Washington Laboratories, Ltd.

FCC Certification Test Report
for the
ReconRobotics OPERATOR CONTROL UNIT 3
FCC ID: UYXRSK2020-01

WLL REPORT# 16417-01 Rev 3
March 2020

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Prepared by:

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Reviewed by:

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Abstract

This report has been prepared on behalf of ReconRobotics to support the attached Application for Equipment Authorization. The test report and application are submitted for a Radio Control Radio Service under Part 95 of the Federal Communications Commission.

Testing was performed at Washington Laboratories, Ltd, 4340 Winchester Boulevard, Frederick, MD. These tests are accredited and meet the requirements of ISO/IEC 17025 as verified by the ANAB-ACLASS. Refer to certificate and scope of accreditation AT-1448.

Revision History	Reason	Date
Rev 0	Initial Release	March 9, 2020
Rev 1	Address comments	March 27, 2020
Rev 2	Address comments	April 13, 2020
Rev 3	Address mask	April 17, 2020

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1 Introduction

1.1 Compliance Statement

The Recon Scout Operator Control Unit OCU3 complied with the requirements of Parts 95 of the FCC Rules and Regulations (2/2020).

1.2 Test Standard

ANSI C63.26-2015 American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services.

1.3 Contract Information

Purchase Order Number:	8923-1
Quotation Number:	71806B

1.4 Test Dates

Testing was performed on the following date(s):	27-28 February 2020

1.5 Test and Support Personnel

Washington Laboratories, Ltd.	John Repella, Michael Violette
Client Representative	Collin LaFave

1.6 EUT Identification

The results obtained relate only to the item(s) tested.

Table 1: Overview of Equipment Under Test

ITEM	DESCRIPTION
Manufacturer:	ReconRobotics
EUT Name	Recon Scout Operator Control Unit OCU3
FCC ID:	UYXRSK2020-01
FCC Rule Parts:	Part 95C
Frequency Range:	75 MHz Command Transmitter: 75.41 ~ 75.99 MHz
Measured Output Power:	0.5W
Modulation:	FM
Emission Bandwidth:	2.877kHz
Keying:	Automatic
Type of Information:	Control Signals
Channels:	75.41, 75.43, 75.45, 75.47, 75.49, 75.51, 75.53, 75.55, 75.57, 75.59, 75.61, 75.63, 75.65, 75.67, 75.69, 75.71, 75.73, 75.75, 75.77, 75.79, 75.81, 75.83, 75.85, 75.87, 75.89, 75.91, 75.93, 75.95, 75.97, and 75.99 MHz
Antenna Connector	N/A
Antenna Type	¼ Wave Monopole
Antenna Gain	-1.15dB
Frequency Tolerance:	<0.002%
Emission Designator:	2K9F01
Interface Cables:	Video Out, Headphones, Battery
Power Source & Voltage:	12VDC

The Recon Scout Operator Control Unit (OCU3) receives video and audio information from the Recon Scout robot and displays that video on a TFT LCD screen on the controller.

The Payload Module is an 802.15.4 protocol radio module that is used to send commands between the controller and the robot. The commands can be used to trigger a response from the robot, such as a ‘flashbang’ or stun grenade. The module will be used in both the controller and in the robot.

1.7 EUT Description

The Recon Scout Operator Control Unit (OCU3) receives video and audio information Recon Scout robot and displays that video on a TFT LCD screen. The OCU sends motion commands to the Recon Scout robot via a 75MHz R/C radio transmitter operating on one of 30 channels between 75.41MHz and 75.99MHz (as specified by Section 95.623) which uses a final-stage power amplifier powered by 5V at 200mA to transmit through a quarter-wave helical monopole antenna with a gain of -1.15dBd.

The unit employs a 2.4GHz radio as a Limited Modular Approval FCC ID: UYXRSK2020-02.

The Recon Scout robot is a surveillance robotic device meant to be deployed into settings where useful real time remote information can be transmitted from hazardous locations thereby improving the safety of personnel.

1.8 Test Configuration

The EUT was configured at normal operating power.

1.9 Equipment Configuration

The EUT was comprised of the following equipment. (All Modules, PCBs, etc. listed were considered as part of the EUT, as tested.)

