.1 Antenna Requirement

2.1.1 Specification Reference

FCC Section: 15.203

2.1.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.1.3 Date of Test

9/24/2021

2.1.4 Test Method

N/A

2.1.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

Ambient Temperature	22.3 °C
Relative Humidity	53.8 %
Atmospheric Pressure	972.2 mbar

2.1.6 Test Results

The EUT utilizes Monopole chip antenna with peak gain 1 dBi which is mounted on the bottom side of the printed circuit board, therefore satisfying the requirements of Section 15.203.

2.2 Power Line Conducted Emissions

2.2.1 Specification Reference

FCC Section: 15.207
ISED Canada: RSS-Gen 8.8

2.2.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state "0", as noted in §1.6.

2.2.3 Date of Test

9/28/2021

2.2.4 Test Method

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

2.2.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

Ambient Temperature	22.3 °C
Relative Humidity	53.8 %
Atmospheric Pressure	972.2 mbar

2.2.6 Test Results

Table 2.2.6-1: Conducted EMI Results-Avg – Line 1 – 900 MHz radio

Frequency (MHz)	Avg Limit	Avg Level Corrected	Avg Level	Correction Fact.	Avg Margin	Result
0.15	56	46.3	36.6	9.682	-9.7	PASS
0.24	53.3	41.3	31.6	9.668	-12	PASS
1.69	46	26.3	16.6	9.664	-19.7	PASS
2.38	46	25.8	16.1	9.685	-20.2	PASS
3.18	46	29.5	19.9	9.686	-16.5	PASS
4.78	46	28	18.3	9.702	-18	PASS

Table 2.2.6-2: Conducted EMI Results-QP – Line 1 - 900 MHz radio

Frequency (MHz)	QP Limit	QP Level Corrected	QP Level	Correction Fact.	QP Margin	Result
0.15	66	55.7	46.1	9.682	-10.3	PASS
0.24	63.3	47.5	37.9	9.668	-15.8	PASS
1.69	56	31.4	21.7	9.664	-24.6	PASS
2.38	56	31.1	21.5	9.685	-24.9	PASS
3.18	56	34.2	24.5	9.686	-21.8	PASS
4.78	56	32.6	22.9	9.702	-23.4	PASS

Table 2.2.6-3: Conducted EMI Results-Avg – Line 2 – 900 MHz radio

Frequency (MHz)	Avg Limit	Avg Level Corrected	Avg Level	Correction Fact.	Avg Margin	Result
0.15	56	42.7	33	9.675	-13.3	PASS
0.5	46	29.7	20.1	9.63	-16.3	PASS
2.85	46	28.5	18.9	9.684	-17.5	PASS
3	46	29.6	19.9	9.69	-16.4	PASS
4.23	46	29.6	19.9	9.7	-16.4	PASS
10.76	50	28.5	18.6	9.868	-21.5	PASS

Table 2.2.6-4: Conducted EMI Results-QP – Line 2 – 900 MHz radio

Frequency (MHz)	QP Limit	QP Level Corrected	QP Level	Correction Fact.	QP Margin	Result
0.15	66	52.2	42.5	9.675	-13.8	PASS
0.5	56	35.9	26.2	9.63	-20.1	PASS
2.85	56	32.3	22.6	9.684	-23.7	PASS
3	56	34.8	25.2	9.69	-21.2	PASS
4.23	56	34.8	25.1	9.7	-21.2	PASS
10.76	60	31.2	21.4	9.868	-28.8	PASS

Table 2.2.6-5: Conducted EMI Results-Avg – Line 1 – 2.4 GHz radio

Frequency (MHz)	Avg Limit	Avg Level Corrected	Avg Level	Correction Fact.	Avg Margin	Result
0.15	56	41.6	31.9	9.682	-14.4	PASS
1.14	46	27.8	18.1	9.674	-18.2	PASS
1.66	46	26	16.4	9.663	-20	PASS
1.93	46	25.6	15.9	9.669	-20.4	PASS
2.23	46	26.5	16.8	9.679	-19.5	PASS
4.34	46	30.5	20.8	9.68	-15.5	PASS

Table 2.2.6-6: Conducted EMI Results-QP – Line 1 – 2.4 GHz radio

Frequency (MHz)	QP Limit	QP Level Corrected	QP Level	Correction Fact.	QP Margin	Result
0.15	66	50.7	41.1	9.682	-15.3	PASS
1.14	56	33.1	23.4	9.674	-22.9	PASS
1.66	56	32	22.3	9.663	-24	PASS
1.93	56	31.8	22.2	9.669	-24.2	PASS
2.23	56	31.6	21.9	9.679	-24.4	PASS
4.34	56	33.5	23.9	9.68	-22.5	PASS

Table 2.2.6-7: Conducted EMI Results-Avg – Line 2 – 2.4 GHz radio

Frequency (MHz)	Avg Limit	Avg Level Corrected	Avg Level	Correction Fact.	Avg Margin	Result
0.17	55.5	38.5	28.8	9.673	-17	PASS
0.5	46	31.8	22.1	9.63	-14.2	PASS
4.14	46	29.3	19.6	9.7	-16.7	PASS
10.38	50	30.2	20.3	9.864	-19.8	PASS
11.51	50	29.6	19.7	9.875	-20.4	PASS
12.82	50	29.8	20	9.888	-20.2	PASS

Table 2.2.6-8: Conducted EMI Results-QP – Line 2 – 2.4 GHz radio

Frequency (MHz)	QP Limit	QP Level Corrected	QP Level	Correction Fact.	QP Margin	Result
0.17	65.5	46.7	37	9.673	-18.8	PASS
0.5	56	37.3	27.7	9.63	-18.7	PASS
4.14	56	32.6	22.9	9.7	-23.4	PASS
10.38	60	31.3	21.5	9.864	-28.7	PASS
11.51	60	31.2	21.3	9.875	-28.8	PASS
12.82	60	31.6	21.7	9.888	-28.4	PASS

2.3 Average Output Power

2.3.1 Specification Reference

FCC Sections: 15.247(b)(3)
ISED Canada: RSS-247 5.4(d)

2.3.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.3.3 Date of Test

9/24/2021

2.3.4 Test Method

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.

2.3.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

Ambient Temperature	22.3 °C
Relative Humidity	53.8 %
Atmospheric Pressure	972.2 mbar

2.3.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See data below for detailed results.

Table 2.3.6-1: RF Output Power

Frequency [MHz]	Average Output Power (dBm)	Data Rate (kbps)	Mode(s)
904.0	23.78	MCS0	1
903.2	24.26	MCS5	2
902.8	24.40	MCS3	3
2410.8	24.99	MCS0	4
914.8	23.82	MCS0	1
915.2	24.30	MCS5	2
914.8	24.26	MCS3	3
2436.0	24.56	MCS0	4
926.8	24.02	MCS0	1
927.2	24.39	MCS5	2
926.8	23.93	MCS3	3
2461.2	24.51	MCS0	4

2.4 6dB / 99% Bandwidth

2.4.1 Specification Reference

FCC Sections: 15.247(a)(2)
ISED Canada: RSS-247 5.2(a), RSS-GEN 6.7

2.4.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.4.3 Date of Test

9/14/2021 to 10/8/2021

2.4.4 Test Method

The 6dB bandwidth was measured in accordance with the ANSI C63.10 Section 11.8. The Resolution Bandwidth (RBW) of the spectrum analyzer was set to 100 kHz. The Video Bandwidth (VBW) was set to ≥ 3 times the RBW. The trace was set to max hold with a peak detector active. The marker-delta function of the spectrum analyzer was utilized to determine the 6 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.

2.4.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

Ambient Temperature	22.3 °C
Relative Humidity	53.8 %
Atmospheric Pressure	972.2 mbar

2.4.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See data below for detailed results.

Table 2.4.6-1: 6dB / 99% Bandwidth

Frequency [MHz]	6dB Bandwidth (kHz)	99% Bandwidth (kHz)	Data Rate (kbps)	Mode(s)
904.0	1085	1145	MCS0	1
903.2	1102	1412	MCS5	2
902.8	605	622	MCS3	3
2410.8	1105	1150	MCS0	4
914.8	1080	1145	MCS0	1
915.2	1113	1464	MCS5	2
914.8	600	618	MCS3	3
2436.0	1105	1130	MCS0	4
926.8	1075	1135	MCS0	1
927.2	1103	1324	MCS5	2
926.8	600	604	MCS3	3
2461.2	1095	1115	MCS0	4

