
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

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 Zygo 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, 2400-2483.5 MHz, 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

| Table 1.6 1 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.

1.7 Applicable Documents and Clauses

| Table 1.7.1: 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-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 |

| Table 1.7.2: Applicable Clauses | | |
|---------------------------------|--------------------------------------|-----------------------------------|
| Parameter | FCC Part 15 Rule Paragraphs | IC RSS References |
| 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 μ V/m @ 3 m | 18 Nov 2019 |

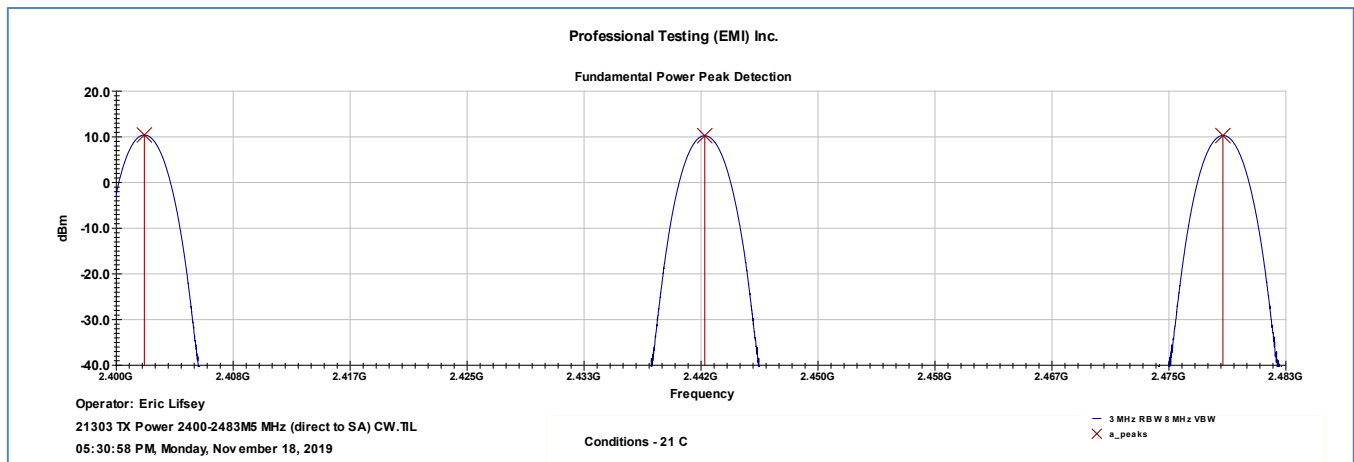
2.3 Test Results, Peak Power

| 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 |

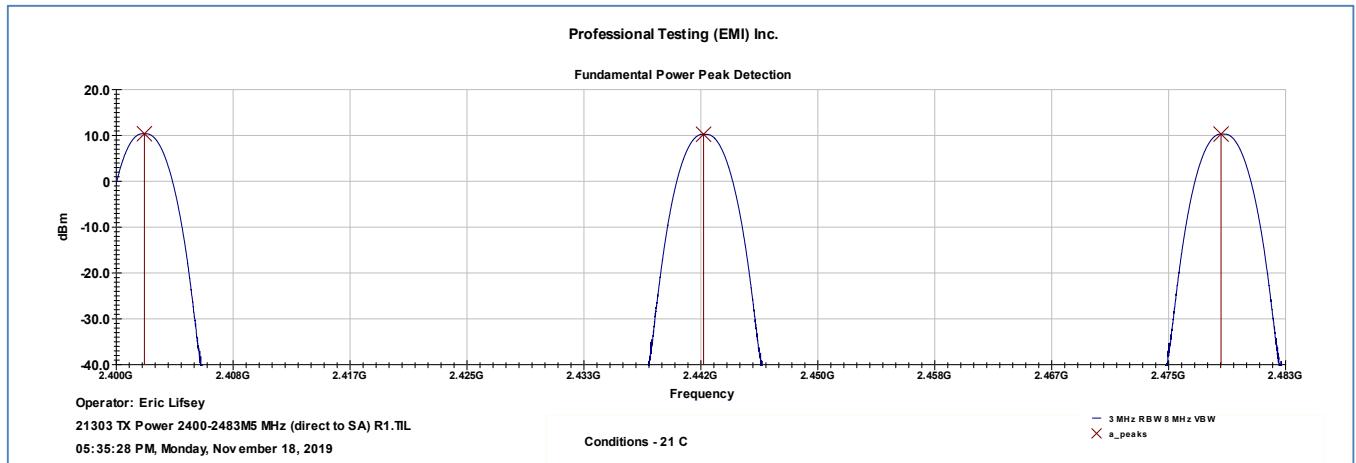
Measured in 3 MHz RBW, 3 MHz VBW.

The EUT satisfied the requirement.

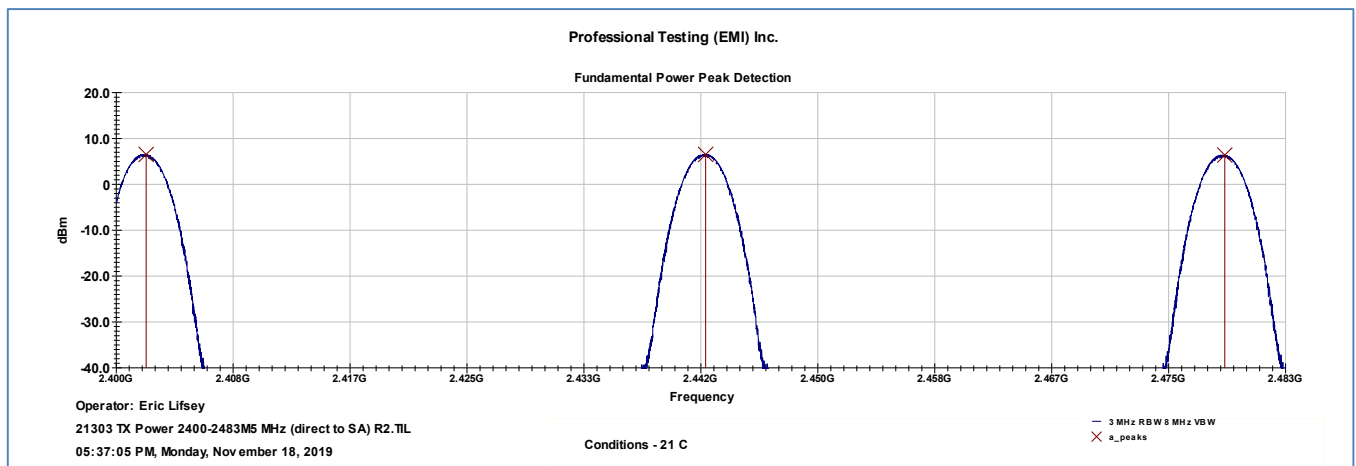
2.3.1 Unmodulated



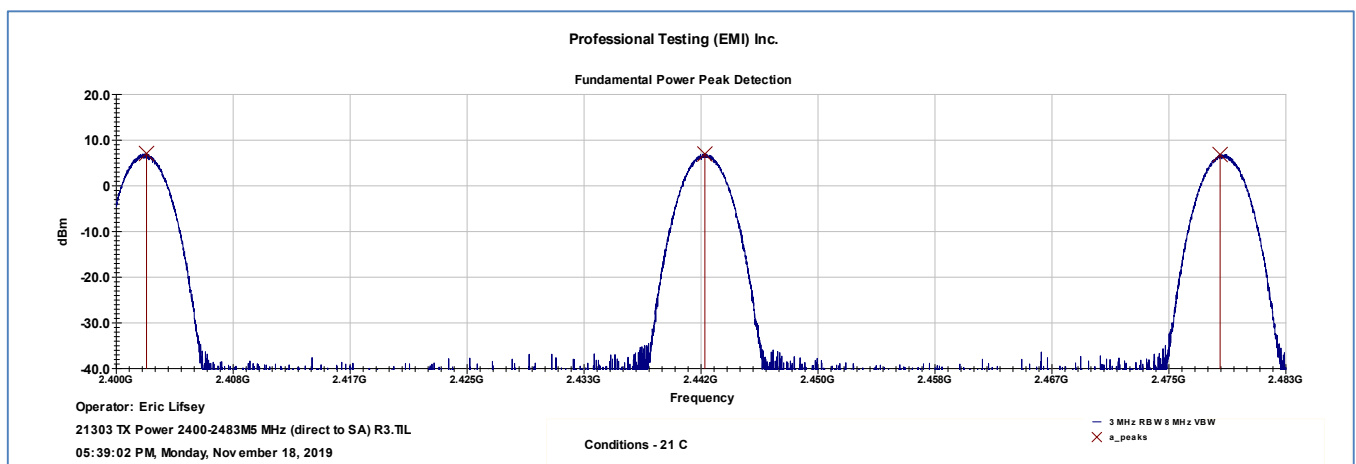
2.3.2 Modulations:



Modulation 1



Modulation 2



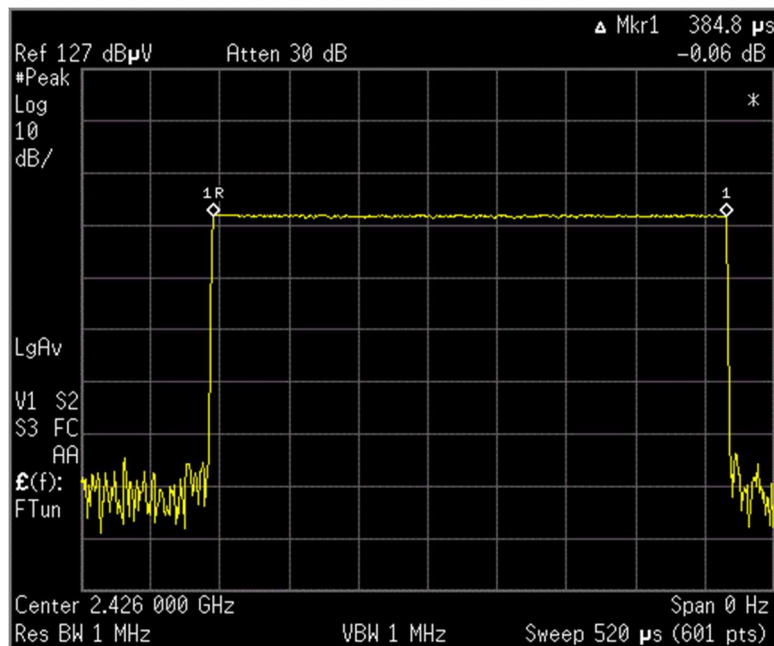
Modulation 3

2.4 Test Results, Duty Cycle

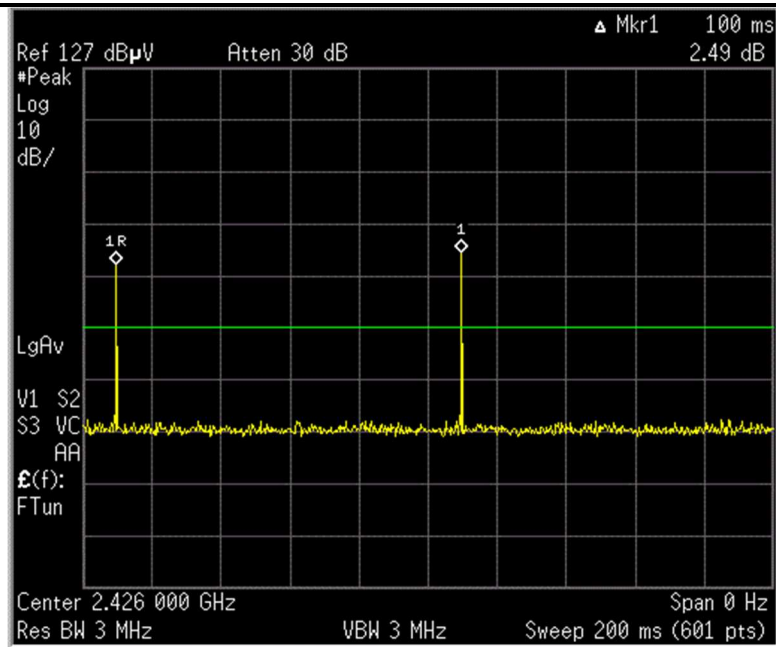
Measurement is based on intervals not to exceed 100 msec. Maximum transmitter on time is divided by the lesser of 100 msec or the actual measured minimum transmitter interval time. The result is converted to dB and applied as needed to peak measurements of transmitter artifacts to determine average power. 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 | $= 20 * \log_{10} (0.3848 \text{ msec} / 100 \text{ msec})$ | -48.3 | -20.0 |



Transmit Event



Transmit Event Interval = Return to Channel Time

3.0 Hopping

3.1 Test Procedure

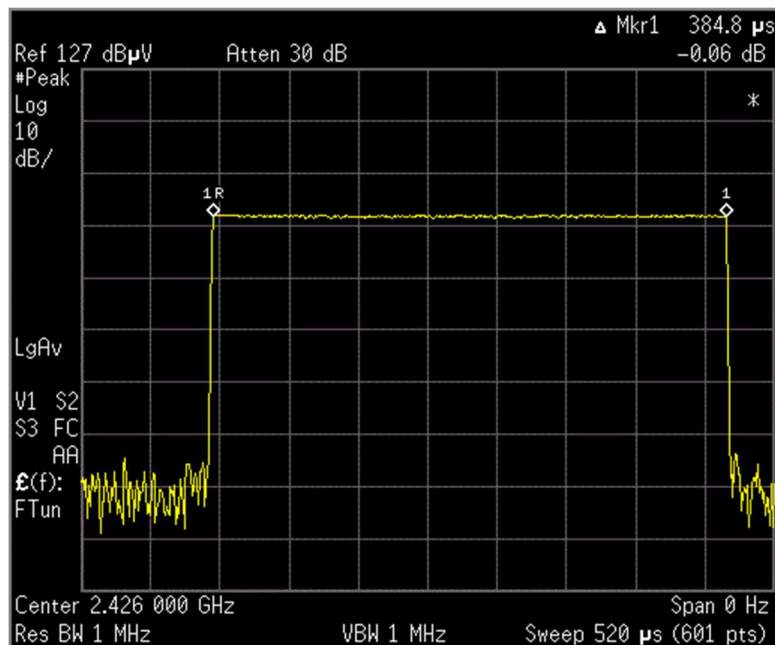
A spectrum analyzer is either connected directly to the EUT or coupled by radiated means to measure the hopping channels and timings.

3.2 Test Criteria

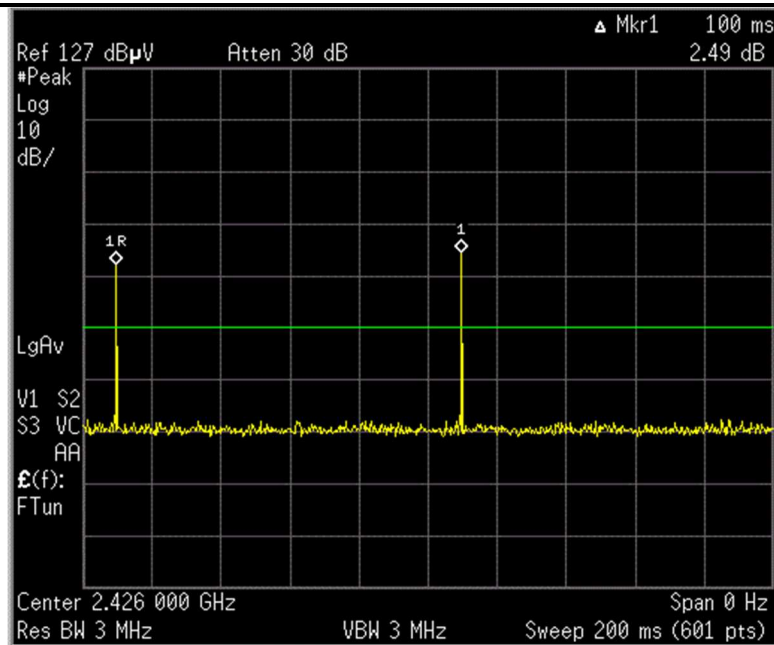
| 47 CFR (USA) // IC (Canada) | | |
|-----------------------------|--|-------------|
| Section Reference | Parameter | Date |
| 15.247 // RSS-247, 5.2 | Hopping: Return to Channel Time Transmit Time Channel Count | 12 Feb 2020 |

3.3 Test Results

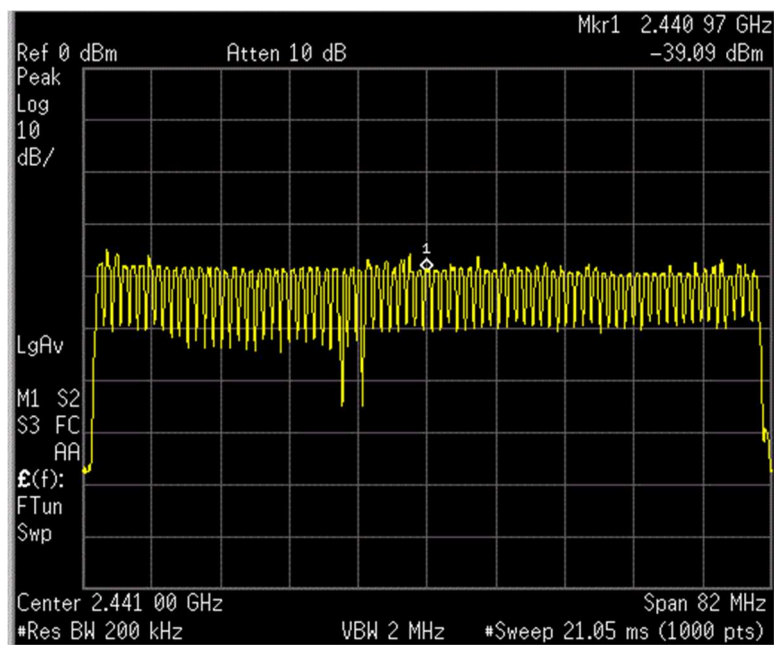
The EUT satisfied the requirements.



Transmit Event



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:

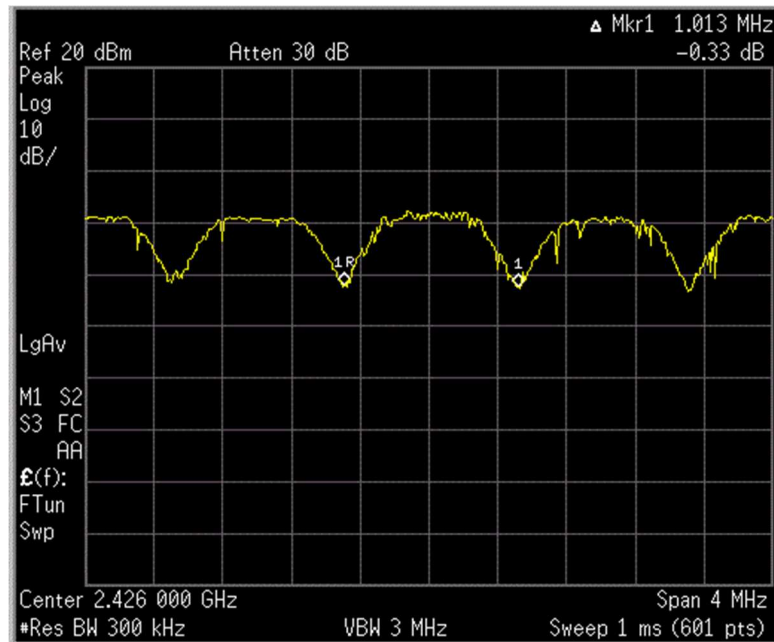
Return to channel time = 0.1 s

Number of channel transmissions in 20 s window = $(20 \text{ s} / 0.1 \text{ s}) = 200$ 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



Measured Channel Separation = 1.01 MHz

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.