Table 2: Equipment Configuration

Name / Description	Model Number	Part Number	Serial Number	Rev. #
Analog Communications Module (Internal to device)	R001742	NA	NA	Ap2
Payload Module (Internal to device)	R001803	NA	Various MAC addresses	Ap2
COTS Headphones				
Video out cable	R001055		NA	

1.10 Support Equipment

The following support equipment was used during testing:

Table 3: Support Equipment

Item	Model/Part Number	Serial Number
None	----	----

1.11 Interface Cables

Video, COTS earphones.

1.12 EUT Modifications

None

1.13 Test Location

All measurements herein were performed at Washington Laboratories, Ltd. test center in Frederick, MD. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Certificate AT-1448 as an independent FCC test laboratory.

1.14 Measurement Uncertainty

All results reported herein relate only to the equipment tested. The basis for uncertainty calculation uses ANSI/NCSL Z540-2-1997 with a type B evaluation of the standard uncertainty. Elements contributing to the standard uncertainty are combined using the method described in
Equation 1 to arrive at the total standard uncertainty. The standard uncertainty is multiplied by the coverage factor to determine the expanded uncertainty which is generally accepted for use in commercial, industrial, and regulatory applications and when health and safety are concerned (see Equation 2). A coverage factor was selected to yield a 95% confidence in the uncertainty estimation.

Equation 1: Standard Uncertainty

$$u_c = \pm \sqrt{\frac{a^2}{div_a^2} + \frac{b^2}{div_b^2} + \frac{c^2}{div_c^2} + \ldots\ldots}$$

where u_c = standard uncertainty
a, b, c,.. = individual uncertainty elements
$div_{a, b, c}$ = the individual uncertainty element divisor based on the probability distribution
divisor = 1.732 for rectangular distribution
divisor = 2 for normal distribution
divisor = 1.414 for trapezoid distribution

Equation 2: Expanded Uncertainty

$$U = k u_c$$

where U = expanded uncertainty
k = coverage factor
$k \leq 2$ for 95% coverage (ANSI/NCSL Z540-2 Annex G)
u_c = standard uncertainty

The measurement uncertainty complies with the maximum allowed uncertainty from CISPR 16-4-2. Measurement uncertainty is not used to adjust the measurements to determine compliance. The expanded uncertainty values for the various scopes in the WLL accreditation are provided in Table 4 below.

Table 4: Expanded Uncertainty List

Scope	Standard(s)	Expanded Uncertainty
Conducted Emissions	FCC Part 15	2.63 dB
Radiated Emissions	FCC Part 15	4.55 dB

2 Test Equipment

Asset #	Manufacturer/Model	Description	Cal. Due
528	AGILENT E4446A	SPECTRUM ANALYZER	02/21/2021
859	TEKTRONIX TBS1102B	OSCILLOSCOPE	09/24/2020
599	TENNEY	TEMPERATURE CHAMBER	10/7/2020
NA	KEYSIGHT MXA	SPECTRUM ANALYZER	6/21/2020
00382	SUNOL SCIENCES CORPORATION	JB1	3/21/2020
00823	AGILENT	N9010A	3/21/2020
00558	HP	8447D	4/3/2020
00075	HP	8648C	3/23/2020
00644	SUNOL SCIENCES CORPORATION	JB1	4/16/2020

3 RCRS Requirements

§95.703 Definitions, RCRS. *Radio Control Radio Service (RCRS).* A non-commercial short-distance radio service for wirelessly controlling the operation of devices, including, but not limited to, model vehicles such as aircraft and surface craft. Complies.

§95.731 Permissible RCRS use. (2) RCRS channels in the 75 MHz frequency band may be used only to control and operate model surface craft. Complies.

§95.741 RCRS antenna height limit. Complies.

§95.745 Operation of an RCRS transmitter by remote control. Complies.

§95.757 Duration of RCRS Communications. Complies.

§95.761 RCRS transmitter certification. Complies.

§95.763 RCRS channel frequencies. Complies.

§95.765 RCRS frequency accuracy. Complies.

§95.767 RCRS transmitter power. Complies.

