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Project 21303-15

**Swimmersive Co. dba Zygo  
Zygo ZY100**

**Wireless Certification Report  
Bluetooth Section**

Prepared for:

Swimmersive  
16854 Mooncrest Dr  
Encino, CA 91436

By

Professional Testing (EMI), Inc.  
1601 North A.W. Grimes Blvd., Suite B  
Round Rock, Texas 78665

29 Apr 2020

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Reviewed by



Shakil Murad  
Lead EMC Engineer

Written by



Eric Lifsey  
EMC Engineer

## Revision History

Revision Number	Description	Date
Draft 01	Draft for review.	17 Mar 2020
Draft 02	Added antenna gain supplied by client. Corrected duplicate plots.	29 Apr 2020
Draft 03	Corrected mislabeled plots. Added receiver radiated spurious	29 Apr 2020
Final 01		29 Apr 2020
Final 02		12 May 2020
Final 03	Correct top frequency in power table.	22 May 2020
Final 04	Added band edge measurements in hopping mode.	3 Jun 2020

## Errata:

Any reference to Coach applies to the model ZY100.

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# Compliance Certificate

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

Applicant	Device & Test Identification
Swimmersive Co. dba Zygō 16854 Mooncrest Dr Encino, CA 91436 Certificate Date: 29 Apr 2020	FCC ID: 2APZQ-ZYGO Industry Canada ID: 23961-ZYGO Model(s): ZY100 Laboratory Project ID: 21303-15

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

Requirement	Reference	Detail
FCC 47 CFR Part 15 C	15.247	Operation within the bands 902-928 MHz, <u>2400-2483.5 MHz</u> , and 5725-5850 MHz.
FCC 47 CFR Part 15 C	15.209	Radiated emission limits; general requirements.
FCC 47 CFR Part 15 C	15.205	Restricted Bands of Operation
KDB 558074 D01	DR01	DTS Measurement Guidance v03r02
KDB 412172	D01	Guidelines for Determining the ERP and EIRP of an RF Transmitting System
OET Bulletin 65*	Edition 97-01, and Supplement C, Ed. 01-01	Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields
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, Eric Lifsey, for Professional Testing (EMI), 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.

Eric Lifsey  
EMC 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

## 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.

Professional Testing (EMI), Inc., (PTI) 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

**Table 1.2.1: Equipment Under Test**

Manufacturer / Model	Serial #	Description
Swimmersive Model: ZY100	none	2400-2483.5 MHz Frequency Hopping transceiver; using Bluetooth classic protocol.

**Table 1.2.2: Support Equipment**

Manufacturer / Model	Serial #	Description
None		

This device is a hand-held remote wireless microphone use in training aquatic athletes by sending the coach's instructions, or other recorded audio, over the air (VHF) to headset receivers worn by the athletes.

This report concerns the 2.4 GHz radio used for transferring recorded or other sources of audio.

The VHF transmitter (subject to FCC 15.236) as contained in the EUT is reported separately.

This device is powered by an internal 3.7 V Li-Ion battery that is recharged on a cradle then via cable to a USB power source.

### 1.3 EUT Operation

The EUT was exercised in a manner consistent with normal operations. Antenna connectors were added to the test samples only to allow conducted measurements.

### 1.4 Modifications to Equipment

None.

### 1.5 Test Site

Measurements were made at the PTI semi-anechoic facility designated Site 45 (FCC 459644, 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.

## 1.6 Radiated Measurements

<b>Table 1.6.1 Measurement Corrections</b>	
<b>Parameter</b>	<b>From Sums Of</b>
<b>Radiated Field Strength</b>	Raw Measured Level + Antenna Factor + Cable Losses – Amplifier Gain
<b>Conducted Antenna Port</b>	Raw Measured Level + Attenuator Factor + Cable Losses
<b>Conducted Mains Port</b>	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.

## 1.7 Applicable Documents and Clauses

<b>Table 1.7.1: Applicable Documents</b>	
<b>Document</b>	<b>Title</b>
47 CFR	Part 15 – Radio Frequency Devices Subpart C -Intentional Radiators
RSS-247 Issue 2	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
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

<b>Table 1.7.2: Applicable Clauses</b>		
<b>Parameter</b>	<b>FCC Part 15 Rule Paragraphs</b>	<b>IC RSS References</b>
Transmitter Characteristics	15.247	RSS-247 5.1 (FHSS) & 5.4, RSS-Gen
Bandwidth	15.247(a)(1), 2.1049, KDB 558074 D01	RSS-Gen 4.6
Spurious Emission	15.247, 15.209, 15.205	RSS-247 5.5, RSS-GEN 4.9, 4.10
Band Edge	15.247, 15.205	RSS-247 5.5, RSS-Gen 4.9
Antenna Requirement	15.247, 15.203	RSS-Gen 8.3

## 2.0 Fundamental Power

### 2.1 Test Procedure

Peak power is measured using the either conducted or radiated method.

### 2.2 Test Criteria

47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date
15.247(a)(3) // RSS-247 5.2	Fundamental Power Conducted Limits 1 W Limit Restated as Field: 125.23 dB $\mu$ V/m @ 3 m	18 Nov 2019

### 2.3 Test Results, Peak Power

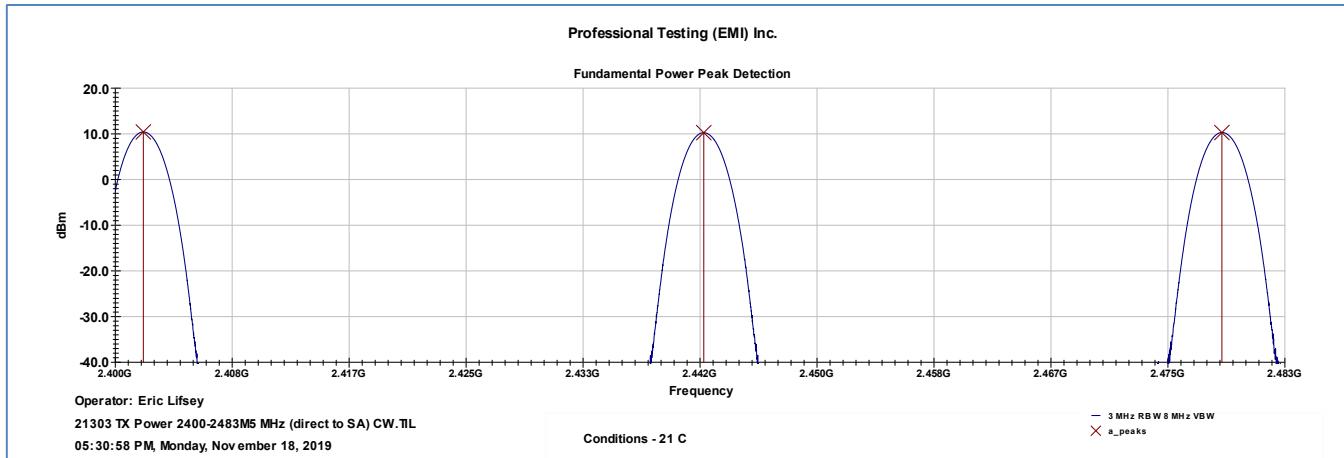
**Table 2.3.1 Power, Peak, Measured Conducted**

Frequency MHz	Unmodulated dBm	Modulated 1 dBm	Modulated 2 dBm	Modulated 3 dBm	Maximum dBm
2402	10.4	10.4	6.5	7.1	10.4
2442	10.2	10.2	6.5	7.0	10.2
2479	10.3	10.3	6.4	6.8	10.3

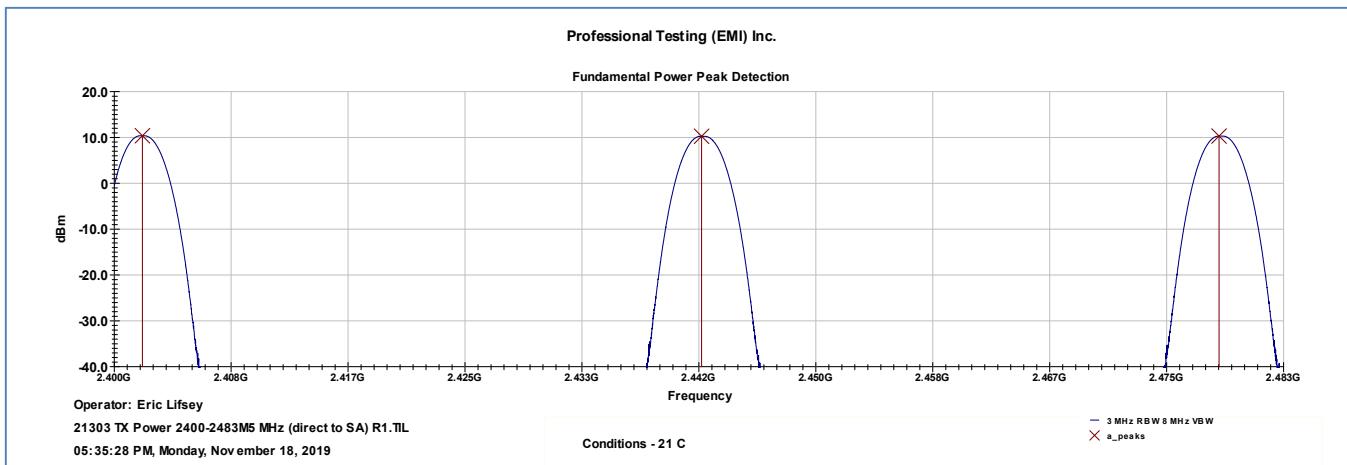
Measured in 3 MHz RBW, 3 MHz VBW.

The EUT satisfied the requirement.