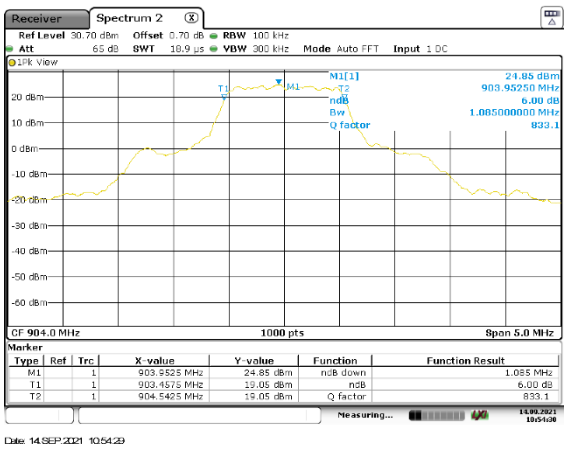

Figure 2.4.6-1: Mode 1 – 6 dB BW – LCH – MCS0

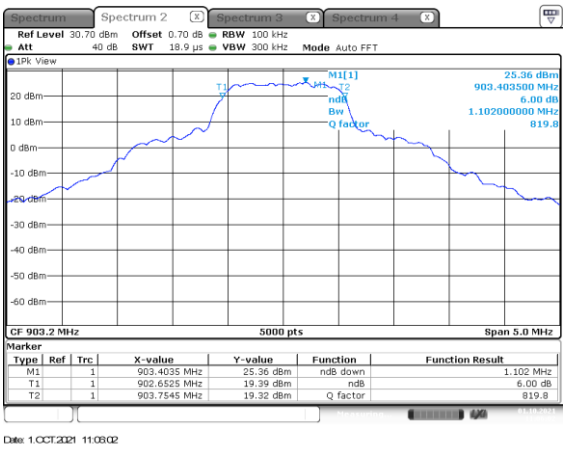

Figure 2.4.6-2: Mode 2 – 6 dB BW – LCH MCS5

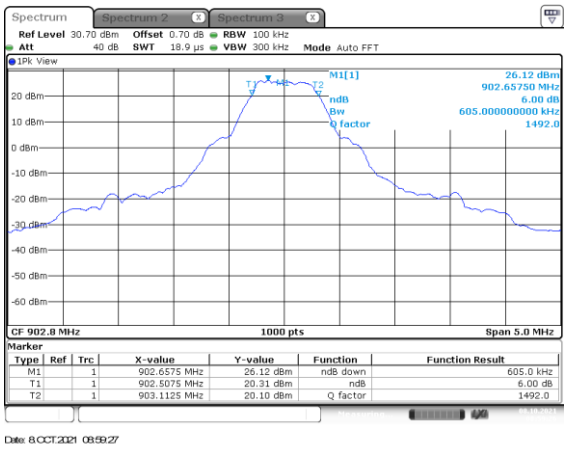

Figure 2.4.6-3: Mode 3 – 6 dB BW – LCH – MCS3

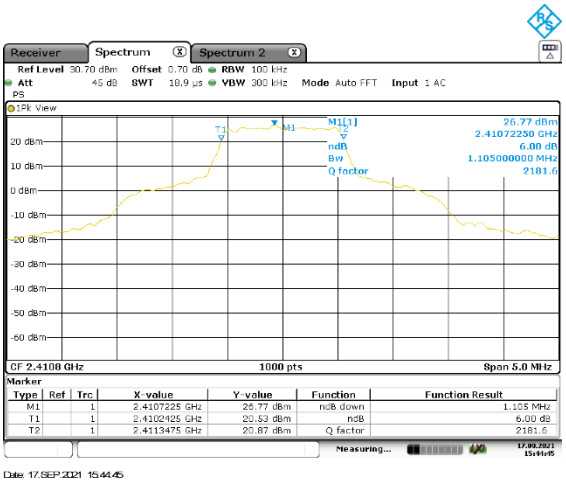

Figure 2.4.6-4: Mode 4 – 6 dB BW – LCH – MCS0

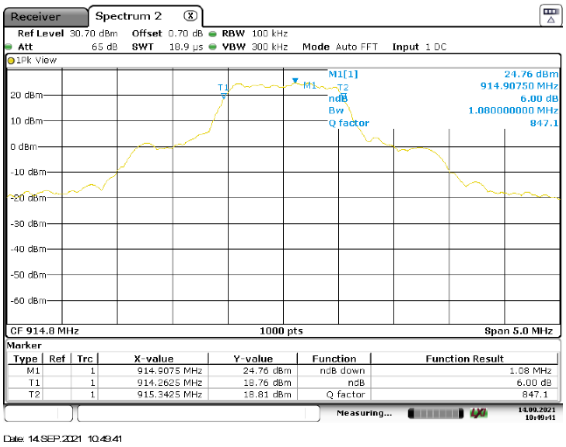

Figure 2.4.6-5: Mode 1 – 6 dB BW – MCH – MCS0

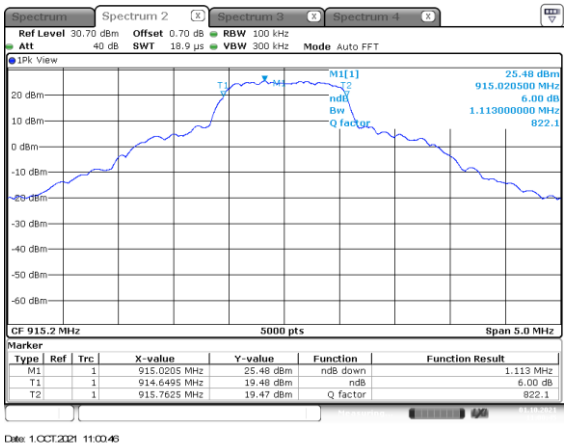

Figure 2.4.6-6: Mode 2 – 6 dB BW – MCH MCS5

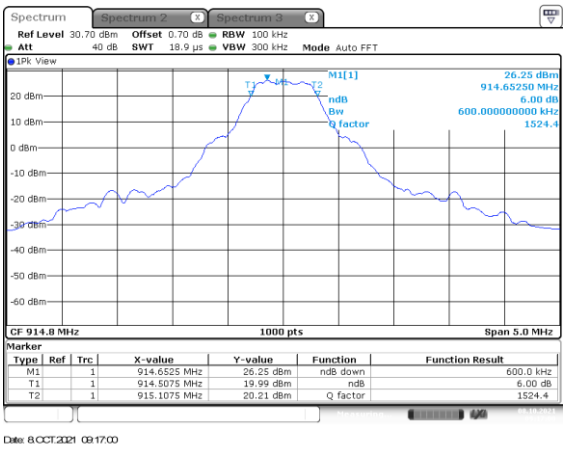

Figure 2.4.6-7: Mode 3 – 6 dB BW – MCH – MCS3

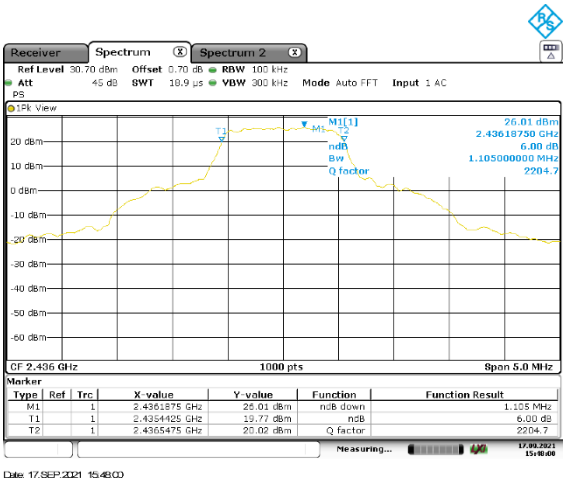

Figure 2.4.6-8: Mode 4 – 6 dB BW – MCH – MCS0

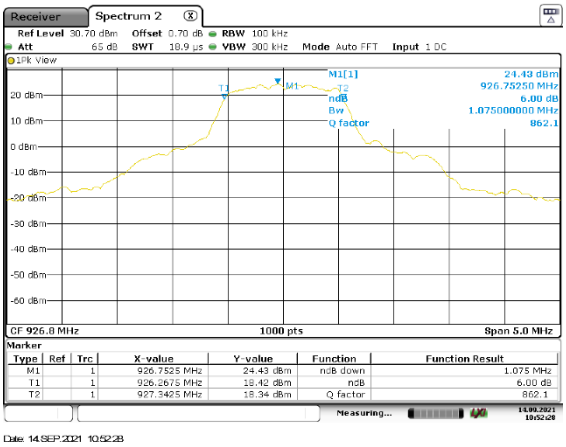

Figure 2.4.6-9: Mode 1 – 6 dB BW – HCH – MCS0

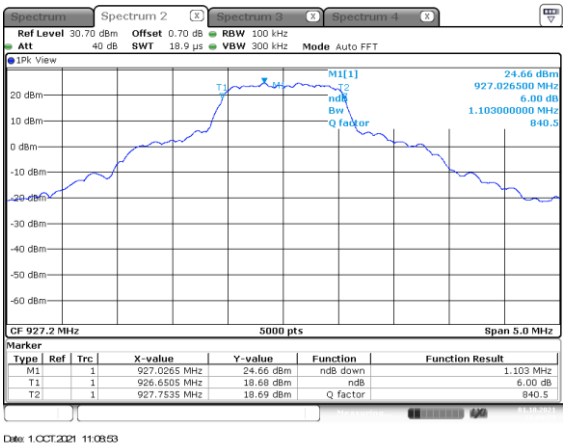

Figure 2.4.6-10: Mode 2 – 6 dB BW – HCH MCS5

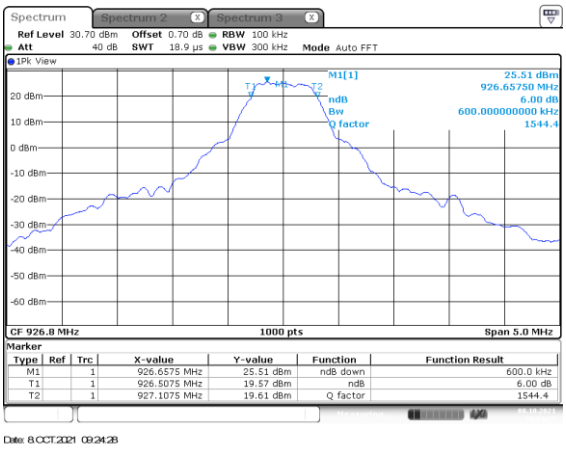

Figure 2.4.6-11: Mode 3 – 6 dB BW – HCH – MCS3

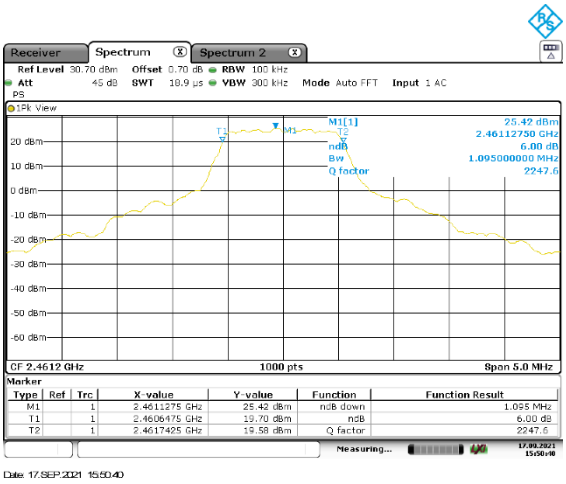

Figure 2.4.6-12: Mode 4 – 6 dB BW – HCH – MCS0

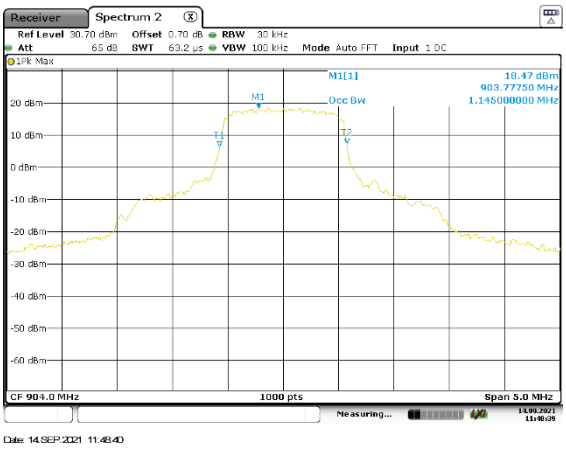

Figure 2.4.6-13: Mode 1 – 99% BW – LCH – MCS0

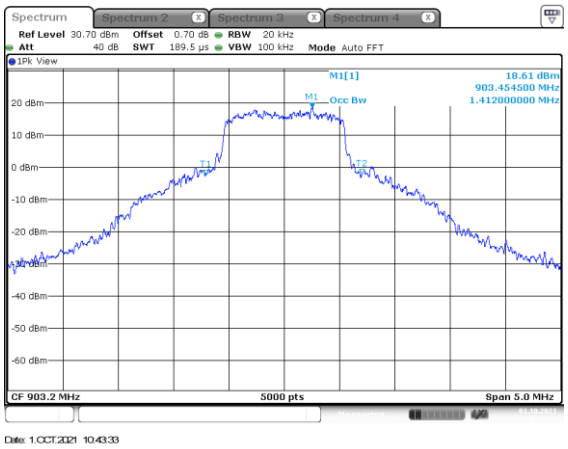

Figure 2.4.6-14: Mode 2 – 99% BW – LCH MCS5

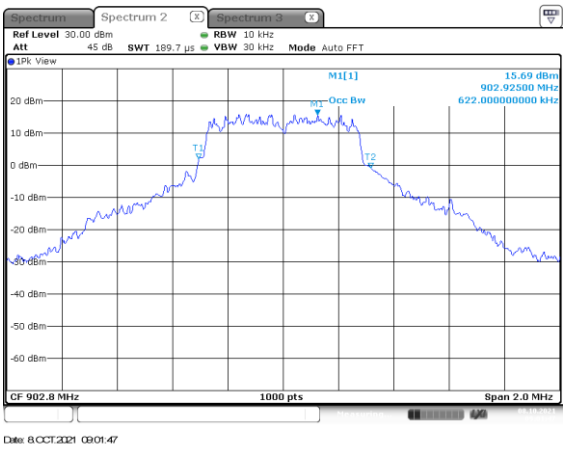

Figure 2.4.6-15: Mode 3 – 99% BW – LCH – MCS3

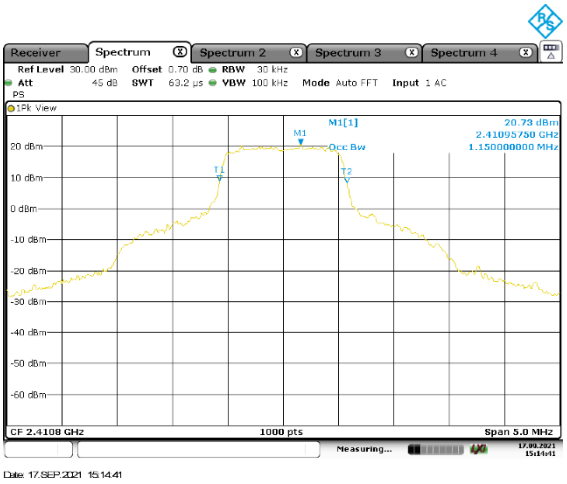

Figure 2.4.6-16: Mode 4 – 99% BW – LCH – MCS0

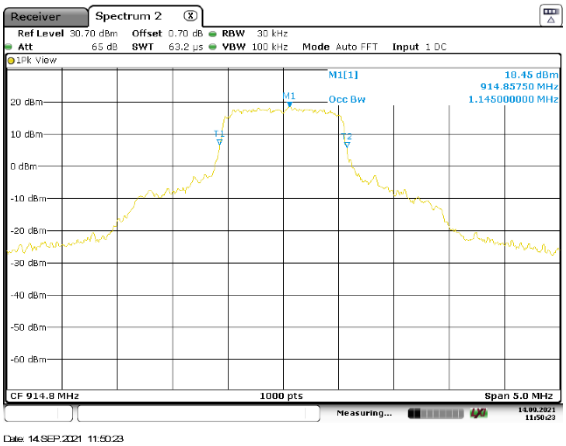

Figure 2.4.6-17: Mode 1 – 99% BW – MCH – MCS0

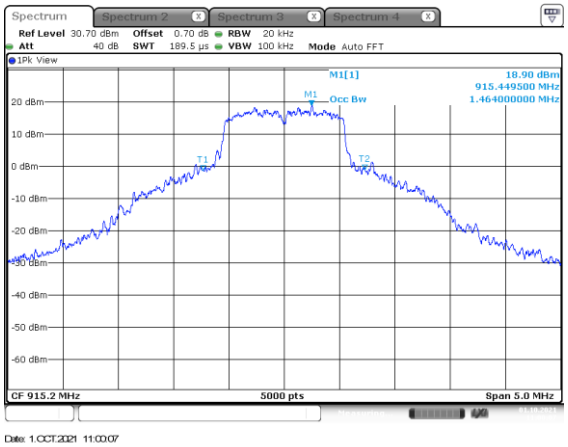