§95.771 RCRS emission types. Complies.

§95.773 RCRS authorized bandwidth. Complies.

§95.779 RCRS unwanted emissions. Complies

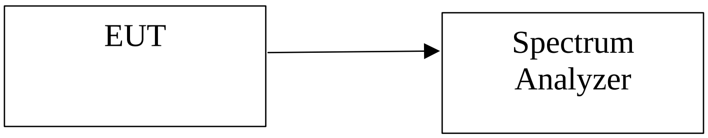
Test	Regulation	Measurement standard	Result
RF Output Power	Part 2.1046, Part 95.767	ANSI C63.26	Complies
RCRS Occupied Bandwidth	Part 2.1047, 95.773	ANSI C63.26	Complies
Emission Mask	Part 2.1049, Part 95.771	ANSI C63.26	Complies
Conducted Spurious Emissions (Antenna Terminal)	Part 2.1051	ANSI C63.26	Complies
Frequency Accuracy	Part 2.1055, 95.765	ANSI C63.26	Complies
Radiated spurious emissions (Cabinet radiation)	Part 2.1053	ANSI C63.26	Complies

3.1 Output Power Part 2.1046, Part 95.767

3.1.1 Test Method

To measure the total power the output of the transmitter was connected to the input of a spectrum analyzer.

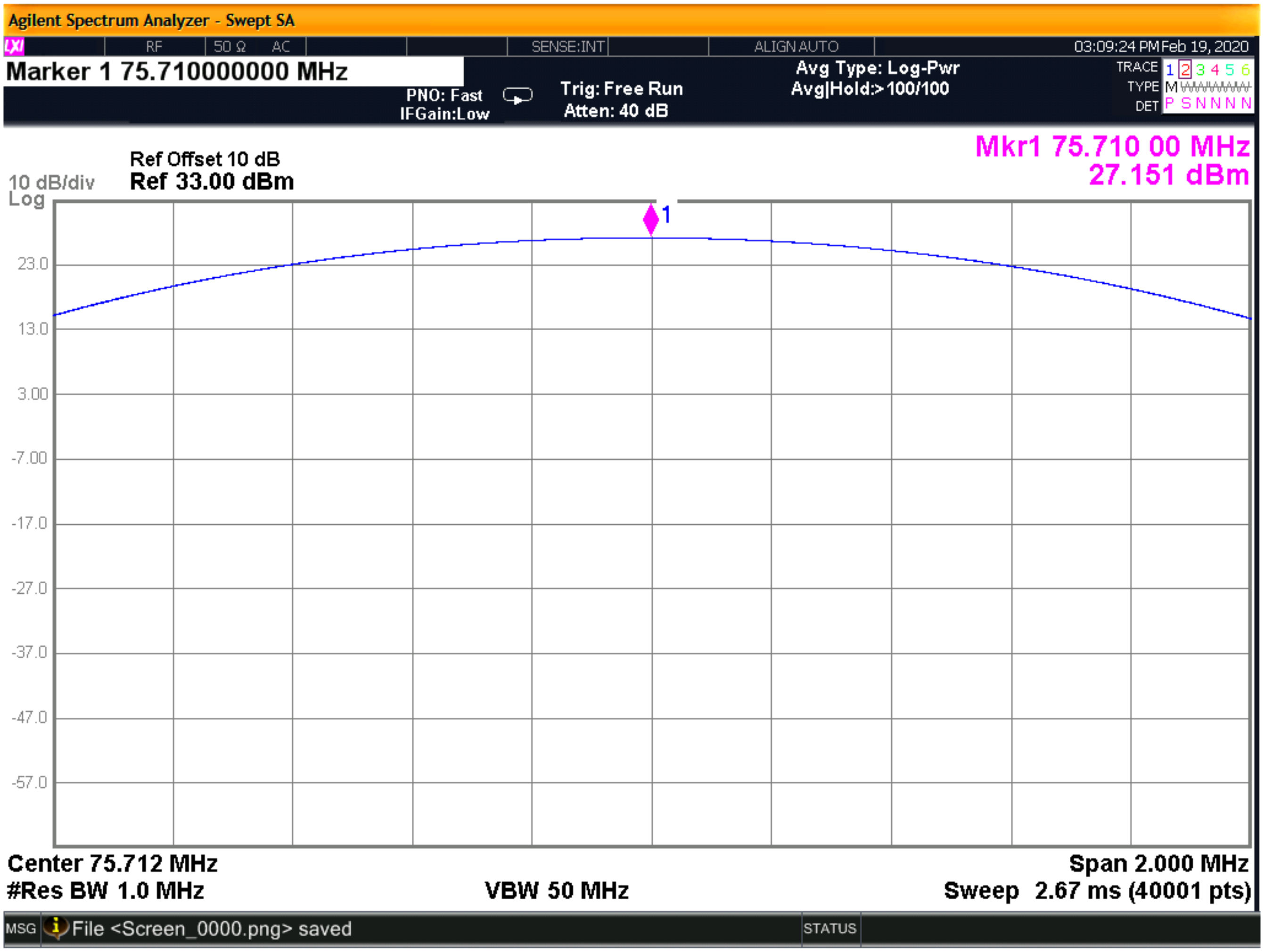
Figure 1. Test Setup Conducted Power Measurements