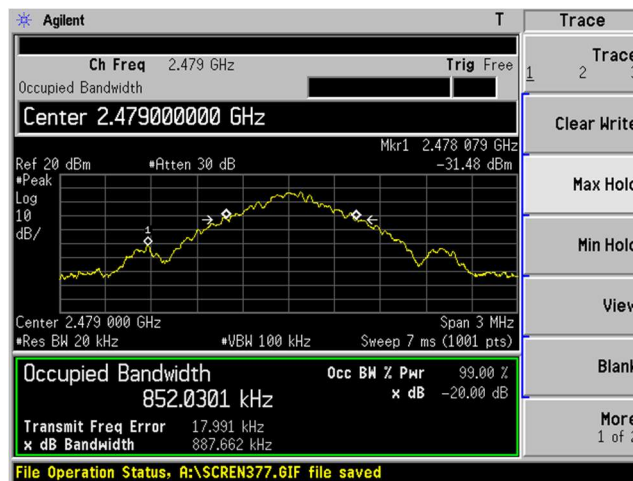
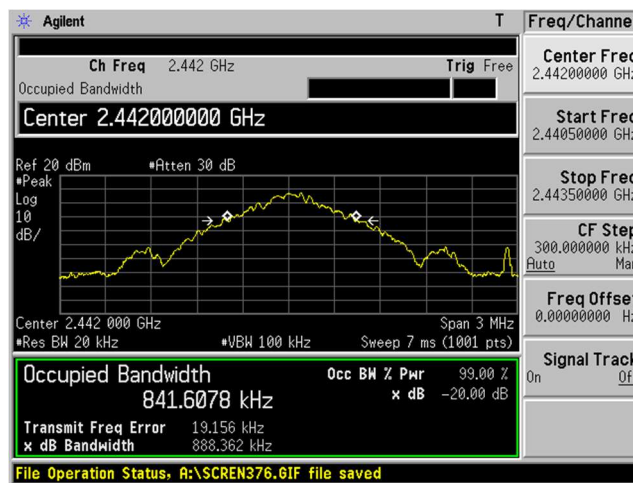
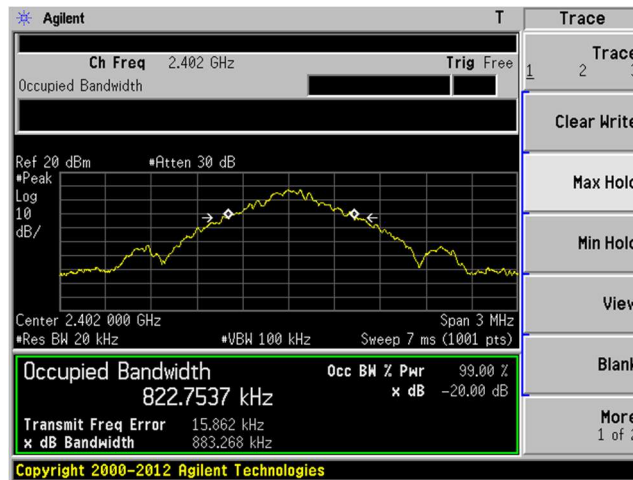
The EUT was found to be in compliance with applicable requirements.

| 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 | 888 |
| 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 | 852 |

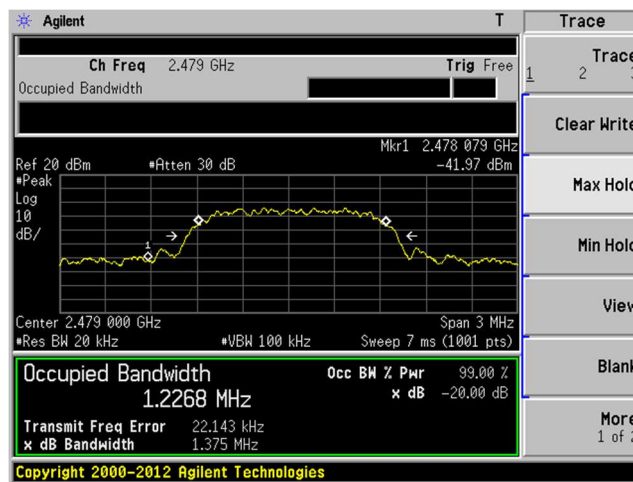
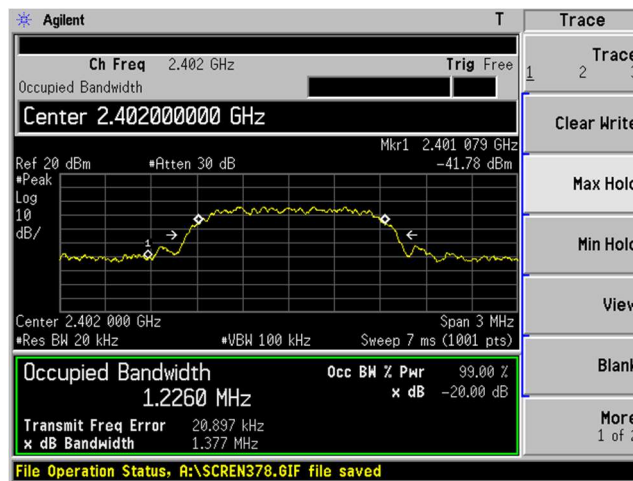
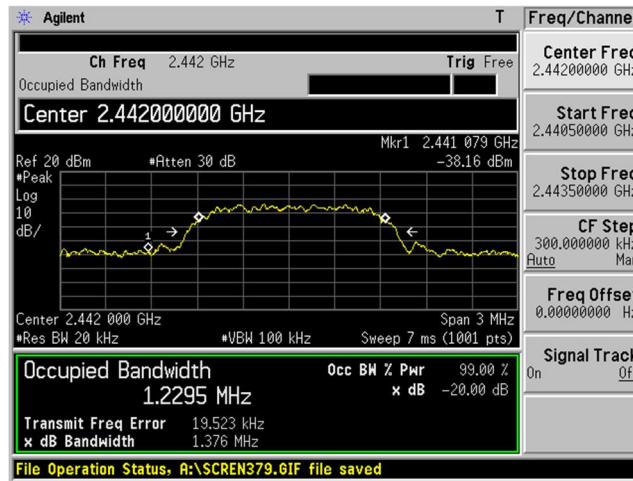
| Table 4.3.2 Modulation 2 | | | |
|-----------------------------------|-------------------------------|--------------------------------|---------------------------|
| Bandwidth 99%, Measure and Report | | | |
| Low Channel Measured BW (kHz) | Mid Channel Measured BW (kHz) | High Channel Measured BW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

| 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 | 1225 |

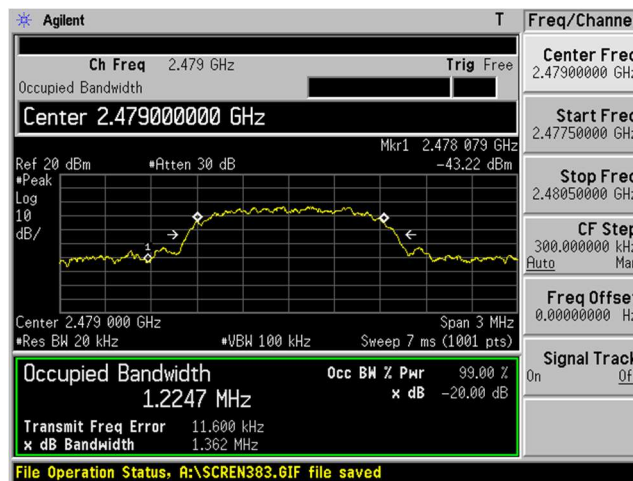
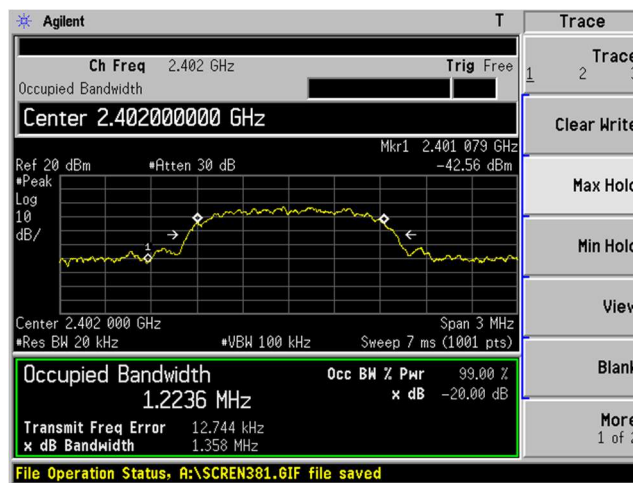
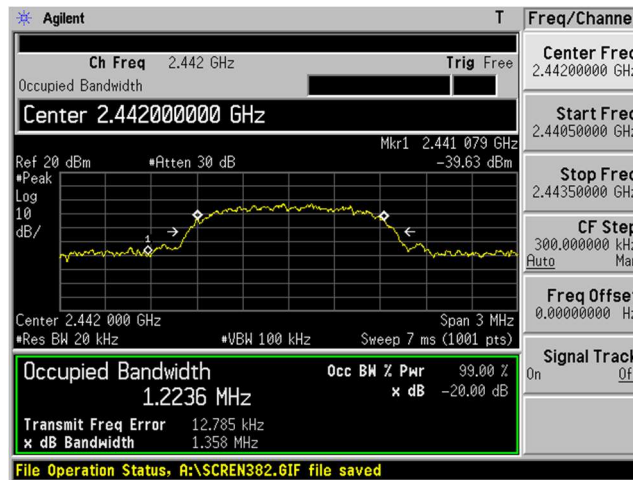
4.3.1 Bandwidth Plots, Modulation 1