Figure 2.4.6-18: Mode 2 – 99% BW – MCH MCS5

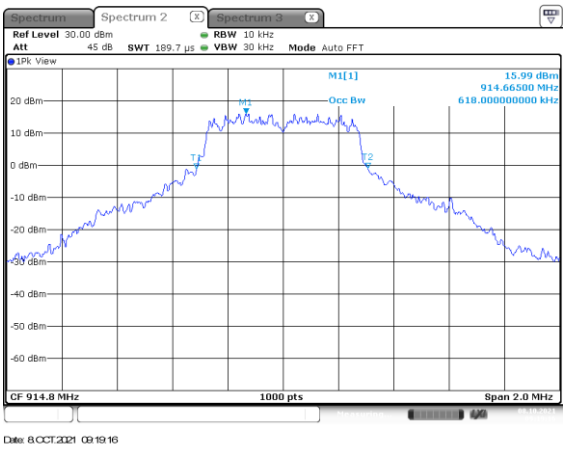

Figure 2.4.6-19: Mode 3 – 99% BW – MCH – MCS3

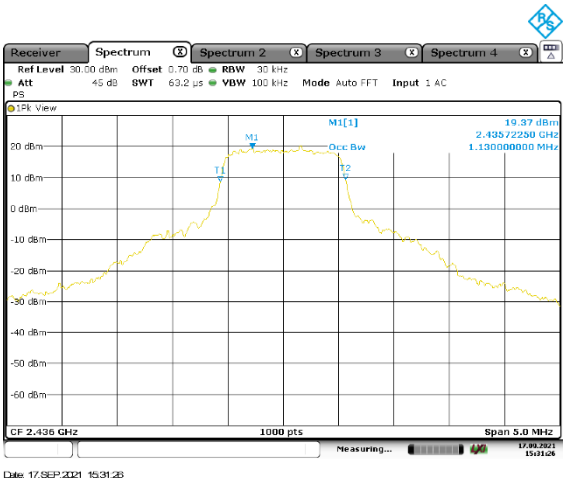

Figure 2.4.6-20: Mode 4 – 99% BW – MCH – MCS0

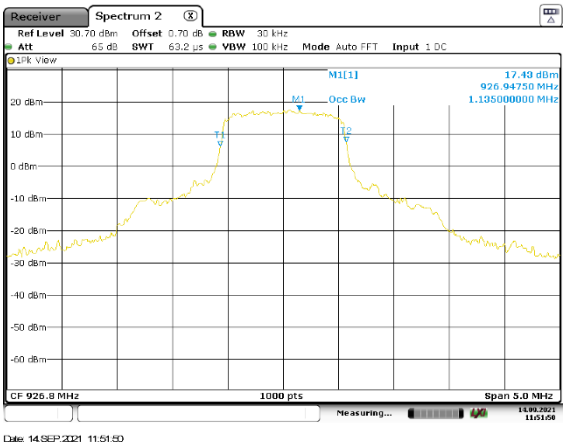

Figure 2.4.6-21: Mode 1 – 99% BW – HCH – MCS0

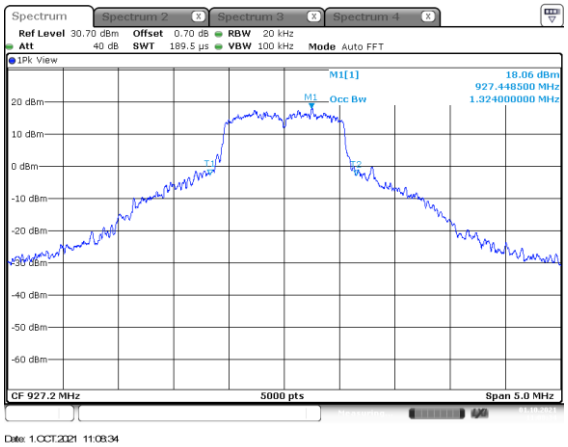

Figure 2.4.6-22: Mode 2 – 99% BW – HCH MCS5

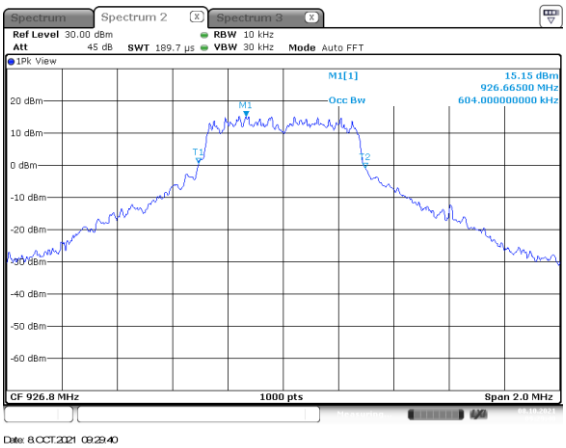

Figure 2.4.6-23: Mode 3 – 99% BW – HCH – MCS3

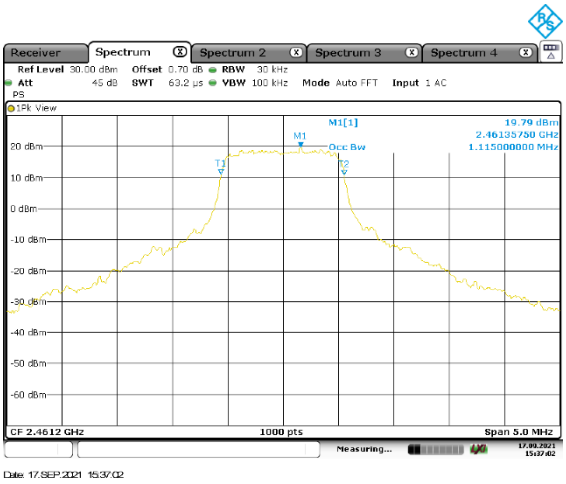

Figure 2.4.6-24: Mode 4 – 99% BW – HCH – MCS0

2.5 Maximum Power Spectral Density in the Fundamental Emission

2.5.1 Specification Reference

FCC Sections: 15.247(e)
ISED Canada: RSS-247 5.2(b)

2.5.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.5.3 Date of Test

9/17/2021 to 10/8/2021

2.5.4 Test Method

The power spectral density was measured in accordance with the ANSI 63.10 Subclause 11.10.3 Method AVGPSD-1. 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.

2.5.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

Ambient Temperature	22.3 °C
Relative Humidity	53.8 %
Atmospheric Pressure	972.2 mbar

2.5.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See data below for detailed results.

Table 2.5.6-1: RF Power Spectral Density

Frequency [MHz]	Average PSD (dBm)	Data Rate (kbps)	Mode(s)
904.0	-1.04	MCS0	1
903.2	2.78	MCS5	2
902.8	-3.59	MCS3	3
2410.8	1.30	MCS0	4
914.8	0.78	MCS0	1
915.2	2.74	MCS5	2
914.8	-3.03	MCS3	3
2436.0	1.95	MCS0	4
926.8	-0.52	MCS0	1
s927.2	2.64	MCS5	2
926.8	-3.75	MCS3	3
2461.2	0.31	MCS0	4