3.1.2 Test Results

Frequency MHz	Power Watts
75.71	0.50

Figure 2. Output Power



3.2 Emission Mask, Part 2.1049, Part 95

§95.773 RCRS authorized bandwidth.

Each RCRS transmitter type must be designed such that the occupied bandwidth does not exceed 8 kHz for any emission type.

3.2.1 Test Method

The transmitter was modulated with its normal signal. The RF output was connected to the input of a spectrum analyzer.

3.2.2 Test Result

The following figure shows the occupied bandwidth.

Figure 3. Occupied Bandwidth

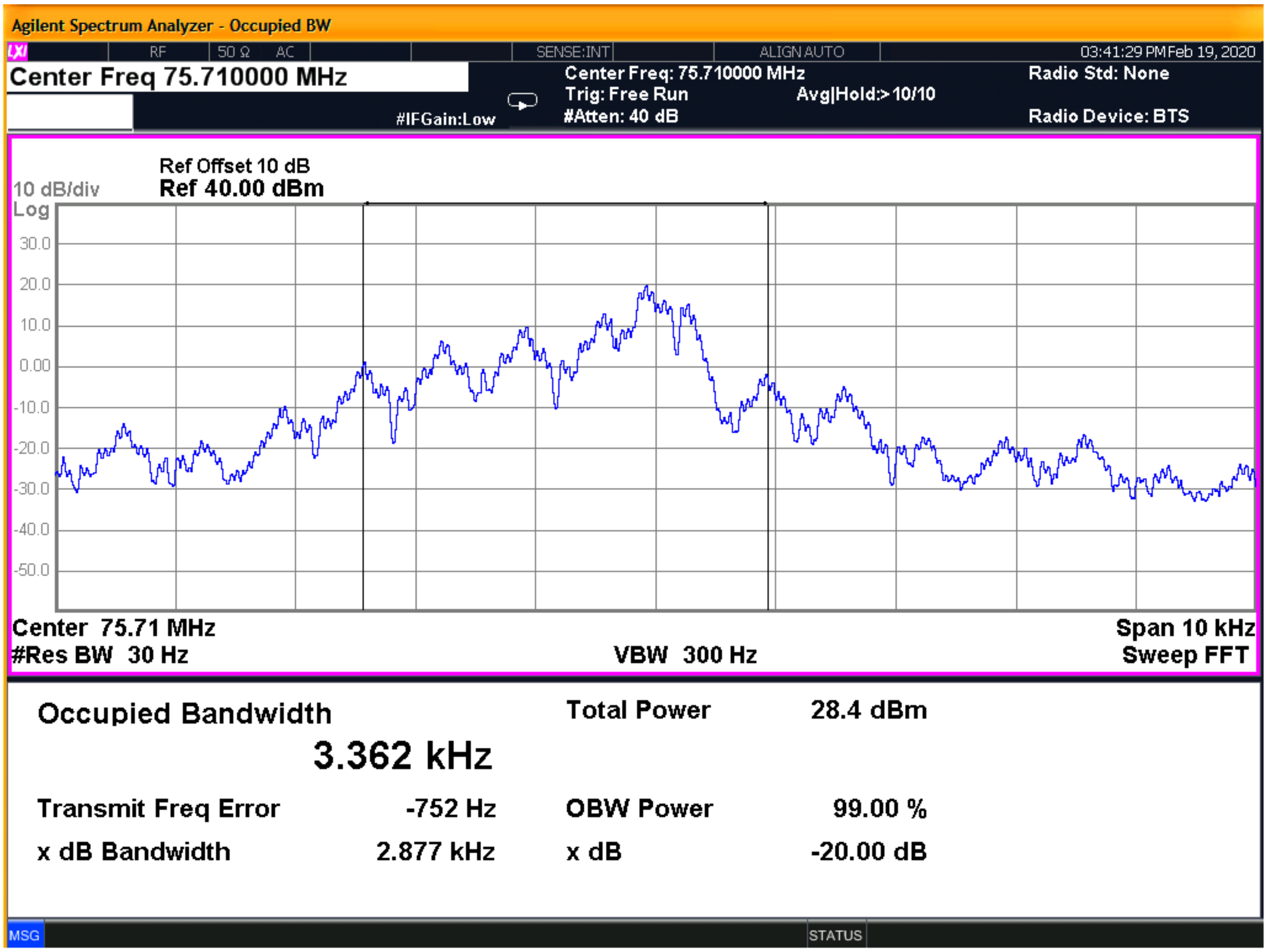
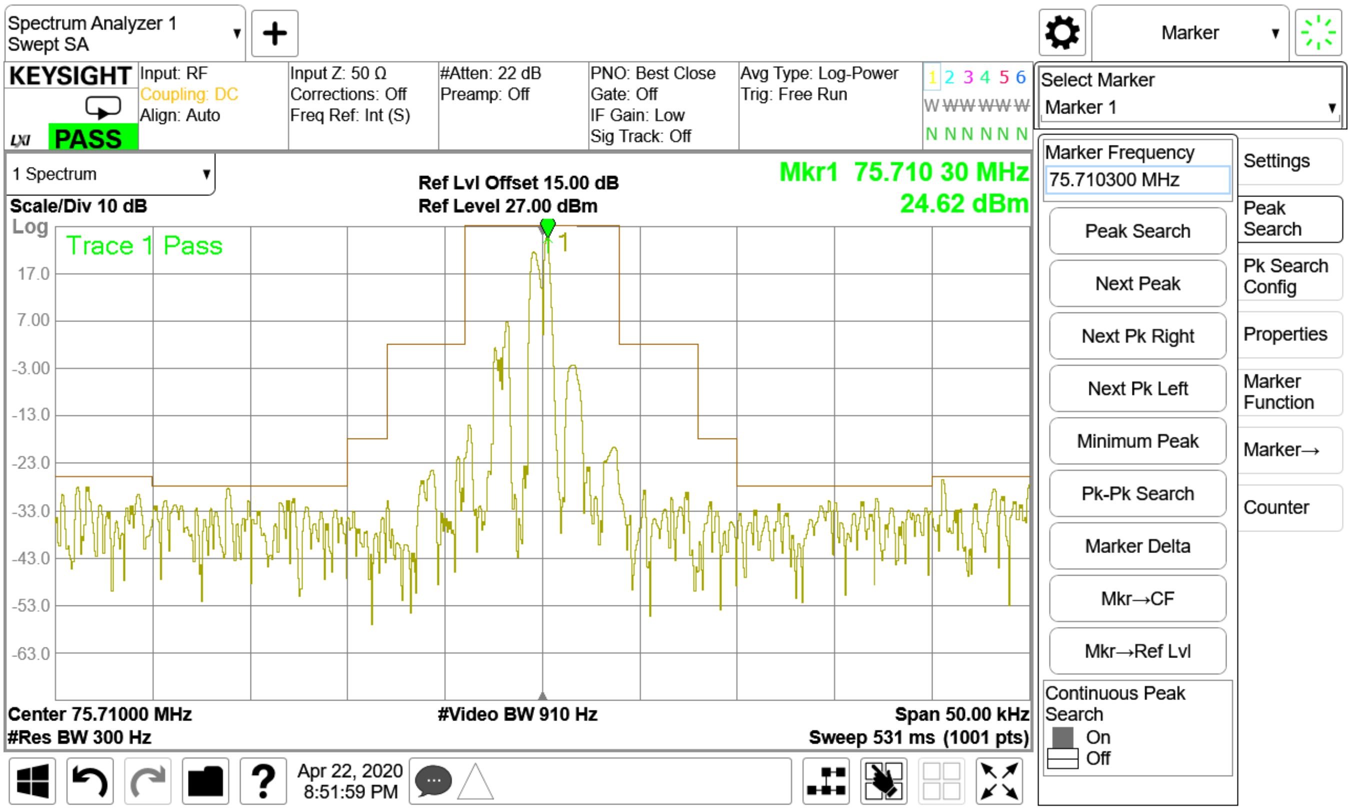


