Project #: 23228-15

Company: Swimmersive Co. dba Zygo

EUT Name: Swimmersive Zygo
EUT Model: ZY300

FCC and ISED Canada

Wireless Test Report

Prepared for:

Swimmersive Co. dba Zygo
16854 Mooncrest Dr
Encino, CA 91436

By

Nemko PTI, Inc.
1601 North A.W. Grimes Blvd., Suite B
Round Rock, Texas 78665

July 22, 2022

Written by

Shakil Murad
Wireless Engineer

Revision History

Revision Number	Description	Date
Draft01	Initial release for review	8/3/2022
Draft02	Changed IC to ISED Canada	8/8/2022

Table of Contents

Compliance Certificate

FCC MRA Designation Number: US5270
NVLAP Accreditation Number: 200062-0

Applicant	Device & Test Identification
Swimmersive Co. dba Zygo **16854 Mooncrest Dr** **Encino, CA 91436**	**Model(s): ZY300** **FCC ID: 2APZQ-ZYGOV2** **IC ID: 23961-ZYGOV2** **Laboratory Project ID: 23228-15**

The device named above was tested utilizing the following standards and found to be in compliance with the required criteria:

Test Requirements:

Requirement	Reference	Test Description
FCC 47 CFR Part 15 C	15.247	Operation within the bands 2400-2483.5 MHz
	15.207	Conducted emission limits
	15.209	Radiated emission limits; general requirements
	15.205	Restricted Bands of Operation
	15.203	Antenna requirement
FCC 47 CFR Part 1 I*	1.1310	Radiofrequency radiation exposure limits
RSS-247	Issue 2	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
RSS-Gen	Issue 5	General Requirements and Information for the Certification of Radio Apparatus
RSS-102	Issue 5	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)

*MPE is reported separately from this document. **Corresponding RSS references are listed in the body of the report.

I, Shakil Murad, for Nemko PTI, Inc., being familiar with the above requirements and test procedures have reviewed the test setup, measured data, and this report. I believe them to be true and accurate.

NVLAP
TESTING
NVLAP LAB CODE 200062-0

Shakil Murad
Wireless Engineer

This report has been reviewed and accepted by the Applicant**.** The undersigned is responsible for ensuring that this device will continue to comply with the requirements listed above.

_____
Representative of Applicant

Test Result Summary

Test	FCC Part 15 Rule Paragraphs	IC RSS References	Test Results
AC Mains Conducted Emissions	15.207 (a)	RSS-Gen 7.2	Pass
Carrier Frequency Separation	15.247(a)(1)	RSS-247 5.1(b	Pass
Number of Hopping Frequencies	15.247(a)(1)(iii)	RSS-247 5.1(d)	Pass
Time of Occupancy (Dwell Time)	15.247(a)(1)(iii)	RSS-247 5.1(d)	Pass
Output Power	15.247 (b)(1)	RSS-247 5.4 (b)	Pass
Occupied Bandwidth	15.247 (a)(1); 2.1049	RSS-247 5.1 (a)	Pass
Duty Cycle	15.247 (f)	RSS-247 5.3 (a)	Pass
Band Edge	15.247 (d); 15.205 (a)	RSS-247 5.5; RSS-Gen 6.13	Pass
Conducted Spurious Emissions	15.247 (d); 15.209 (a)	RSS-247 5.5; RSS-GEN 6.13	Pass
Transmitter Spurious Emissions	15.247 (d); 15.209 (a)	RSS-247 5.5; RSS-Gen 6.13 & 8.10	Pass
Receiver Radiated Spurious Emissions	15.109	RSS-Gen 7.3	Pass
Antenna Requirement	15.203	RSS-Gen 6.8	Pass

1.0 Introduction

1.1 Scope

This report describes the extent to which the equipment under test (EUT) conformed to the intentional radiator requirements of the United States and Canada.

Nemko PTI, Inc., follows the guidelines of National Institute of Standards and Technology (NIST) for all uncertainty calculations, estimates, and expressions thereof for electromagnetic compatibility testing.

1.2 EUT Description

Manufacturer / Model	Serial #	Description
Swimmersive Co. dba Zygo Model: ZY300	RB44B1233	DSS 2400-2483.5 MHz FHSS transceiver Bluetooth protocols.

1.3 Support Equipment

Manufacturer / Model	Serial #	Description
ZYGO / ZY400	HC07C0827	Headset
Motorola / Moto	N/A	Cell Phone
Belkin / WC8002dq	N/A	USB Charger

1.4 EUT Test Configuration

The EUT was exercised in a manner consistent with normal operations.

1.5 Modifications to Equipment

A PCB mounted 50 ohm resistor was soldered in place of the 200 MHz radio antenna to facilitate Radiated Spurious Emissions measurements.

1.6 Test Site

Measurements were made at the Nemko PTI semi-anechoic facility designated Site 45 (FCC 776781, IC 3036B-1) in Austin, Texas. The site is registered with the FCC under Section 2.948 and Industry Canada per RSS-GEN, and is subsequently confirmed by laboratory accreditation (NVLAP). The test site is located at 11400 Burnet Road, Austin, Texas 78758, while the main office is located at 1601 North A.W. Grimes Boulevard, Suite B, Round Rock, Texas, 78665. CAB Identifier: US 0123.

1.7 Measurement Corrections

Parameter	From Sums Of
Radiated Field Strength	Raw Measured Level + Antenna Factor + Cable Losses – Amplifier Gain
Conducted Antenna Port	Raw Measured Level + Attenuator Factor + Cable Losses
Conducted Mains Port	Raw Measured Level + LISN Factor + Cable/Filter/Limiter Losses

Additionally, measurement distance extrapolation factors (such as 1/d above 30 MHz) are applied and documented where used.

1.8 Applicable Documents

Table 1.8.1: Applicable Documents

Document	Title
47 CFR	Part 15 – Radio Frequency Devices Subpart C -Intentional Radiators
RSS-247 Issue 2	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
RSS-102 Issue 5	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)
RSS-Gen Issue 5	General Requirements and Information for the Certification of Radio Apparatus
ANSI C63.10 2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
KDB 558074 D01	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
KDB 412172 D01	GUIDELINES FOR DETERMINING THE EFFECTIVE RADIATED POWER (ERP) AND EQUIVALENT ISOTROPICALLY RADIATED POWER (EIRP) OF AN RF TRANSMITTING SYSTEM
KDB 447498 D01	RF EXPOSURE PROCEDURES AND EQUIPMENT AUTHORIZATION POLICIES FOR MOBILE AND PORTABLE DEVICES
OET Bulletin 65 Edition 97-01	Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields

2.0 AC Power-line Conducted Emissions

2.1 Test Procedure

Measure emissions of the EUT from the AC mains network terminated into a standard line impedance network (LISN).

2.2 Test Criteria

AC Power-line Conducted Emissions Limit		
Frequency (MHz)	Quasi-Peak (dBuV)	Average (dBuV)
0.150 – 0.500	66 – 56 *	56 – 46 *
0.500 - 5	56	46
5 - 30	60	50
Note 1: * Decreases with the logarithm of the frequency.		

2.3 Test Results

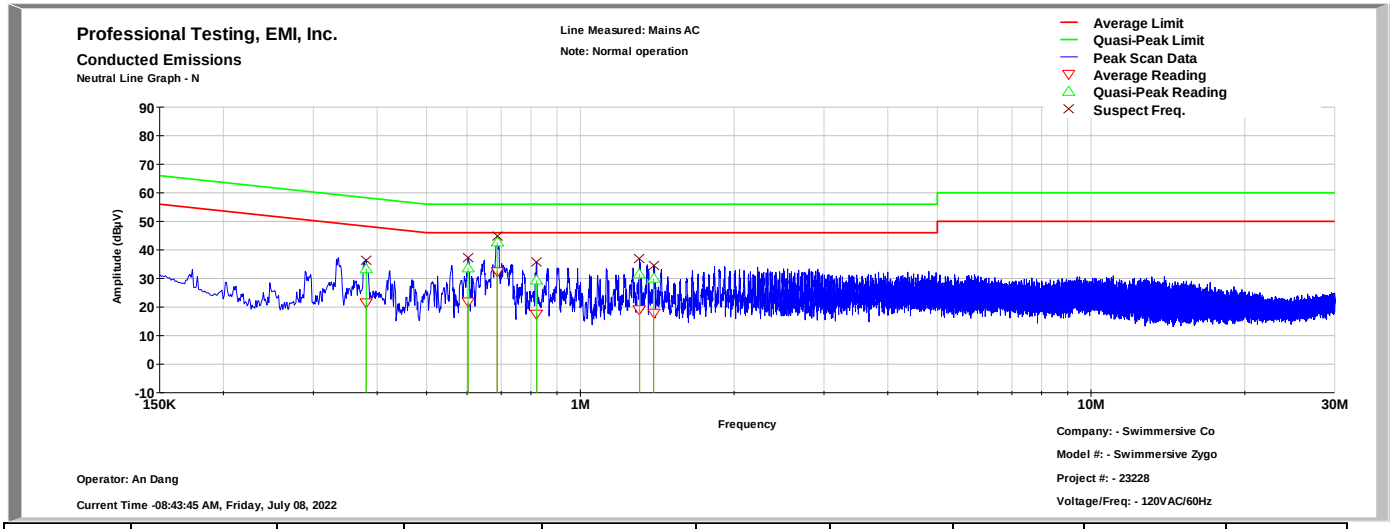
Table 2.3.1: Conducted Emissions Test Results – AC Mains

EUT Name	**Swimmersive Zygo**		**Model or Serial #**	**Model ZY100**	
EUT Line Voltage	**120**	**VAC**	**Frequency**	**60**	**Hz**
Emissions Limit Level	**FCC.15 Class B**		**EUT Test Mode or Configuration**	**Charging**	
Frequency Range			**Line Tested**	**Test Results**	
150kHz to 30MHz			**Neutral Line**	**Pass**	
			Phase A (Line 1)	**Pass**	
Notes:					

The requirements were satisfied. Test plots and tabular data are presented on the following page.

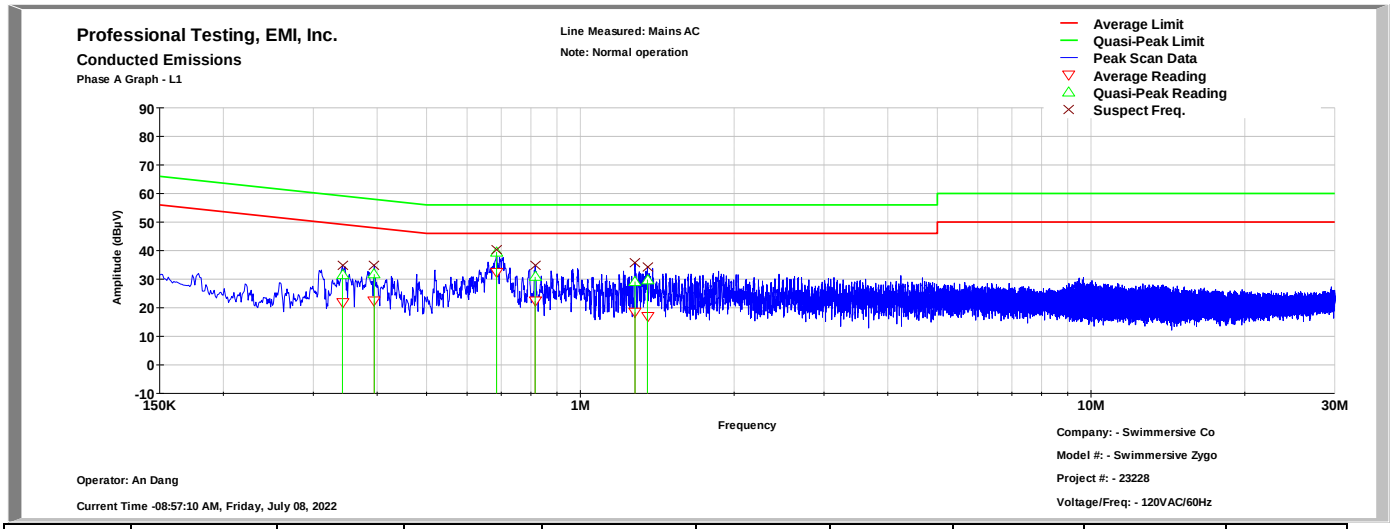
2.3.2 AC Power-line Conducted Emissions Test Data

Neutral Line Emissions Data



Frequency (MHz)	Quasi-peak Reading (dBµV)	Quasi-peak Limit (dBµV)	Quasi-peak Margin (dB)	Quasi-peak Results	Average Reading (dBµV)	Average Limit (dBµV)	Average Margin (dB)	Average Results	Peak Reading (dBµV)
(MHz)	(dBµV)	(dBµV)	(dB)	(Pass/Fail)	(dBµV)	(dBµV)	(dB)	(Pass/Fail)	(dBµV)
0.381	33.4	58.3	-24.9	PASS	21.4	48.3	-26.9	PASS	39.4
0.603	33.7	56.0	-22.3	PASS	21.7	46.0	-24.3	PASS	39.6
0.687	42.7	56.0	-13.3	PASS	32.4	46.0	-13.6	PASS	49.7
0.822	29.3	56.0	-26.7	PASS	17.5	46.0	-28.5	PASS	37.2
1.306	31.7	56.0	-24.3	PASS	19.2	46.0	-26.8	PASS	38.0
1.392	30.1	56.0	-25.9	PASS	17.9	46.0	-28.1	PASS	37.4

Line 1 Emissions Data



Frequency (MHz)	Quasi-peak Reading (dBµV)	Quasi-peak Limit (dBµV)	Quasi-peak Margin (dB)	Quasi-peak Results	Average Reading (dBµV)	Average Limit (dBµV)	Average Margin (dB)	Average Results	Peak Reading (dBµV)
(MHz)	(dBµV)	(dBµV)	(dB)	(Pass/Fail)	(dBµV)	(dBµV)	(dB)	(Pass/Fail)	(dBµV)
0.342	31.6	59.2	-27.5	PASS	21.7	49.2	-27.4	PASS	37.5
0.395	31.7	58.0	-26.2	PASS	22.5	48.0	-25.4	PASS	37.8
0.685	39.5	56.0	-16.5	PASS	32.3	46.0	-13.7	PASS	46.4
0.816	30.8	56.0	-25.2	PASS	22.3	46.0	-23.7	PASS	35.8
1.279	29.2	56.0	-26.8	PASS	18.4	46.0	-27.6	PASS	36.5
1.353	29.9	56.0	-26.1	PASS	17.0	46.0	-29.0	PASS	38.8

3.0 Carrier Frequency Separation

3.1 Test Procedure

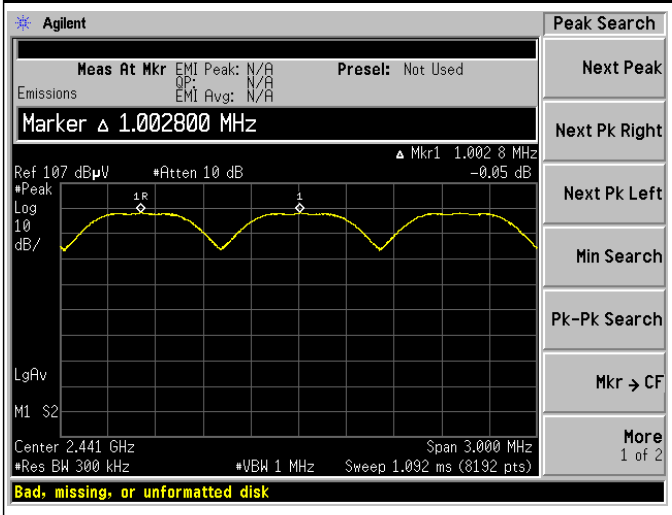
The EUT was connected through an attenuator to the spectrum analyzer. The radio was allowed to hop normally while the analyzer was in max hold mode. ANSI C63.10-2013, section 7.8.2, procedure is used for the measurements.