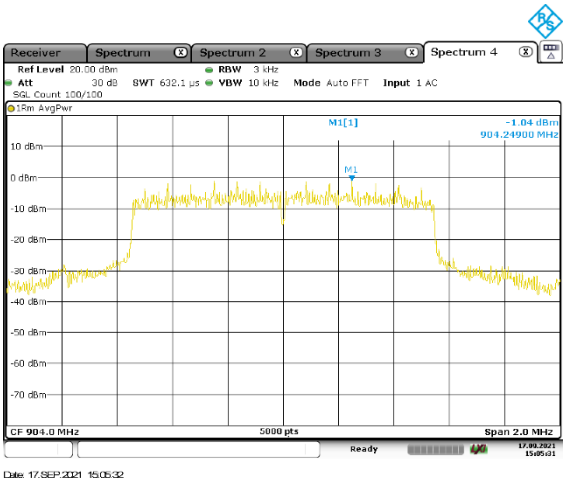

Figure 2.5.6-1: Mode 1 – PSD – LCH – MCS0

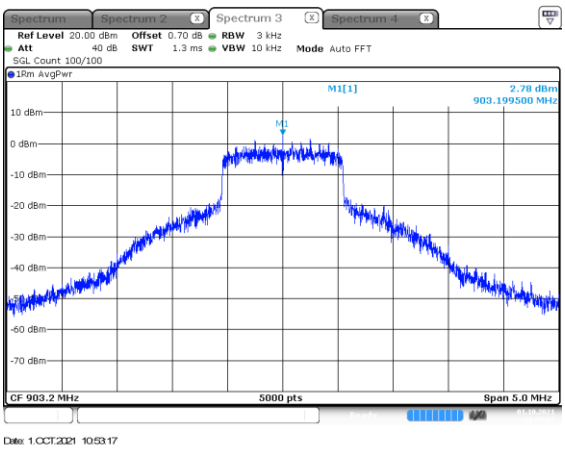

Figure 2.5.6-2: Mode 2 – PSD – LCH – MCS5

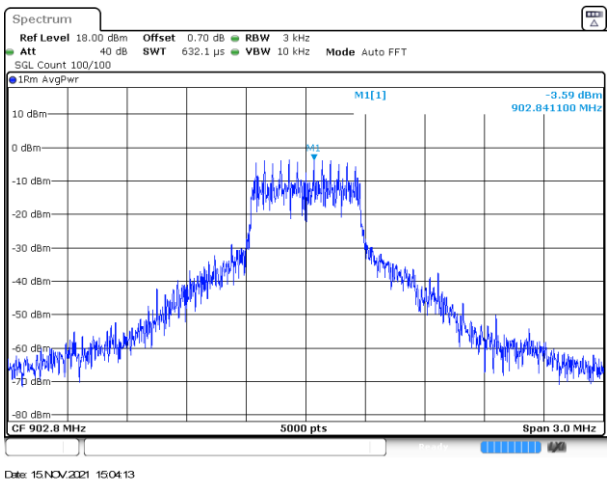

Figure 2.5.6-3: Mode 3 – PSD – LCH – MCS3

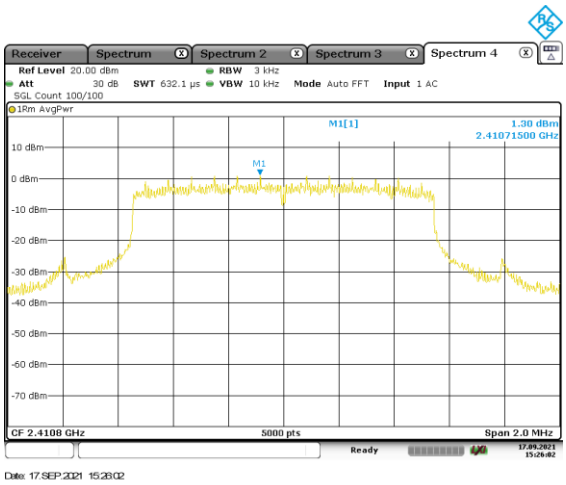

Figure 2.5.6.3-4: Mode 4 – PSD – LCH – MCS0

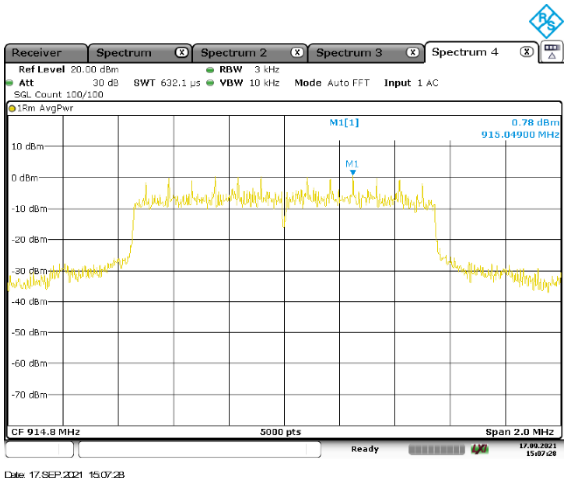

Figure 2.5.6-5: Mode 1 – PSD – MCH – MCS0

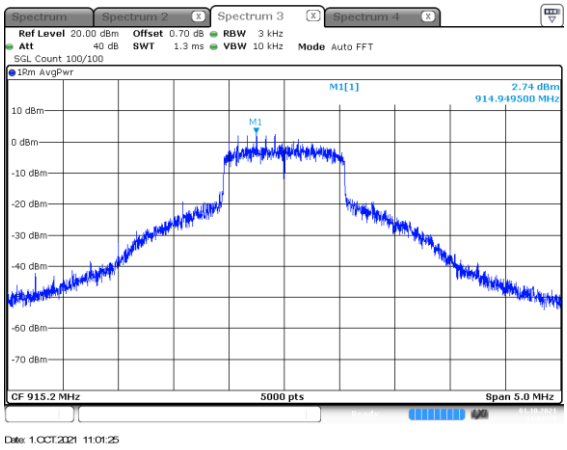

Figure 2.5.6-6: Mode 2 – PSD – MCH – MCS5

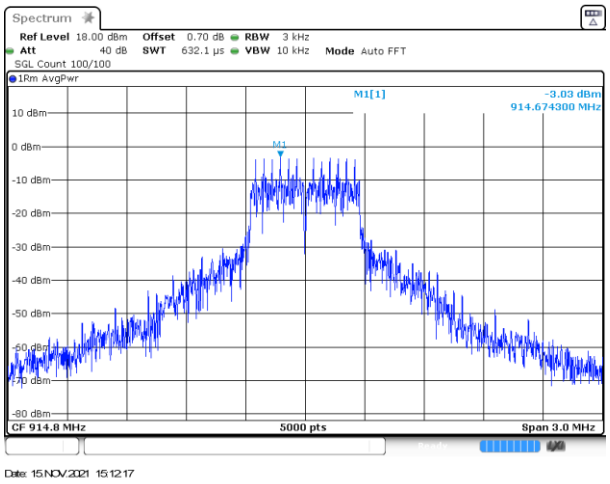

Figure 2.5.6-7: Mode 3 – PSD – MCH – MCS3

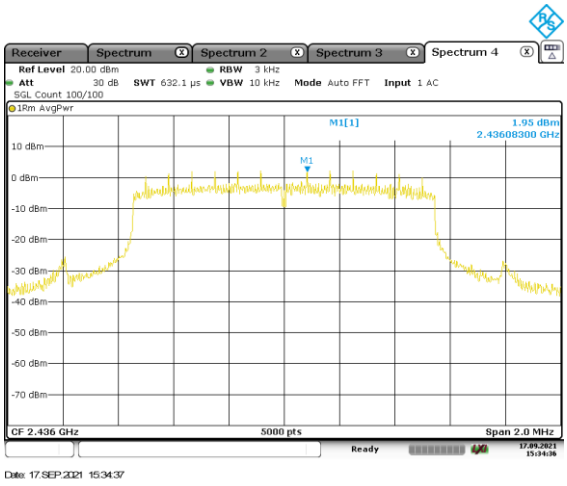

Figure 2.5.6.3-8: Mode 4 – PSD – MCH – MCS0

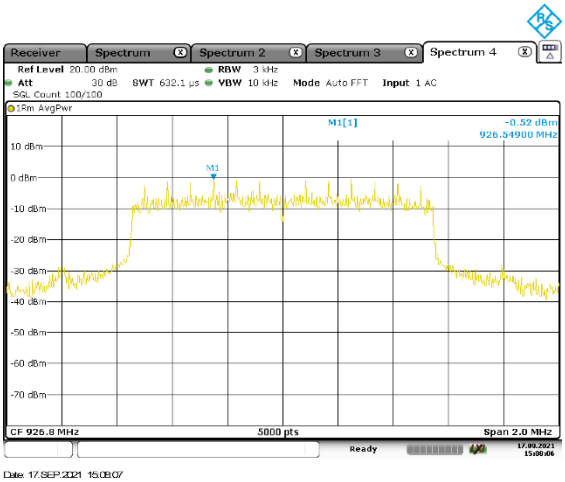

Figure 2.5.6-9: Mode 1 – PSD – HCH – MCS0

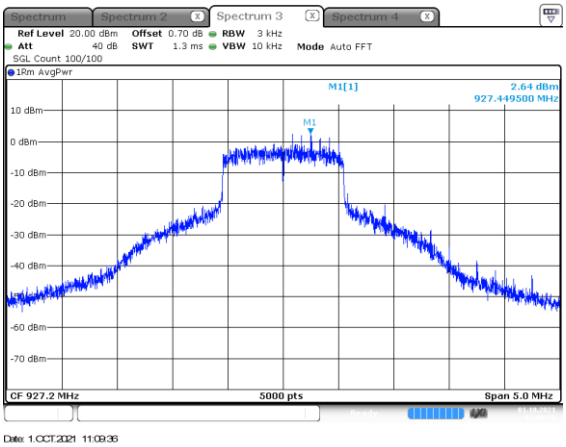

Figure 2.5.6-10: Mode 2 – PSD – HCH – MCS5

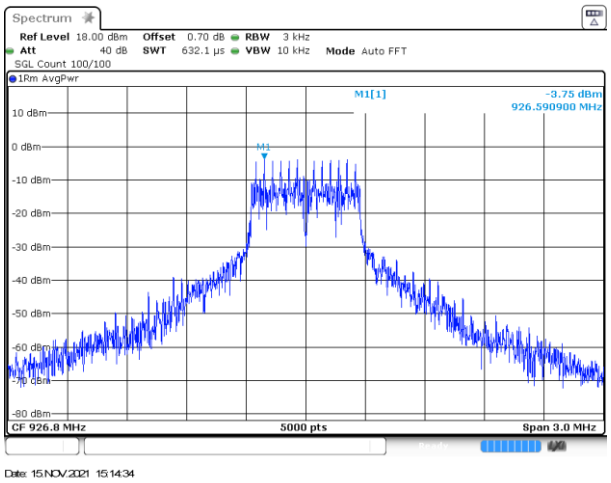

Figure 2.5.6-11: Mode 3 – PSD – HCH – MCS3

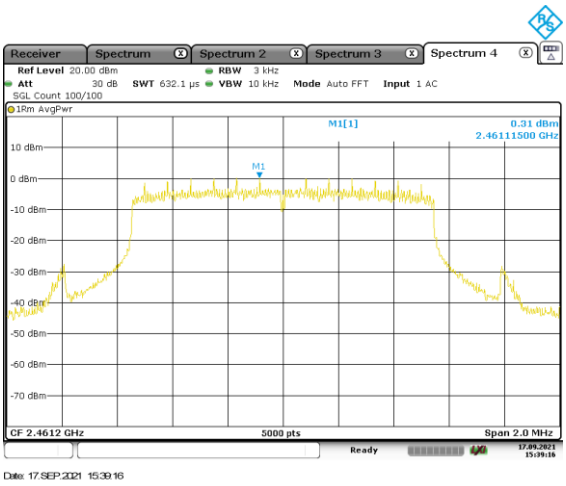

Figure 2.5.6.3-12: Mode 4 – PSD – HCH – MCS0

2.6 Band-Edge Compliance of RF Conducted Emissions

2.6.1 Specification Reference

FCC Sections: 15.247(d)
ISED Canada: RSS-247 5.5

2.6.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.6.3 Date of Test

9/14/2021 to 10/8/2021

2.6.4 Test Method

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.

If maximum conducted (average) output power was used to determine compliance, then the peak power in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 30 dB relative to the maximum in-band peak PSD level in 100 kHz (i.e., 30 dBc).

2.6.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

Ambient Temperature	22.3 °C
Relative Humidity	53.8 %
Atmospheric Pressure	972.2 mbar

2.6.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See data below for detailed results.

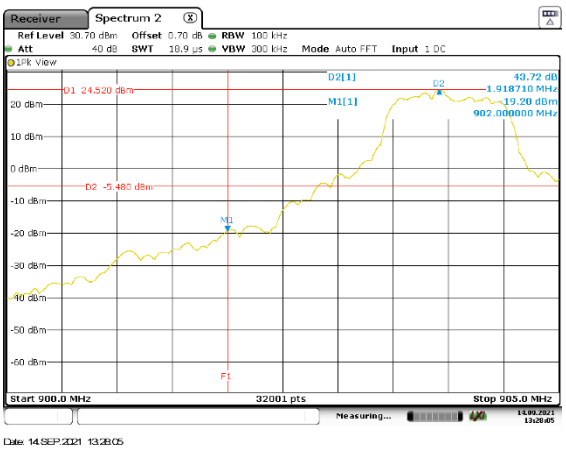

Figure 2.6.6-1: Lower Band edge – Mode 1 – MCS0

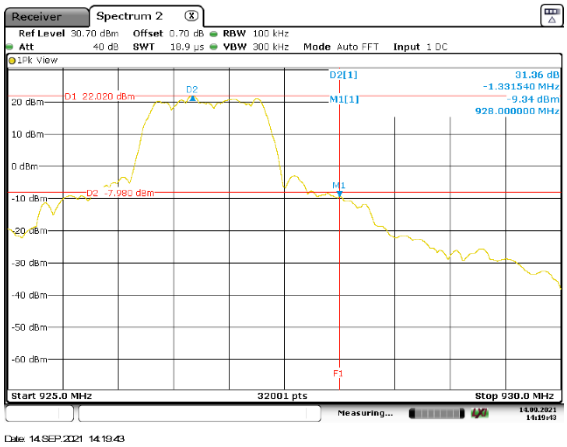

Figure 2.6.6-2: Higher Band edge – Mode 1 – MCS0

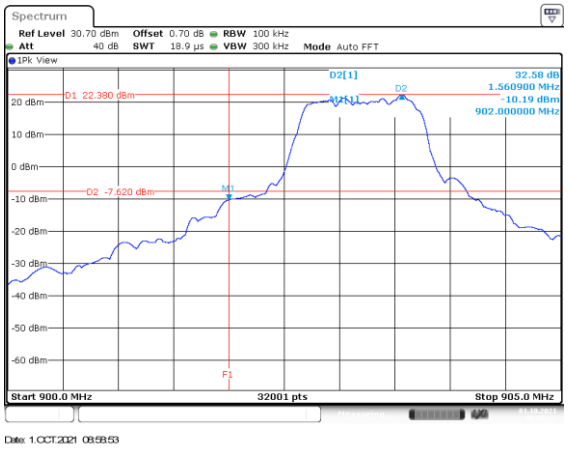

Figure 2.6.6-3: Lower Band edge – Mode 2 – MCS5

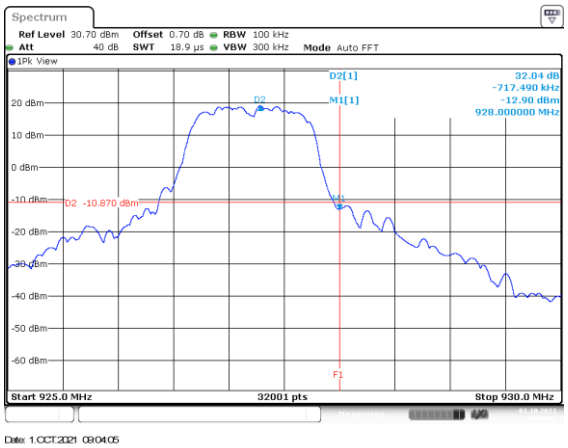

Figure 2.6.6-4: Higher Band edge – Mode 2 – MCS5

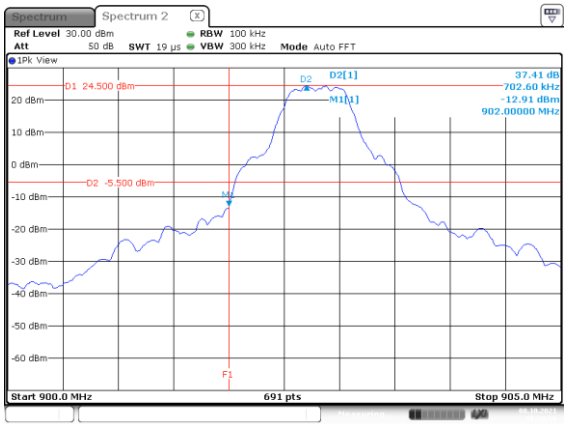

Figure 2.6.6-5: Lower Band edge – Mode 3 – MCS3

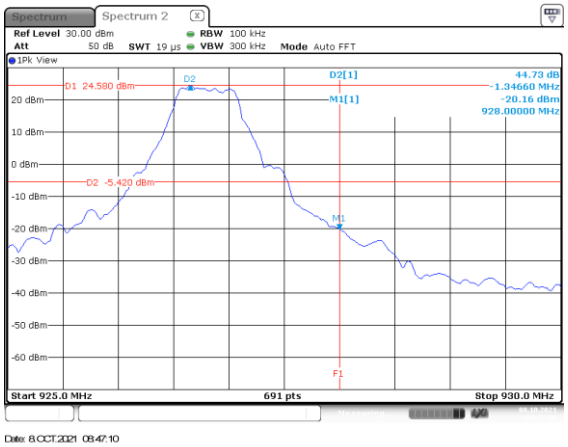

Figure 2.6.6-6: Higher Band edge – Mode 3 – MCS3

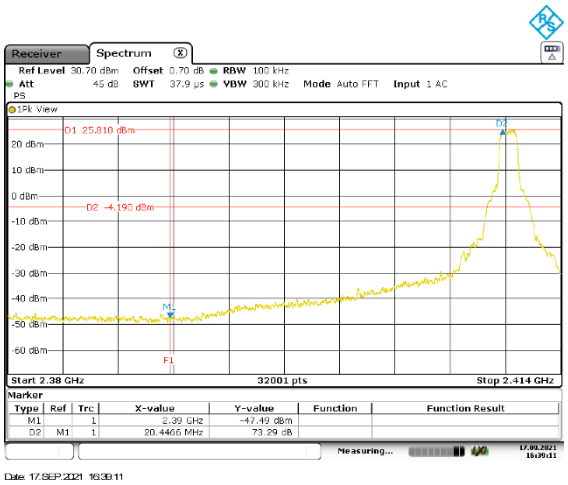

Figure 2.6.6-7: Lower Band edge – Mode 4 – MCS0

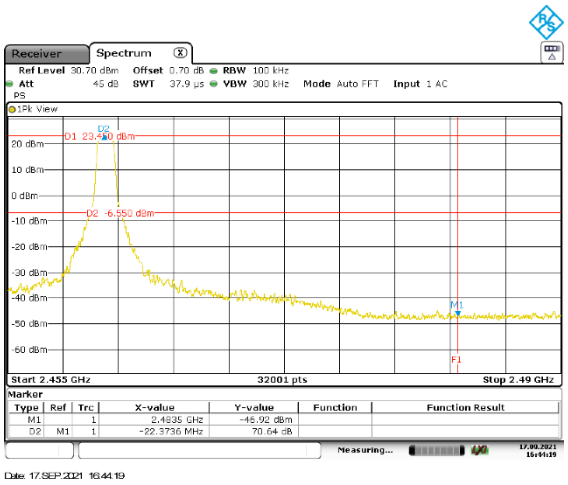

Figure 2.6.6-8: Higher Band edge – Mode 4 – MCS0

2.7 RF Conducted Spurious Emissions

2.7.1 Specification Reference

FCC Sections: 15.247(d)
ISED Canada: RSS-247 5.5

2.7.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.7.3 Date of Test

9/14/2021 to 10/8/2021

2.7.4 Test Method

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.

If maximum conducted (average) output power was used to determine compliance, then the peak power in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 30 dB relative to the maximum in-band peak PSD level in 100 kHz (i.e., 30 dBc).

2.7.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

Ambient Temperature	22.3 °C
Relative Humidity	53.8 %
Atmospheric Pressure	972.2 mbar

2.7.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See data below for detailed results.