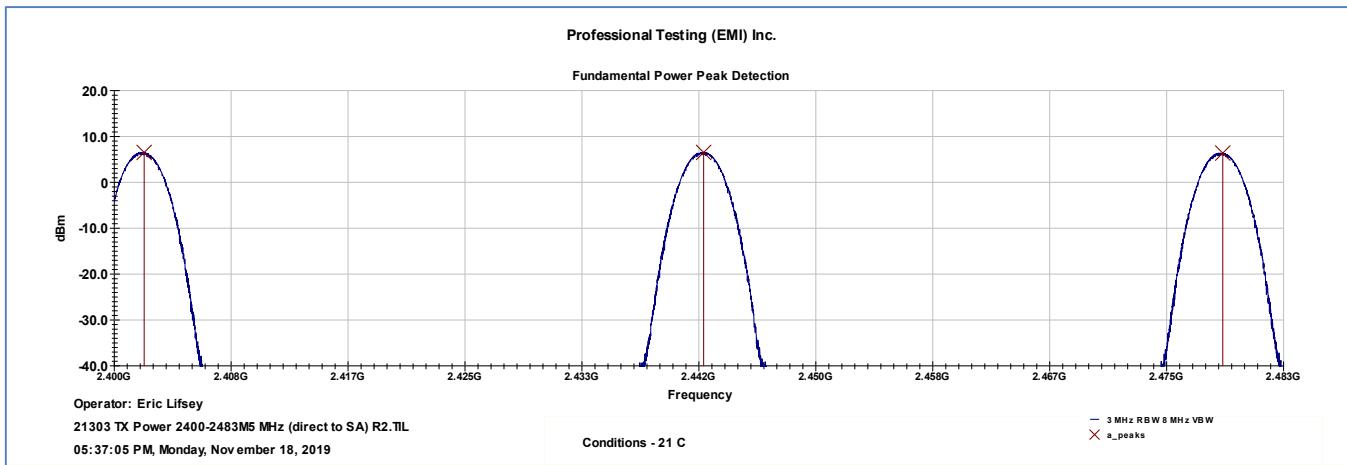
#### 2.3.1 Unmodulated



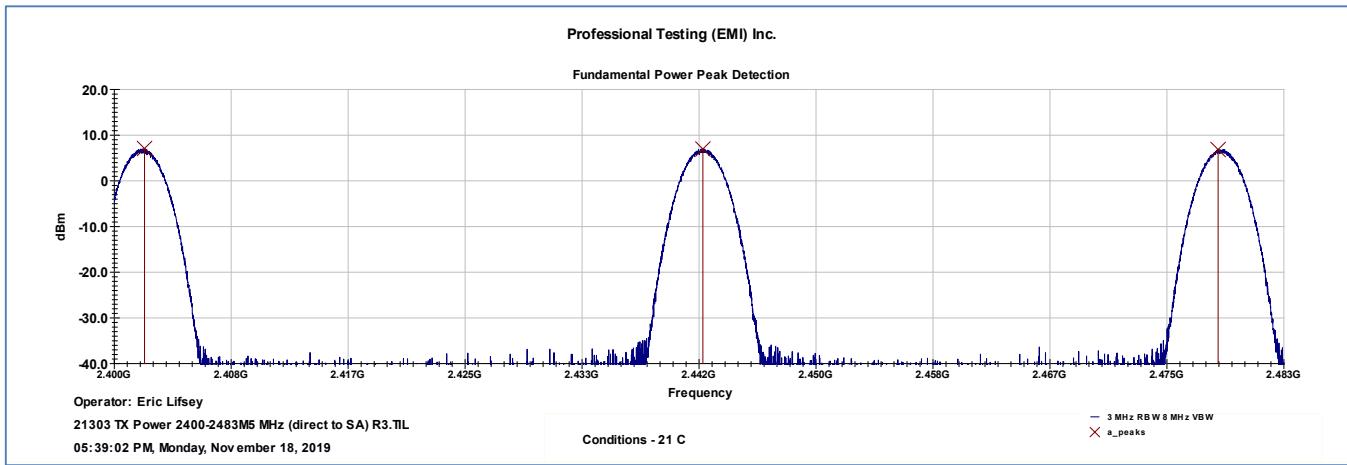
### 2.3.2 Modulations:



### Modulation 1



### Modulation 2



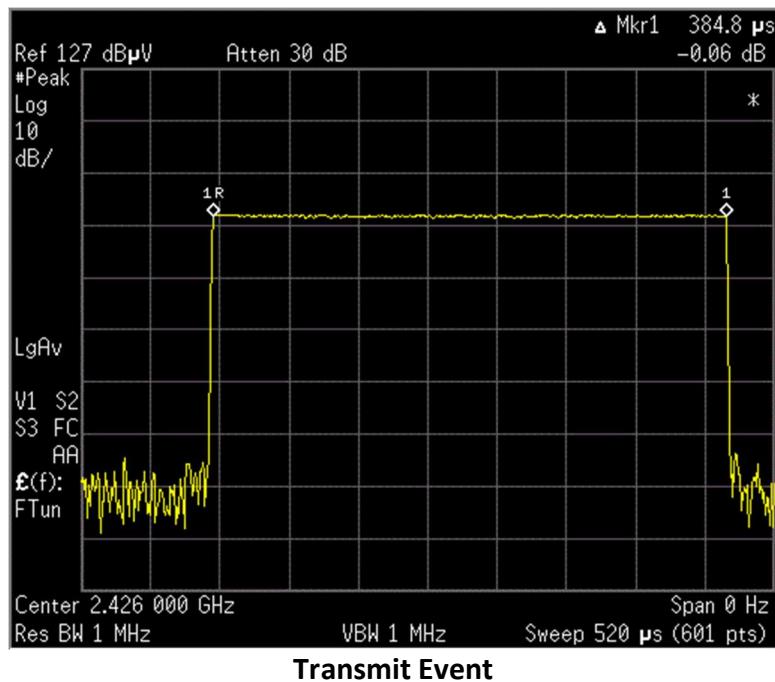
### Modulation 3

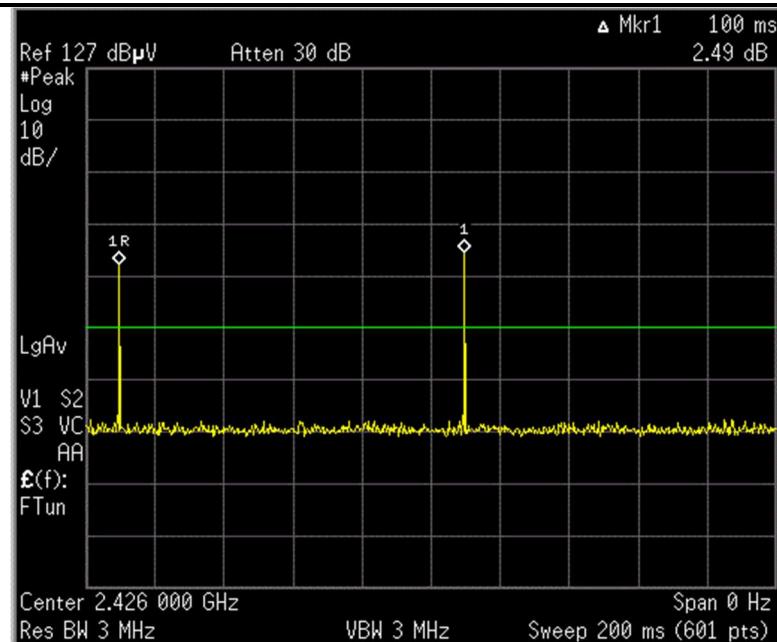
## 2.4 Test Results, Duty Cycle

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.

**Table 2.4.1 Duty Cycle with Average Duty Cycle Factor**

Total Measured On Time (msec)	Measured Time Interval (msec)	Duty Cycle Factor Calculation	Result (dB)	Duty Cycle Factor Allowed (dB)
0.3848	100	= 20 * Log <sub>10</sub> (0.3848 msec / 100 msec )	-48.3	-20.0





**Transmit Event Interval = Return to Channel Time**

## 3.0 Hopping

### 3.1 Test Procedure

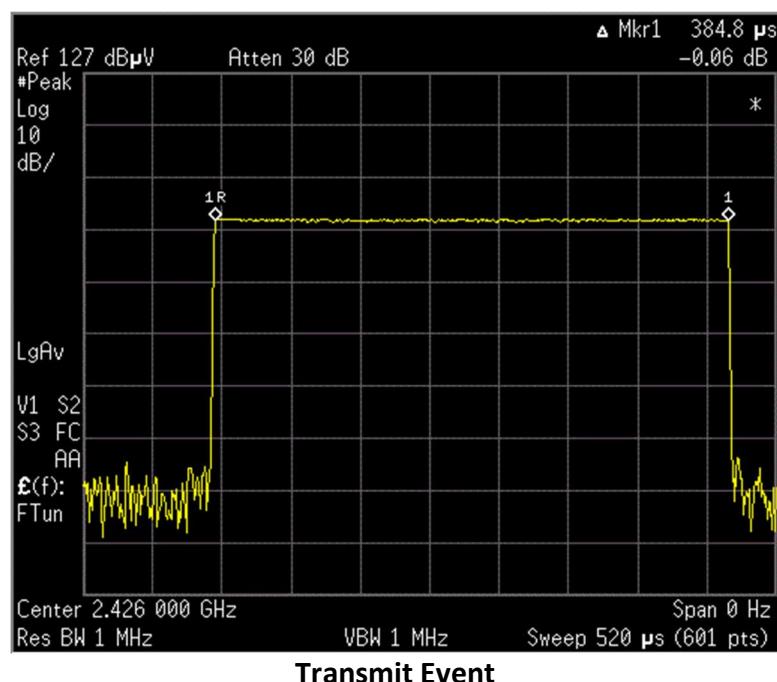
A spectrum analyzer is either connected directly to the EUT or coupled by radiated means to measure the hopping channels and timings.

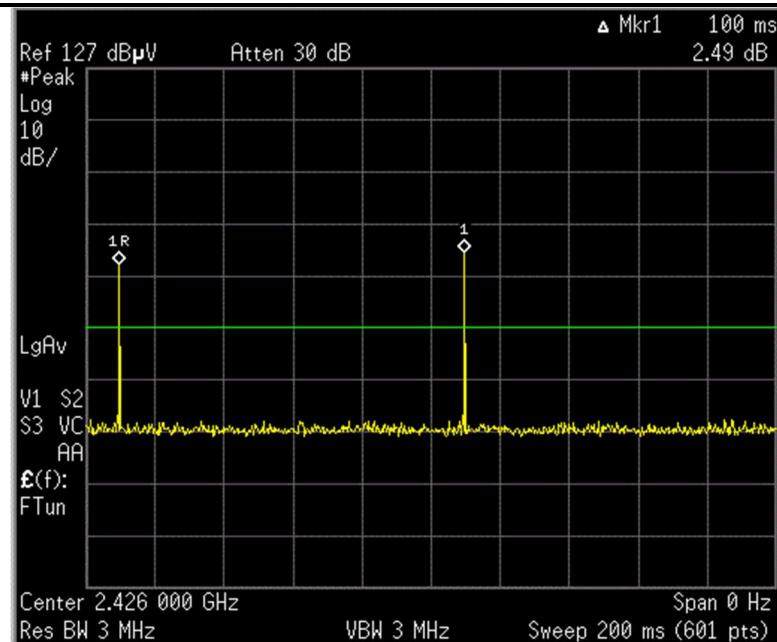
### 3.2 Test Criteria

47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date
15.247 // RSS-247, 5.2	Hopping: Return to Channel Time Transmit Time Channel Count	12 Feb 2020

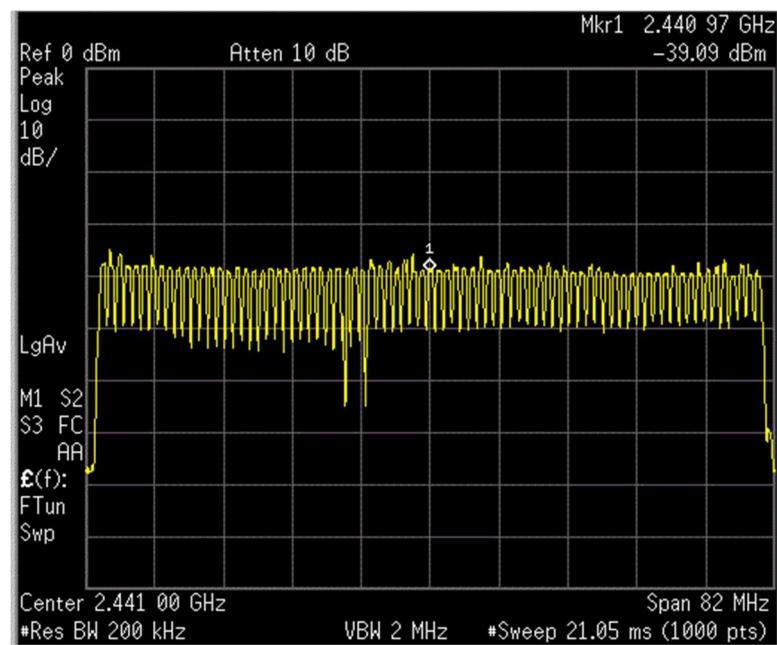
### 3.3 Test Results

The EUT satisfied the requirements.





Transmit Event Interval = Return to Channel Time



Channel Count = 79

### 3.1 Test Results, Timing

Channel separation is 1 MHz and satisfies minimum 25 kHz requirement.

Channel count is 79 and satisfies the requirement for minimum 15 channels and 1 W (30 dBm) power.