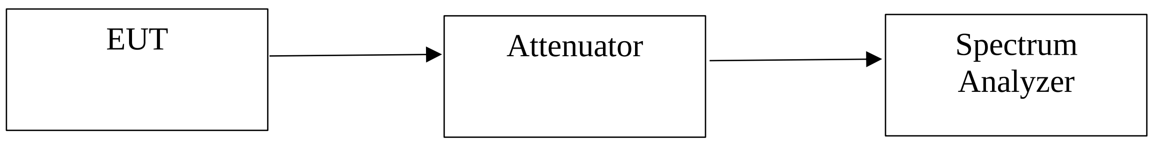
Figure 4. Emissions Mask



3.3 Conducted Spurious Emissions (Antenna Terminal), Part 2.1051

3.3.1 Test Method

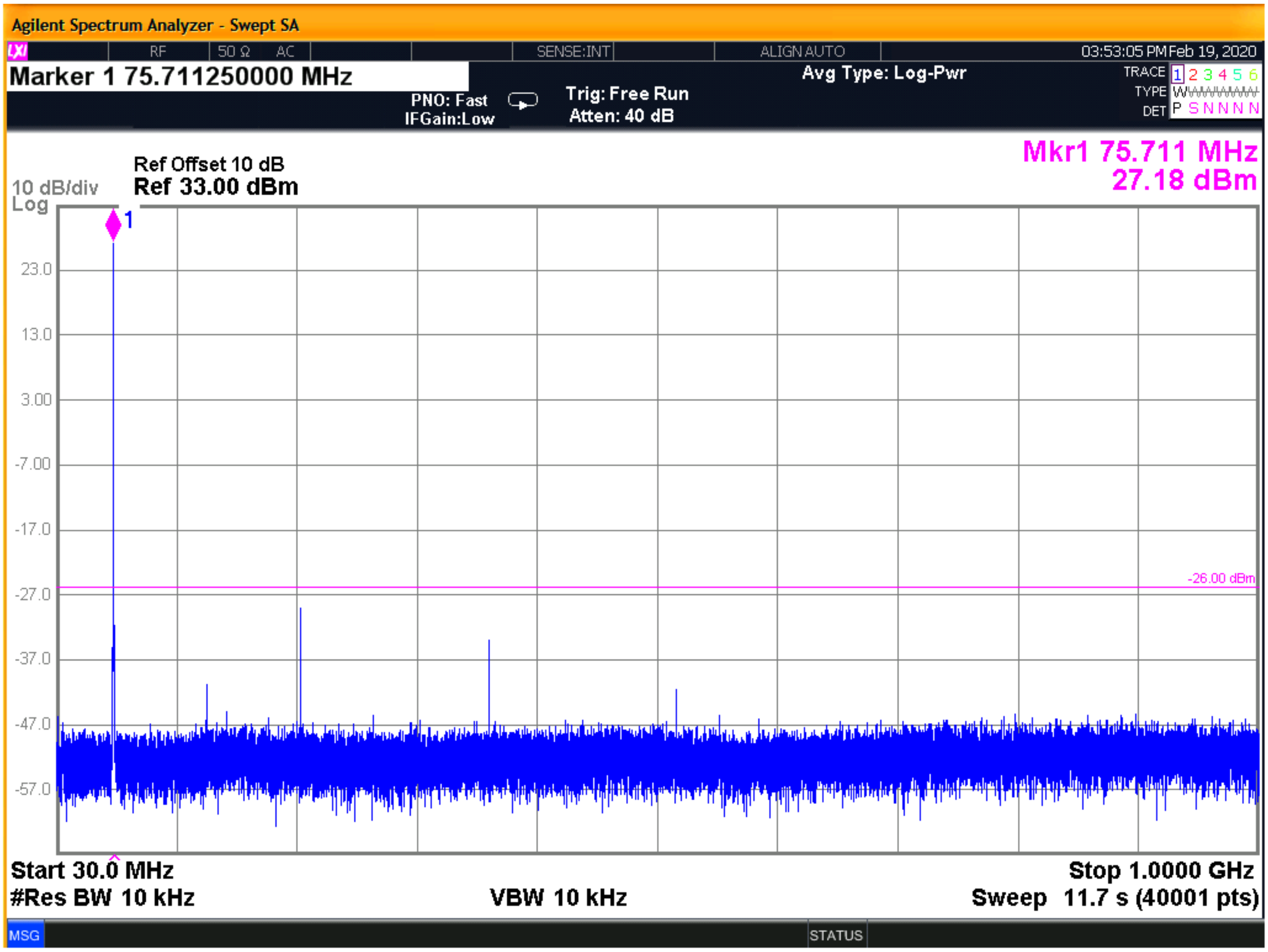
The output of the EUT was connected through an attenuator. The output of the attenuator was connected to the input of the spectrum analyzer. The conducted spurious emissions were measured from 9kHz to 1100 MHz.