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 |

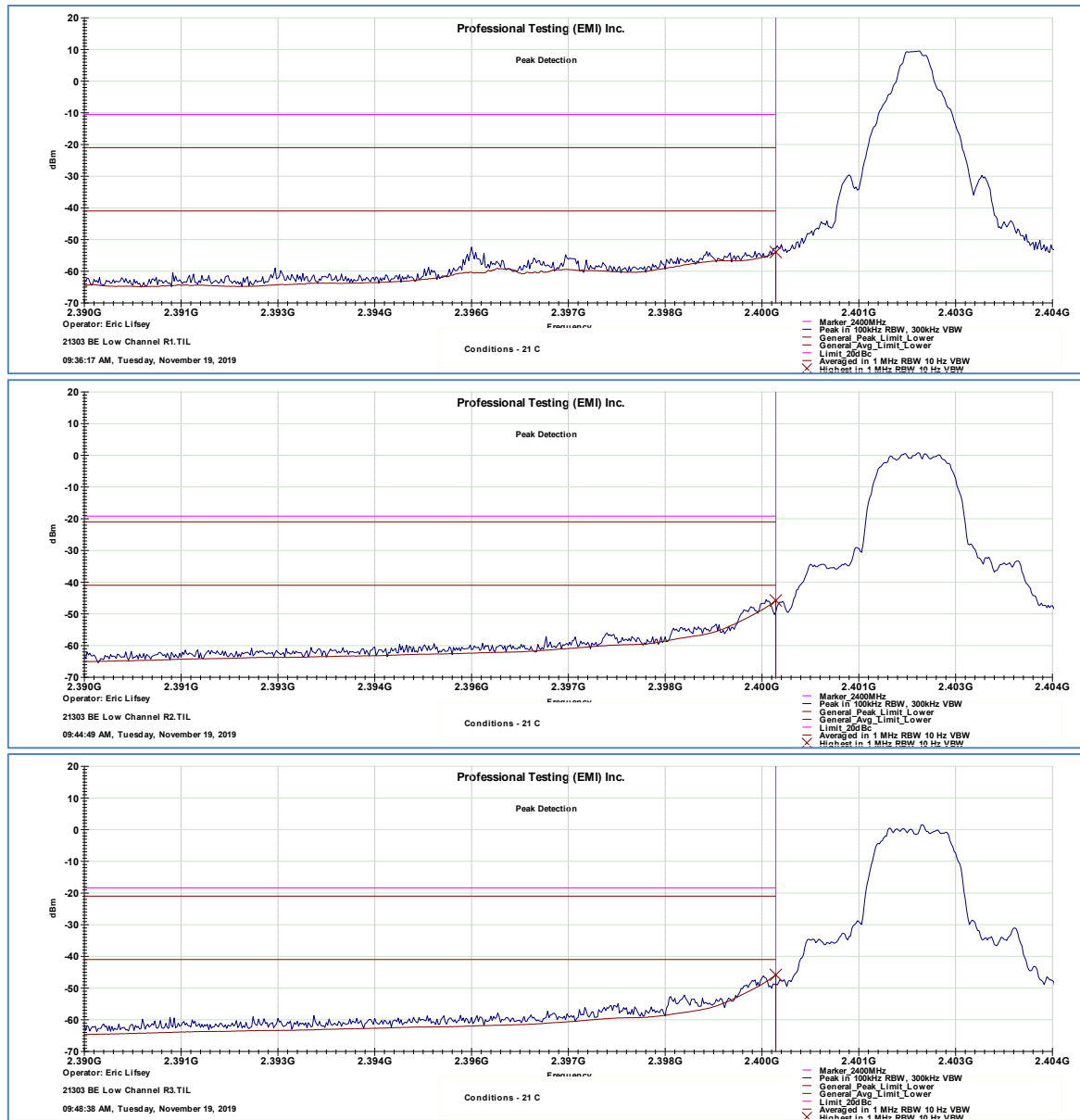
5.3 Test Results

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.

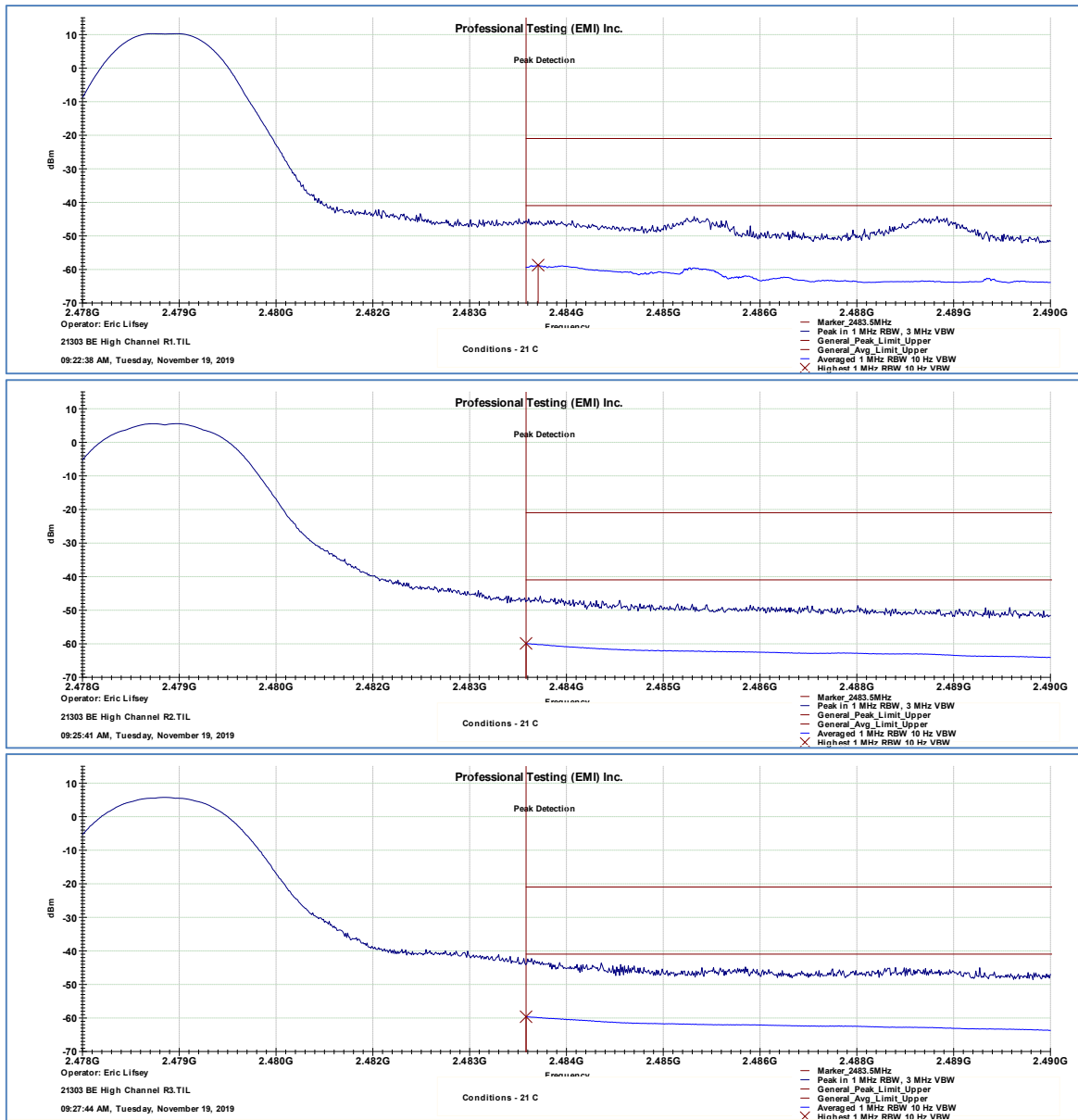
The hopping mode measurement required the use of an external Bluetooth device to stream audio to the EUT. As a result, the signal from the external device also appears on the measurement at a level only a few dB below the EUT. The EUT mainly sends acknowledgement packets so they appear as very short 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.