Channel occupancy time in 20 second window:

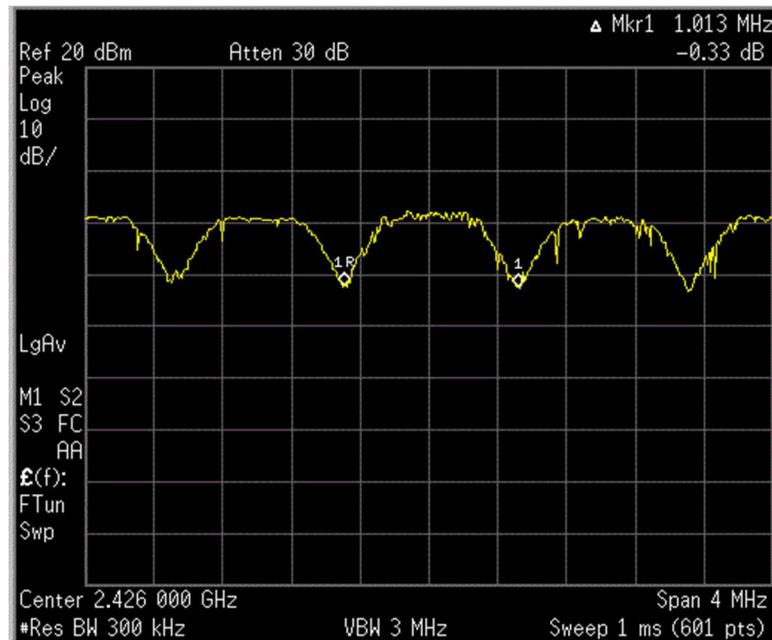
Return to channel time = 0.1 s

Number of channel transmissions in 20 s window = (20 s / 0.1 s) = 200 transmissions

Time spent on channel = 200 transmissions \* 0.384 ms = 76.8 ms

Transmit time in (channel \* 0.4 s) window (Limit is 20 s) = 76.8 ms \* 79 channels = 6.07 s

### 3.2 Test Results, Channel Separation



## 4.0 Occupied Bandwidth

### 4.1 Test Procedure

Bandwidth is measured by conducted means. A recording of the results is included.

### 4.2 Test Criteria

47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date(s)
14.247(a)(2), 2.1049, KDB 558074 D01 // RSS-Gen 4.6	Bandwidth: 99% and 20 dB	18 Nov 2020

### 4.3 Test Results

The bandwidth measurement is used to verify DTS or hopping characteristics and/or for general reporting for agency application.

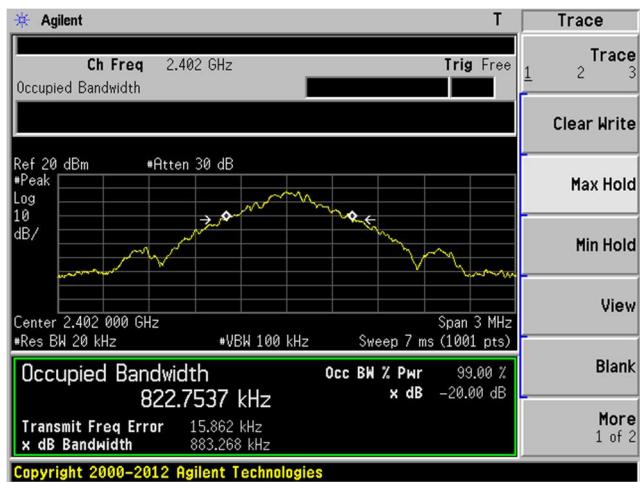
The EUT was found to be in compliance with applicable requirements.

Table 4.3.1 Modulation 1			
Bandwidth 20 dB, Measure and Report			
Low Channel Measured BW (kHz)	Mid Channel Measured BW (kHz)	High Channel Measured BW (kHz)	Reported Maximum BW (kHz)
883	888	888	<b>888</b>
Bandwidth 99%, Measure and Report			
Low Channel Measured BW (kHz)	Mid Channel Measured BW (kHz)	High Channel Measured BW (kHz)	Reported Maximum BW (kHz)
823	842	852	<b>852</b>

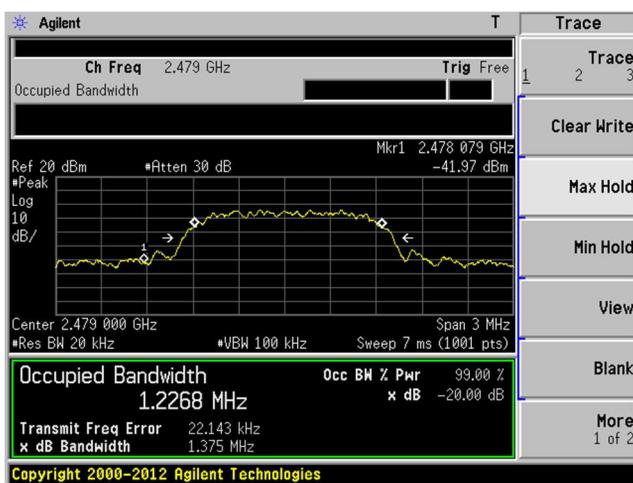
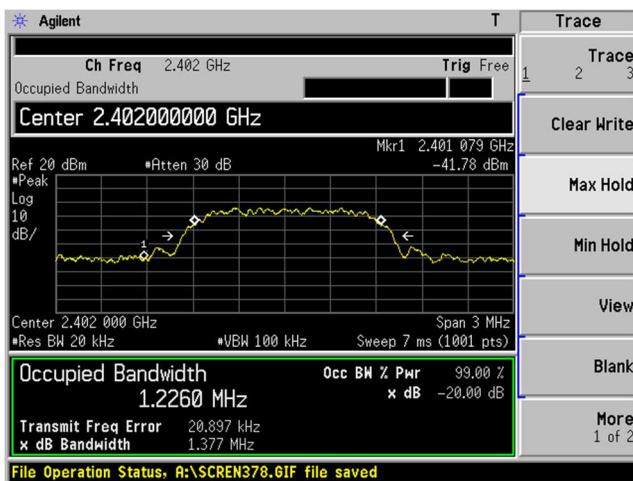
Table 4.3.2 Modulation 2			
Bandwidth 99%, Measure and Report			
Low Channel Measured BW (kHz)	Mid Channel Measured BW (kHz)	High Channel Measured BW (kHz)	Reported Maximum BW (kHz)
1230	1226	1227	<b>1230</b>

Table 4.3.3 Modulation 3			
Bandwidth 99%, Measure and Report			
Low Channel Measured BW (kHz)	Mid Channel Measured BW (kHz)	High Channel Measured BW (kHz)	Reported Maximum BW (kHz)
1224	1224	1225	<b>1225</b>

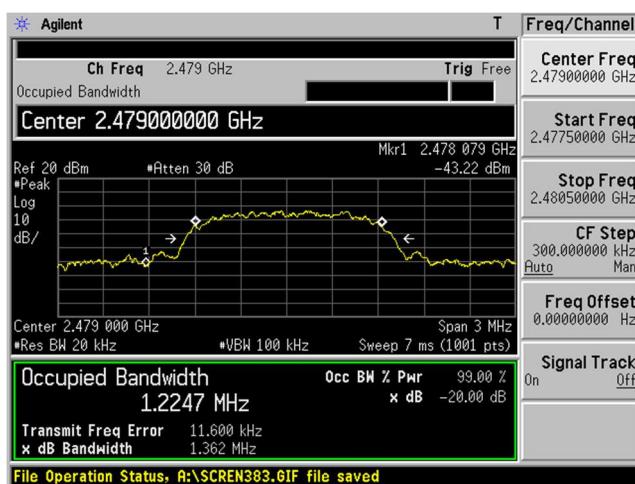
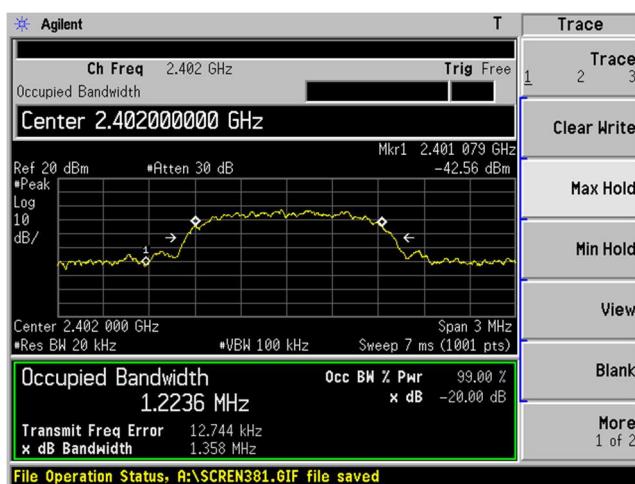
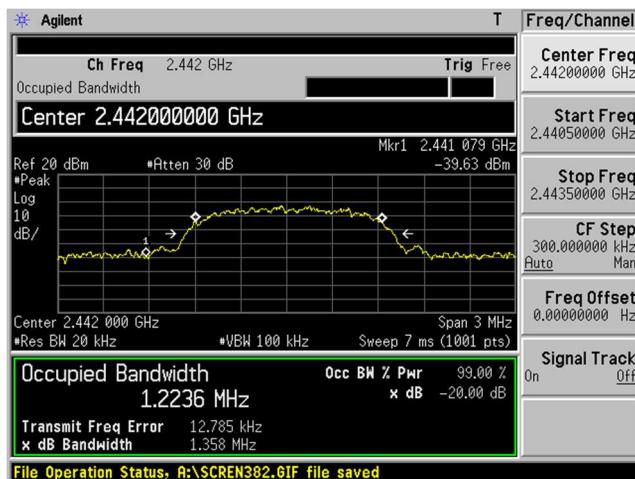
### 4.3.1 Bandwidth Plots, Modulation 1



### 4.3.2 Bandwidth Plots, Modulation 2



### 4.3.3 Bandwidth Plots, Modulation 3



## 5.0 Band Edge

### 5.1 Test Procedure

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.

### 5.2 Test Criteria

47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date(s)
15.247, 15.205 // RSS-247 5.5, RSS-Gen 4.9	Unwanted Emissions Adjacent to Authorized Band; hopping and non-hopping	19 Nov 2019 3 Jun 2020