3.3.2 Test Result

The results are provided in the following figure.

Figure 5. Spurious emissions



3.4 Frequency Stability, Part 2.1055

3.4.1 Stability vs Voltage

3.4.1.1 Test Method

A variable supply was used to vary the supply voltage while the transmitter was connected to the input of the spectrum analyzer. The frequency was measured at nominal voltage and at the battery end-point.

The results are in the following table.

Table 5. Frequency Stability vs Voltage

Input Voltage	Frequency (MHz)	Frequency Difference (Hz)	Limit (Hz)	Result
7.2 VDC (nominal)	75.709925	-	+/- 1514	-
6.4 (endpoint)	75.709926	0.000001	+/- 1514	Pass

3.4.1.2 Test Result

3.4.2 Stability vs Temperature

3.4.2.1 Test Method

The EUT was placed in a calibrated temperature chamber with the dummy load located outside the chamber. A receive near field probe was placed along the dummy load to receive the RF signal.

The EUT was set to transmit at 75.71MHz.

A frequency reading was taken with the temperature at ambient (22C). The EUT was turned off and the temperature chamber set to -30 Celsius after 1 hour at this temperature the unit was turned on and a frequency reading was taken. The unit was turned back off and the temperature changed to -20 C. This process was repeated in 10 degree increments up to 50 Degrees Celsius allowing the unit to stabilize for 1 hour at each level before turning on the unit and recording the frequency. At each level the frequency recorded was compared to the ambient reading with the amount of deviation in Hz compared to the limit.

3.4.2.2 Test Result

Table 6. Frequency Stability vs Temperature

Temperature (C)	Frequency (MHz)	Deviation (Hz)	Limit (+/- Hz)	Pass/Fail
22 (ambient)	75.709934	0	1514	NA
-30	75.709967	33	1514	Pass
-20	75.709944	10	1514	Pass
-10	75.709916	-18	1514	Pass
0	75.709924	-11	1514	Pass
10	75.709925	-10	1514	Pass
20	75.709925	-10	1514	Pass
30	75.709928	-6	1514	Pass
40	75.709931	-3	1514	Pass
50	75.709952	18	1514	Pass

3.5 Voltage and Current of Final Power Amplifier (FCC Part 2)

The voltage and current present at the transmitter final RF power amplifier is as follows:

Voltage = 5VDC
Current = 0.2 A

4 Radiated Emissions

4.1 Requirements

§2.1053 Measurements required: Field strength of spurious radiation.

(a) Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation.