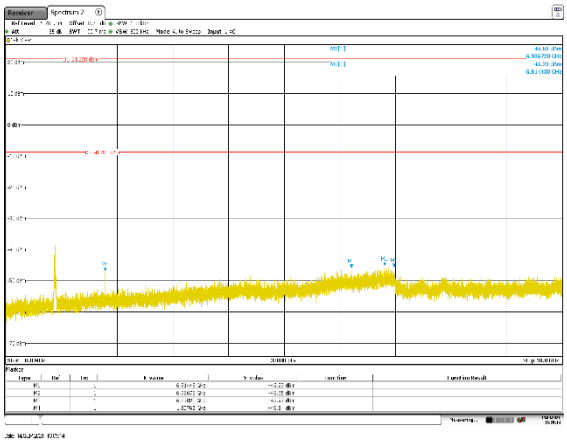

Figure 2.7.6-1:30MHz – 10GHz – LCH – Mode 1

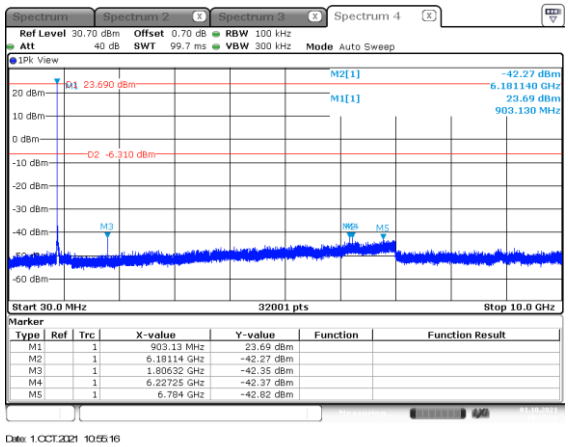

Figure 2.7.6-2:30MHz – 10GHz – LCH – Mode 2

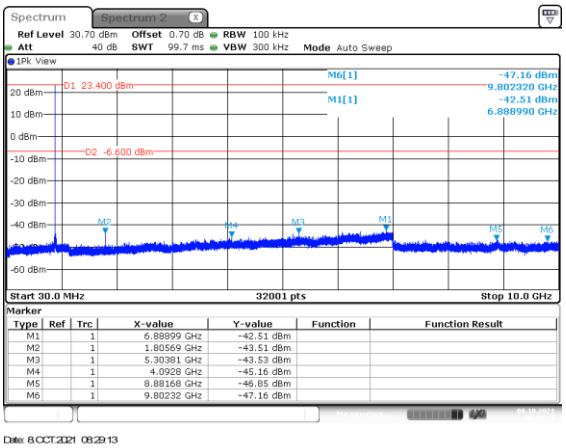

Figure 2.7.6-3:30MHz – 10GHz – LCH – Mode 3

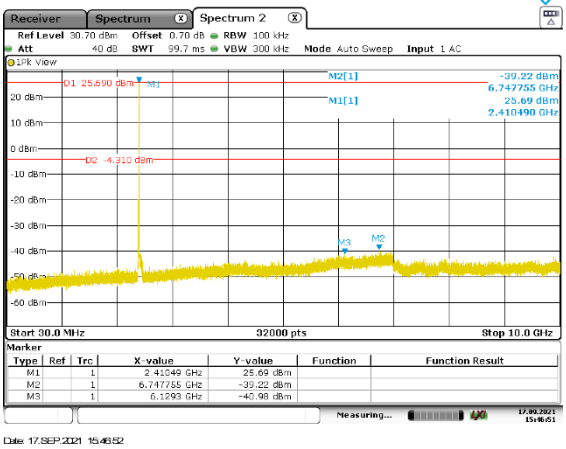

Figure 2.7.6-4:30MHz – 10GHz – LCH – Mode 4

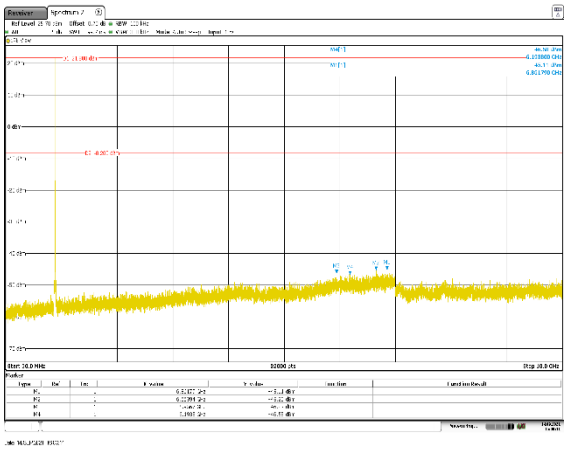

Figure 2.7.6-5:30MHz – 10GHz – MCH – Mode 1

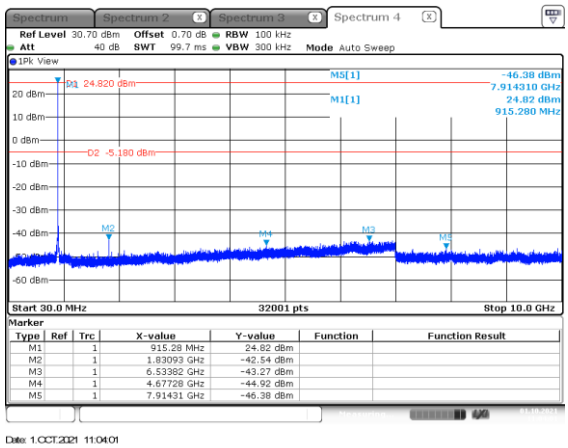

Figure 2.7.6-6:30MHz – 10GHz – MCH – Mode 2

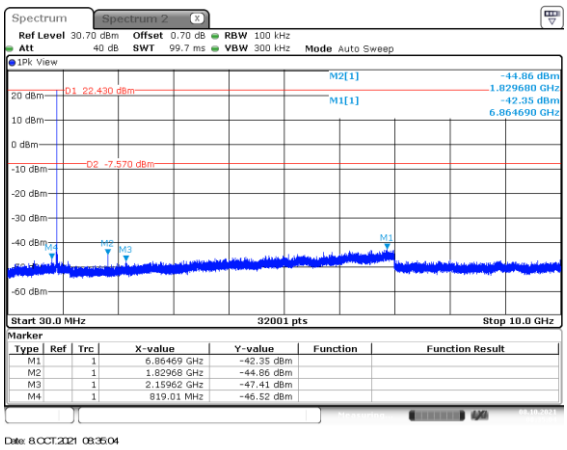

Figure 2.7.6-7:30MHz – 10GHz – MCH – Mode 3

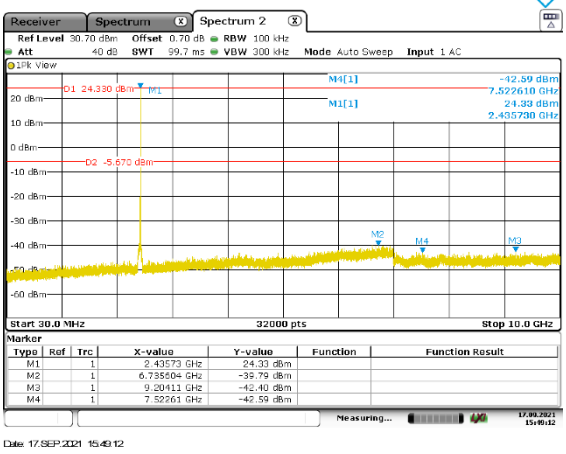

Figure 2.7.6-8:30MHz – 10GHz – MCH – Mode 4

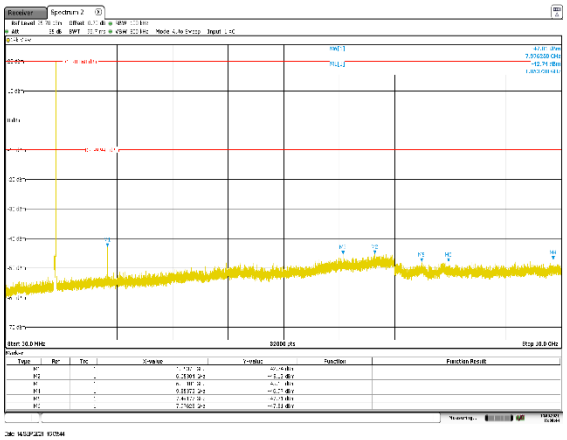

Figure 2.7.6-9:30MHz – 10GHz – HCH – Mode 1

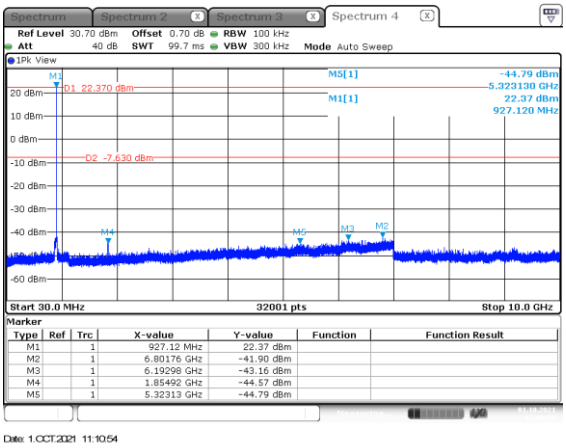

Figure 2.7.6-10:30MHz – 10GHz – HCH – Mode 2

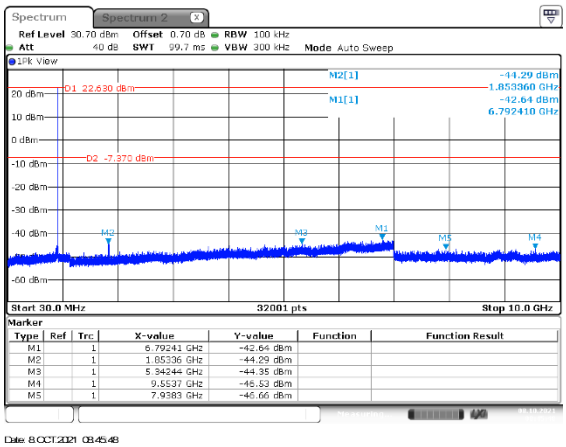

Figure 2.7.6-11:30MHz – 10GHz – HCH – Mode 3

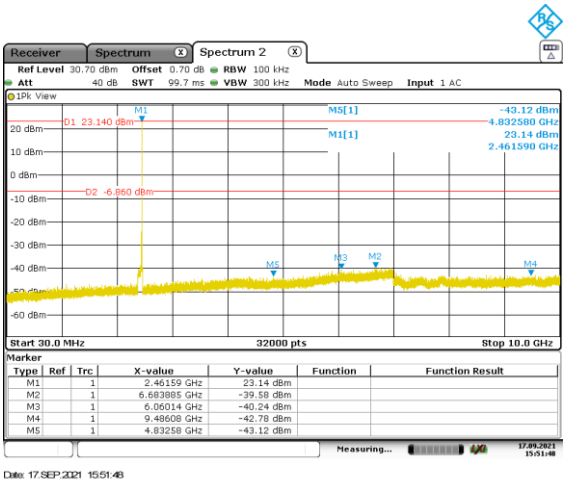

Figure 2.7.6-12:30MHz – 10GHz – HCH – Mode 4

2.8 Radiated Spurious Emissions into Restricted Frequency Bands

2.8.1 Specification Reference

FCC Sections: 15.205, 15.209.
ISED Canada RSS – Gen 8.9/8.10

2.8.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state "0", as noted in §1.6.

2.8.3 Date of Test

10/1/2021 to 10/8/2021

2.8.4 Test Method

Radiated emissions tests were made over the frequency range of 9 kHz to 10 GHz, 10 times the highest fundamental frequency of 900 MHz and 9 kHz to 26 GHz, 10 times the highest fundamental frequency of 2.4 GHz. Each emission found to be in a restricted band as defined by section 15.205, including any emission at the operational band-edge, was compared to the radiated emission limits as defined in Section 15.209.

For measurements below 30 MHz, the receive antenna height was set to 1 m and the EUT was rotated through 360 degrees. The resolution bandwidth was set to 200 Hz below 150 kHz and to 9 kHz above 150 kHz.

The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. For frequencies below 150 kHz, quasi-peak measurements were made using a resolution bandwidth RBW of 300 Hz and a video bandwidth VBW of 1 kHz and frequencies below 30MHz, quasi-peak measurements were made using a resolution bandwidth RBW of 10 kHz and a video bandwidth VBW of 30 kHz. 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 below 1000 MHz, quasi-peak measurements were made using a resolution bandwidth RBW of 120 kHz and a video bandwidth VBW of 300 kHz. For frequencies above 1000 MHz, peak and average measurements are made with RBW of 1 MHz and VBW of 3 MHz.

2.8.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

Ambient Temperature	22.3 °C
Relative Humidity	53.8 %
Atmospheric Pressure	972.2 mbar

2.8.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See data below for detailed results.

Table 2.8.6-1: Radiated Spurious Emissions Tabulated Data – Mode 1

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
LCH										
2712	42.30	27.40	H	5.83	48.13	33.23	74.0	54.0	25.9	20.8
2712	41.50	27.40	V	5.83	47.33	33.23	74.0	54.0	26.7	20.8
3616	41.60	27.10	H	7.45	49.05	34.55	74.0	54.0	25.0	19.5
3616	41.40	27.10	V	7.45	48.85	34.55	74.0	54.0	25.2	19.5
MCH										
2744.4	41.90	27.20	H	5.91	47.81	33.11	74.0	54.0	26.2	20.9
2744.4	41.50	27.20	V	5.91	47.41	33.11	74.0	54.0	26.6	20.9
3659.2	41.80	27.20	H	7.53	49.33	34.73	74.0	54.0	24.7	19.3
3659.2	41.50	27.20	V	7.53	49.03	34.73	74.0	54.0	25.0	19.3
HCH										
2780.4	41.50	26.90	H	5.99	47.49	32.89	74.0	54.0	26.5	21.1
2780.4	41.20	26.90	V	5.99	47.19	32.89	74.0	54.0	26.8	21.1
3707.2	41.20	27.00	H	7.62	48.82	34.62	74.0	54.0	25.2	19.4
3707.2	41.10	27.00	V	7.62	48.72	34.62	74.0	54.0	25.3	19.4

Table 2.8.6-2: Radiated Spurious Emissions Tabulated Data – Mode 2

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
LCH										
No restricted band frequency detected above noise floor.										
MCH										
No restricted band frequency detected above noise floor.										
HCH										
No restricted band frequency detected above noise floor.										