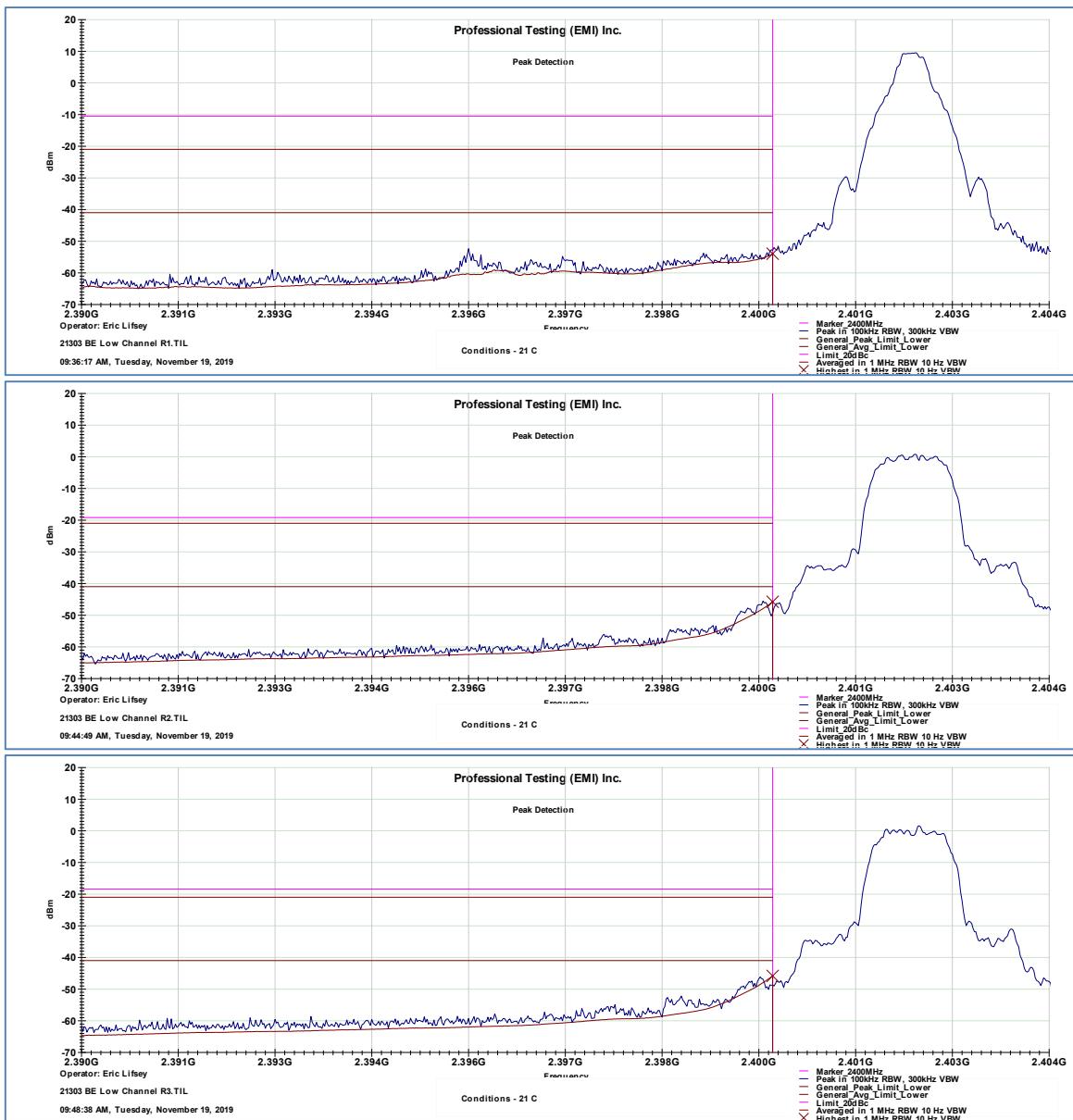
### 5.3 Test Results

Measurements included fundamental and more than 2 standard bandwidths (standard bandwidth 1 MHz) beyond the band edges to provide a clear view of the fundamental and the declining emission levels.

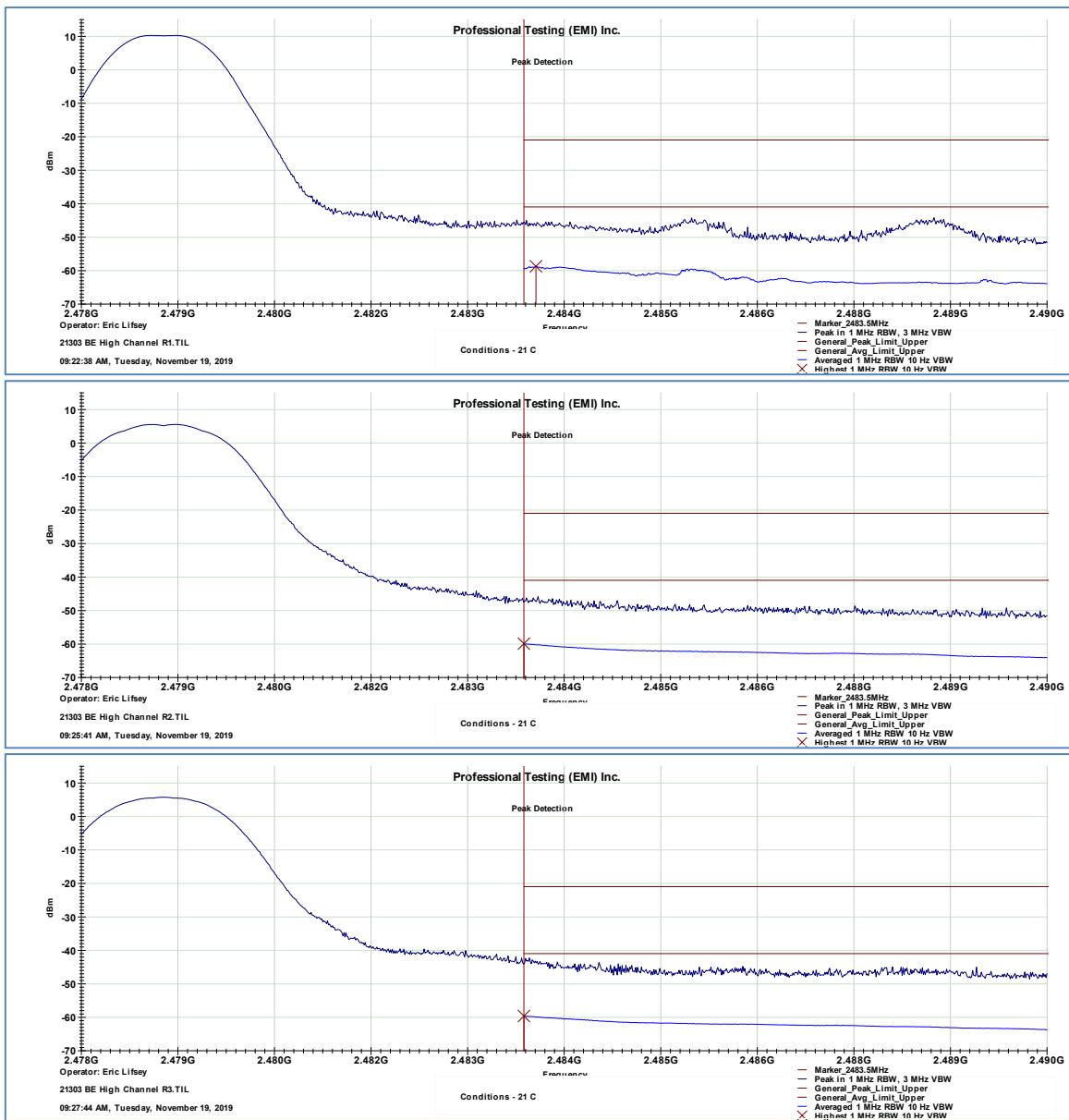
The hopping mode measurement required the use of an external Bluetooth device to stream audio to the EUT. As a result, the signal from the external device also appears on the measurement at a level only a few dB below the EUT. The EUT mainly sends acknowledgement packets so they appear as very short transmissions compared to the other device. As such, the sweep time, sweep count, and frequency subdivisions were set to maximize capture of the short transmissions.

The EUT satisfied the criteria. Plotted results appear on the following pages.

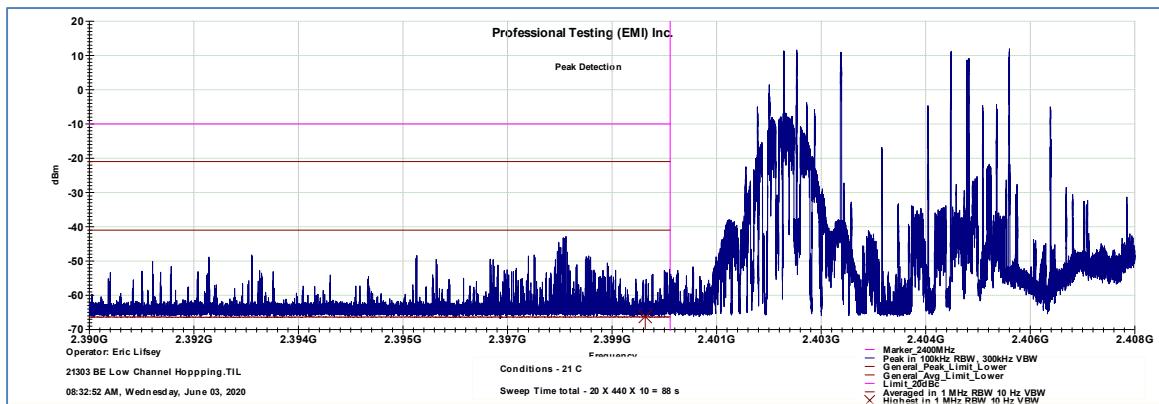
### 5.3.1 Bottom Channel Band Edge, 3 Modulations, Non-Hopping



### 5.3.2 Top Channel Band Edge, 3 Modulations, Non-Hopping

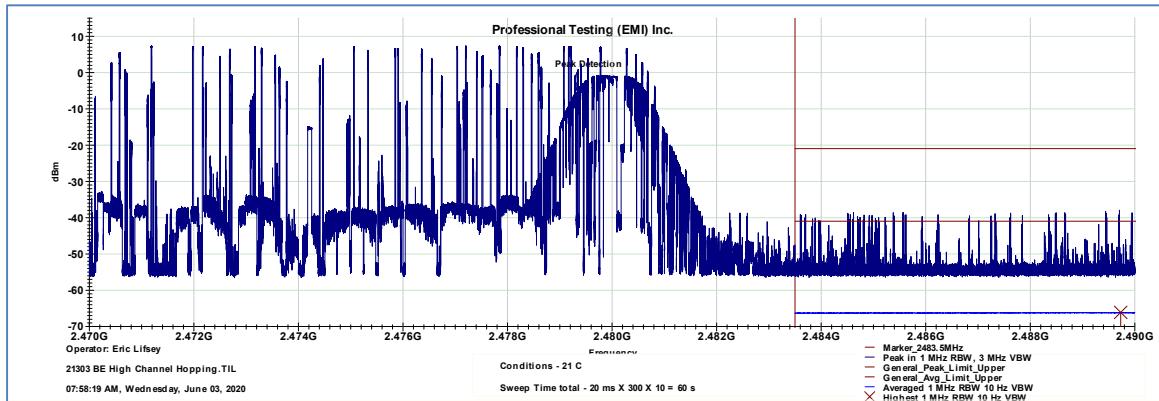


### 5.3.3 Bottom Channel Band Edge, Hopping



Note that the short/narrow transmissions are from the EUT while the wider transmissions were from support equipment used to stimulate the EUT.

### 5.3.4 Top Channel Band Edge, Hopping

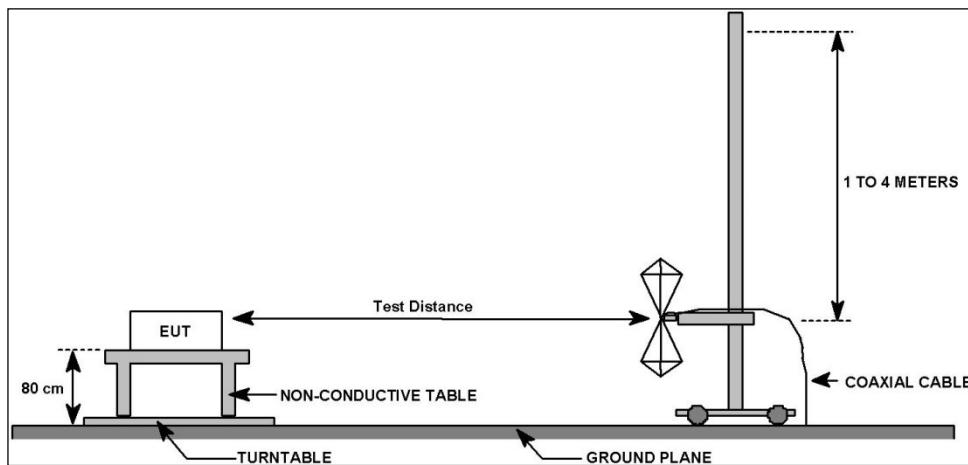


Note that the short/narrow transmissions are from the EUT while the wider transmissions were from support equipment used to stimulate the EUT.

## 6.0 Radiated Spurious Emissions, Transmit Mode

### 6.1 Test Procedure

Radiated emissions are measured with the EUT transmitting on the required frequencies.