3.1 Test Criteria

47 CFR (USA) // IC (Canada)	
Section Reference	Limit
15.247(a)(1) // RSS-247 5.1(b)	FHSs shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

3.1 Test Results

Project Number:	23228-15				Test Date(s):	7/5/2022							
Environmental Conditions:	Temperature	22.3	°C		Humidity	53	RH	Barometric Pressure	29.92	in Hg			
Measurement Parameters:	RBW	300	kHz		VBW	900	kHz	Span	3	MHz	Detector	Peak	
Frequency	Minimum Frequency Separation Required (kHz)				Measured Frequency Separation (kHz)			Test Result					
Adjacent channels	25				1002			Pass					



Antenna Port	

The requirements were satisfied.

4.0 Number of Hopping Frequencies

4.1 Test Procedure

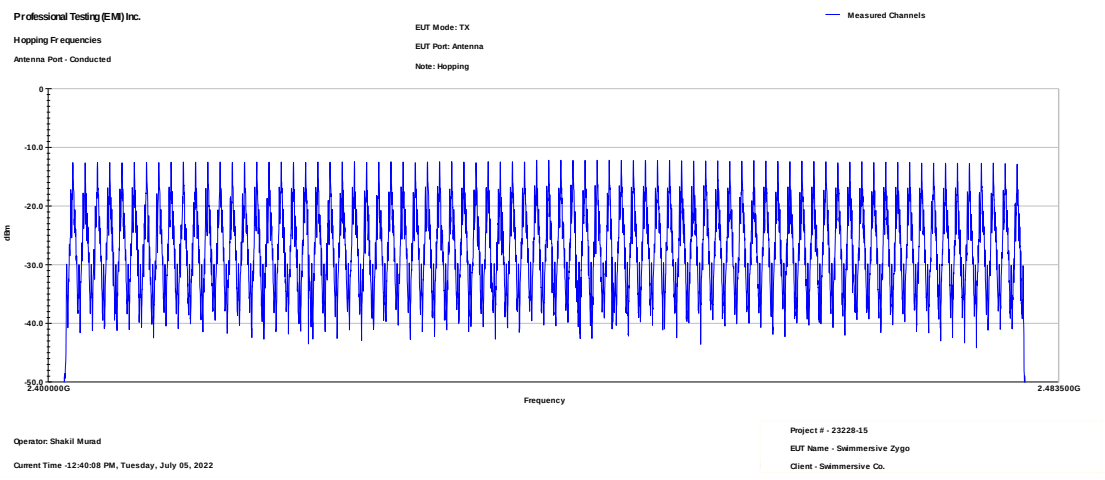
The EUT was connected through an attenuator to the spectrum analyzer. The radio was allowed to hop normally while the analyzer was in max hold mode. ANSI C63.10-2013, section 7.8.3, procedure is used for the measurements.

4.2 Test Criteria

47 CFR (USA) // IC (Canada)	
Section Reference	Limit
15.247(a)(1)(iii) // RSS-247 5.1(d)	FHSs operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels.

4.3 Test Results

Project Number:	23228-15				Test Date(s):	7/5/2022				
Environmental Conditions:	Temperature	22.3	°C		Humidity	53	RH	Barometric Pressure	29.92	in Hg
Measurement Parameters:	RBW	30	kHz	VBW	100	kHz		Detector	Peak	
Frequency Band (MHz)	Measured Hopping Frequencies				Limit			Test Result		
2400 2483.5	79				> 15			Pass		



Hopping Channels (MHz)									
2402.01	2412.01	2422.01	2432.01	2442.01	2452.01	2462.01	2472.01		
2403.02	2413.02	2423.01	2433.01	2443.01	2453.01	2463.01	2473.01		
2404.01	2414.02	2424.02	2434.02	2444.01	2454.01	2464.01	2474.01		
2405.01	2415.01	2425.01	2435.02	2445.02	2455.02	2465.02	2475.01		
2406.01	2416.01	2426.01	2436.01	2446.01	2456.01	2466.02	2476.02		
2407.01	2417.01	2427.01	2437.01	2447.01	2457.01	2467.01	2477.01		
2408.02	2418.02	2428.01	2438.01	2448.01	2458.01	2468.01	2478.01		
2409.01	2419.02	2429.02	2439.02	2449.01	2459.01	2469.01	2479.01		
2410.01	2420.01	2430.01	2440.02	2450.02	2460.02	2470.01	2480.01		
2411.01	2421.01	2431.01	2441.01	2451.01	2461.02	2471.02			

5.0 Time of Occupancy (Dwell Time)

5.1 Test Procedure

The EUT was connected through an attenuator to the spectrum analyzer. The radio was allowed to hop normally while the analyzer was in max hold mode. ANSI C63.10-2013, section 7.8.4, procedure is used for the measurements.

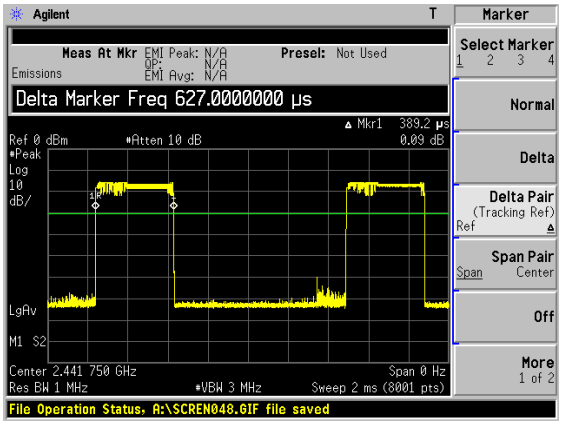
5.2 Test Criteria

47 CFR (USA) // IC (Canada)	
Section Reference	Limit
15.247(a)(1)(iii) // RSS-247 5.1(d)	The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed.

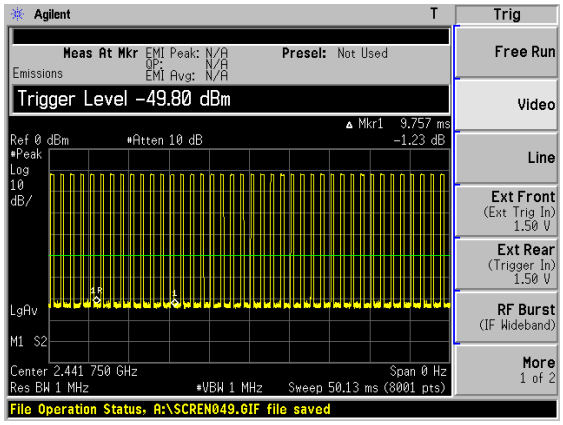
5.3 Test Results

Project Number:	**23228-15**			**Test Date(s):**	**7/5/2022**				
Environmental Conditions:	**Temperature**	**22.3**	**°C**	**Humidity**	**53**	**RH**	**Barometric Pressure**	**29.92**	**in Hg**
Measurement Parameters:	**RBW**	**1**	**MHz**	**VBW**	**3**	**MHz**	**Detector**	**Peak**	
Total Number of Channels:		**79**		**Time of Occupancy (0.4 sec * # of Chs):**				**31.6**	**sec.**
Sweep Time:	**50**	**ms**	**Number of Hopps:**	**40**	**Hopping Time Within 1sec (# of Hopps/Sweep Time):**			**800**	**Hopps/sec**

Frequency (MHz)	Transmitter ON Time (ms)	Maximum Occupancy Time on a Single Channel ((On Time*# of Hopps/sec.)/# of Chs)*Time of Occupancy	Limit (ms)	Test Result
2441	0.3892	124.544	< 400	PASS



Transmitter ON Time



Number of Hopps within 50 ms

6.0 Output Power

6.1 Test Procedure

The EUT was connected directly to the spectrum analyzer with an attenuator for the measurements. Low, mid, and high channel were measured. ANSI C63.10-2013, section 7.8.5, procedure is used for the measurements.

6.2 Test Criteria

47 CFR (USA) // IC (Canada)	
Section Reference	Limit
15.247(b)(1) // RSS-247 (b)	1 W peak (+30 dBm) Limit Restated as Field: 125.23 dBµV/m @ 3 m

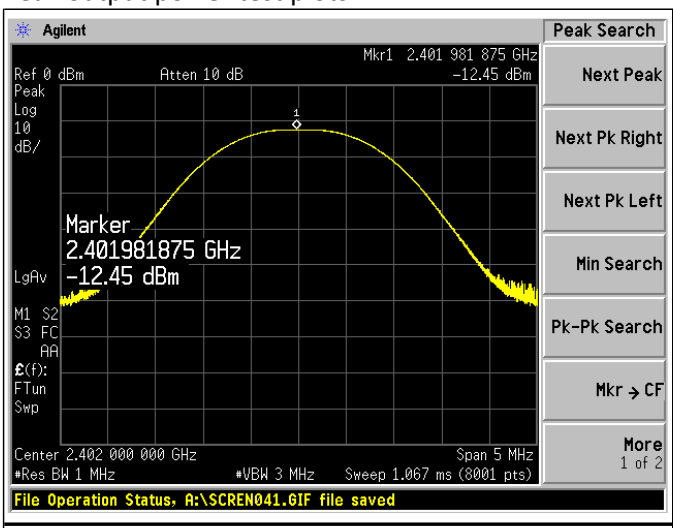
6.3 Test Results

Project Number:	23228-15					Test Date(s):	7/1/2022				
Environmental Conditions:	Temperature	22.4	°C	Humidity	52	RH	Barometric Pressure	29.88	in Hg		
EUT (6 or 20 dB) Bandwidth:	1.034	MHz									
Measurement Parameters:	RBW	1	MHz	VBW	3	MHz	Span	3	MHz	Detector	Peak

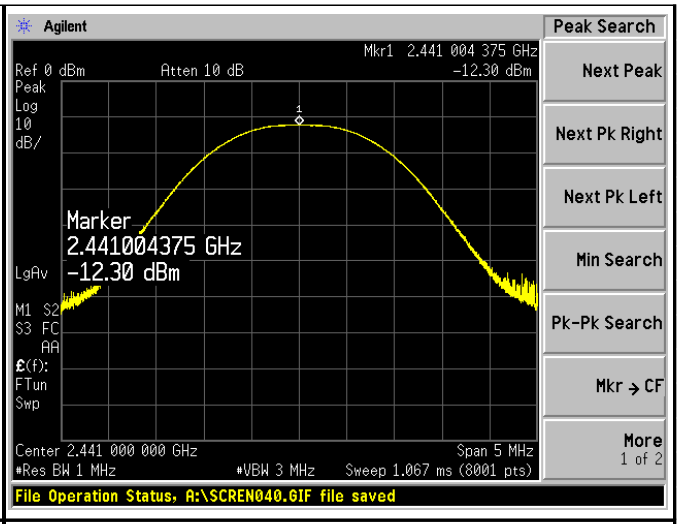
Channel	Frequency (MHz)	Measured Power (dBm)	Attenuator Factor (dB)	Corrected Power (dBm)	Limit (dBm)	Test Result
0	2402	-12.45	20.115	7.665	30	Pass
39	2441	-12.3	20.115	7.815	30	Pass
80	2480	-12.6	20.115	7.515	30	Pass

The requirements were satisfied. Test plots are presented on the following page.

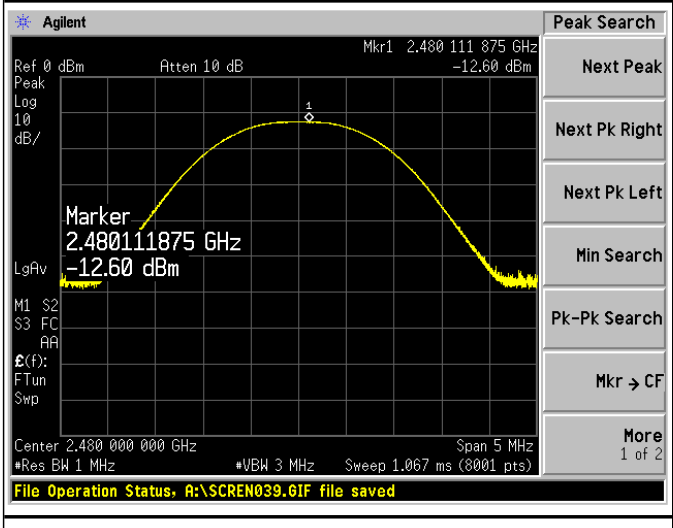
Peak output power test plots:



Low Channel



Mid Channel



High Channel

7.0 Occupied Bandwidth

7.1 Test Procedure

The EUT was connected directly to the spectrum analyzer with an attenuator for the measurements. Low, mid, and high channel were measured. ANSI C63.10-2013, section 6.9.2 and 6.9.3, procedure is used for the measurements.