Table 2.8.6-3: Radiated Spurious Emissions Tabulated Data – Mode 3

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
LCH										
165.235	36.10	30.10	H	-9.70	---------	20.40	--------	43.5	---------	23.1
165.235	35.50	28.80	V	-9.70	---------	19.10	--------	43.5	---------	24.4
MCH										
165.269	37.20	30.25	H	-9.70	---------	20.55	--------	43.5	---------	22.9
165.269	35.20	39.50	V	-9.70	---------	29.80	--------	43.5	---------	13.7
HCH										
131.88	31.00	23.80	H	-7.98	---------	15.82	--------	43.5	---------	27.7
131.88	29.80	21.00	V	-7.98	---------	13.02	--------	43.5	---------	30.5

Table 2.8.6-4: Radiated Spurious Emissions Tabulated Data – Mode 4

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
LCH										
2698.48	44.80	29.00	H	5.36	50.16	34.36	74.0	54.0	23.8	19.6
2698.48	44.40	29.00	V	5.36	49.76	34.36	74.0	54.0	24.2	19.6
4821.6	46.20	29.20	H	9.75	55.95	38.95	74.0	54.0	18.1	15.1
4821.6	45.90	28.90	V	9.75	55.65	38.65	74.0	54.0	18.4	15.4
MCH										
4872	49.10	29.70	H	9.83	58.93	39.53	74.0	54.0	15.1	14.5
4872	49.80	29.20	V	9.83	59.63	39.03	74.0	54.0	14.4	15.0
7308	41.40	27.80	H	13.00	54.40	40.80	74.0	54.0	19.6	13.2
7308	41.50	27.80	V	13.00	54.50	40.80	74.0	54.0	19.5	13.2
HCH										
4922.4	49.10	29.00	H	9.34	58.44	38.34	74.0	54.0	15.6	15.7
4922.4	48.30	28.80	V	9.34	57.64	38.14	74.0	54.0	16.4	15.9
7376.6	41.50	28.00	H	12.50	54.00	40.50	74.0	54.0	20.0	13.5
7376.6	42.30	28.00	V	12.50	54.80	40.50	74.0	54.0	19.2	13.5

Table 2.8.6-5: Radiated Band-edge Tabulated Data – Mode 4

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
LCH										
2390	52.80	29.30	H	4.83	57.63	34.13	74.0	54.0	16.4	19.9
2390	54.20	31.50	V	4.83	59.03	36.33	74.0	54.0	15.0	17.7
HCH										
2483.5	45.40	28.00	H	4.95	50.35	32.95	74.0	54.0	23.7	21.1
2483.5	43.80	27.90	V	4.95	48.75	32.85	74.0	54.0	25.3	21.2

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 – Mode 1

Corrected Level: 42.30 + 5.83 = 48.13 dBuV/m

Margin: 74dBuV/m – 48.13dBuV/m = 25.9dB

Example Calculation: Average – Mode 1

Corrected Level: 27.00+ 7.62- 0 = 34.62dBuV

Margin: 54dBuV – 34.62dBuV = 19.4dB

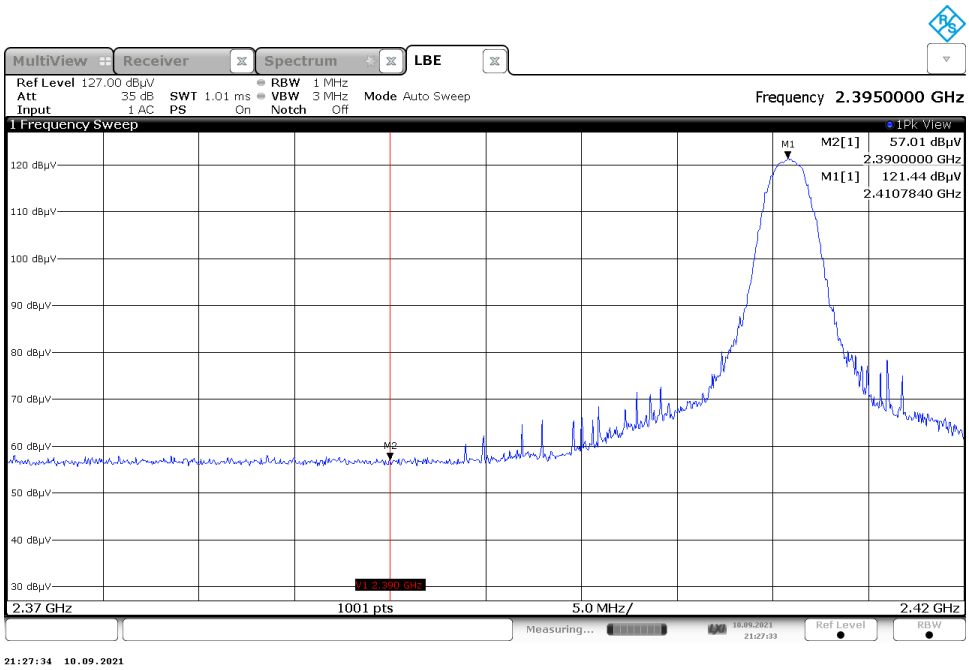

Figure 1: Radiated Band-edge – LCH – Mode 4

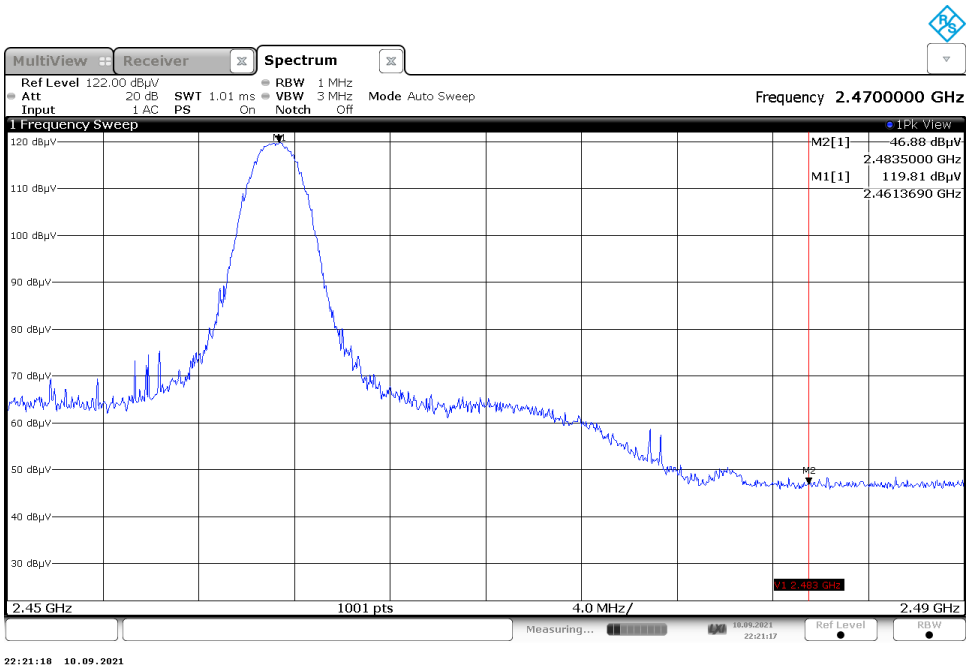

Figure 2: Radiated Band-edge – HCH – Mode 4

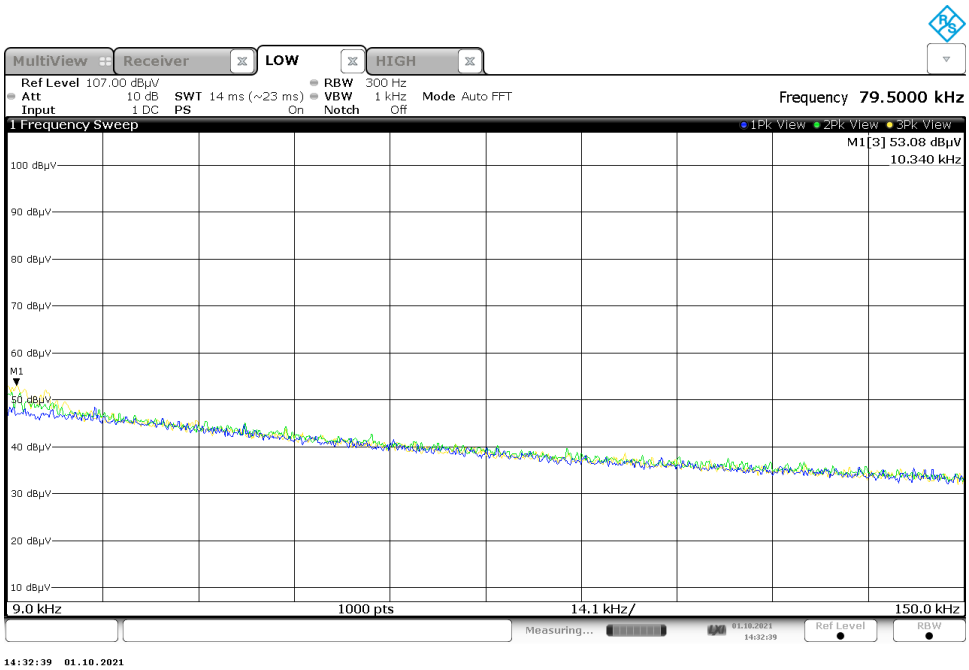

Figure 3: Reference plot for Radiated Spurious Emissions – 9 kHz – 150 kHz – Mode 2

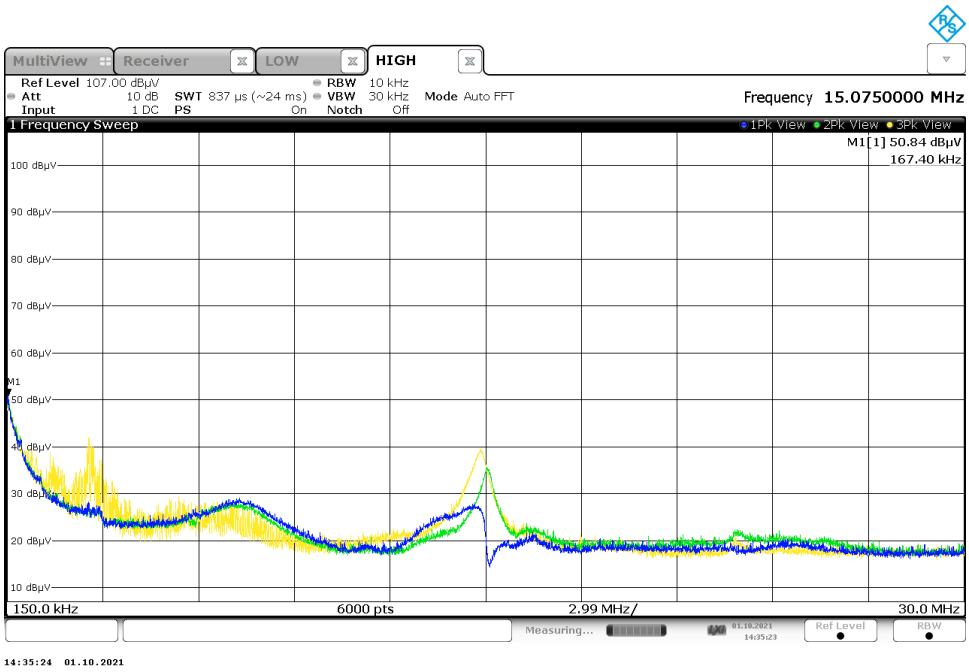

Figure 4: Reference plot for Radiated Spurious Emissions– 150 kHz – 30MHz – Mode 2
Note: Emissions above the noise floor are ambient not associated with the EUT.

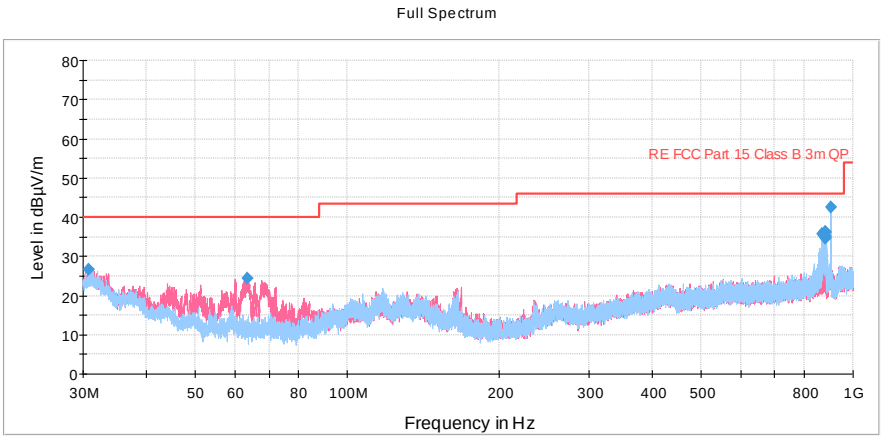

Figure 5: Reference plot for Radiated Spurious Emissions – 30 MHz – 1 GHz – Mode 2
Note: Emissions above the noise floor do not falls within restricted bands.