#### 6.1.1 Test Distance, Table Height, Detection Method

	30 MHz to 1 GHz	1 GHz to 18 GHz	18 GHz to 25 GHz
Distance	10 m	3 m	1 m
EUT Height	80 cm	1.5 m	80 cm
Detector	Quasi-peak	Peak	Peak

### 6.2 Test Criteria

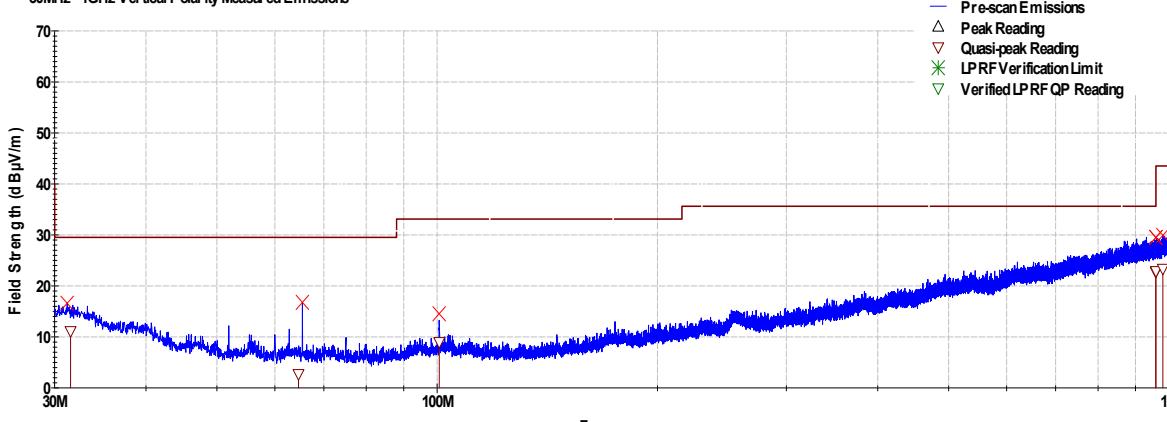
47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date(s)
15.247, 15.209 // RSS-247 5.5, RSS-Gen 4.9 & 4.10	Field Strength of Radiated Spurious/Harmonic Emissions Transmit Mode	5 Feb 2020 10 Feb 2020

### 6.3 Test Results

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

The EUT satisfied the requirement. Graphical and tabular data appears below.

## 6.3.1 Center Channel, Up To 1 GHz

Professional Testing, EMI, Inc.								
<b>Test Method:</b>	ANSI C63.10: 2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices							
<b>In accordance with:</b>	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits							
<b>Section:</b>	15.209							
<b>Test Date(s):</b>	2/4/2020	<b>EUT Serial #:</b>	Sample B					
<b>Customer:</b>	Swimmersive	<b>EUT Part #:</b>	0					
<b>Project Number:</b>	21303-15	<b>Test Technician:</b>	Eric Lifsey					
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Shakil Murad					
<b>Equip. Under Test:</b>	Coach	<b>Witness' Name:</b>	none					
Radiated Emissions Test Results Data Sheet								
<b>EUT Line Voltage:</b>	3.7	<b>VDC</b>	<b>EUT Power</b>	0 N/A				
<b>Antenna Orientation:</b>	Vertical			<b>Frequency</b>	30MHz to 1GHz			
<b>EUT Mode of Operation:</b>	Transmit Middle Chan							
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
31.554	10	308	3.06	Quasi-peak	11.139	29.5	-18.4	Pass
64.639	10	38	3.63	Quasi-peak	2.72	29.5	-26.8	Pass
100.671	10	180	1.36	Quasi-peak	8.994	33.1	-24.1	Pass
959.266	10	80	1.61	Quasi-peak	22.775	35.6	-12.8	Pass
959.837	10	3	1.12	Quasi-peak	22.9	35.6	-12.7	Pass
980.877	10	108	1.41	Quasi-peak	23.361	43.5	-20.1	Pass
Professional Testing, EMI, Inc Radiated Emissions 30MHz - 1GHz Vertical Polarity Measured Emissions								
 Field Strength (dB $\mu$ V/m) vs Frequency (MHz)								
Operator: Eric Lifsey Current Time: 09:29:20 AM, Wednesday, February 05, 2020 Mode: TX BT; Mid Chan Power: 3.7V Battery Notes: no antenna, in case Setup: ANSI (80+150cm) Project Number: 21303 Client: Swimmersive Zygō								
≤ 1GHz Vertical Antenna Polarity Measured Emissions								

Professional Testing, EMI, Inc.								
Test Method:		ANSI C63.10: 2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices						
In accordance with:		FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits						
Section:		15.209						
Test Date(s):		2/4/2020		EUT Serial #:		Sample B		
Customer:		Swimmersive		EUT Part #:		0		
Project Number:		21303-15		Test Technician:		Eric Lifsey		
Purchase Order #:		0		Supervisor:		Shakil Murad		
Equip. Under Test:		Coach		Witness' Name:		none		
Radiated Emissions Test Results Data Sheet								
EUT Line Voltage:		3.7 VDC		EUT Power		0 N/A		
Antenna Orientation:		Horizontal		Frequency		30MHz to 1GHz		
EUT Mode of Operation:					Transmit Middle Chan			
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
31.585	10	250	3.73	Quasi-peak	11.084	29.5	-18.4	Pass
102.679	10	65	2.44	Quasi-peak	3.804	33.1	-29.3	Pass
804.653	10	160	1.48	Quasi-peak	20.654	35.6	-14.9	Pass
960.177	10	2	1.27	Quasi-peak	22.897	43.5	-20.6	Pass
960.343	10	340	1.02	Quasi-peak	22.9	43.5	-20.6	Pass
988.622	10	291	3.98	Quasi-peak	23.491	43.5	-20.0	Pass
<b>Professional Testing, EMI, Inc</b> <b>Radiated Emissions</b> <b>30MHz - 1GHz Horizontal Polarity Measured Emissions</b>								
<p>Field Strength (dB<math>\mu</math>V/m)</p> <p>Frequency</p> <p>Legend:</p> <ul style="list-style-type: none"> <li>FCC Peak Limit</li> <li>FCC Quasi-peak Limit</li> <li>ETSI Quasi-peak Limit</li> <li>Ambient Scan</li> <li>Pre-scan Emissions</li> <li>Peak Reading</li> <li>Quasi-peak Reading</li> <li>LPRF Verification Limit</li> <li>Verified LPRF QP Reading</li> </ul>								
Operator: Eric Lifsey			Mode: TX BT; Mid Chan			EUT: Coach (Sample B)		
Current Time: 09:44:52 AM, Wednesday, February 05, 2020			Power: 3.7V Battery Notes: no antenna, in case			Project Number: 21303		
			Setup: ANSI (80+150cm)			Client: Swimmersive Zygō		
≤ 1GHz Horizontal Antenna Polarity Measured Emissions								

## 6.3.2 Bottom Channel, Up To 18 GHz

Professional Testing, EMI, Inc.								
<b>Test Method:</b>	ANSI C63.10: 2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices							
<b>In accordance with:</b>	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits							
<b>Section:</b>	15.209							
<b>Test Date(s):</b>	2/4/2020	<b>EUT Serial #:</b>	Sample B					
<b>Customer:</b>	Swimmersive	<b>EUT Part #:</b>	0					
<b>Project Number:</b>	21303-15	<b>Test Technician:</b>	Eric Lifsey					
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Shakil Murad					
<b>Equip. Under Test:</b>	Coach	<b>Witness' Name:</b>	none					
Radiated Emissions Test Results Data Sheet								
<b>EUT Line Voltage:</b>	3.7	<b>VDC</b>		<b>EUT Power</b>	0	<b>N/A</b>		
<b>Frequency:</b>				<b>Frequency:</b>				
<b>Antenna Orientation:</b>	Vertical			<b>Range:</b>	Above 1GHz			
EUT Mode of Operation:					Transmit Bottom Chan			
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
4958.07	3	272	1.02	Peak	51.82	74.0	-22.1	Pass
7436.99	3	356	1.26	Peak	55.223	74.0	-18.7	Pass
11172.03	3	17	1.46	Peak	49.397	74.0	-24.6	Pass

# Professional Testing, EMI, Inc.

**Test Method:** ANSI C63.10: 2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

**In accordance with:** FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits

**Section:** 15.209

**Test Date(s):** 2/4/2020

**Customer:** Swimmersive

**Project Number:** 21303-15

**Purchase Order #:** 0

**Equip. Under Test:** Coach

**EUT Serial #:** Sample B

**EUT Part #:** 0

**Test Technician:** Eric Lifsey

**Supervisor:** Shakil Murad

**Witness' Name:** none

## Radiated Emissions Test Results Data Sheet

<b>EUT Line Voltage:</b>	3.7 VDC	<b>EUT Power</b>	0	N/A
<b>Antenna Orientation:</b>	Horizontal	<b>Frequency</b>	Above 1GHz	

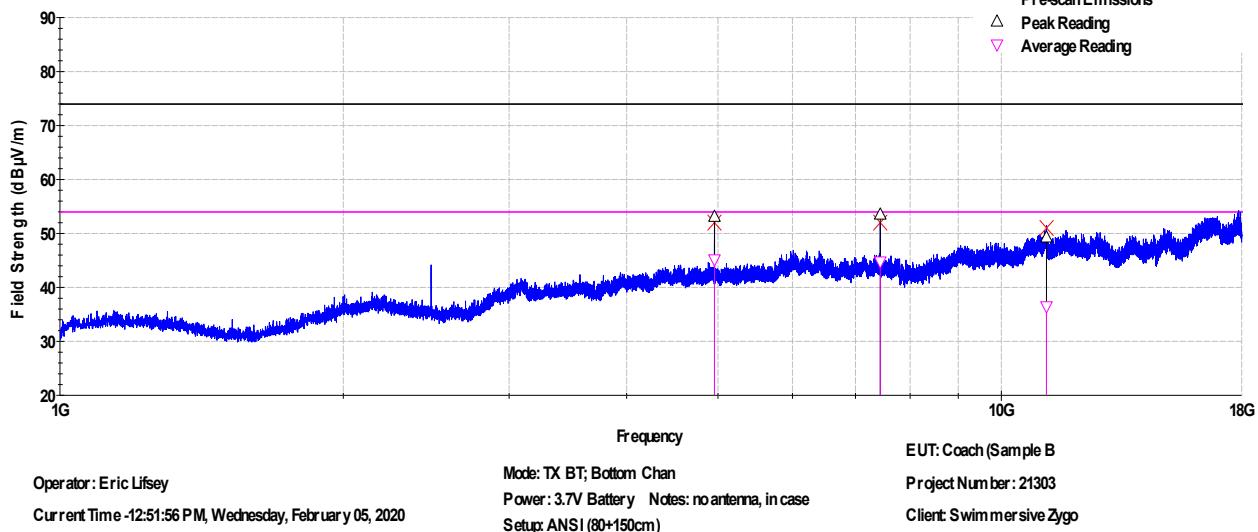
### EUT Mode of Operation: Transmit Bottom Chan

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
4958.15	3	294	1.02	Peak	53.105	74.0	-20.9	Pass
7436.54	3	203	1.62	Peak	53.503	74.0	-20.5	Pass
11167.91	3	207	2.74	Peak	49.265	74.0	-24.7	Pass