7.2 Test Criteria

47 CFR (USA) // IC (Canada)	
Section Reference	Limit
15.247(a)(1), 2.1049 // RSS-247 5.1(a)	20 dB Bandwidth 99% (all methods)

In cases where the software function fails to find/mark the correct edge of the modulated envelope, a manual measurement (marker-delta over display line) is taken with the same spectrum analyzer settings.

7.3 Test Results

Project Number:	23228-15	Test Date(s):	7/1/2022

Environmental Conditions:	Temperature	22.1 °C	Humidity	52 RH	Barometric Pressure	29.87 in Hg

Measurement Parameters:	RBW	30 kHz	VBW	90 kHz	Span	3 MHz	Detector	Peak

Measurement Bandwidth:	20 dB

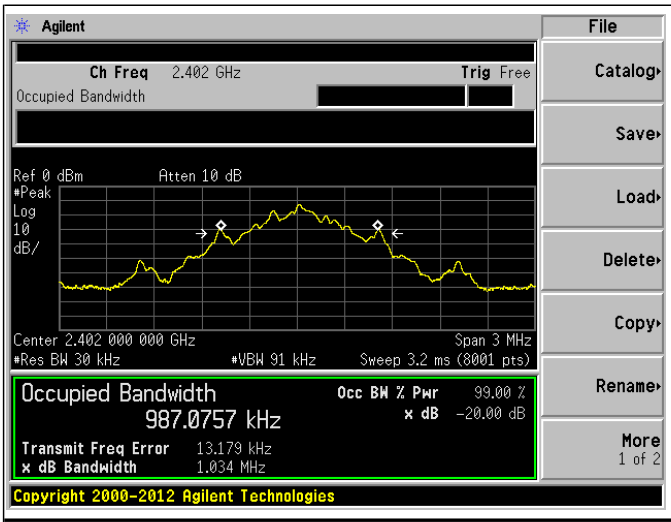
Channel	Frequency (MHz)	Measured Bandwidth (kHz)	Reported Minimum Bandwidth (kHz)
0	2402	1034	1034
39	2441	1034	
80	2480	1034	

Measurement Bandwidth:	99 %

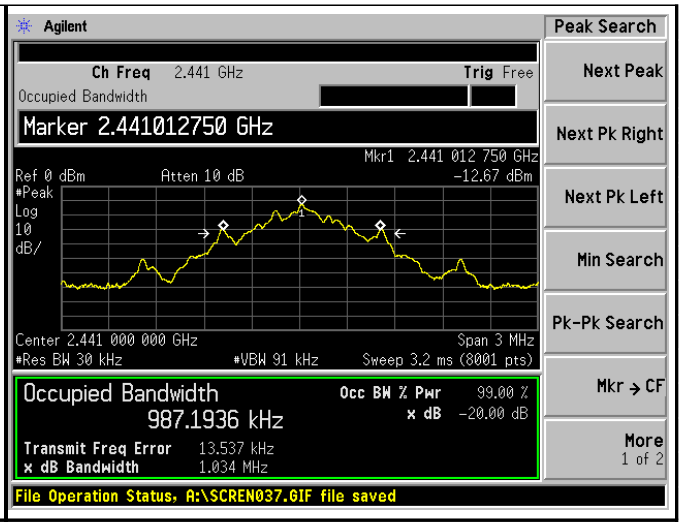
Channel	Frequency (MHz)	Measured Bandwidth (kHz)	Reported Maximum Bandwidth (kHz)
0	2402	987.0757	987.7058
39	2441	987.1936	
80	2480	986.7058	

The EUT met the requirements. Test plots are presented on the following page.

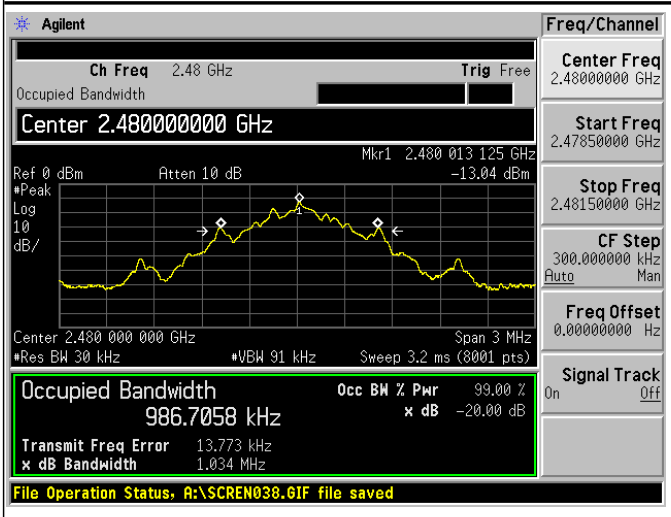
Occupied Bandwidth data plots, Recorded: 20 dB, 99% BW



Low Channel



Mid Channel



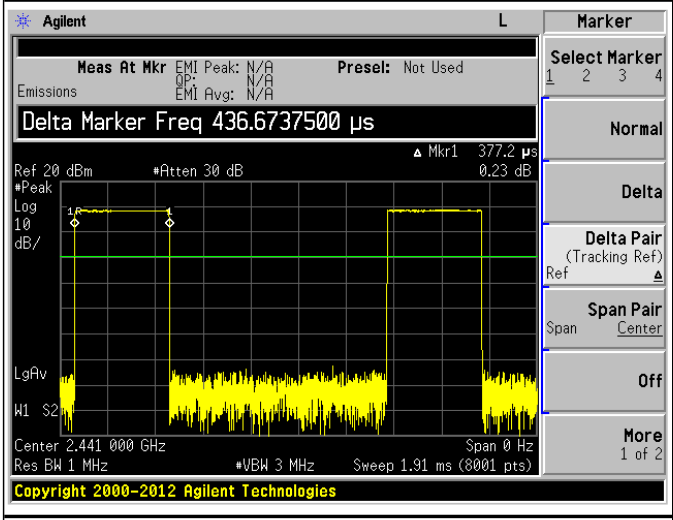
High Channel

8.0 Duty Cycle

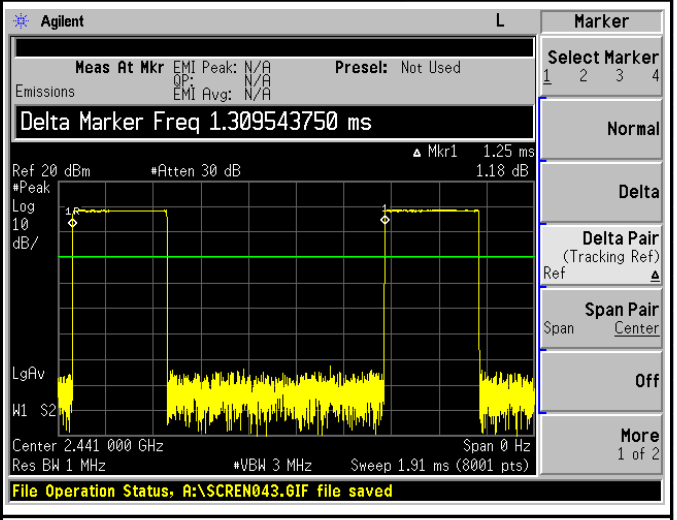
Measurement is based on intervals not to exceed 100 msec. Maximum transmitter on time is divided by the lesser of 100 msec or the actual measured minimum transmitter interval time. The result is converted to dB and applied as needed to peak measurements of transmitter artifacts to determine average power. This is not a pass/fail measurement. ANSI C63.10-2013, section 7.5, procedure is used for the measurements.

Project Number:	23228				Test Date(s):	7/1/20222					
Environmental Conditions:	Temperature	22.4	°C	Humidity	52	RH	Barometric Pressure	29.88	in Hg		
Measurement Parameters:	RBW	1	MHz	VBW	3	MHz	Span	0	MHz	Detector	Peak

On Time (ms)	Max On Time Allowed (ms)	On Time Result	Time Interval (ms)	Duty Cycle Factor (dB) (20 * Log(On time/Interval)	Duty Cycle Factor Allowed (dB)
0.3772	100	Pass	1.25	-10.41	-20
RF Exposure Duty Cycle Reduction Factor (10 * Log(On Time/Period), (dB)					-5.2



Transmit Event Time



Time Interval (Return to channel time)

9.0 Band Edge

9.1 Test Procedure

The EUT was connected directly to the spectrum analyzer with an attenuator for the measurements. EUT is placed into normal transmit operation on the nearest band edge channel. The spectrum analyzer is approximately centered on the band edge frequency with span sufficient to include the peak of the adjacent fundamental signal. Measurement includes at least two standard bandwidths from the respective band edge. If required, the band-edge marker-delta method is utilized. ANSI C63.10-2013, section 6.10.4 and 6.10.5, procedure is used for the measurements.

9.2 Test Criteria

47 CFR (USA) // IC (Canada)	
Section Reference	Limit
15.247 (d), 15.205 (a) // RSS-247 5.5, RSS-Gen 6.13	Unwanted Emissions Adjacent to Authorized Band

9.3 Test Results

Measurements included fundamental with 2 standard bandwidths (standard bandwidth 1 MHz) beyond the band edges to provide a clear view of the fundamental and the declining emission levels. Beyond this point, the general emission limits are applied in the radiated emission tests reported elsewhere in the report.

This is a conducted measurement with limits derived from the general emission field strength limits. The far field path loss equation is utilized to convert the field strength limits to EIRP limits in dBm as follows:

Given EIRP = $E_{dB\mu V/m}$ + 20Log_{10}(d) – 104.8

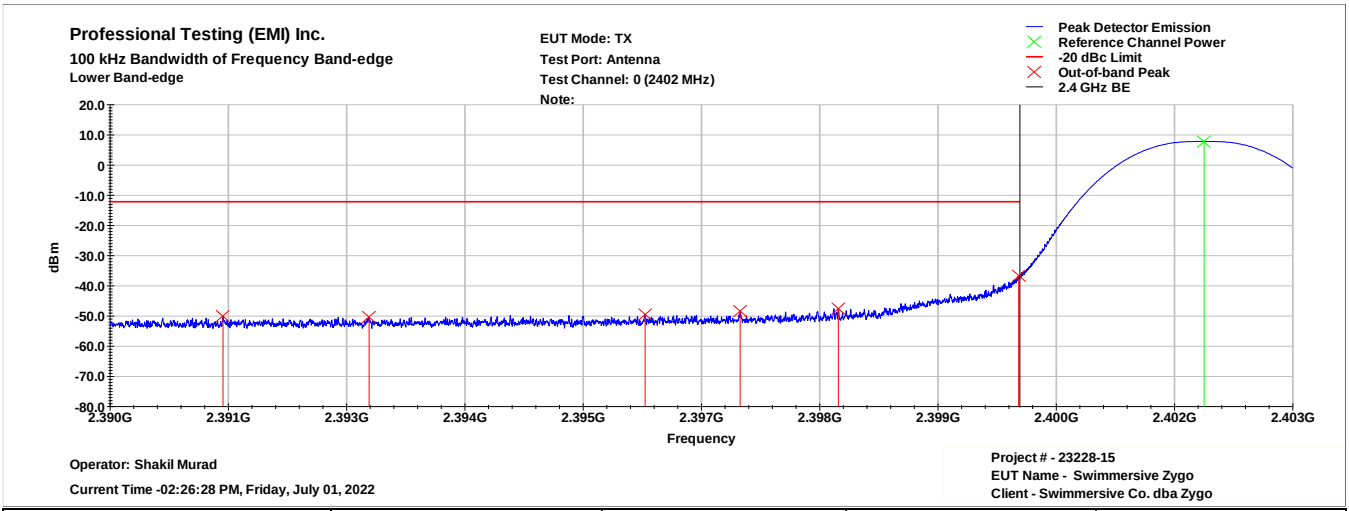
EIRP = 54 dBµV/m + 20Log_{10}(3 m) – 104.8 dB = -41.25 dBm (commonly -41 dBm is applied)

Emissions below band measured with peak detection in 100 kHz RBW.

Emissions above band measured with peak detection and 1 Hz video average in 1 MHz RBW if the peak emission exceeds the average limit.

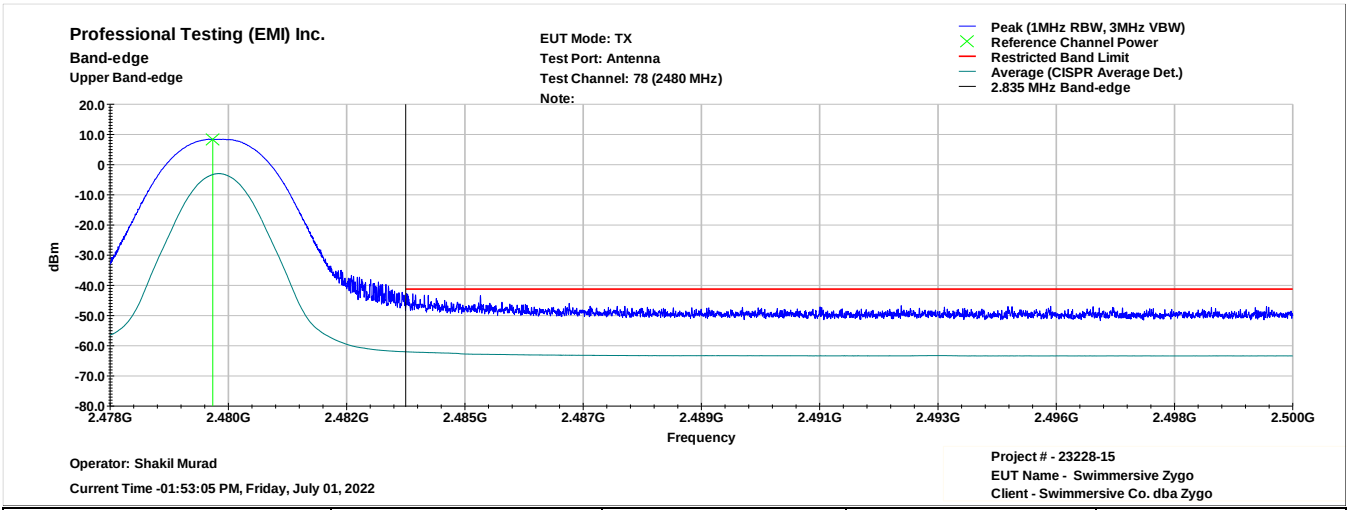
The requirement was satisfied. Test plots and tabular data are presented on the following page.