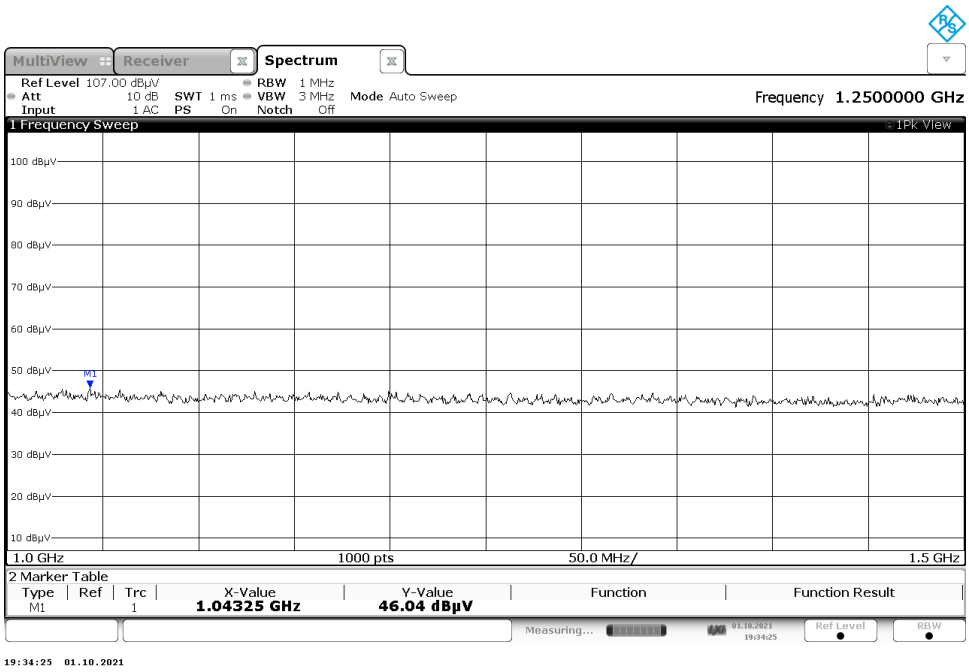

Figure 6: Reference plot for Radiated Spurious Emissions – 1 GHz – 1.5 GHz – Mode 2

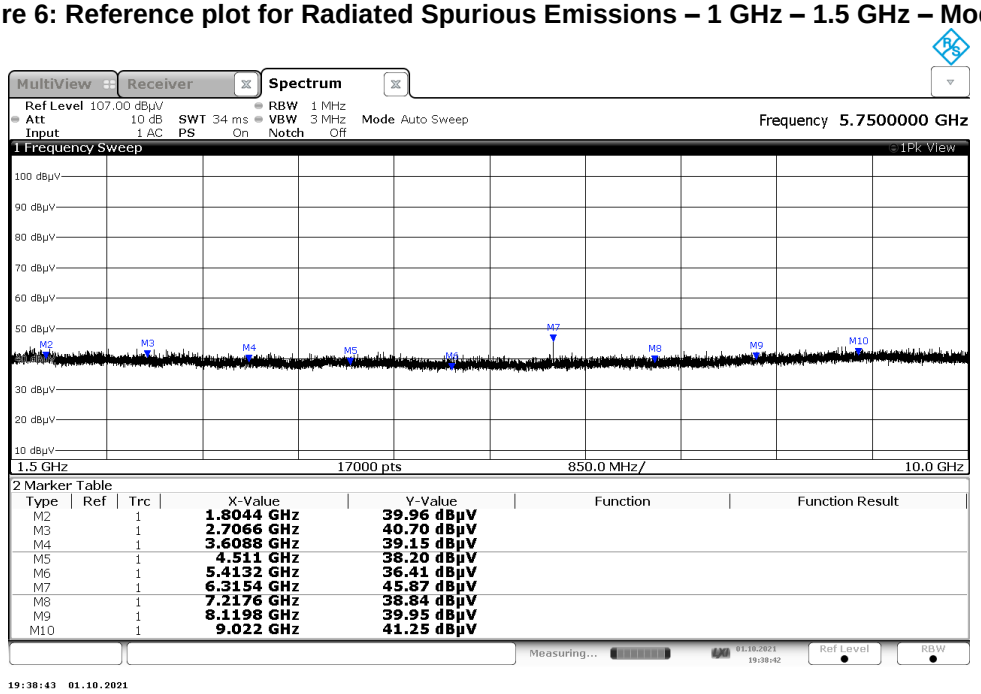

Figure 7: Reference plot for Radiated Spurious Emissions – 1.5 GHz – 10 GHz – Mode 2

Note: Emissions above the noise floor do not falls within restricted bands.

2.9 Test Equipment Used

Table 2.9-1 –Equipment List

Asset ID	Manufacturer	Model	Equipment Type	Serial Number	Last Calibration Date	Calibration Due Date
628	EMCO	6502	Active Loop Antenna 10kHz-30MHz	9407-2877	6/8/2021	6/8/2023
857	ETS Lindgren	3117	Horn Antenna 1-18GHz	00153608	11/12/2019	11/12/2021
DEMC3161	Ametek CTS Germany GmbH	CBL 6112D	Bilog Antenna; Attenuator	51323	3/19/2021	3/19/2022
213	TEC	PA 102	Amplifier	44927	7/30/2021	7/30/2022
22	Hewlett Packard	8449B	High Frequency Pre-Amp	3008A00526	11/19/2020	11/19/2021
331	Microwave Circuits	H1G513G1	Microwave Bandpass Filter	31417	6/9/2021	6/9/2022
827	(-)	997 Rack Cable	TS8997 Rack Cable Set	N/A	9/4/2020	12/4/2021
267	Hewlett Packard	N1911A	Power Meter	MY45100129	7/27/2021	7/27/2023
882	Rohde & Schwarz	ESW44	Test Receiver	111961	6/24/2021	6/24/2022
836	ETS Lindgren	SAC Cable Set	SAC Cable Set includes 620, 837, 838	N/A	5/11/2021	5/11/2022
3010	Rohde & Schwarz	ENV216	Two-Line V-Network	3010	6/23/2021	6/23/2022
872	Agilent	E7402A	EMC Spectrum Analyzer	US40240258	6/22/2021	6/22/2022
861	Com-Power Corporation	LI-1100C	Line Impedance Stabilization Network	20180038	2/26/2021	2/26/2022
862	Com-Power Corporation	LI01100C	Line Impedance Stabilization Network	20180039	2/26/2021	2/26/2022
703	Hewlett Packard	8594E	Spectrum Analyzer	3523A02134	NCR	NCR
856	Huber & Suhner	Multiflex 104	Blue Cable	326050	NCR	NCR
691	Com-Power Corp.	691	E-Field Fine Tip (100kHz to 5GHz), H-Field Loop (9kHz to 5GH	151514	NCR	NCR
494	Omega	iBTHX-W	Environmental Sensor	9460211	11/3/2020	11/3/2021
813	PMM	9010	EMI Receiver; RF Input 50ohm; 10Hz-50MHz; 10Hz-30MHz	697WW30606	6/8/2021	6/8/2022
168	Hewlett Packard	11947A	Transient Pulse Limiter	44829	3/3/2021	3/3/2022

N/A – Not Applicable
NCR – No Calibration Required

3 Diagram of Test Set-ups

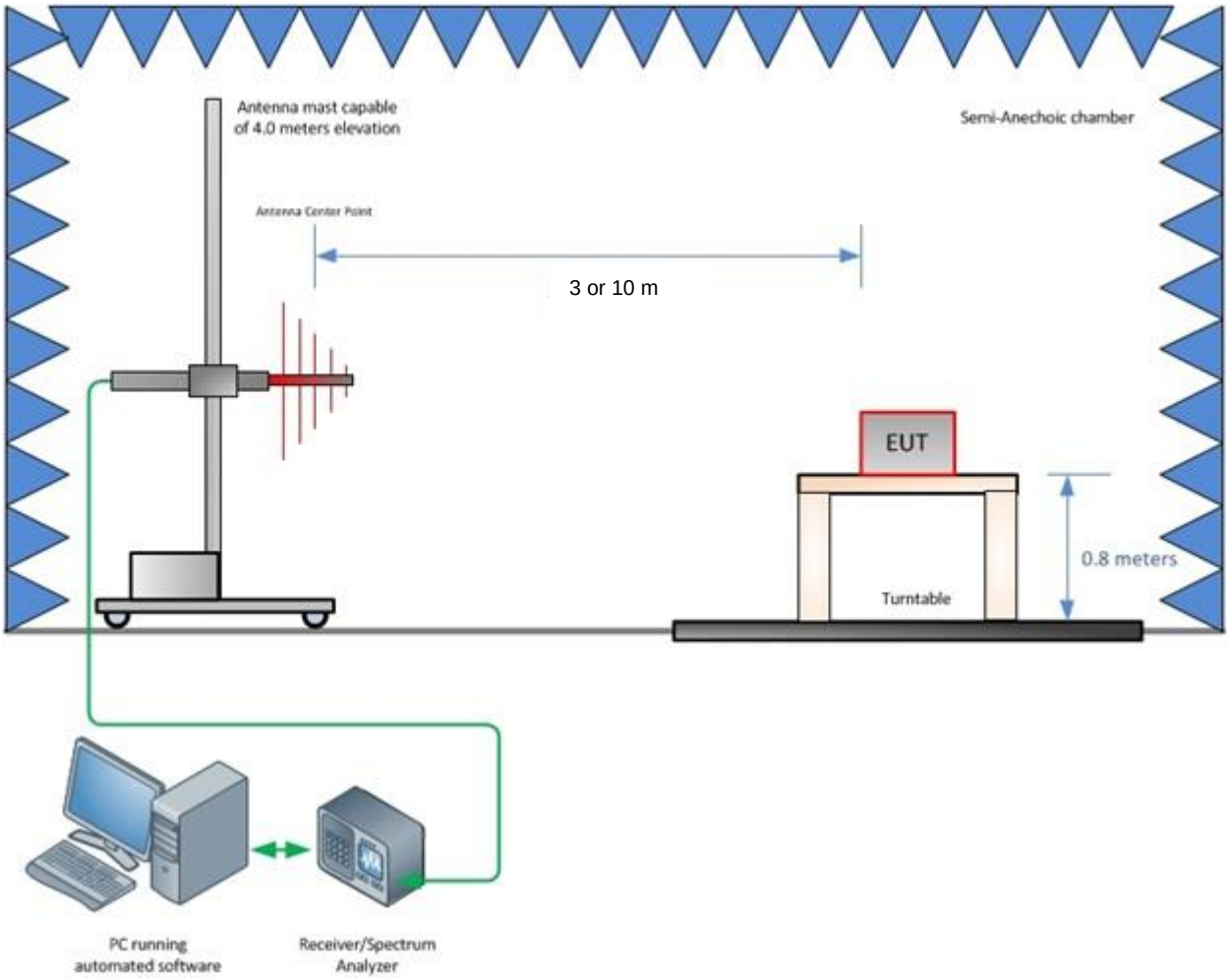

Figure 3-1 – Radiated Emissions Test Setup up to 1 GHz

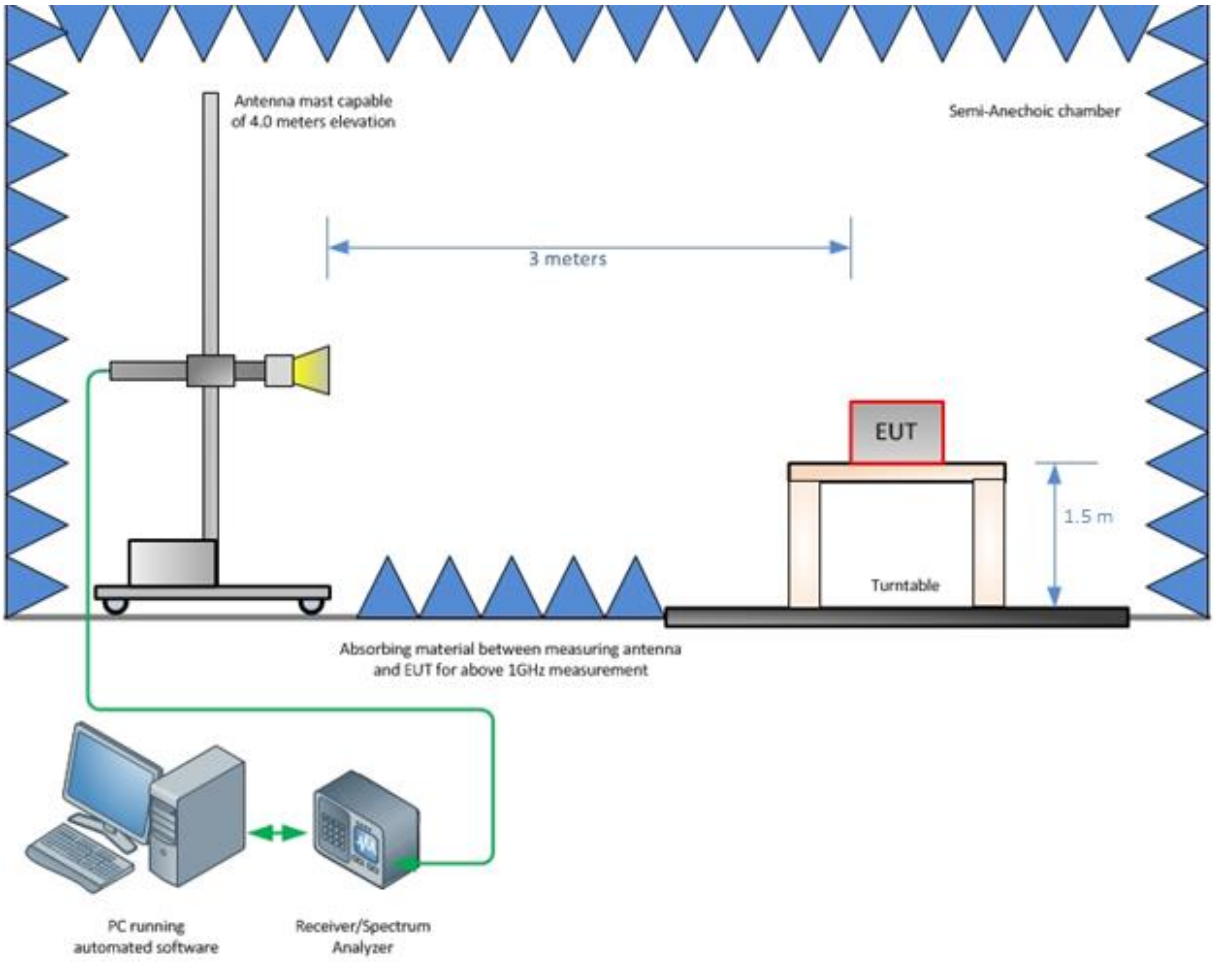

Figure 3-2 – Radiated Emissions Test Setup above 1 GHz

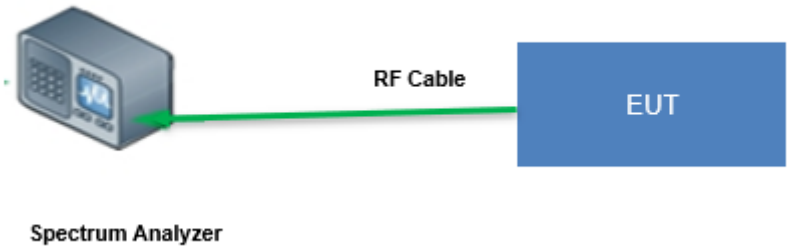

Figure 3-3 – Conducted Test Setup: Antenna Port measurement

4 Accreditation, Disclaimers and Copyright

TÜV SÜD America Inc.'s reports apply only to the specific sample tested under stated test conditions. It is the manufacturer's responsibility to assure the continued compliance of production units of this model. TÜV SÜD America, Inc. shall have no liability for any deductions, inferences or generalizations drawn by the client or others from TÜV SÜD America, Inc.'s issued reports.