### Professional Testing, EMI, Inc

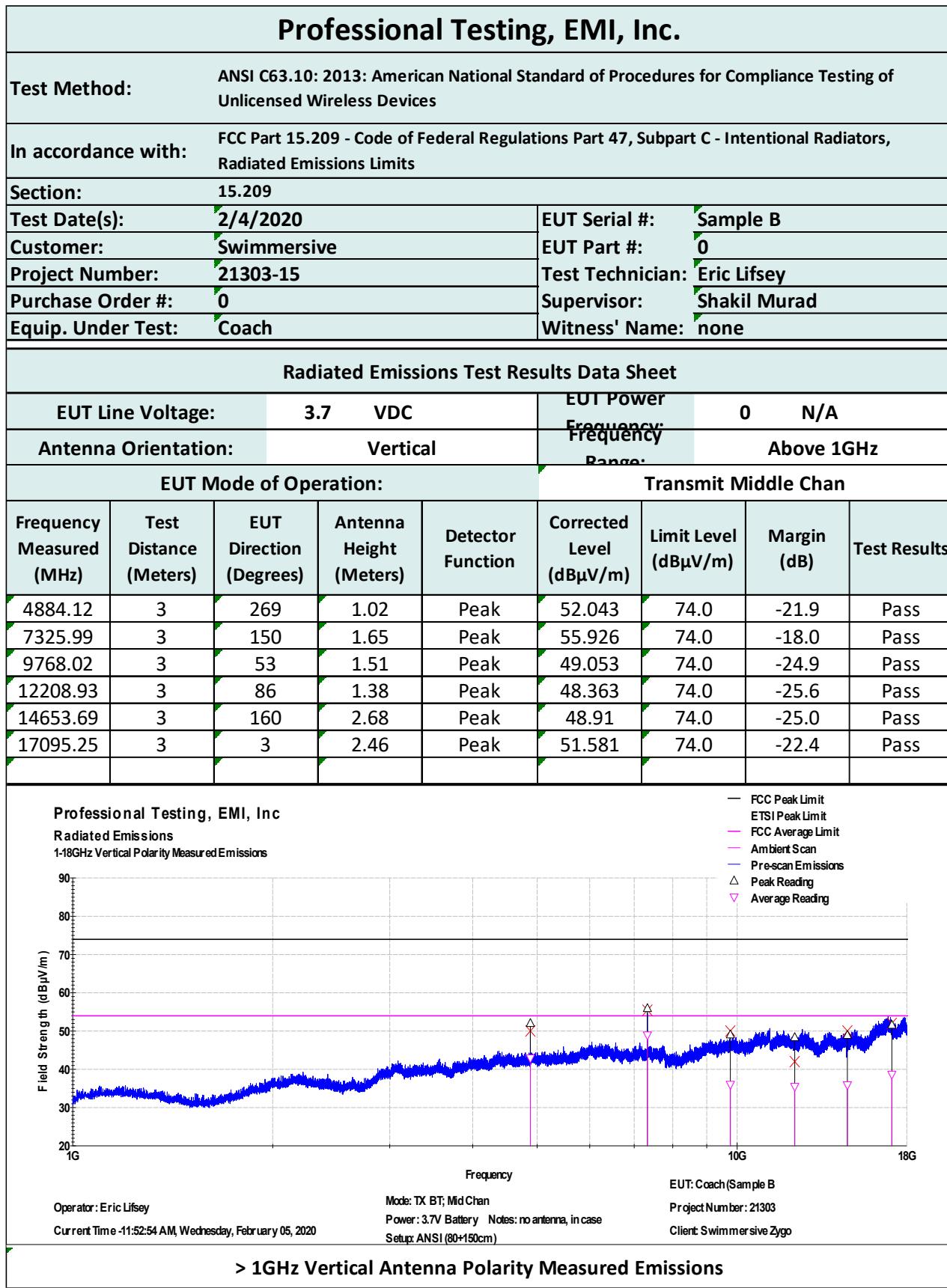
#### Radiated Emissions

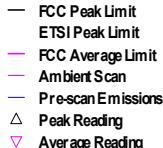
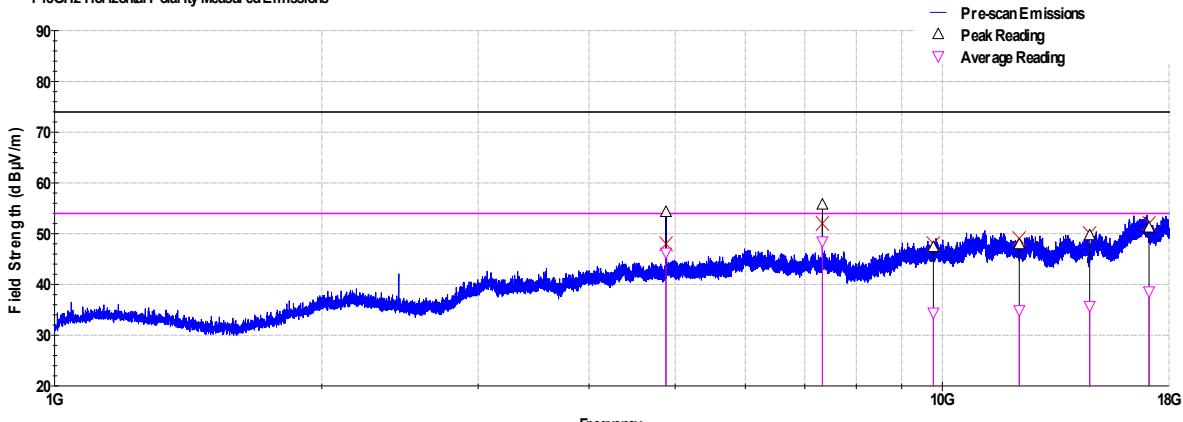
##### 1-18GHz Horizontal Polarity Measured Emissions



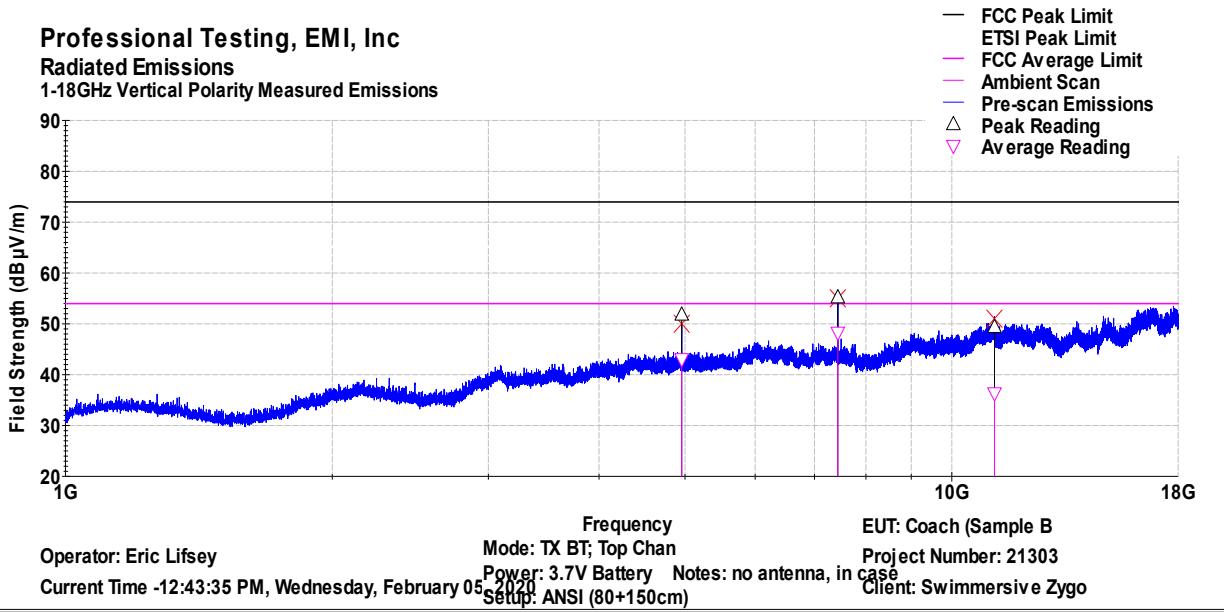
### > 1GHz Horizontal Antenna Polarity Measured Emissions

## 6.3.3 Middle Channel, Up To 18 GHz



Professional Testing, EMI, Inc.								
Test Method:		ANSI C63.10: 2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices						
In accordance with:		FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits						
Section:		15.209						
Test Date(s):		2/4/2020		EUT Serial #:		Sample B		
Customer:		Swimmersive		EUT Part #:		0		
Project Number:		21303-15		Test Technician:		Eric Lifsey		
Purchase Order #:		0		Supervisor:		Shakil Murad		
Equip. Under Test:		Coach		Witness' Name:		none		
Radiated Emissions Test Results Data Sheet								
EUT Line Voltage:		3.7 VDC		EUT Power		0 N/A		
Antenna Orientation:		Horizontal		Frequency		Above 1GHz		
EUT Mode of Operation:					Transmit Middle Chan			
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
4883.74	3	282	1.02	Peak	54.244	74.0	-19.7	Pass
7326.06	3	341	1.02	Peak	55.69	74.0	-18.3	Pass
9769.65	3	152	3.68	Peak	47.311	74.0	-26.6	Pass
12210.41	3	337	1.02	Peak	47.879	74.0	-26.1	Pass
14654.62	3	316	1.85	Peak	49.654	74.0	-24.3	Pass
17092.99	3	357	3.65	Peak	51.173	74.0	-22.8	Pass
<b>Professional Testing, EMI, Inc</b> <b>Radiated Emissions</b> <b>1-18GHz Horizontal Polarity Measured Emissions</b>								
								
Operator: Eric Lifsey			Mode: TX BT; Mid Chan			EUT: Coach (Sample B)		
Current Time: 11:55:58 AM, Wednesday, February 05, 2020			Power: 3.7V Battery Notes: no antenna, in case			Project Number: 21303		
			Setup: ANSI (80x150cm)			Client: Swimmersive Zygō		
> 1GHz Horizontal Antenna Polarity Measured Emissions								

## 6.3.4 Top Channel, Up To 18 GHz

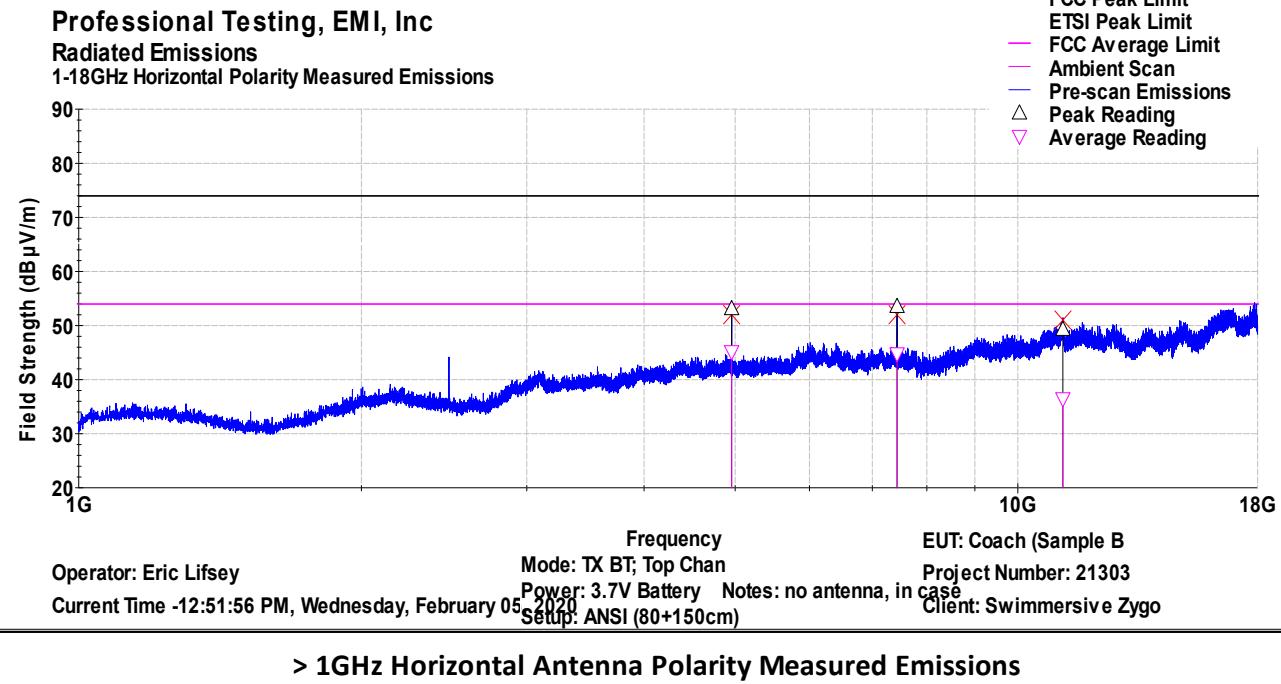
Professional Testing, EMI, Inc.								
<b>Test Method:</b>	ANSI C63.10: 2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices							
<b>In accordance with:</b>	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits							
<b>Section:</b>	15.209							
<b>Test Date(s):</b>	2/4/2020				<b>EUT Serial #:</b>	Sample B		
<b>Customer:</b>	Swimmersive				<b>EUT Part #:</b>	0		
<b>Project Number:</b>	21303-15				<b>Test Technician:</b>	Eric Lifsey		
<b>Purchase Order #:</b>	0				<b>Supervisor:</b>	Shakil Murad		
<b>Equip. Under Test:</b>	Coach				<b>Witness' Name:</b>	none		
Radiated Emissions Test Results Data Sheet								
<b>EUT Line Voltage:</b>	3.7	VDC			<b>EUT Power</b>	0	N/A	
<b>Antenna Orientation:</b>	Vertical				<b>Frequency:</b>	Above 1GHz		
<b>EUT Mode of Operation:</b>					<b>Transmit Middle Chan</b>			
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
4958.07	3	272	1.02	Peak	51.82	74.0	-22.1	Pass
7436.99	3	356	1.26	Peak	55.223	74.0	-18.7	Pass
11172.03	3	17	1.46	Peak	49.397	74.0	-24.6	Pass
								