Lower Band-edge



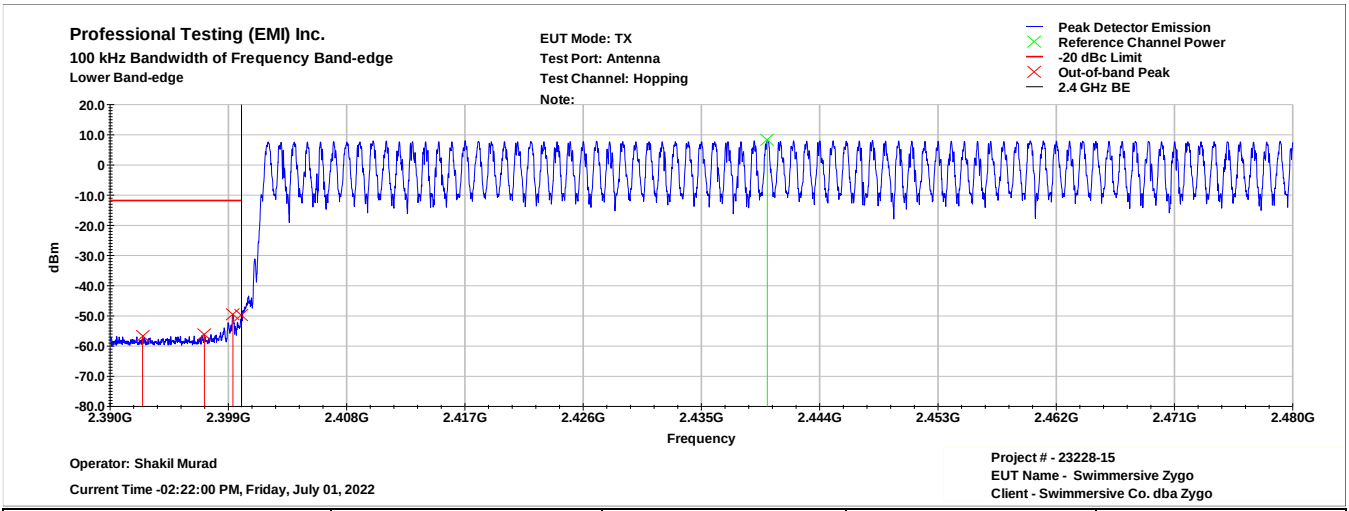
Frequency (MHz)	Corrected Reading (dBm)	Limit -20 dBc (dBm)	Margin (dB)	Results
2391.242	-50.088	-12.142	-37.946	PASS
2392.847	-50.248	-12.142	-38.106	PASS
2395.881	-49.483	-12.142	-37.341	PASS
2396.926	-48.442	-12.142	-36.300	PASS
2398.005	-47.523	-12.142	-35.381	PASS
2399.987	-36.804	-12.142	-24.662	PASS

Upper Band-edge



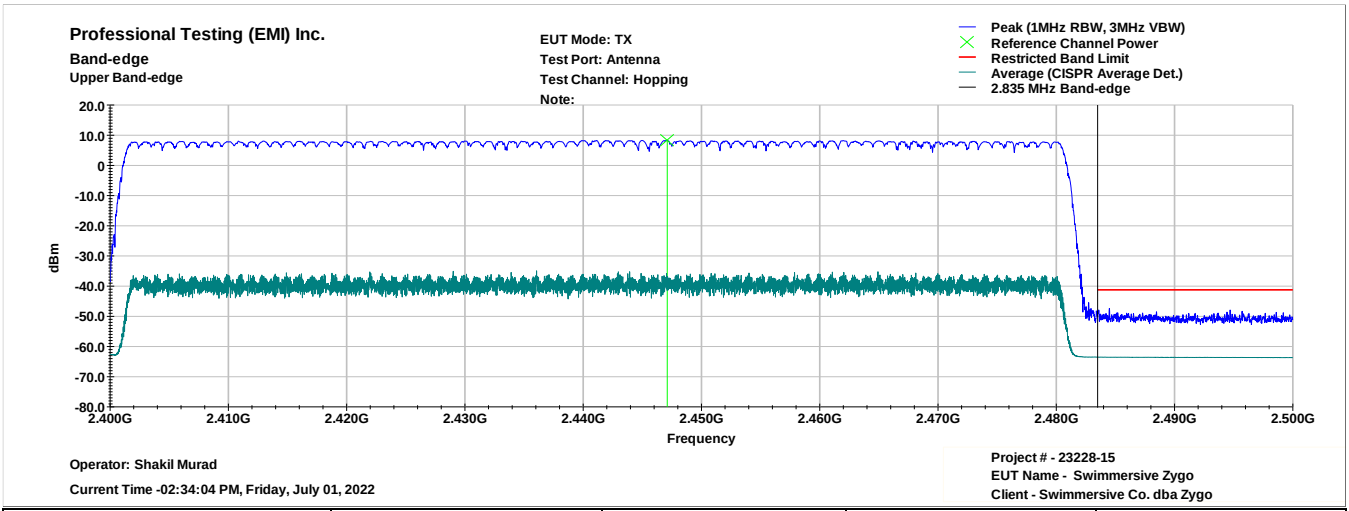
Frequency (MHz)	Corrected Reading (dBm)	Limit (dBm)	Margin (dB)	Results
2483.500	-62.014	-41.250	-20.764	PASS
2483.506	-62.018	-41.250	-20.768	PASS
2484.539	-62.702	-41.250	-21.452	PASS
2485.543	-62.971	-41.250	-21.721	PASS
2486.577	-63.142	-41.250	-21.892	PASS
2487.597	-63.262	-41.250	-22.012	PASS

Lower Band-edge - Hopping



Frequency (MHz)	Corrected Reading (dBm)	Limit -20 dBc (dBm)	Margin (dB)	Results
2392.475	-56.540	-11.770	-44.770	PASS
2397.177	-56.042	-11.770	-44.272	PASS
2399.349	-49.535	-11.770	-37.765	PASS
2400.000	-49.619	-11.770	-37.849	PASS

Upper Band-edge - Hopping



Frequency (MHz)	Corrected Reading (dBm)	Limit (dBm)	Margin (dB)	Results
2483.550	-63.518	-41.250	-22.268	PASS
2485.425	-63.554	-41.250	-22.304	PASS
2487.800	-63.577	-41.250	-22.327	PASS
2488.875	-63.597	-41.250	-22.347	PASS
2490.012	-63.608	-41.250	-22.358	PASS
2492.100	-63.609	-41.250	-22.359	PASS

10.0 Conducted Antenna Port Spurious Emissions, Transmit Mode

10.1 Test Procedure

The EUT was connected directly to the spectrum analyzer with an attenuator for the measurements. Conducted antenna port emissions are measured with the EUT transmitting on Low, Mid, and High channels. ANSI C63.10-2013, section 7.8.8 and 11.12.2, procedure is used for the measurements.

10.2 Test Criteria

47 CFR (USA) // IC (Canada)	
Section Reference	Limit
15.247 (d), 15.209 (a) // RSS-247 5.5, RSS-Gen 6.13	Unwanted Emissions at Antenna Port Conducted Spurious/Harmonic Emissions Transmit Mode

10.3 Test Results

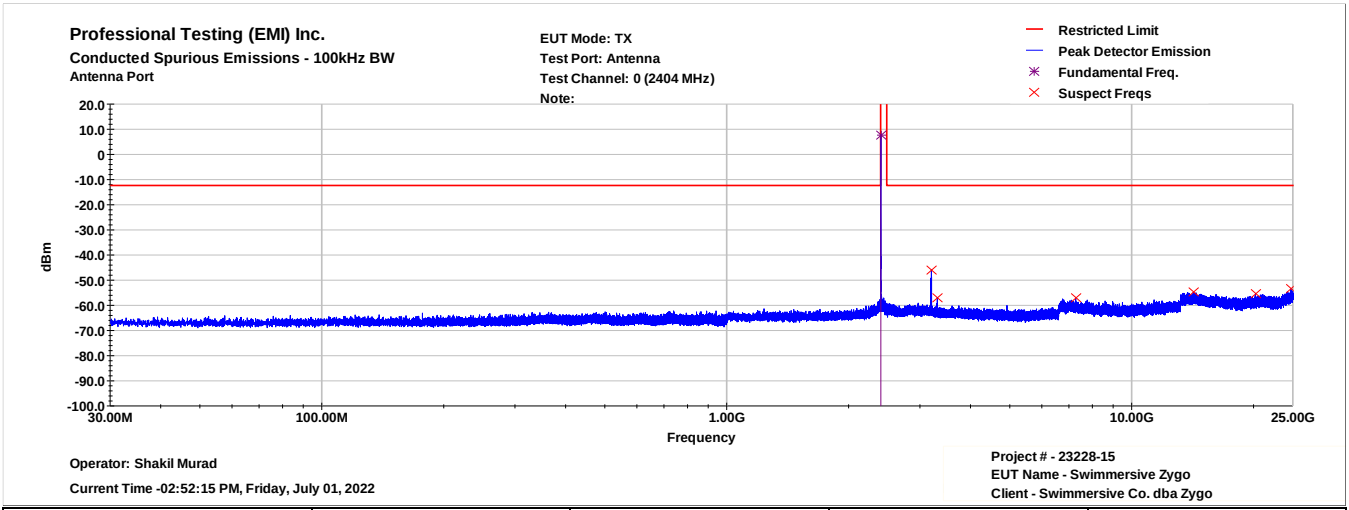
Three channels were tested. EUT was transmitting continuously and modulated.

The top, middle, and bottom channels were tested. Testing was conducted with 100 kHz RBW with 20 dBc Limit, and with 15.209 limits with required resolution/video bandwidths.

The EUT satisfied the requirements. Test plots and tabular data are presented on the following page.

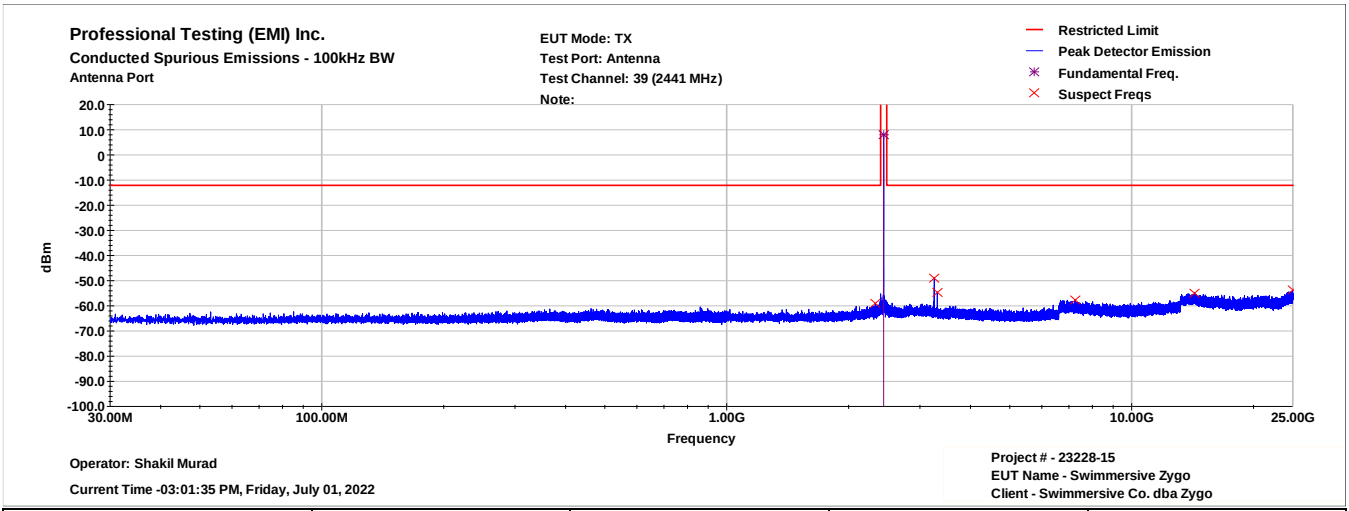
10.3.1 100 kHz Bandwidth with 20 dBc Limit Test data