This report is the confidential property of the client. As a mutual protection to our clients, the public and TÜV SÜD America, Inc., extracts from the test report shall not be reproduced, except in full without TÜV SÜD America, Inc.'s written approval.

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

STATEMENT OF MEASUREMENT UNCERTAINTY – Emissions

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 4-1: 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

TEST EQUIPMENT

All measurement instrumentation is traceable to the National Institute of Standards and Technology and is calibrated to meet test method standard requirements and/or manufacturer's specifications

Appendix A: Test Setup Photos

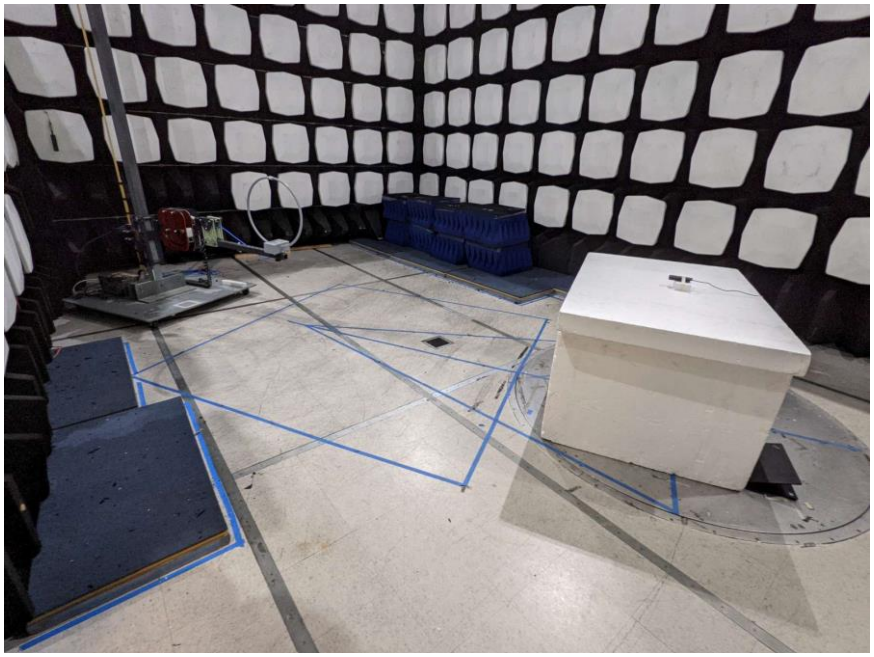

Figure A-1 – Test Set up - Radiated Emissions <30 MHz

Figure A-2 – Test Set up - Radiated Emissions <1 GHz

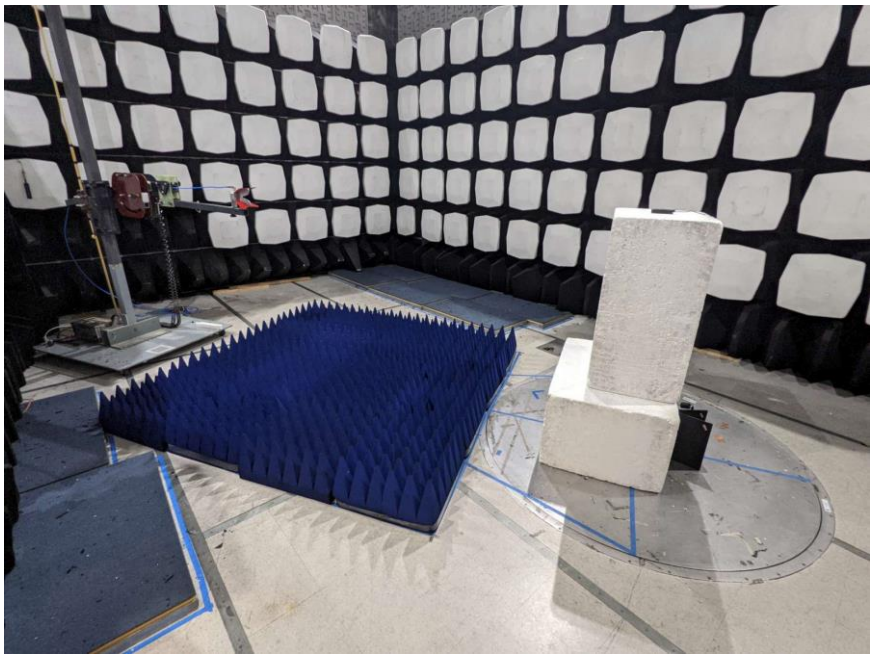

Figure A-3 – Test Set up - Radiated Emissions <10 GHz

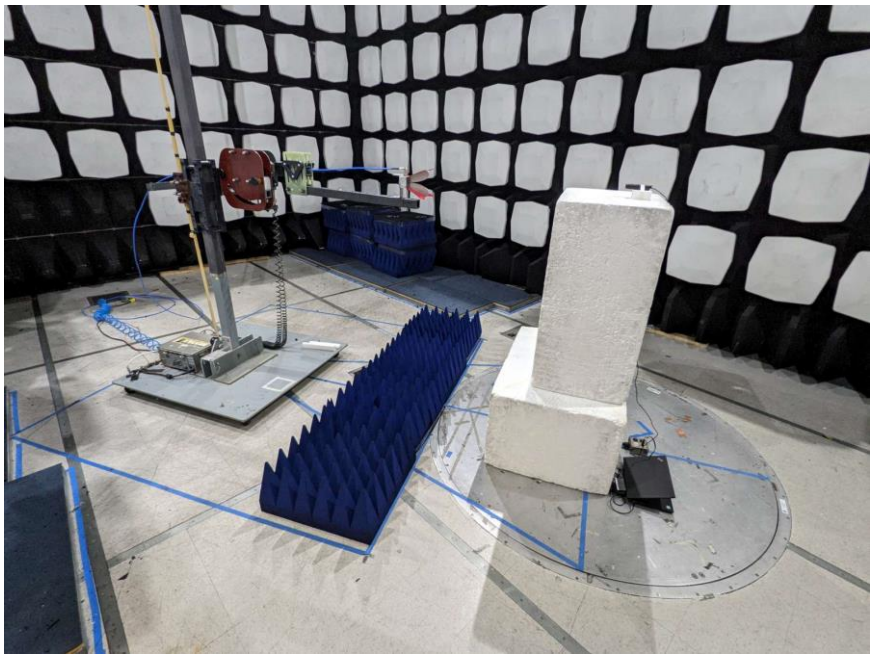

Figure A-4 – Test Set up - Radiated Emissions <18 GHz

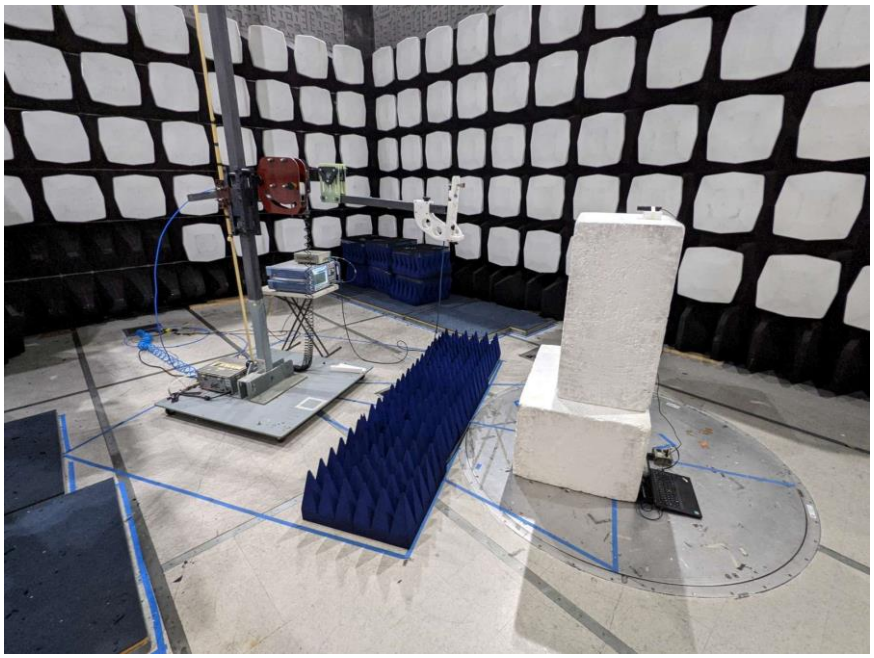

Figure A-5 – Test Set up - Radiated Emissions >18 GHz

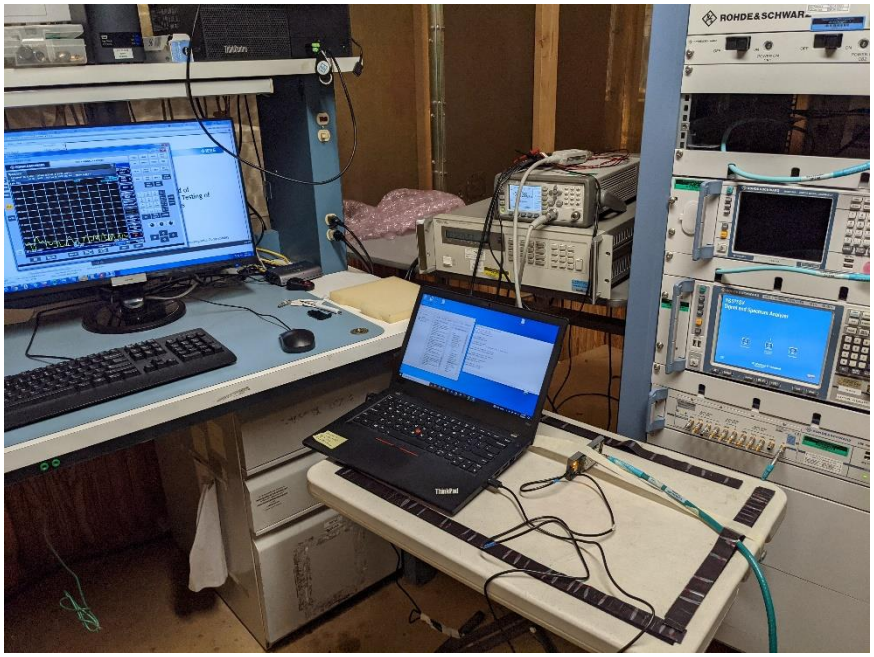

Figure A-6 – Test Set up – Antenna Port measurement

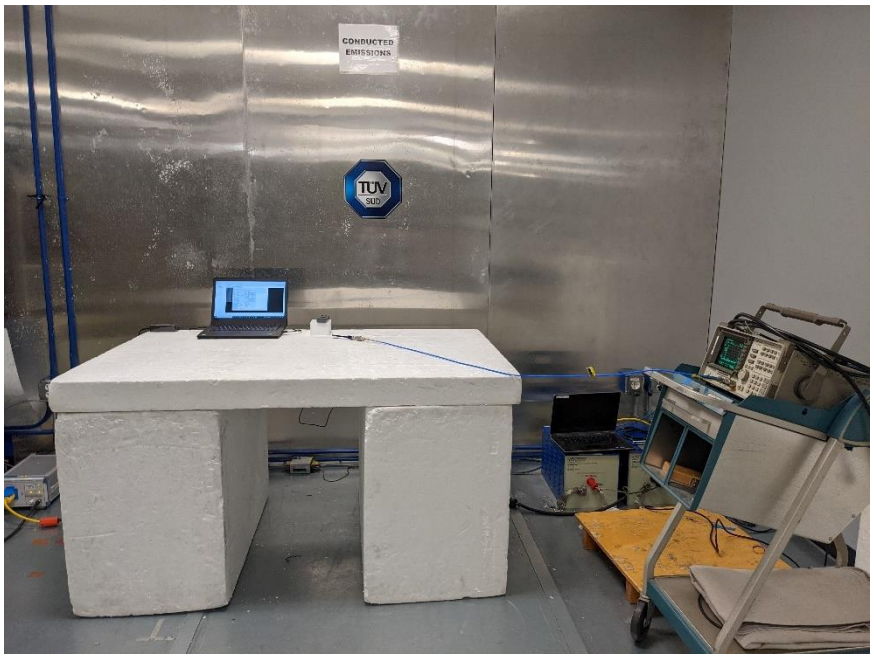

Figure A-7 – Test Set up – Conducted Emissions