<b>Professional Testing, EMI, Inc</b> <b>Radiated Emissions</b> <b>1-18GHz Vertical Polarity Measured Emissions</b>								
Field Strength (dB $\mu$ V/m) vs Frequency (GHz). The graph shows measured emissions (blue line) staying below the FCC Peak Limit (purple line) and ETSI Peak Limit (black line). A pink line shows the average reading.								
Frequency: Mode: TX BT; Top Chan Power: 3.7V Battery Notes: no antenna, in case Setup: ANSI (80+150cm) EUT: Coach (Sample B) Project Number: 21303 Client: Swimmersive Zygö								
Operator: Eric Lifsey Current Time -12:43:35 PM, Wednesday, February 05, 2020								
> 1GHz Vertical Antenna Polarity Measured Emissions								

# Professional Testing, EMI, Inc.

Test Method:	ANSI C63.10: 2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices		
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
Section:	15.209		
Test Date(s):	2/4/2020	EUT Serial #:	Sample B
Customer:	Swimmersive	EUT Part #:	0
Project Number:	21303-15	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Shakil Murad
Equip. Under Test:	Coach	Witness' Name:	none

## Radiated Emissions Test Results Data Sheet

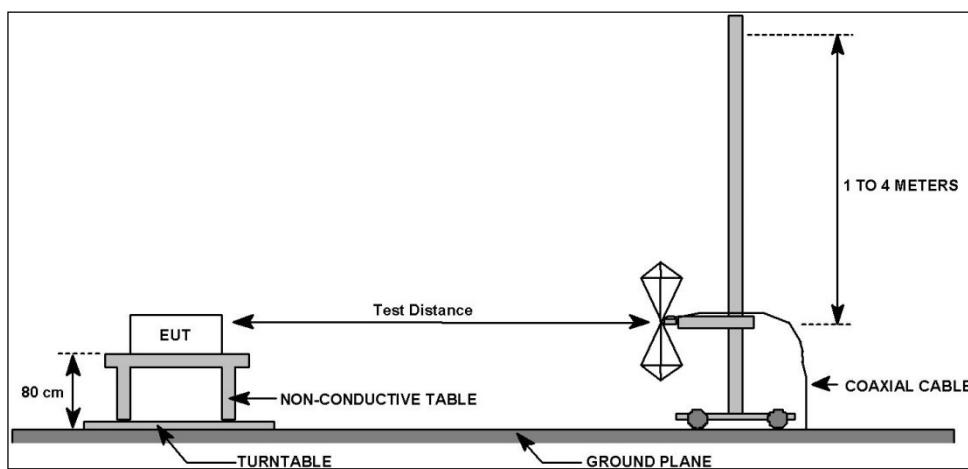
EUT Line Voltage:	3.7 VDC	EUT Power	0	N/A
Antenna Orientation:	Horizontal	EUT Frequency	Above 1GHz	
EUT Mode of Operation:		Transmit Middle Chan		
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function
4958.15	3	294	1.02	Peak
7436.54	3	203	1.62	Peak
11167.91	3	207	2.74	Peak



## 7.0 Radiated Spurious Emissions, Receive Mode

### 7.1 Test Procedure

Radiated emissions are measured with the EUT receiving on the center channel.



#### 7.1.1 Test Distance, Table Height, Detection Method

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

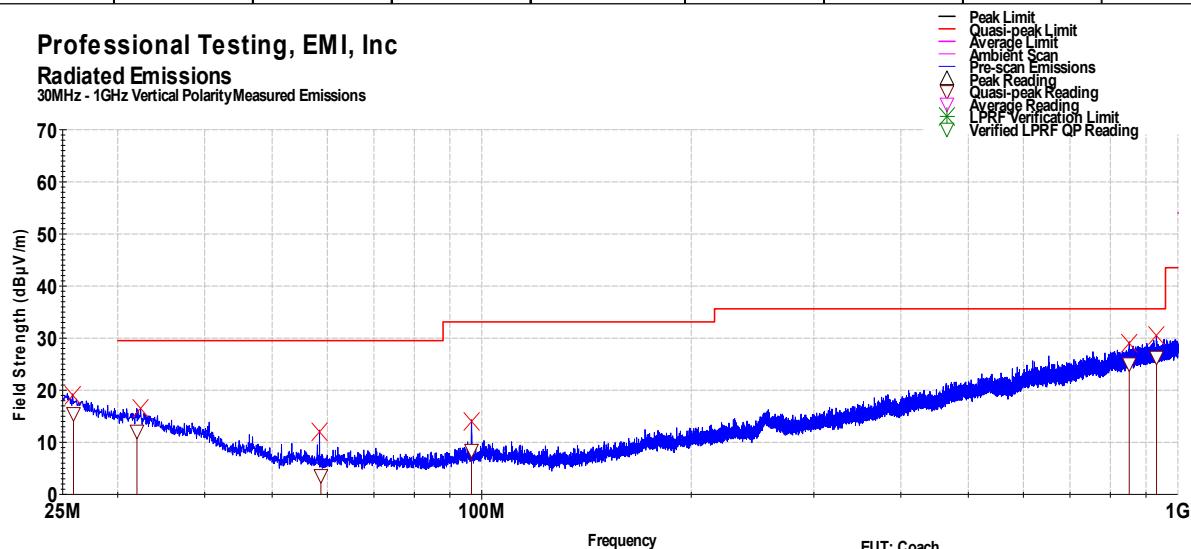
### 7.2 Test Criteria

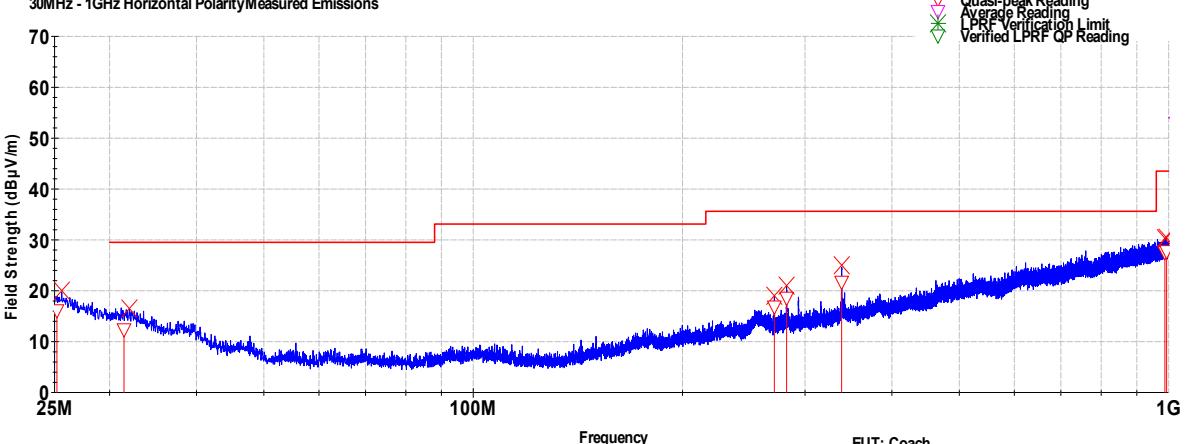
47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date(s)
15.247, 15.209 // RSS-247 5.5, RSS-Gen 4.9 & 4.10	Field Strength of Radiated Spurious/Harmonic Emissions Transmit Mode	N/A

### 7.3 Test Results

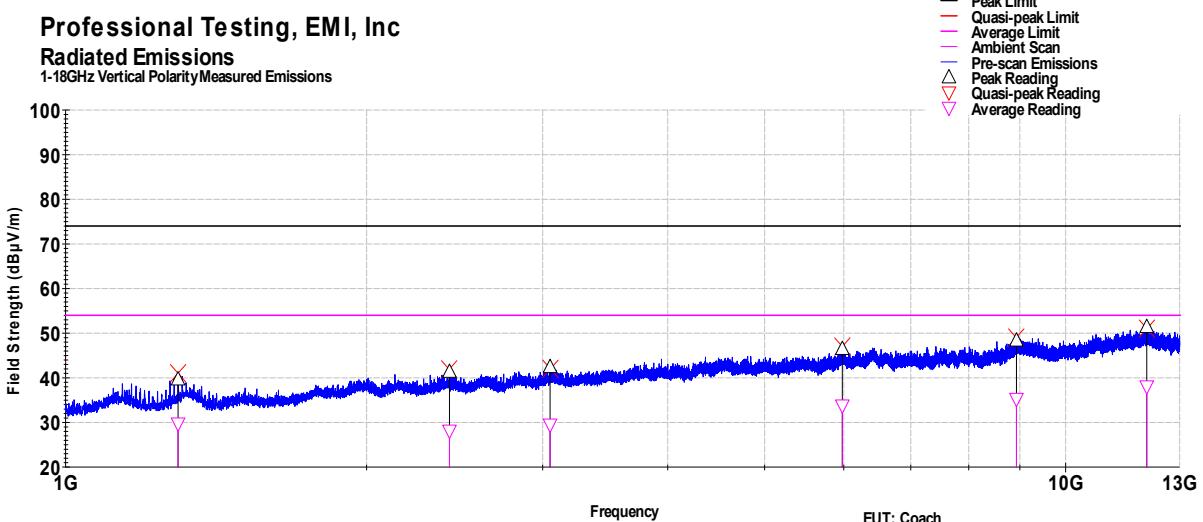
EUT satisfied the requirements.