Bottom Channel: 100 kHz Bandwidth



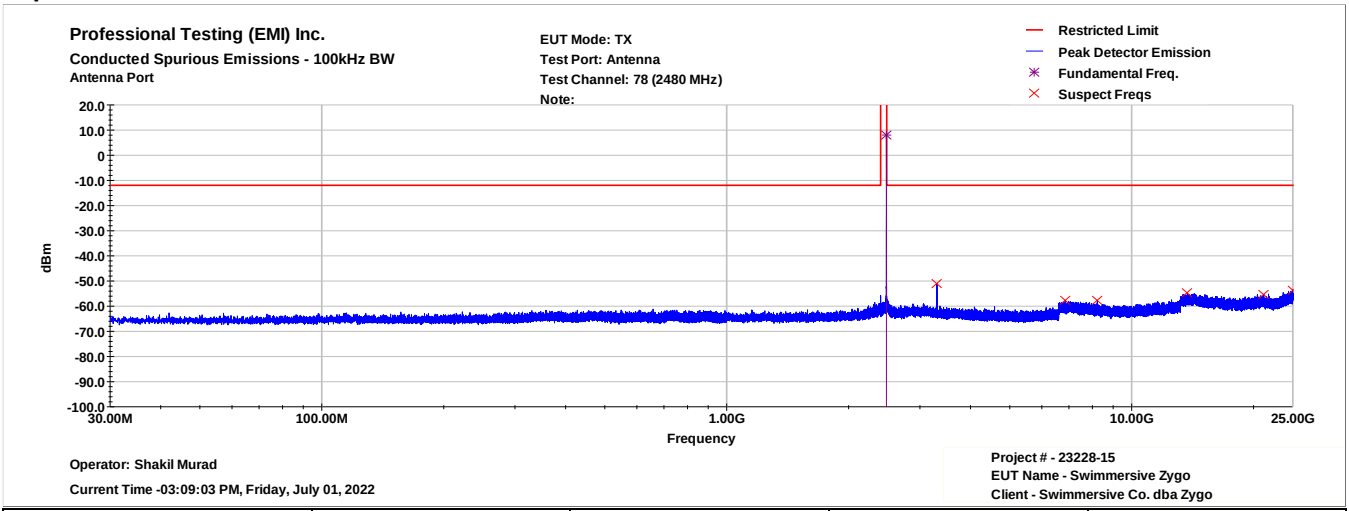
Frequency (MHz)	Corrected Reading (dBm)	Limit (dBm)	Margin (dB)	Results
3202.750	-45.960	-12.375	33.585	PASS
3311.925	-56.874	-12.375	44.499	PASS
7277.150	-57.163	-12.375	44.788	PASS
14205.667	-54.794	-12.375	42.419	PASS
20220.333	-55.353	-12.375	42.978	PASS
24729.167	-53.489	-12.375	41.114	PASS

Middle Channel: 100 kHz Bandwidth



Frequency (MHz)	Corrected Reading (dBm)	Limit (dBm)	Margin (dB)	Results
2328.525	-58.941	-12.130	46.811	PASS
3254.725	-48.869	-12.130	36.739	PASS
3311.925	-54.543	-12.130	42.413	PASS
7252.400	-57.584	-12.130	45.454	PASS
14297.208	-54.863	-12.130	42.733	PASS
24981.042	-53.820	-12.130	41.690	PASS

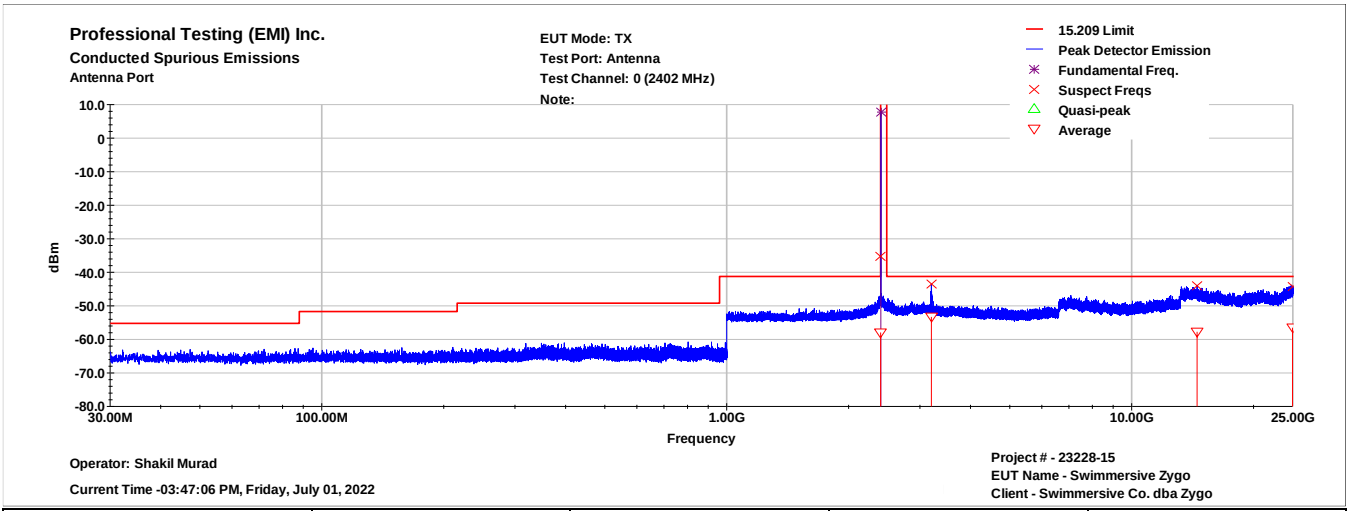
Top Channel: 100 kHz Bandwidth



Frequency (MHz)	Corrected Reading (dBm)	Limit (dBm)	Margin (dB)	Results
3306.700	-51.040	-11.962	39.078	PASS
6855.575	-57.809	-11.962	45.847	PASS
8226.175	-57.821	-11.962	45.859	PASS
13725.208	-54.697	-11.962	42.735	PASS
21193.708	-55.253	-11.962	43.291	PASS
24969.667	-53.580	-11.962	41.618	PASS

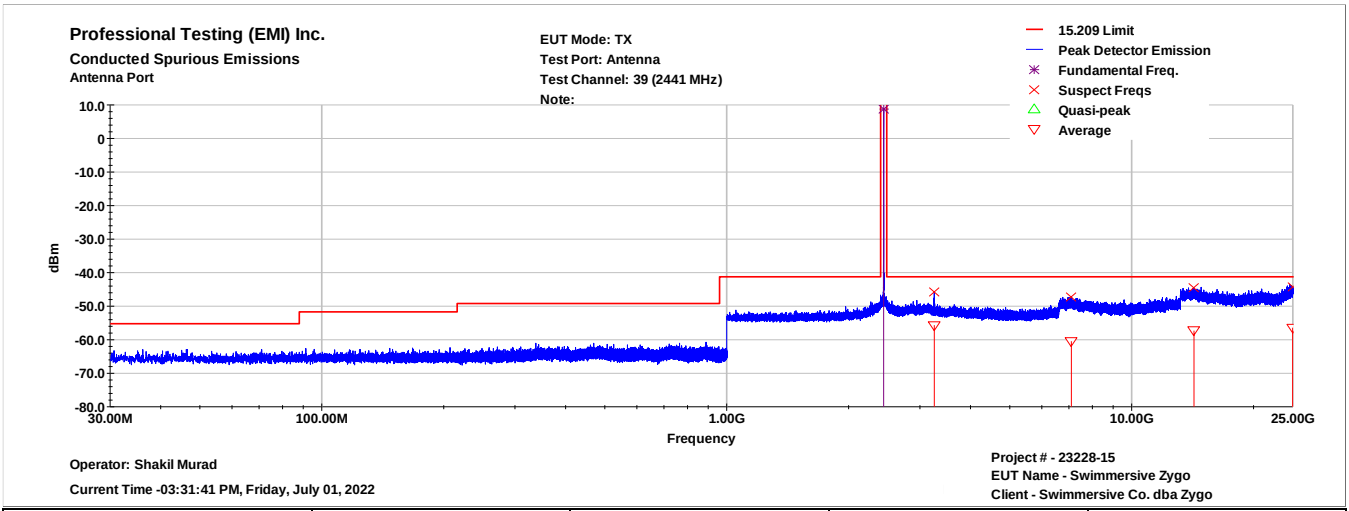
10.3.2 15.209 Limit Test data

Bottom Channel – 15.209 Limit



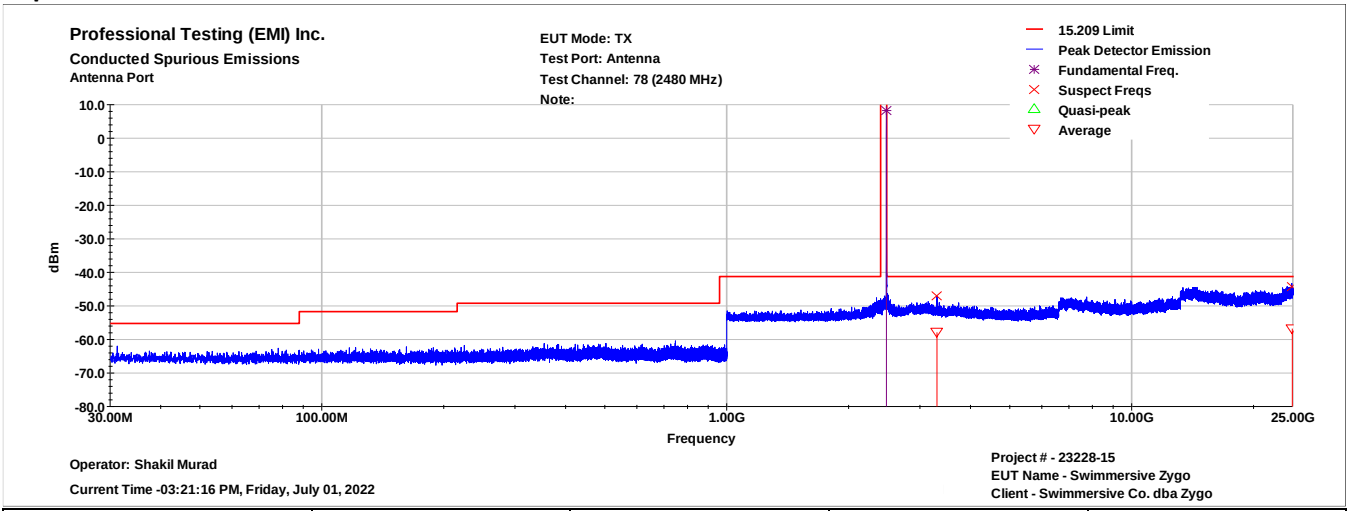
Frequency (MHz)	Corrected Reading (dBm)	Limit (dBm)	Margin (dB)	Results
2399.006	-57.962	-41.250	16.712	PASS
3202.794	-53.309	-41.250	12.059	PASS
14508.462	-57.731	-41.250	16.481	PASS
24969.075	-56.531	-41.250	15.281	PASS

Middle Channel – 15.209 Limit



Frequency (MHz)	Corrected Reading (dBm)	Limit (dBm)	Margin (dB)	Results
3254.786	-55.674	-41.250	14.424	PASS
7096.835	-60.470	-41.250	19.220	PASS
14254.744	-57.315	-41.250	16.065	PASS
24982.813	-56.431	-41.250	15.181	PASS

Top Channel – 15.209 Limit

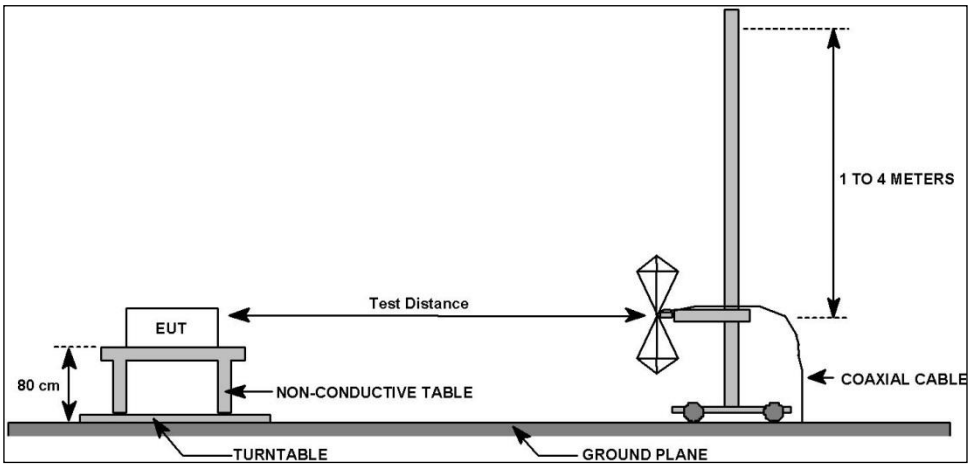


Frequency (MHz)	Corrected Reading (dBm)	Limit (dBm)	Margin (dB)	Results
3306.443	-57.865	-41.250	16.615	PASS
24937.310	-56.763	-41.250	15.513	PASS

11.0 Transmitter Radiated Spurious Emissions

11.1 Test Procedure

Radiated emissions are measured with the EUT in normal operation transmitting on normal hopping channels. ANSI C63.10-2013, section 6.3, 6.5 and 6.6, procedure is used for the measurements.