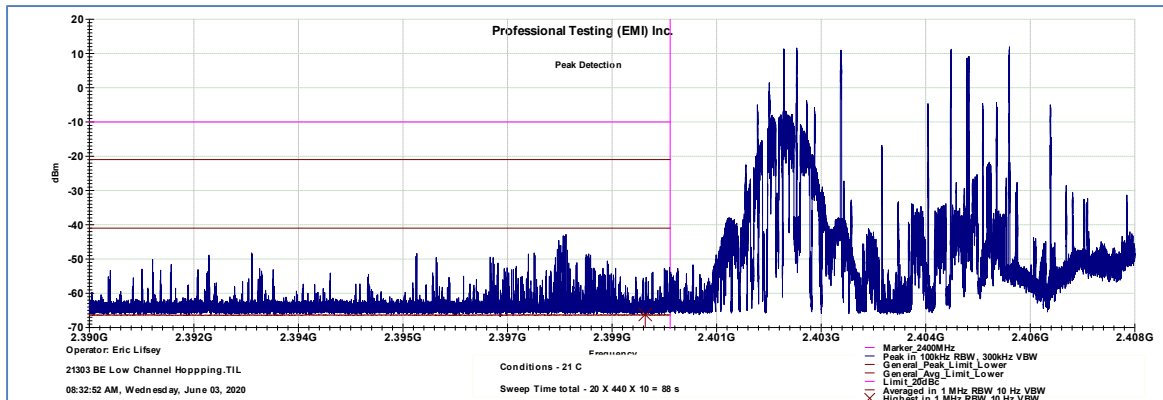
5.3.1 Bottom Channel Band Edge, 3 Modulations, Non-Hopping



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

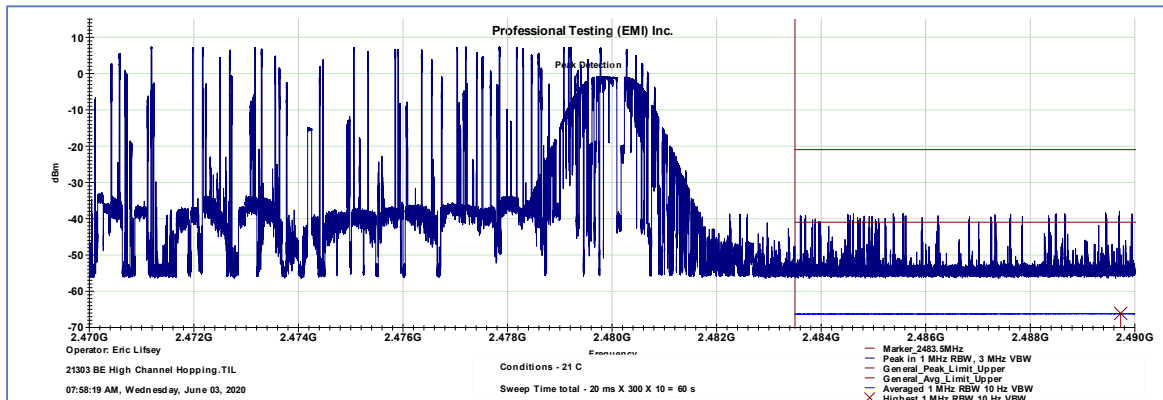


5.3.3 Bottom Channel Band Edge, Hopping



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

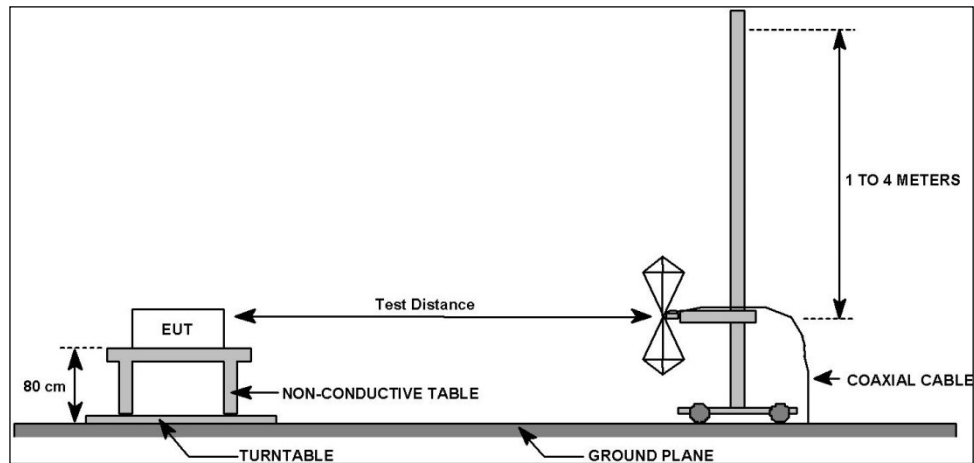


Note that the short/narrow transmissions are from the EUT while the wider transmissions were from support equipment used to stimulate the EUT.

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.

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: Vertical

Frequency Range: 30MHz to 1GHz

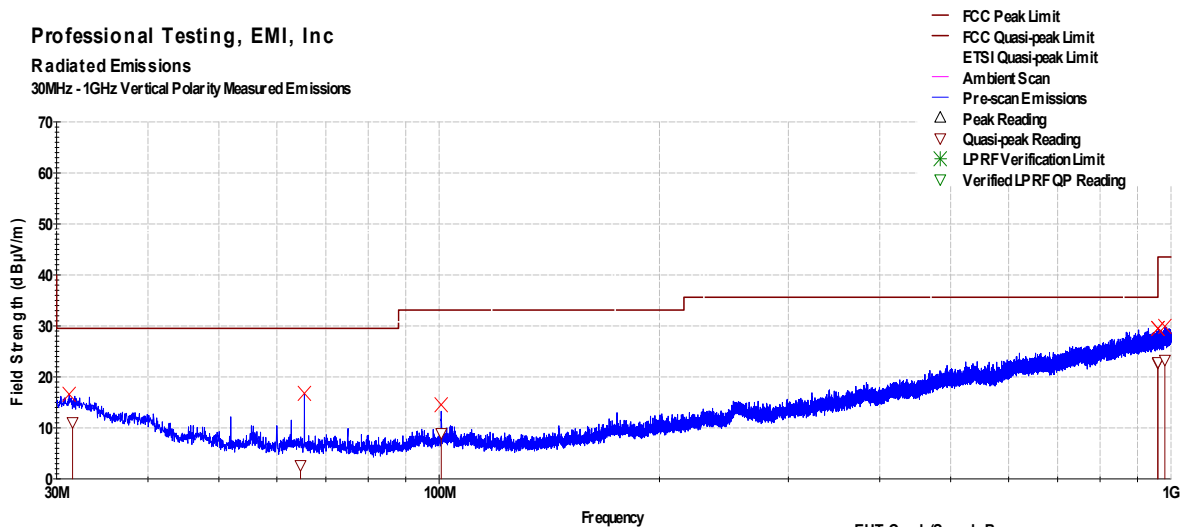
EUT Mode of Operation:

Transmit Middle Chan

| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Corrected Level (dBμV/m) | Limit Level (dBμV/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



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)

EUT: Coach (Sample B)

Project Number: 21303

Client: Swimmersive Zygo

≤ 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 Range: 30MHz to 1GHz

EUT Mode of Operation:

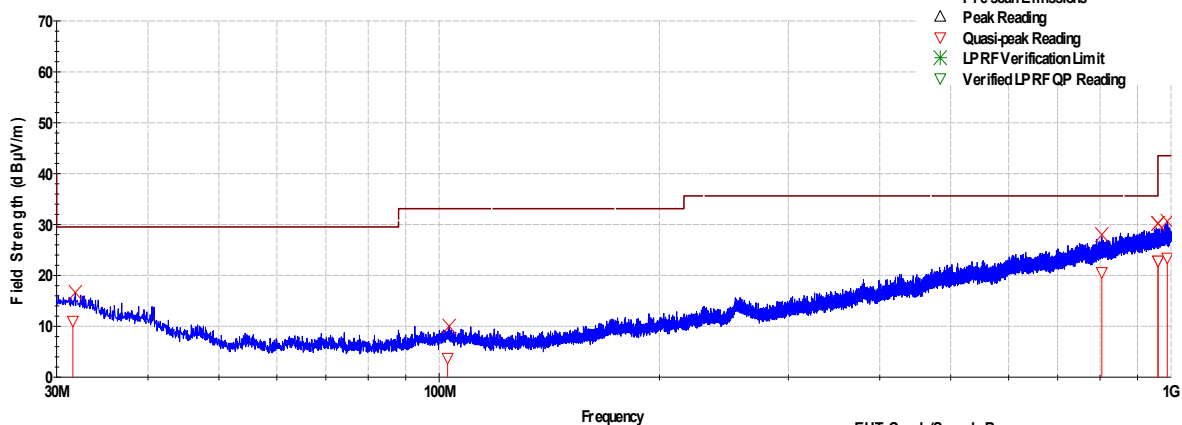
Transmit Middle Chan

| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Corrected Level (dBμV/m) | Limit Level (dBμV/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 |

Professional Testing, EMI, Inc

Radiated Emissions

30MHz - 1GHz Horizontal Polarity Measured Emissions



Operator : Eric Lifsey

Mode: TX BT; Mid Chan

EUT: Coach (Sample B)

Power: 3.7V Battery Notes: no antenna, in case

Project Number: 21303

Current Time -09:44:52 AM, Wednesday, February 05, 2020

Setup: ANSI (80+150cm)

Client: Swimmersive Zygo

≤ 1GHz Horizontal Antenna Polarity Measured Emissions

6.3.2 Bottom 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: | | Vertical | | | Frequency Range: | | 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 (dBμV/m) | Limit Level (dBμV/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 |
| <div style="display: flex; justify-content: space-between;"> <div> <p>Professional Testing, EMI, Inc</p> <p>Radiated Emissions</p> <p>1-18GHz Vertical Polarity Measured Emissions</p> </div> <div> <p>— FCC Peak Limit</p> <p>— ETSI Peak Limit</p> <p>— FCC Average Limit</p> <p>— Ambient Scan</p> <p>— Pre-scan Emissions</p> <p>△ Peak Reading</p> <p>▽ Average Reading</p> </div> </div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <div> <p>Operator: Eric Lifsey</p> <p>Current Time: 12:43:35 PM, Wednesday, February 05, 2020</p> </div> <div> <p>Mode: TX BT; Bottom Chan</p> <p>Power: 3.7V Battery Notes: no antenna, in case</p> <p>Setup: ANSI (80+150cm)</p> </div> <div> <p>EUT: Coach (Sample B)</p> <p>Project Number: 21303</p> <p>Client: Swimmersive Zygo</p> </div> </div> | | | | | | | | |
| > 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 Range: Above 1GHz

EUT Mode of Operation:

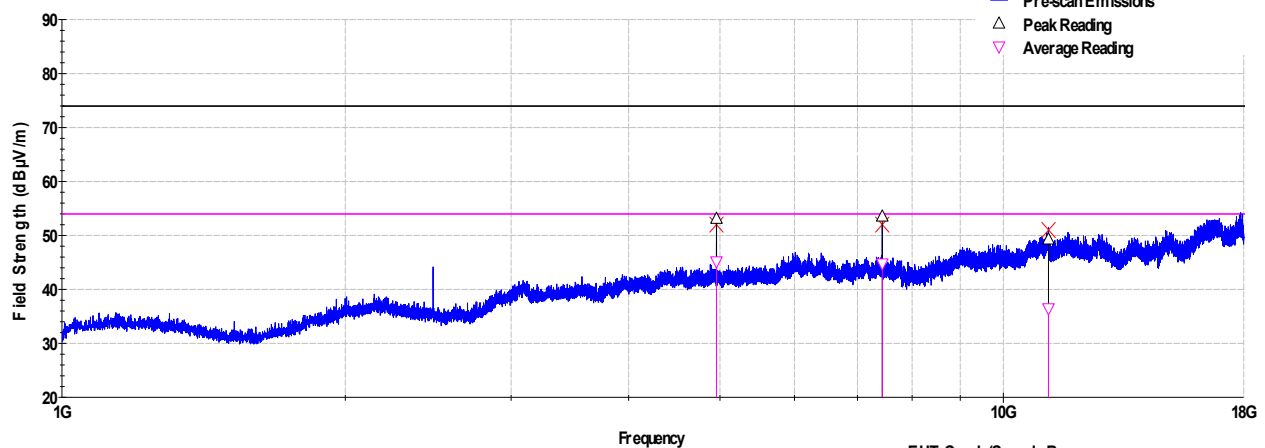
Transmit Bottom Chan

| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Corrected Level (dBμV/m) | Limit Level (dBμV/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



Operator: Eric Lifsey

Mode: TX BT; Bottom Chan

EUT: Coach (Sample B)

Current Time -12:51:56 PM, Wednesday, February 05, 2020

Power: 3.7V Battery Notes: no antenna, in case

Project Number: 21303

Setup: ANSI (80+150cm)

Client: Swimmersive Zygo

> 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: Vertical

Frequency Range: Above 1GHz

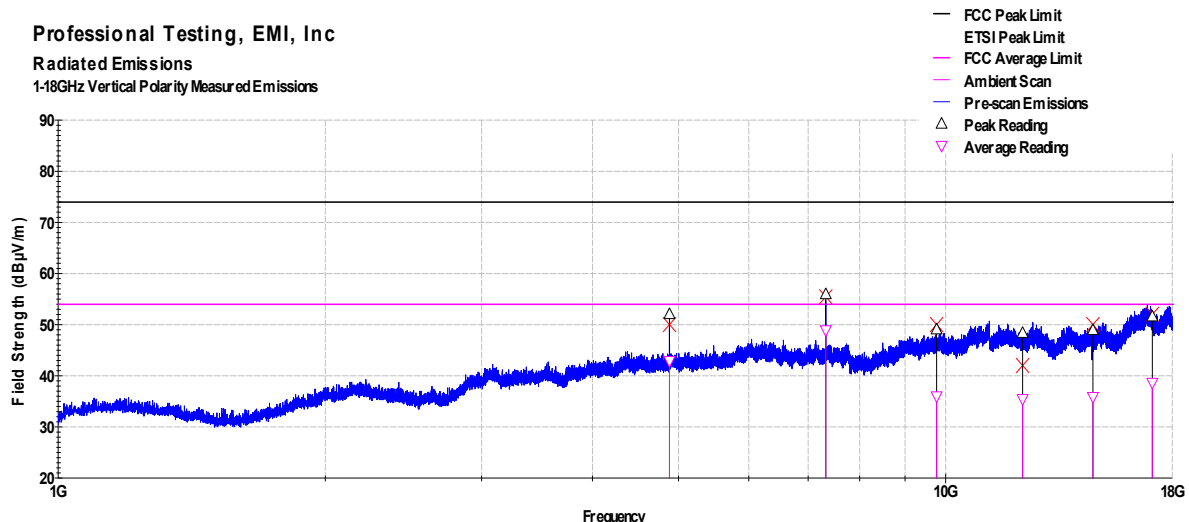
EUT Mode of Operation:

Transmit Middle Chan

| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Corrected Level (dBμV/m) | Limit Level (dBμV/m) | Margin (dB) | Test Results |
|--------------------------|------------------------|-------------------------|-------------------------|-------------------|--------------------------|----------------------|-------------|--------------|
| 4884.12 | 3 | 269 | 1.02 | Peak | 52.043 | 74.0 | -21.9 | Pass |
| 7325.99 | 3 | 150 | 1.65 | Peak | 55.926 | 74.0 | -18.0 | Pass |
| 9768.02 | 3 | 53 | 1.51 | Peak | 49.053 | 74.0 | -24.9 | Pass |
| 12208.93 | 3 | 86 | 1.38 | Peak | 48.363 | 74.0 | -25.6 | Pass |
| 14653.69 | 3 | 160 | 2.68 | Peak | 48.91 | 74.0 | -25.0 | Pass |
| 17095.25 | 3 | 3 | 2.46 | Peak | 51.581 | 74.0 | -22.4 | Pass |

Professional Testing, EMI, Inc.

Radiated Emissions
1-18GHz Vertical Polarity Measured Emissions



Operator: Eric Lifsey

Mode: TX BT; Mid Chan

EUT: Coach (Sample B)

Current Time: 11:52:54 AM, Wednesday, February 05, 2020

Power: 3.7V Battery Notes: no antenna, in case

Project Number: 21303

Setup: ANSI (80x150cm)

Client: Swimmersive Zygo

> 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 Range: Above 1GHz

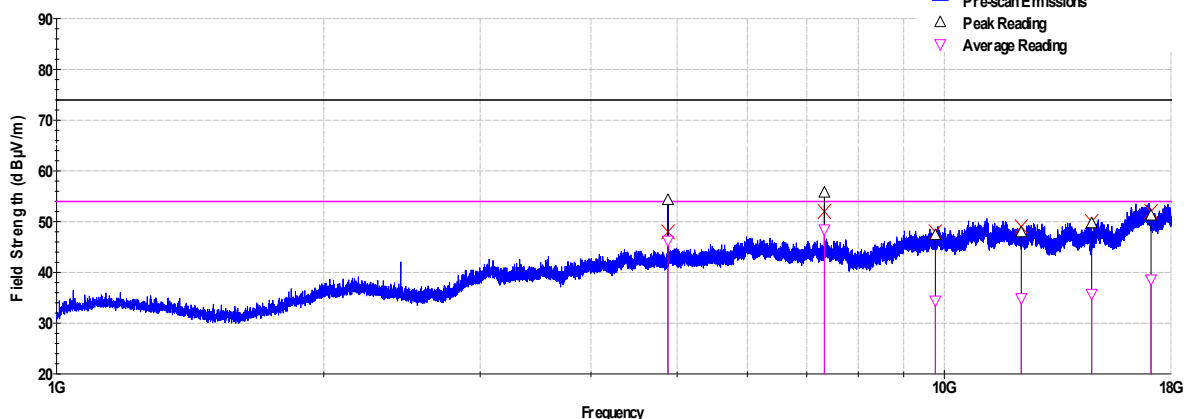
EUT Mode of Operation:

Transmit Middle Chan

| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Corrected Level (dBμV/m) | Limit Level (dBμV/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 |

Professional Testing, EMI, Inc

Radiated Emissions
1-18GHz Horizontal Polarity Measured Emissions



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
Setup: ANSI (80+150cm)

Project Number: 21303

Client: Swimmersive Zygo

> 1GHz Horizontal Antenna Polarity Measured Emissions

6.3.4 Top 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: Vertical

Frequency Range: Above 1GHz

EUT Mode of Operation:

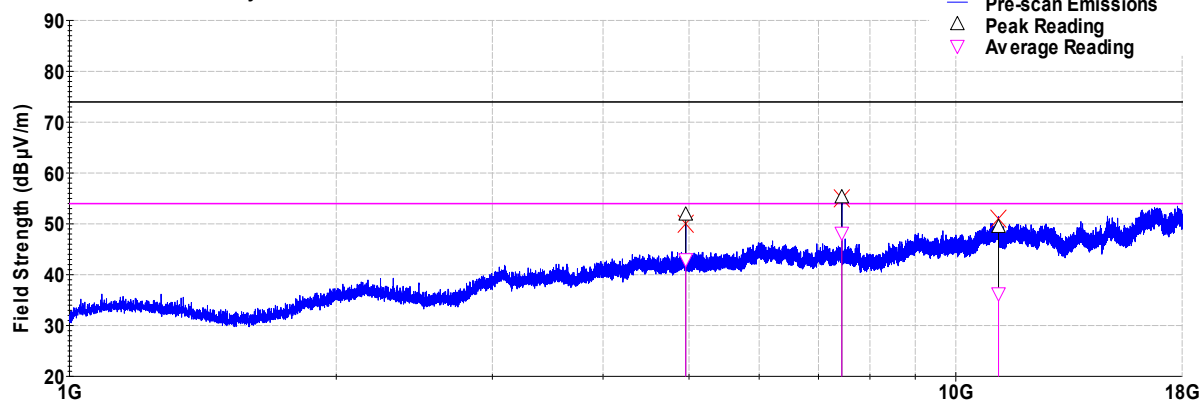
Transmit Middle Chan

| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Corrected Level (dBμV/m) | Limit Level (dBμV/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