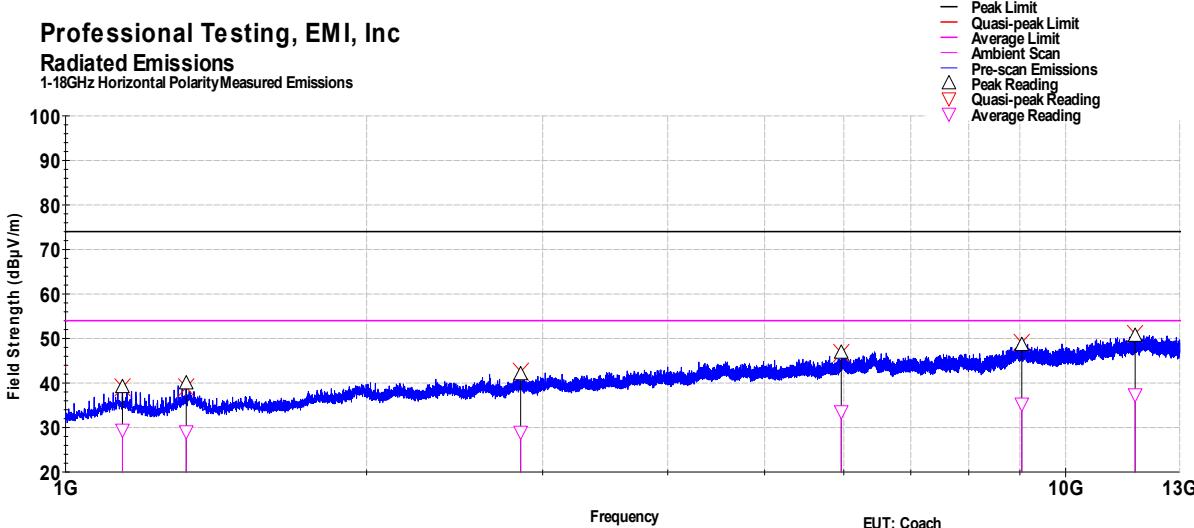
### 7.3.1 Up to 1 GHz

Professional Testing, EMI, Inc.								
<b>Test Method:</b>	ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz							
<b>In accordance with:</b>	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits							
<b>Section:</b>	15.109							
<b>Test Date(s):</b>	11/20/2019		<b>EUT Serial #:</b>	165				
<b>Customer:</b>	Zygō		<b>EUT Part #:</b>	0				
<b>Project Number:</b>	21303-15		<b>Test Technician:</b>	Eric Lifsey				
<b>Purchase Order #:</b>	0		<b>Supervisor:</b>	Shakil Murad				
<b>Equip. Under Test:</b>	Coach		<b>Witness' Name:</b>	None				
Radiated Emissions Test Results Data Sheet								
<b>EUT Line Voltage:</b>	3.7 VDC		<b>EUT Power:</b>	0 N/A				
<b>Antenna Orientation:</b>	Vertical		<b>Frequency:</b>	30MHz to 1GHz				
EUT Mode of Operation:				Receive				
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
25.916	10	293	2.18	Quasi-peak	15.54	29.5	-14.0	Pass
31.967	10	21	3.68	Quasi-peak	12.175	29.5	-17.3	Pass
58.737	10	251	3.71	Quasi-peak	3.639	29.5	-25.9	Pass
96.688	10	21	1.24	Quasi-peak	8.492	33.1	-24.6	Pass
851.478	10	14	1.26	Quasi-peak	25.084	35.6	-10.5	Pass
931.898	10	99	4.12	Quasi-peak	26.377	35.6	-9.2	Pass
<b>Professional Testing, EMI, Inc</b> <b>Radiated Emissions</b> 30MHz - 1GHz Vertical Polarity Measured Emissions								
								
<b>≤ 1GHz Vertical Antenna Polarity Measured Emissions</b>								

Professional Testing, EMI, Inc.								
ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz								
<b>Test Method:</b>		Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz						
<b>In accordance with:</b>		FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits						
<b>Section:</b>		15.109						
<b>Test Date(s):</b>		11/20/2019		<b>EUT Serial #:</b>		165		
<b>Customer:</b>		Zygō		<b>EUT Part #:</b>		0		
<b>Project Number:</b>		21303-15		<b>Test Technician:</b>		Eric Lifsey		
<b>Purchase Order #:</b>		0		<b>Supervisor:</b>		Shakil Murad		
<b>Equip. Under Test:</b>		Coach		<b>Witness' Name:</b>		None		
<b>Radiated Emissions Test Results Data Sheet</b>								
<b>EUT Line Voltage:</b>			3.7	VDC	<b>EUT Power</b>	0	N/A	
<b>Antenna Orientation:</b>			Horizontal		<b>Frequency</b>	30MHz to 1GHz		
<b>EUT Mode of Operation:</b>					Receive			
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
25.195	10	229	3.48	Quasi-peak	16.126	29.5	-13.4	Pass
31.468	10	142	2.89	Quasi-peak	12.385	29.5	-17.1	Pass
271.089	10	86	3.52	Quasi-peak	16.866	35.6	-18.7	Pass
282.273	10	250	2.59	Quasi-peak	18.605	35.6	-17.0	Pass
338.729	10	111	2.15	Quasi-peak	21.737	35.6	-13.9	Pass
987.723	10	165	1.16	Quasi-peak	27.556	43.5	-15.9	Pass
993.498	10	10	3.25	Quasi-peak	27.743	43.5	-15.8	Pass
<b>Professional Testing, EMI, Inc</b> <b>Radiated Emissions</b> 30MHz - 1GHz Horizontal Polarity Measured Emissions								
 Field Strength (dB $\mu$ V/m) vs Frequency (MHz). The graph shows measured emissions (blue line) and limit levels (red lines). The measured emissions are generally below the limits, with a notable peak around 1GHz.								
Mode: Receive Power: Battery Notes: Test Code Operator: Eric Lifsey EUT: Coach Project Number: 21303 Client: Zygō								
<b>≤ 1GHz Horizontal Antenna Polarity Measured Emissions</b>								

### 7.3.2 Up to 13 GHz

Professional Testing, EMI, Inc.								
<b>Test Method:</b>	ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz							
<b>In accordance with:</b>	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits							
<b>Section:</b>	15.109							
<b>Test Date(s):</b>	11/20/2019		<b>EUT Serial #:</b>	165				
<b>Customer:</b>	Zygō		<b>EUT Part #:</b>	0				
<b>Project Number:</b>	21303-15		<b>Test Technician:</b>	Eric Lifsey				
<b>Purchase Order #:</b>	0		<b>Supervisor:</b>	Shakil Murad				
<b>Equip. Under Test:</b>	Coach		<b>Witness' Name:</b>	None				
Radiated Emissions Test Results Data Sheet								
<b>EUT Line Voltage:</b>	3.7 VDC		<b>EUT Power</b>	0		N/A		
<b>Antenna Orientation:</b>	Vertical		<b>Frequency</b>	Frequency		Above 1GHz		
<b>EUT Mode of Operation:</b>					Receive			
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
1295.68	3	78	2.35	Peak	39.646	74.0	-34.3	Pass
2420.26	3	112	1.01	Peak	41.357	74.0	-32.6	Pass
3051.44	3	67	2.92	Peak	42.413	74.0	-31.5	Pass
5979.61	3	228	1.37	Peak	46.474	74.0	-27.5	Pass
8928.57	3	263	1.13	Peak	48.353	74.0	-25.6	Pass
12053.76	3	147	0.99	Peak	51.39	74.0	-22.6	Pass
<b>Professional Testing, EMI, Inc</b> <b>Radiated Emissions</b> 1-18GHz Vertical Polarity Measured Emissions								
 Field Strength (dB $\mu$ V/m) vs Frequency (GHz)								
Mode: Receive Power: Battery Notes: Test Code Operator: Eric Lifsey EUT: Coach Project Number: 21303 Client: Zygō								
<b>&gt; 1GHz Vertical Antenna Polarity Measured Emissions</b>								

Professional Testing, EMI, Inc.								
<b>Test Method:</b>		ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz						
<b>In accordance with:</b>		FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits						
<b>Section:</b>		15.109						
<b>Test Date(s):</b>	11/20/2019	<b>EUT Serial #:</b>	165					
<b>Customer:</b>	Zygō	<b>EUT Part #:</b>	0					
<b>Project Number:</b>	21303-15	<b>Test Technician:</b>	Eric Lifsey					
<b>Purchase Order #:</b>	0	<b>Supervisor:</b>	Shakil Murad					
<b>Equip. Under Test:</b>	Coach	<b>Witness' Name:</b>	None					
Radiated Emissions Test Results Data Sheet								
<b>EUT Line Voltage:</b>	3.7	<b>VDC</b>		<b>EUT Power</b>		0	N/A	
<b>Antenna Orientation:</b>	Horizontal			<b>Frequency</b>			Above 1GHz	
<b>EUT Mode of Operation:</b>					Receive			
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dB $\mu$ V/m)	Limit Level (dB $\mu$ V/m)	Margin (dB)	Test Results
1139.98	3	127	2.95	Peak	39.083	74.0	-34.9	Pass
1320.3	3	2	1.46	Peak	39.914	74.0	-34.0	Pass
2851.18	3	201	2.88	Peak	41.961	74.0	-32.0	Pass
5965.71	3	57	1.57	Peak	46.814	74.0	-27.1	Pass
9039.42	3	193	3.63	Peak	48.546	74.0	-25.4	Pass
11734.36	3	357	3.97	Peak	50.605	74.0	-23.4	Pass
<b>Professional Testing, EMI, Inc</b> <b>Radiated Emissions</b> 1-18GHz Horizontal Polarity Measured Emissions								
 Field Strength (dB $\mu$ V/m) vs Frequency (GHz)								
Mode: Receive Power: Battery Notes: Test Code Operator: Eric Lifsey EUT: Coach Project Number: 21303 Client: Zygō								
<b>&gt; 1GHz Horizontal Antenna Polarity Measured Emissions</b>								

## 8.0 Antenna Construction

### 8.1 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.

### 8.2 Criteria

47 CFR (USA) // IC (Canada)		
Section Reference	Parameter	Date(s)
15.203, 15.247 // RSS-Gen 8.3	Antenna Construction	4 Feb 2020

### 8.3 Results

**Table 8.3.1 Antenna Construction Details**

Manufacturer: Swimmersive

Part Number: N/A

Type: Printed circuit, monopole inverted-F with slight curvature.

Gain: -0.52 dBi peak

Construction: No connector provided. Antenna is internal to device and not subject to user modification.

The antenna system design above satisfies the requirements of the rules.

## 9.0 Equipment

### 9.1 Radiated Emissions 30 MHz to 18 GHz

Radiated Emissions Test Equipment List					
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:		2019_May_Unintentional RE_TILE7_v2.5.til			
Asset #	Manufacturer	Model	Equipment Nomenclature	Serial Number	Calibration Due Date
1509A	Braden	TDK 10M	TDK 10M Chamber, NSA < 1 GHz	DAC-012915-005	9/17/2021
1890	HP	8447F-H64	Preamp/Amp, 9kHz-1300MHz, 28/25dB	3313A05298	1/9/2022
1937	Agilent	E4440A - AYZ	PSA , 3 Hz - 26.5 GHz, Opt. AYZ	MY44808298	11/8/2020
1926	ETS-Lindgren	3142D	Antenna, Biconilog, 26 MHz - 6 GHz	135454	3/11/2021
C027	none	RG214	Cable Coax, N-N, 25m, 25MHz - 1GHz	None	9/9/2020
1327	EMCO	1050	Controller, Antenna Mast	none	N/A
0942	EMCO	11968D	Turntable, 4ft.	9510-1835	N/A
1969	HP	11713A	Attenuator/Switch Driver	3748A04113	N/A
1509B	Braden	TDK 10M	TDK 10M Chamber,sVSWR > 1 GHz	DAC-012915-005	9/21/2021
2004	Miteq	AFS44-00101800-2S-10P-44	Amplifier, 40dB, 100MHz-18GHz	None	1/9/2022
C030	none	none	Cable Coax, N-N, 30m, 1 - 18GHz	None	9/9/2020
1325	EMCO	1050	Controller, Antenna Mast	9003-1461	N/A
1780	ETS-Lindgren	3117	Antenna, Double Ridged Guide Horn, 1 - 18 GHz	110313	3/11/2021

## 9.2 Fundamental Power, Bandwidth, Duty Cycle, Band Edge

Asset #	Manufacturer	Model #	Description	Calibration Due
1937	Agilent	E4440A	Spectrum Analyzer	8 Nov 2020

## 9.3 Radiated Emissions 18-25 GHz

Asset #	Manufacturer	Model #	Description	Calibration Due
1937	Agilent	E4440A	Spectrum Analyzer	8 Nov 2020
1974	Agilent	83017A	Microwave Amplifier	7 Nov 2020
1542	A H Systems	SAS-572	Antenna, Horn, 18-26.5 GHz	CNR
0524	EMCO	1060	Turntable controller	CNR

## 10.0 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.

## 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 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 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