Radiated Spurious Emissions Test Setup

Table 11.1.1: Test Distance, Table Height, and Detection Method

30 MHz to 1 GHz	1 GHz to 18 GHz	18 GHz to 26.5 GHz
10 m, 80 cm	3 m, 1.5 m	1 m, 1.5 m
Quasi-peak	Peak & Average	Peak & Average

11.2 Test Criteria

47 CFR (USA) // IC (Canada)	
Section Reference	Limit
15.247(d), 15.209 (a) // RSS-247 5.5, RSS-Gen 6.13 & 8.10	Field Strength of Radiated Spurious/Harmonic Emissions Transmit Mode

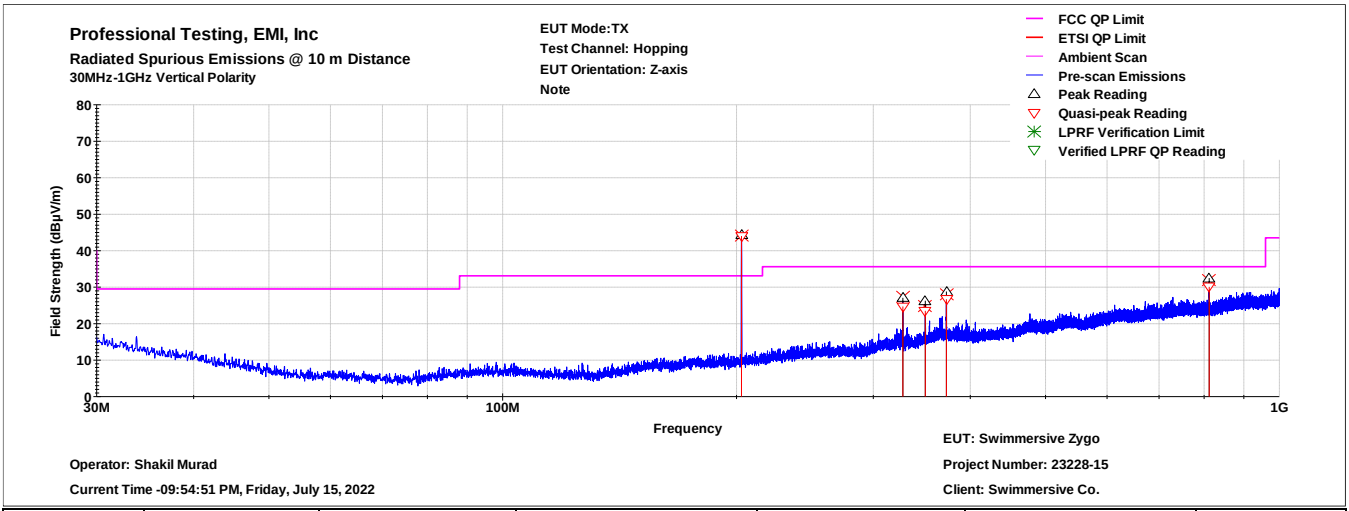
11.3 Test Results

EUT was tested in normal operation and transmitting continuously modulated. Device tested in normal operational orientation.

The EUT satisfied the requirement. Test plots and tabular data are presented on the following page.

11.3.1 Hopping Mode, 30 MHz to 25 GHz

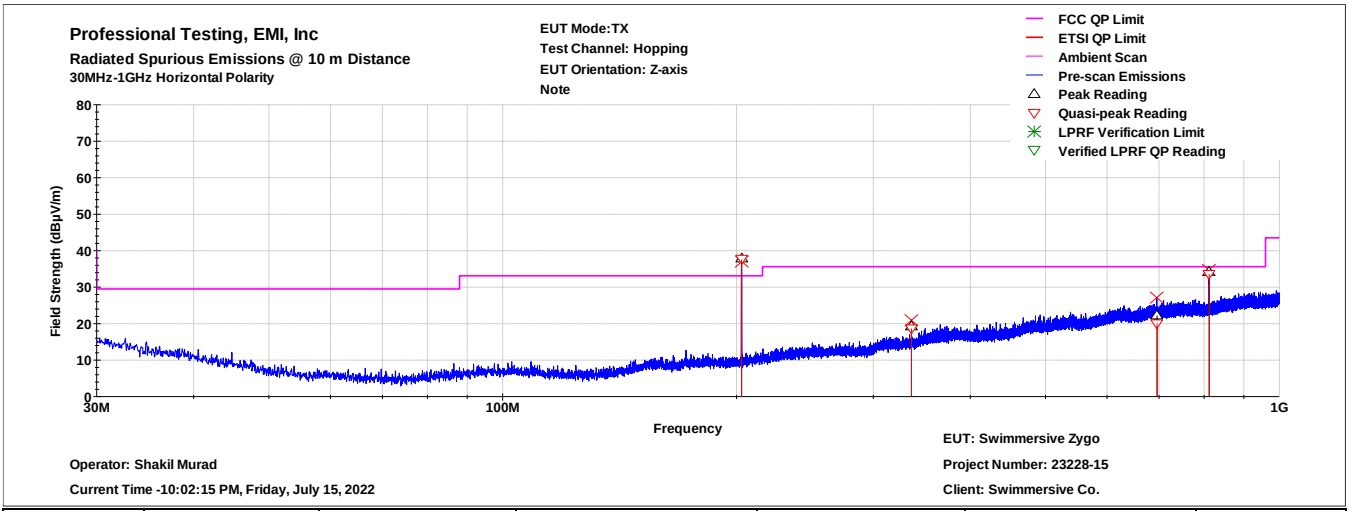
30MHz - 1GHz Vertical Polarity Emissions Data



Frequency (MHz)	EUT Direction (Degrees)	Antenna Height (cm)	Quasi-peak Reading (dBµV)	Quasi-peak Limit (dBµV)	Quasi-peak Margin (dB)	Quasi-peak Results
202.957	175.000	104.000	44.004			*PASS
327.494	315.000	363.000	24.690	35.600	-10.910	PASS
350.013	220.000	382.000	23.505	35.600	-12.095	PASS
372.632	219.000	407.000	26.702	35.600	-8.898	PASS
812.139	65.000	165.000	30.086	35.600	-5.514	PASS

*Note: 203 MHz is the fundamental frequency of low frequency radio.

30MHz - 1GHz Horizontal Polarity Emissions Data

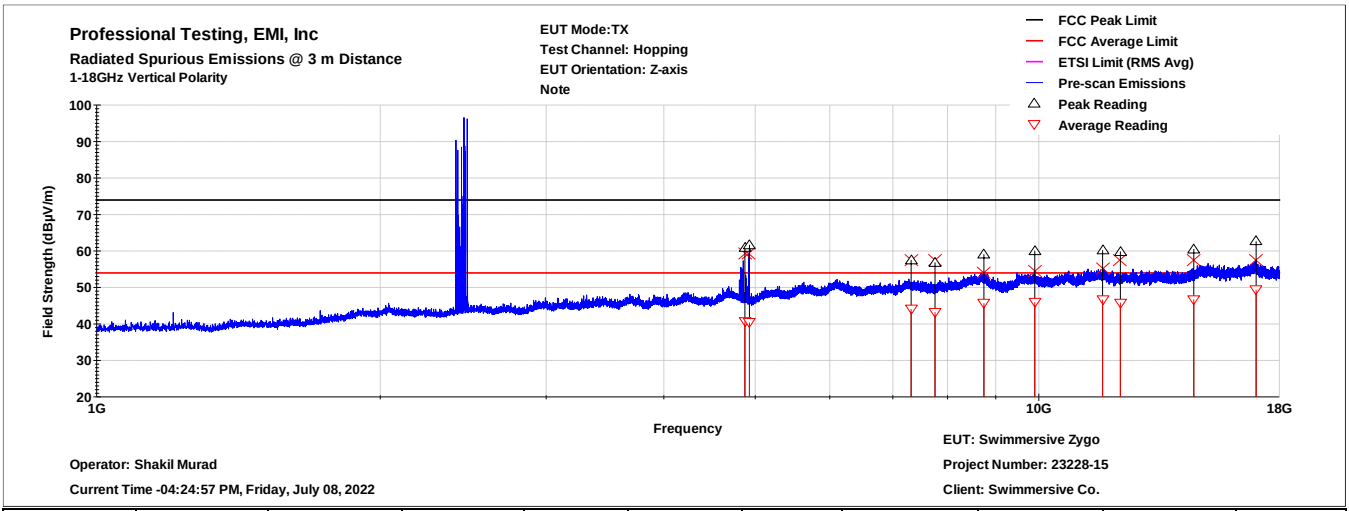


Frequency (MHz)	EUT Direction (Degrees)	Antenna Height (cm)	Quasi-peak Reading (dBµV)	Quasi-peak Limit (dBµV)	Quasi-peak Margin (dB)	Quasi-peak Results
203.037	317.000	347.000	37.600			*PASS
335.965	45.000	190.000	18.670	35.600	-16.930	PASS
695.943	231.000	176.000	20.091	35.600	-15.509	PASS
812.121	5.000	127.000	33.598	35.600	-2.002	PASS

*Note: 203 MHz is the fundamental frequency of low frequency radio.

1GHz - 18GHz Vertical Polarity Emissions Data

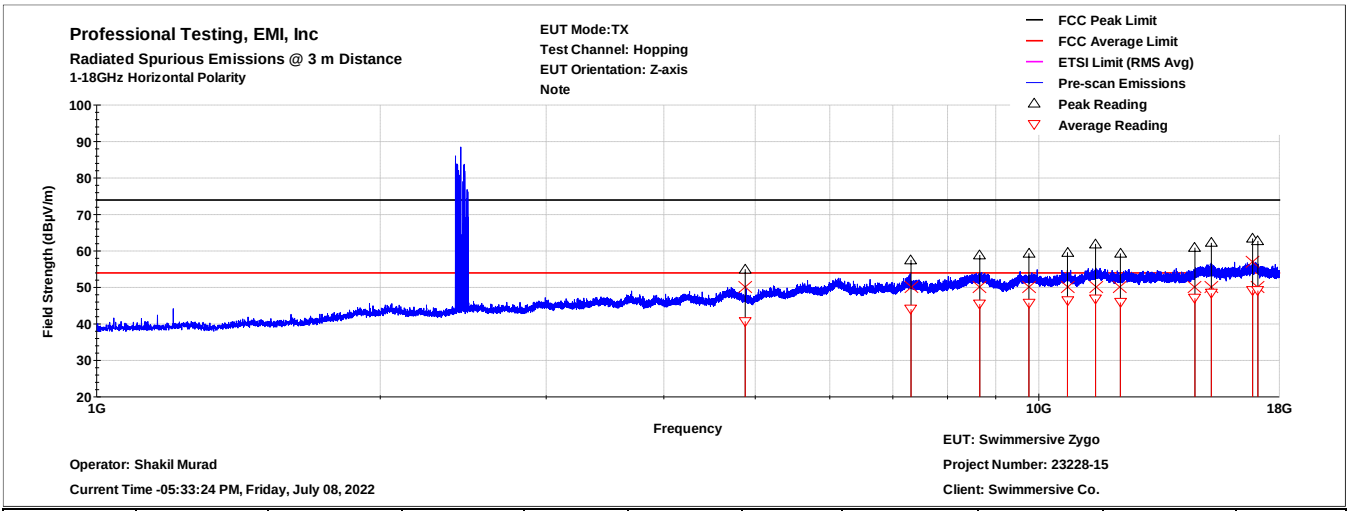
Note: a 10 dB attenuator was used at the input of the preamp for this frequency range to prevent preamp from saturating.



Frequency (MHz)	EUT Direction (Degrees)	Antenna Height (cm)	Peak Reading (dBµV)	Peak Limit (dBµV)	Peak Margin (dB)	Peak Results	Average Reading (dBµV)	Average Limit (dBµV)	Average Margin (dB)	Average Results
4876.04	56	210	60.935	73.958	-13.023	PASS	40.693	53.958	-13.265	PASS
4929.74	19	199	61.682	73.958	-12.276	PASS	40.381	53.958	-13.577	PASS
7319.24	6	108	57.516	73.958	-16.442	PASS	44.052	53.958	-9.906	PASS
7759.01	6	103	56.855	73.958	-17.103	PASS	43.203	53.958	-10.755	PASS
8744.42	59	106	59.091	73.958	-14.867	PASS	45.671	53.958	-8.287	PASS
9902.55	21	355	60.077	73.958	-13.881	PASS	45.958	53.958	-8.000	PASS
11687.93	260	108	60.211	73.958	-13.747	PASS	46.683	53.958	-7.275	PASS
12205.36	244	103	59.875	73.958	-14.083	PASS	45.821	53.958	-8.137	PASS
14605.10	255	106	60.518	73.958	-13.440	PASS	46.744	53.958	-7.214	PASS
17009.53	182	203	62.641	73.958	-11.317	PASS	49.370	53.958	-4.588	PASS

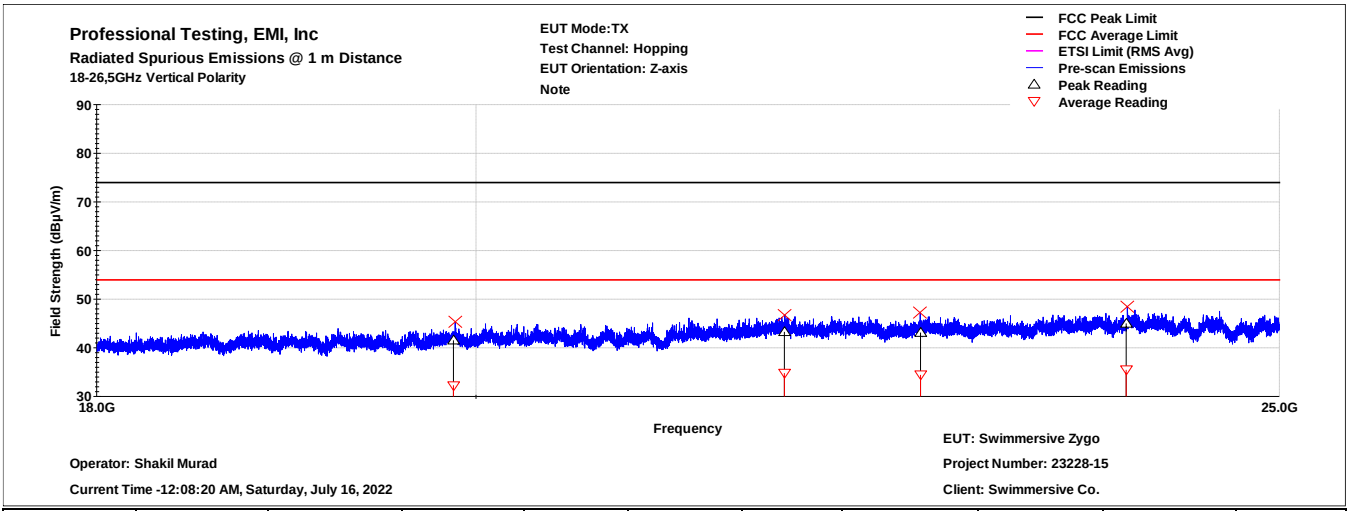
1GHz - 18GHz Horizontal Polarity Emissions Data

Note: a 10 dB attenuator was used at the input of the preamp for this frequency range to prevent preamp from saturating.