Radiated Emissions

1-18GHz Vertical Polarity Measured Emissions



Operator: Eric Lifsey

Mode: TX BT; Top Chan

EUT: Coach (Sample B)

Current Time -12:43:35 PM, Wednesday, February 05, 2020

Power: 3.7V Battery

Project Number: 21303

Setup: ANSI (80+150cm)

Client: Swimmersive Zygo

> 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 Range: Above 1GHz

EUT Mode of Operation:

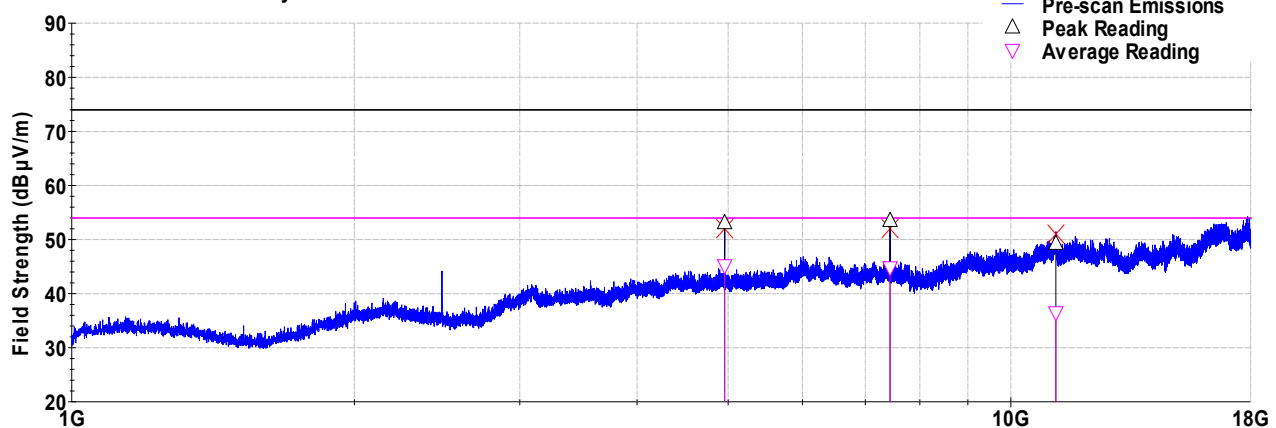
Transmit Middle Chan

| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Corrected Level (dBμV/m) | Limit Level (dBμV/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



Operator: Eric Lifsey

Mode: TX BT; Top Chan

EUT: Coach (Sample B)

Current Time -12:51:56 PM, Wednesday, February 05, 2020

Power: 3.7V Battery

Project Number: 21303

Setup: ANSI (80+150cm)

Notes: no antenna, in case

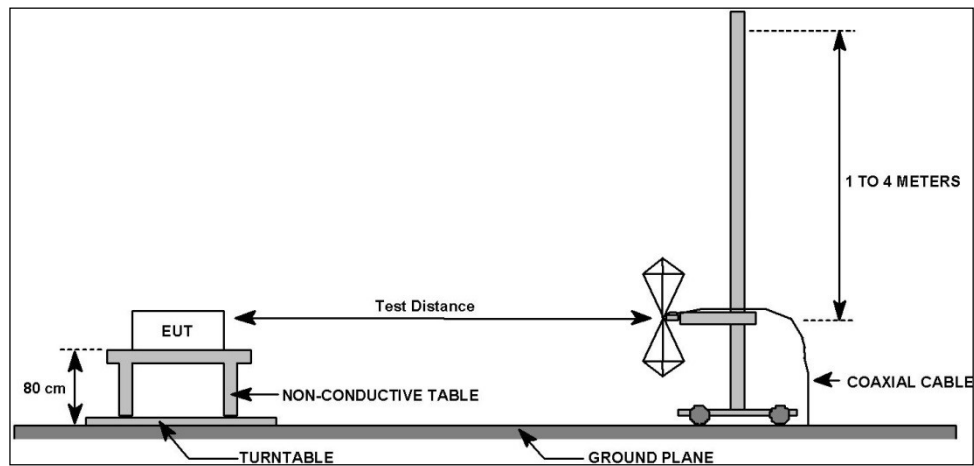
Client: Swimmersive Zygo

> 1GHz Horizontal Antenna Polarity Measured Emissions

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.

| | | | |
|---------------------|---|------------------|--------------|
| Test Method: | 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 | | |
| In accordance with: | FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits | | |
| Section: | 15.109 | | |
| Test Date(s): | 11/20/2019 | EUT Serial #: | 165 |
| Customer: | Zygo | EUT Part #: | 0 |
| Project Number: | 21303-15 | Test Technician: | Eric Lifsey |
| Purchase Order #: | 0 | Supervisor: | Shakil Murad |
| Equip. Under Test: | Coach | Witness' Name: | None |

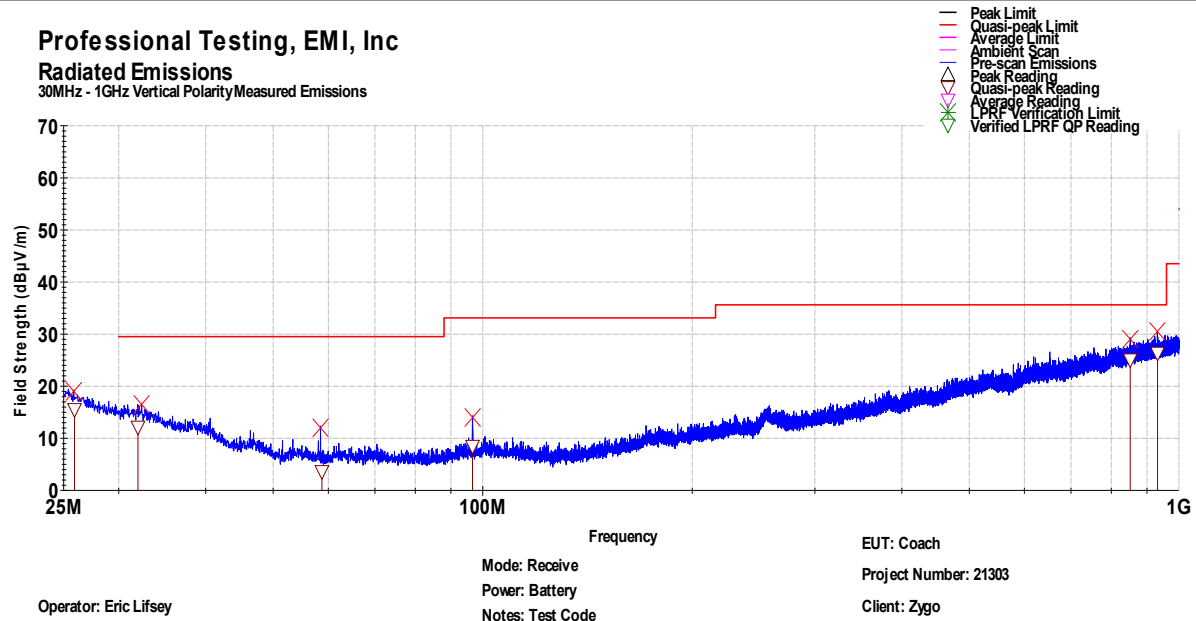
Radiated Emissions Test Results Data Sheet

| | | | | | | | | | |
|--------------------------|------------------------|-------------------------|-------------------------|-------------------|--------------------------|----------------------|---------------|--------------|-----|
| EUT Line Voltage: | | 3.7 | | VDC | EUT Power | | 0 | | N/A |
| Antenna Orientation: | | Vertical | | | Frequency Range: | | 30MHz to 1GHz | | |
| EUT Mode of Operation: | | | | | Receive | | | | |
| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Corrected Level (dBμV/m) | Limit Level (dBμV/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 | |
| | | | | | | | | | |

Professional Testing, EMI, Inc.

Radiated Emissions

30MHz - 1GHz Vertical Polarity Measured Emissions



≤ 1GHz Vertical Antenna Polarity Measured Emissions

Professional Testing, EMI, Inc.

| | | | |
|----------------------------|---|-------------------------|--------------|
| Test Method: | 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 | | |
| In accordance with: | FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits | | |
| Section: | 15.109 | | |
| Test Date(s): | 11/20/2019 | EUT Serial #: | 165 |
| Customer: | Zygo | EUT Part #: | 0 |
| Project Number: | 21303-15 | Test Technician: | Eric Lifsey |
| Purchase Order #: | 0 | Supervisor: | Shakil Murad |
| Equip. Under Test: | Coach | Witness' Name: | None |