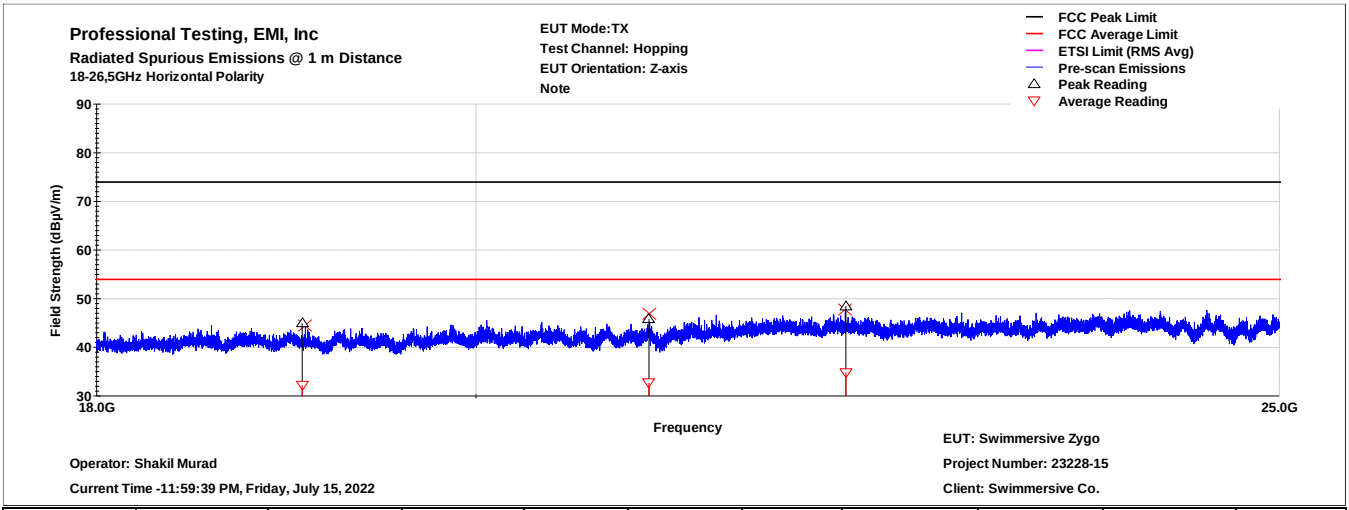
Frequency (MHz)	EUT Direction (Degrees)	Antenna Height (cm)	Peak Reading (dBµV)	Peak Limit (dBµV)	Peak Margin (dB)	Peak Results	Average Reading (dBµV)	Average Limit (dBµV)	Average Margin (dB)	Average Results
4879.13	5	273	54.982	73.958	-18.976	PASS	40.700	53.958	-13.258	PASS
7316.73	213	202	57.557	73.958	-16.401	PASS	44.061	53.958	-9.897	PASS
8657.30	40	156	58.875	73.958	-15.083	PASS	45.442	53.958	-8.516	PASS
9761.27	227	132	59.356	73.958	-14.602	PASS	45.795	53.958	-8.163	PASS
10724.03	352	107	59.620	73.958	-14.338	PASS	46.396	53.958	-7.562	PASS
11488.75	134	134	61.923	73.958	-12.035	PASS	46.801	53.958	-7.157	PASS
12205.33	8	287	59.304	73.958	-14.654	PASS	45.889	53.958	-8.069	PASS
14645.44	3	143	60.881	73.958	-13.077	PASS	47.040	53.958	-6.918	PASS
15244.27	59	374	62.219	73.958	-11.739	PASS	48.413	53.958	-5.545	PASS
16861.58	3	351	63.423	73.958	-10.535	PASS	49.211	53.958	-4.747	PASS
17082.10	167	263	62.737	73.958	-11.221	PASS	49.108	53.958	-4.850	PASS

18GHz - 25GHz Vertical Polarity Emissions Data



Frequency (MHz)	EUT Direction (Degrees)	Antenna Height (cm)	Peak Reading (dBµV)	Peak Limit (dBµV)	Peak Margin (dB)	Peak Results	Average Reading (dBµV)	Average Limit (dBµV)	Average Margin (dB)	Average Results
19875.19	358	100.000	41.526	73.958	-32.432	PASS	32.281	53.958	-21.677	PASS
21788.99	357	100.000	43.262	73.958	-30.696	PASS	34.797	53.958	-19.161	PASS
22628.95	357	100.000	43.126	73.958	-30.832	PASS	34.425	53.958	-19.533	PASS
23959.06	296	100.000	45.022	73.958	-28.936	PASS	35.453	53.958	-18.505	PASS

18GHz - 25GHz Horizontal Polarity Emissions Data



Frequency (MHz)	EUT Direction (Degrees)	Antenna Height (cm)	Peak Reading (dBµV)	Peak Limit (dBµV)	Peak Margin (dB)	Peak Results	Average Reading (dBµV)	Average Limit (dBµV)	Average Margin (dB)	Average Results
19057.67	258	100.000	44.943	73.958	-29.015	PASS	32.227	53.958	-21.731	PASS
20984.56	102	100.000	45.794	73.958	-28.164	PASS	32.690	53.958	-21.268	PASS
22164.17	242	100.000	48.461	73.958	-25.497	PASS	34.874	53.958	-19.084	PASS

12.0 Radiated Spurious Emissions, Receive Mode

12.1 Test Procedure

Receive mode radiated emissions were measured with the EUT in normal operation transmitting/receiving on the hopping channel. ANSI C63.10-2013, section 6.3, 6.5 and 6.6, procedure is used for the measurements.

Table 12.1.1: Test Distance, Table Height, and Detection Method

30 MHz to 1 GHz	1 GHz to 18 GHz	18 GHz to 25 GHz
10 m, 80 cm	3 m, 80 cm	1 m, 80 cm
Quasi-peak	Peak & Average	Peak & Average

12.2 Test Criteria

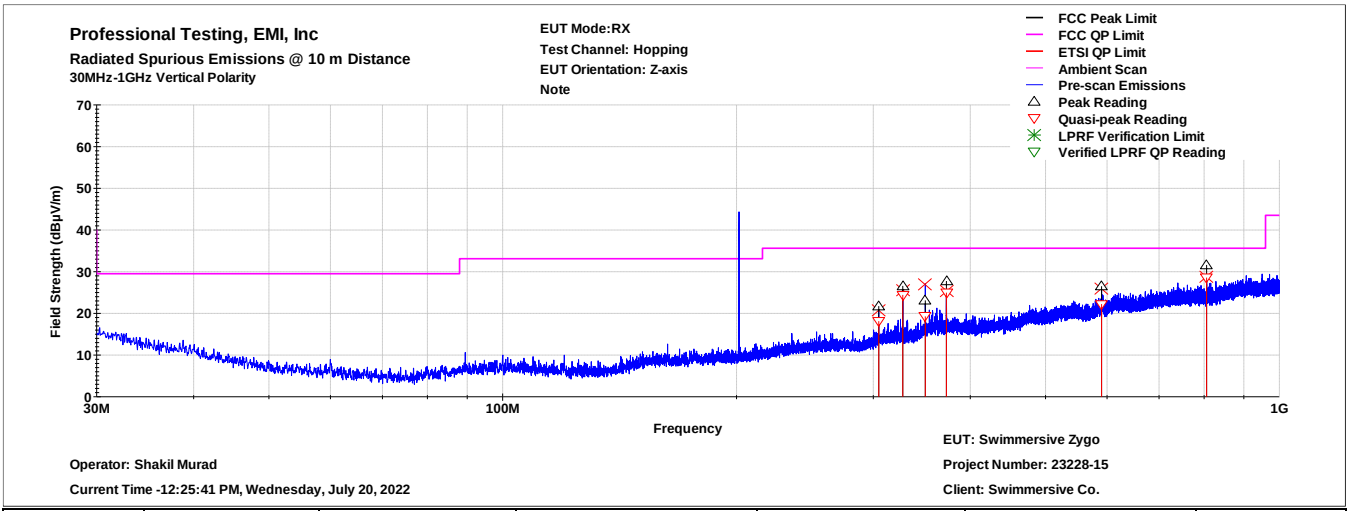
47 CFR (USA) // IC (Canada)	
Section Reference	Parameter
15.109 // RSS-Gen 7.3	Field Strength of Radiated Spurious/Harmonic Emissions Receive Mode

12.3 Test Results

The requirement was satisfied. Test plots and tabular data are presented on the following page.

12.3.1 Hopping Mode, 30 MHz to 18 GHz

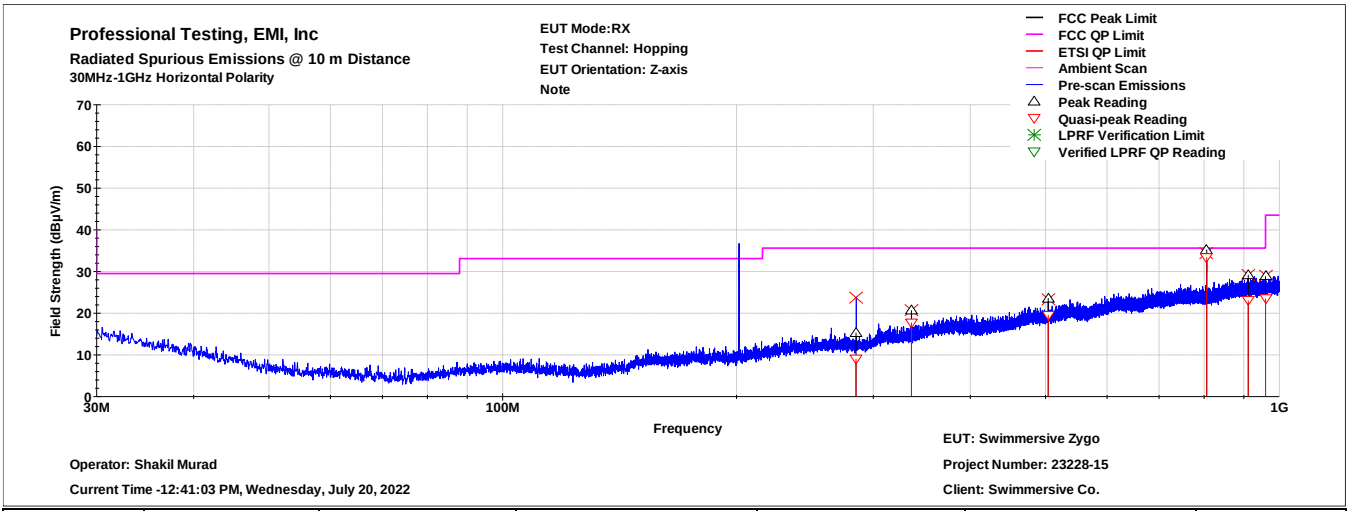
30MHz - 1GHz Vertical Polarity Emissions Data



Frequency (MHz)	EUT Direction (Degrees)	Antenna Height (cm)	Quasi-peak Reading (dBµV)	Quasi-peak Limit (dBµV)	Quasi-peak Margin (dB)	Quasi-peak Results
304.907	75.000	135.000	18.112	35.600	-17.488	PASS
327.450	121.000	418.000	24.417	35.600	-11.183	PASS
350.067	231.000	262.000	19.267	35.600	-16.333	PASS
372.624	63.000	111.000	24.968	35.600	-10.632	PASS
590.290	256.000	363.000	22.213	35.600	-13.387	PASS
806.139	7.000	146.000	28.566	35.600	-7.034	PASS

Note: Emission appears in above plot at approximately 203 MHz is the fundamental single of low frequency radio.

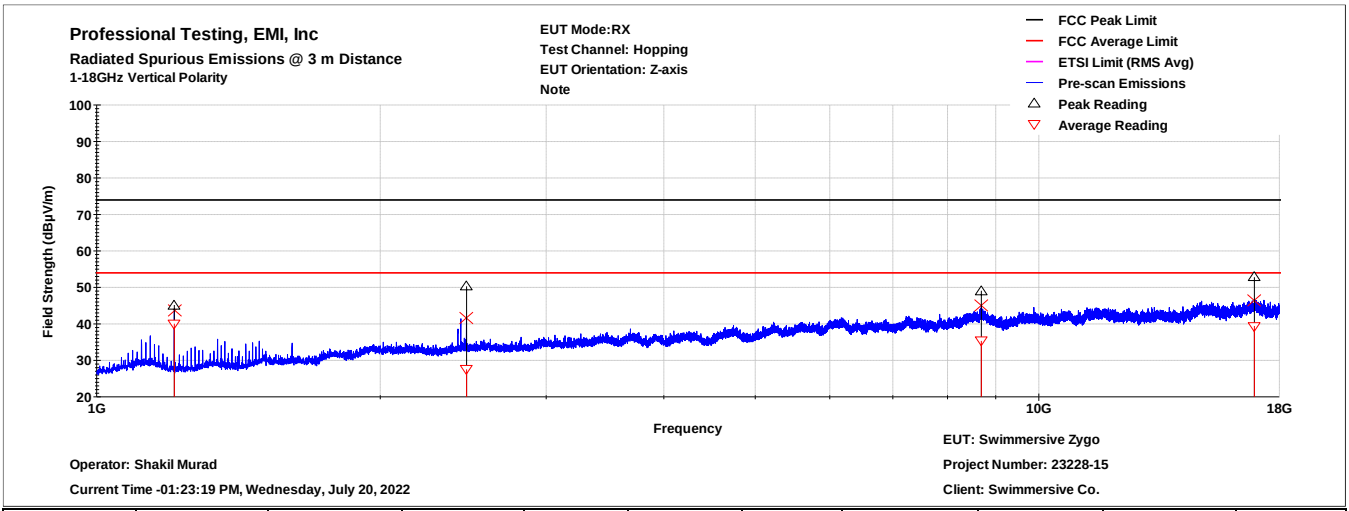
30MHz - 1GHz Horizontal Polarity Emissions Data