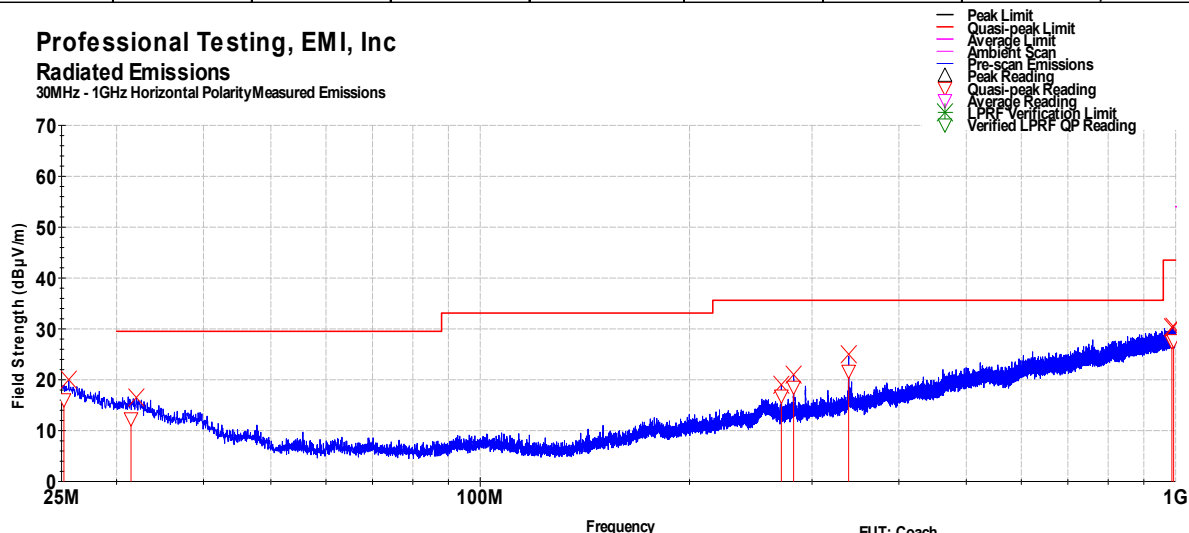
Radiated Emissions Test Results Data Sheet

| | | | | | | | | |
|--------------------------|------------------------|-------------------------|-------------------------|-------------------|--------------------------|----------------------|---------------|--------------|
| EUT Line Voltage: | | 3.7 VDC | | | EUT Power | | 0 N/A | |
| Antenna Orientation: | | Horizontal | | | Frequency Range: | | 30MHz to 1GHz | |
| EUT Mode of Operation: | | | | | Receive | | | |
| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Corrected Level (dBμV/m) | Limit Level (dBμV/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 |
| | | | | | | | | |

Professional Testing, EMI, Inc

Radiated Emissions

30MHz - 1GHz Horizontal Polarity Measured Emissions



Operator: Eric Lifsey

Mode: Receive
Power: Battery
Notes: Test Code

EUT: Coach
Project Number: 21303
Client: Zygo

≤ 1GHz Horizontal Antenna Polarity Measured Emissions

7.3.2 Up to 13 GHz

Professional Testing, EMI, Inc.

| | | | |
|----------------------------|---|-------------------------|--------------|
| Test Method: | 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 | | |
| In accordance with: | FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits | | |
| Section: | 15.109 | | |
| Test Date(s): | 11/20/2019 | EUT Serial #: | 165 |
| Customer: | Zygo | EUT Part #: | 0 |
| Project Number: | 21303-15 | Test Technician: | Eric Lifsey |
| Purchase Order #: | 0 | Supervisor: | Shakil Murad |
| Equip. Under Test: | Coach | Witness' Name: | None |

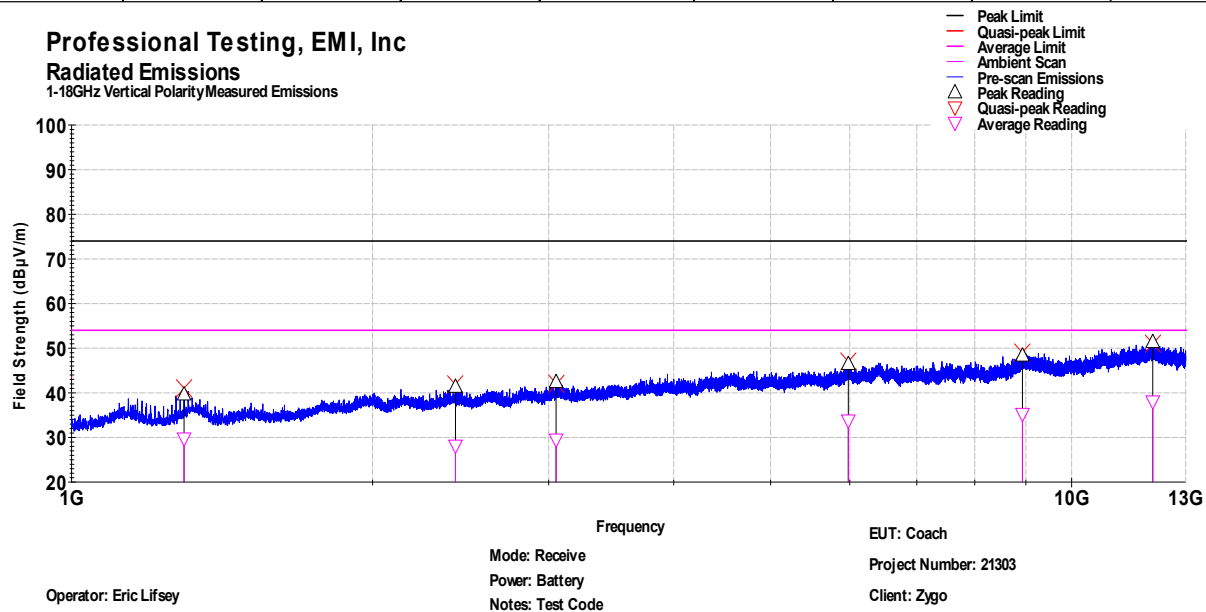
Radiated Emissions Test Results Data Sheet

| | | | | | | | | |
|-------------------------------|------------------------|-------------------------|-------------------------|-------------------|-----------------------------|----------------------|-------------|--------------|
| EUT Line Voltage: 3.7 VDC | | | | | EUT Power Frequency: 0 | | N/A | |
| Antenna Orientation: Vertical | | | | | Frequency Range: Above 1GHz | | | |
| EUT Mode of Operation: | | | | | Receive | | | |
| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Corrected Level (dBμV/m) | Limit Level (dBμV/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 |
| | | | | | | | | |

Professional Testing, EMI, Inc

Radiated Emissions

1-18GHz Vertical Polarity Measured Emissions



> 1GHz Vertical Antenna Polarity Measured Emissions

Professional Testing, EMI, Inc.

| | | | |
|----------------------------|---|-------------------------|--------------|
| Test Method: | 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 | | |
| In accordance with: | FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits | | |
| Section: | 15.109 | | |
| Test Date(s): | 11/20/2019 | EUT Serial #: | 165 |
| Customer: | Zygo | EUT Part #: | 0 |
| Project Number: | 21303-15 | Test Technician: | Eric Lifsey |
| Purchase Order #: | 0 | Supervisor: | Shakil Murad |
| Equip. Under Test: | Coach | Witness' Name: | None |

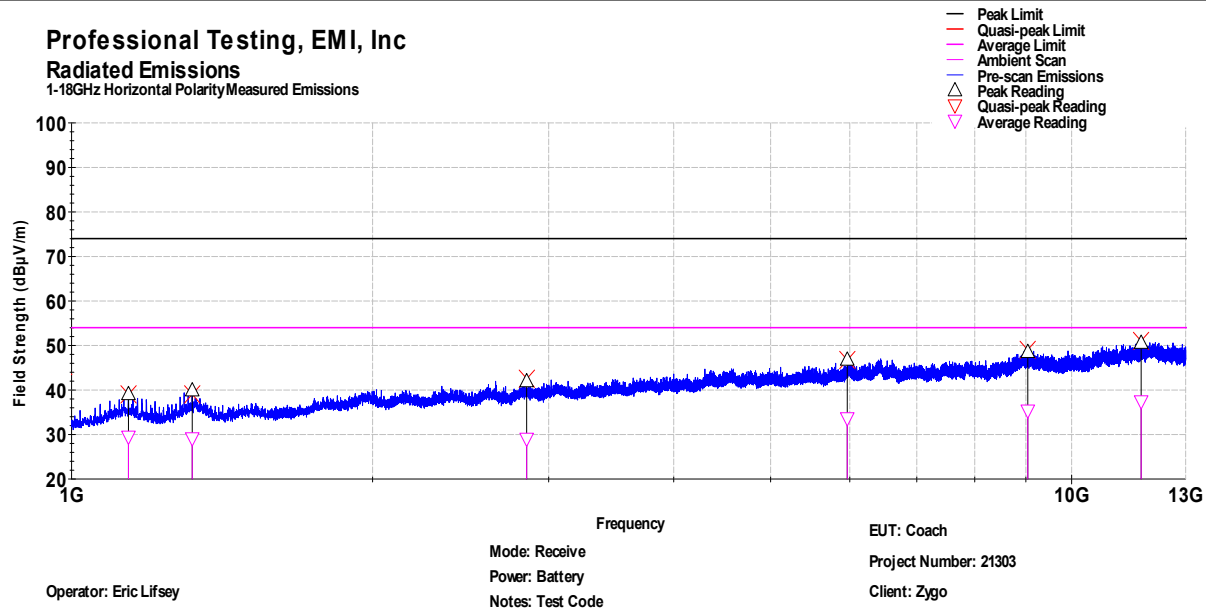
Radiated Emissions Test Results Data Sheet

| | | | | | | | | |
|--------------------------|------------------------|-------------------------|-------------------------|-------------------|--------------------------|----------------------|-------------|--------------|
| EUT Line Voltage: | | 3.7 VDC | | | EUT Power Frequency: | | 0 N/A | |
| Antenna Orientation: | | Horizontal | | | Frequency Range: | | Above 1GHz | |
| EUT Mode of Operation: | | | | | Receive | | | |
| Frequency Measured (MHz) | Test Distance (Meters) | EUT Direction (Degrees) | Antenna Height (Meters) | Detector Function | Corrected Level (dBμV/m) | Limit Level (dBμV/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 |
| | | | | | | | | |

Professional Testing, EMI, Inc

Radiated Emissions

1-18GHz Horizontal Polarity Measured Emissions



> 1GHz Horizontal Antenna Polarity Measured Emissions

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 |
|---|
| <p>Manufacturer: Swimmersive</p> <p>Part Number: N/A</p> <p>Type: Printed circuit, monopole inverted-F with slight curvature.</p> <p>Gain: -0.52 dBi peak</p> <p>Construction: No connector provided. Antenna is internal to device and not subject to user modification.</p> |

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