Frequency (MHz)	EUT Direction (Degrees)	Antenna Height (cm)	Quasi-peak Reading (dBµV)	Quasi-peak Limit (dBµV)	Quasi-peak Margin (dB)	Quasi-peak Results
285.047	299.000	123.000	9.032	35.600	-26.568	PASS
335.991	215.000	128.000	17.765	35.600	-17.835	PASS
504.007	263.000	236.000	19.587	35.600	-16.013	PASS
806.156	38.000	128.000	33.438	35.600	-2.162	PASS
911.938	245.000	413.000	23.047	35.600	-12.553	PASS
959.966	357.000	221.000	23.465	35.600	-12.135	PASS

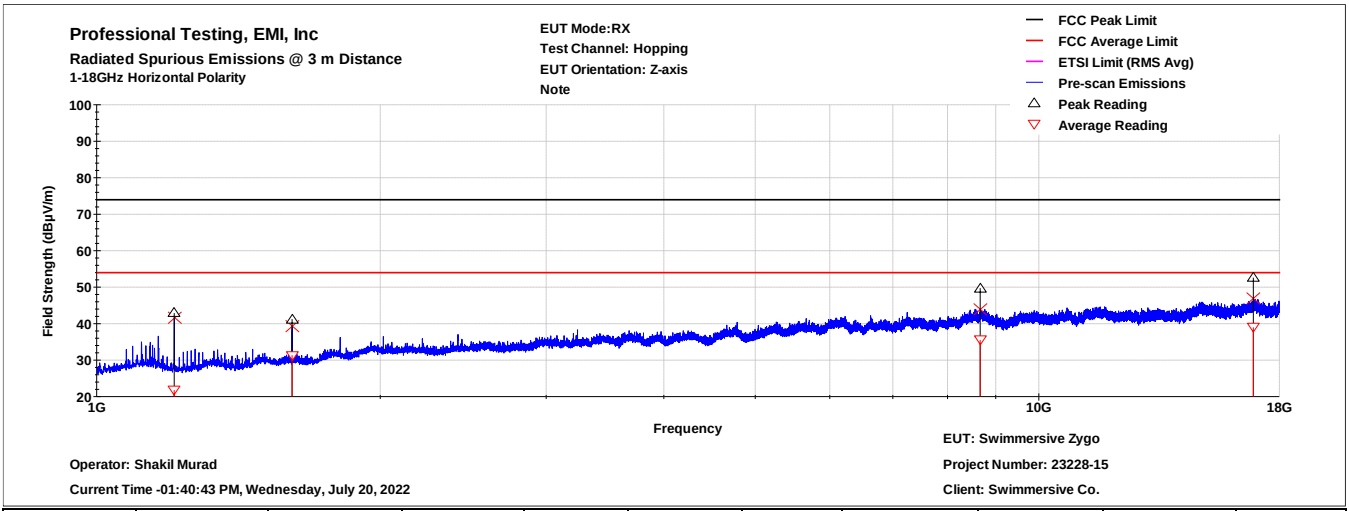
Note: Emission appears in above plot at approximately 203 MHz is the fundamental single of low frequency radio.

1GHz - 18GHz Vertical Polarity Emissions Data



Frequency (MHz)	EUT Direction (Degrees)	Antenna Height (cm)	Peak Reading (dBµV)	Peak Limit (dBµV)	Peak Margin (dB)	Peak Results	Average Reading (dBµV)	Average Limit (dBµV)	Average Margin (dB)	Average Results
1209.10	7	171	45.173	73.958	-28.785	PASS	40.046	53.958	-13.912	PASS
2469.64	77	217	50.284	73.958	-23.674	PASS	27.525	53.958	-26.433	PASS
8689.68	16	235	49.059	73.958	-24.899	PASS	35.319	53.958	-18.639	PASS
16935.71	166	265	52.790	73.958	-21.168	PASS	39.396	53.958	-14.562	PASS

1GHz - 18GHz Horizontal Polarity Emissions Data



Frequency (MHz)	EUT Direction (Degrees)	Antenna Height (cm)	Peak Reading (dBµV)	Peak Limit (dBµV)	Peak Margin (dB)	Peak Results	Average Reading (dBµV)	Average Limit (dBµV)	Average Margin (dB)	Average Results
1208.73	90	363	42.889	73.958	-31.069	PASS	21.757	53.958	-32.201	PASS
1612.32	106	375	41.227	73.958	-32.731	PASS	31.351	53.958	-22.607	PASS
8665.73	4	357	49.720	73.958	-24.238	PASS	35.525	53.958	-18.433	PASS
16891.06	329	374	52.570	73.958	-21.388	PASS	38.986	53.958	-14.972	PASS

13.0 Antenna Construction

13.1 Procedure

A direct examination of the antenna construction is performed and compared to rule criteria that prevent wireless device antennas from being modified by end users.

13.2 Criteria

47 CFR (USA) // IC (Canada)	
Section Reference	Antenna Construction
15.203 // RSS-Gen 6.8	Type of Antenna(s) Type of Connector Gain

13.3 Results

Table 8.3.1 Antenna Construction Details
Chip Antenna
Manufacturer: Swimmersive Co. dba Zygo Model/PN: None Antenna peak gain: -0.52 dBi. Antenna Type: Inverted 'F' Antenna Connector: No connector. Chip is soldered to circuit board.

User cannot substitute antenna.

Gain is under maximum limit of 6 dBi.

The requirement was satisfied.

14.0 Measurement Bandwidths

Radiated Emissions Spectrum Analyzer Bandwidth and Measurement Time - Peak Scan				
Frequency Band Start (MHz)	**Frequency Band Stop (MHz)**	**6 dB Bandwidth (kHz)**	**Number of Ranges Used**	**Measurement Time per Range**
0.009	0.15	0.3	2	Multiple Sweeps
0.15	30	9	6	Multiple Sweeps
30	1000	120	2	Multiple 800 mS Sweeps
1000	6000	1000	2	Multiple Sweeps
6000	18000	1000	2	Multiple Sweeps
18000	26500	1000	2	Multiple Sweeps

*Notes:
1. The settings above are specifically calculated for the E4440A series of spectrum analyzers, which have 8,000 data points per range.
2. The measurement receiver resolution bandwidth setting was 300 Hz for quasi-peak measurements from 9-150 kHz.
3. The measurement receiver resolution bandwidth setting was 9 kHz for quasi-peak measurements from 0.15-30 MHz.
4. The measurement receiver resolution bandwidth setting was 120 kHz for quasi-peak measurements from 30-1000 MHz.
5. The measurement receiver resolution bandwidth setting was 1 MHz for average measurements from 1-18 GHz.

15.0 Test Equipment

15.1 Conducted Measurements at the Antenna Port

Asset#	Manufacturer	Model	Equipment Nomenclature	Serial Number	Calibration Due Date
1930	Agilent	E4440A-239	Spectrum Analyzer, 3 Hz - 26.5 GHz	MY45304903	4/1/2023
A118	Narda	768A-20	20 dB 20 W Attenuator, DC - 11GHz	105357	12/10/2022

15.1 Conducted Emissions

Tile! Software Version:			Version: 7.1.2.17 (Jan 08, 2016 - 02:12:48 PM) or 4.1.A.0, April 14, 2009, 11:01:00PM		
Test Profile:			2020_CE_TILE7_v4		
Asset #	**Manufacturer**	**Model**	**Equipment Nomenclature**	**Serial Number**	**Calibration Due Date**
1145	HP	8568B	Spectrum Analyzer 100Hz-1.5GHz	2517A01821	7/21/2023
2113	HP	85662A	Spec Anal Dsply for A/N 1842	2403A07470	N/A
990	HP	85685A	RF Preselector	3010A01119	7/9/2022
1279	HP	85650A	Quasi Peak Adapter	2521A00935	7/8/2022
C192	HP	none	Cable, RF, BNC-BNC, 0.2032m, Grey	None	1/14/2024
C029	HP	HP92227C	Cable, RF, BNC-BNC, 4.06m, Grey	None	2/8/2023
C107	Pomona	RG-223	Cable, BNC-BNC, 2.64m, RG-223 (black)	None	8/3/2022
1185	EMCO	3825/2	LISN, 10kHz-100MHz	1235	8/23/2022
1088	PTI	PTI-ALF4	Attenuator Limiter Filter	none	2/26/2023
1173	PTI	100k HPF	Filter, High Pass, 100kHz	none	2/14/2024
303	EMCO	3109	Antenna, Bi Con, 20-300MHz	2002	1/10/2023

15.2 Radiated Emissions

Tile! Software Version:	Version: 7.1.2.17 (Jan 08, 2016 - 02:12:48 PM) or 4.1.A.0, April 14, 2009, 11:01:00PM				
Test Profile:	2020_RE_Unintentional_TILE7_v4				
Asset #	**Manufacturer**	**Model**	**Equipment Nomenclature**	**Serial Number**	**Calibration Due Date**
2262	Keysight	E4440A	Spectrum Analyzer, 3 Hz - 26.5 GHz	MY42510155	11/8/2022
1509A	Braden	TDK 10M	TDK 10M Chamber, NSA < 1 GHz	DAC-012915-005	4/9/2023
1969	HP	11713A	Attenuator/Switch Driver	3748A04113	N/A
942	EMCO	11968D	Turntable, 4ft.	9510-1835	N/A
1326	EMCO	1051-12	Controller, Antenna Mast	9101-1564	N/A
1244	EMCO	1050C	Controller, Antenna Mast	1100	N/A
C026A	none	RG-233U	Cable Coax, N-N, 0.914m, 9 kHz - 30 MHz	None	10/21/2022
C026	none	RG214	Cable Coax, N-N, 25m, 9 kHz - 30 MHz	None	10/21/2022
C027A	none	RG214	Cable Coax, N-N, 25m, 25MHz - 1GHz	None	9/9/2022
1293	EMCO	6502	Antenna, Loop, Active, .01-30MHz	2040	9/14/2022
C027	none	RG214	Cable Coax, N-N, 25m, 25MHz - 1GHz	None	9/14/2022
C233	Sucoflex	None	Cable, SMA-SMA, 7.62m, 9kHz - 1.5 GHz, Purple	None	10/22/2023
1926	ETS-Lindgren	3142D	Antenna, Biconilog, 26 MHz - 6 GHz	135454	7/15/2023
1425	Electro-Metrics	BPA-1000	Preamp, Broadband 10k-1GHz	123	3/23/2024
C289	Pasternack	PE354-24	Cable, N-SMA, 0.610m Blue	1310	9/9/2022
C030	none	none	Cable Coax, N-N, 30m, 1 - 18GHz	None	9/15/2022
C038	none	LMR-400	Cable Coax, N-N, 0.15m	None	N/A
1780	ETS-Lindgren	3117	Antenna, Double Ridged Guide Horn, 1 - 18 GHz	110313	4/16/2023
2004	Miteq	AFS44-00101800-2S-10P-44	Amplifier, 40dB, 100MHz-18GHz	None	1/14/2024
1326	EMCO	1051-12	Controller, Antenna Mast	9101-1564	N/A
1542	A.H. Systems	SAS-572	Antenna, Horn 18-26.5GHz, 20dB gain	225	N/A
1973	Agilent	83017A	Amplifier, Microwave 0.5-26.5 GHz	MY39500497	11/10/2022
A114	none	None	Attenuator, SMA, 10dB, 1W, DC-18GHz	None	10/1/2022

Appendix: Policy, Rationale, and Evaluation of EMC Measurement Uncertainty

All uncertainty calculations, estimates and expressions thereof shall be in accordance with NIST policy. Since PTI operates in accordance with NIST (NVLAP) Handbook 150-11: 2007, all instrumentation having an effect on the accuracy or validity of tests shall be periodically calibrated or verified traceable to national standards by a competent calibration laboratory. The certificates of calibration or verification on this instrumentation shall include estimates of uncertainty as required by NIST Handbook 150-11.

1. Rationale and Summary of Expanded Uncertainty.

Each piece of instrumentation at Nemko PTI that is used in making measurements for determining conformance to a standard (or limit), shall be assessed to evaluate its contribution to the overall uncertainty of the measurement in which it is used. The assessment of each item will be based on either a type A evaluation or a type B evaluation. Most of the evaluations will be type B, since they will be based on the manufacturer's statements or specifications of the calibration tolerances, or uncertainty will be stated along with a brief rationale for the type of evaluation and the resulting stated uncertainties.

The individual uncertainties included in the combined standard uncertainty for a specific test result will depend on the configuration in which the item of instrumentation is used. The combination will always be based on the law of propagation of uncertainty. Any systematic effects will be accommodated by including their uncertainties, in the calculation of the combined standard uncertainty; except that if the direction and amount of the systematic effect cannot be determined and separated from its uncertainty, the whole effect will be treated as uncertainty and combined along with the other elements of the test setup.

Type A evaluations of standard uncertainty will usually be based on calculating the standard deviation of the mean of a series of independent observations, but may be based on a least-squares curve fit or the analysis of variance for unusual situations. Type B evaluations of standard uncertainty will usually be based on manufacturer's specifications, data provided in calibration reports, and experience. The type of probability distribution used (normal, rectangular, a priori, or u-shaped) will be stated for each Type B evaluation.

In the evaluation of the uncertainty of each type of measurement, the uncertainty caused by the operator will be estimated. One notable operator contribution to measurement uncertainty is the manipulation of cables to maximize the measured values of radiated emissions. The operator contribution to measurement uncertainty is evaluated by having several operators independently repeat the same test. This results in a Type A evaluation of operator-contributed measurement uncertainty.

A summary of the expanded uncertainties of Nemko PTI measurements is shown as Table 1. These are the worst-case uncertainties considering all operative influence factors.

Table 1: Summary of Measurement Uncertainties for Site 45

Type of Measurement	Frequency Range	Meas. Dist.	Expanded Uncertainty U, dB (k=2)
Mains Conducted Emissions	150 kHz to 30 MHz	N/A	2.9
Telecom Conducted Emissions	150 kHz to 30 MHz	N/A	2.8
Radiated Emissions	30 to 1,000 MHz	10 m	4.8
	1 to 18 GHz	3 m	5.7

End of Report