The limit of case radiated spurious emissions is -13dBm.

4.1.1 Test Procedure

The device's antenna terminal was disconnected from the RF output and terminated in a 50-ohm load.

The device was placed on an 80 cm high 1 X 1.5 meters non-conductive motorized turntable for radiated testing on a 3-meter open field test site.

The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. Broadband antennas were mounted on an antenna mast to determine the height of maximum emissions. The height of the antenna was varied between 1 and 4 meters. The output of the antenna was connected to the input of the spectrum analyzer and the emissions in the frequency range of 30 MHz to 1 GHz were measured. Both the horizontal and vertical field components were measured.

The output from the antenna was connected, via a preamplifier, to the input of the spectrum analyzer. The detector function was set to quasi-peak or peak, as appropriate. Above 1GHz average measurement are recorded. The measurement bandwidth of the spectrum analyzer system was set to at least 120 kHz, with all post-detector filtering no less than 10 times the measurement bandwidth. Frequencies above 1GHz were performed using a measurement bandwidth of 1MHz with a video bandwidth setting of 10 Hz for the average measurement.

4.1.2 Radiated Data Reduction and Reporting

To convert the raw spectrum analyzer radiated data into a form that can be compared with the FCC limits, it is necessary to account for various calibration factors that are supplied with the antennas and other measurement accessories. These factors are included into the antenna factor (AF) column of the table and in the cable factor (CF) column of the table. The AF (in dB/m) and the CF (in dB) is algebraically added to the raw Spectrum Analyzer Voltage in dBµV to obtain the Radiated Electric Field in dBµV/m. This logarithm amplitude is converted to a linear amplitude, then compared to the FCC limit.

Example:
Spectrum Analyzer Voltage: VdBµV
Antenna Correction Factor: AFdB/m
Cable Correction Factor: CFdB
Pre-Amplifier Gain (if applicable): GdB
Electric Field: EdBµV/m = V dBµV + AFdB/m + CFdB - GdB
To convert to linear units of measure: EdBµV/m/20 Inv log

The test data were taken as spurious radiated measurements and converted to EIRP using the familiar formula for three-meter test distance:

EIRP (dBm) = EdBµV/m - 95.2

Data are provided in the following table.

Table 7. Summary EIRP Data

Frequency (MHz)	Polarity (H/V)	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Corr. Level (dBuV/m)	EIRP Calc (dBm)	Limit (dBm)	Margin (dB)	Peak or Average	Note
75.715	V	180.0	2.0	46.0	-17.9	28.1	-67.1	-13.0	-54.1	Peak	
151.430	V	0.0	1.5	39.8	-13.1	26.7	-68.5	-13.0	-55.5	Peak	NF
227.145	V	180.0	1.5	40.0	-13.5	26.5	-68.7	-13.0	-55.7	Peak	
302.860	V	0.0	2.0	32.0	-10.2	21.8	-73.4	-13.0	-60.4	Peak	NF
378.575	V	0.0	2.0	44.2	-7.9	36.3	-58.9	-13.0	-45.9	Peak	
454.290	V	0.0	2.0	29.0	-6.0	23.0	-72.2	-13.0	-59.2	Peak	NF
530.005	V	90.0	1.5	36.0	-4.2	31.8	-63.4	-13.0	-50.4	Peak	
605.720	V	0.0	2.0	53.0	-3.1	49.9	-45.3	-13.0	-32.3	Peak	Ambient
681.435	V	0.0	1.3	33.0	-0.9	32.1	-63.1	-13.0	-50.1	Peak	NF
757.150	V	0.0	2.0	40.2	0.6	40.8	-54.4	-13.0	-41.4	Peak	Ambient
75.715	H	180.0	2.0	48.0	-17.9	30.1	-65.1	-13.0	-52.1	Peak	
151.430	H	0.0	1.5	38.0	-13.1	24.9	-70.3	-13.0	-57.3	Peak	
227.145	H	180.0	2.0	40.0	-13.5	26.5	-68.7	-13.0	-55.7	Peak	NF
302.860	H	0.0	2.0	34.0	-10.2	23.8	-71.4	-13.0	-58.4	Peak	
378.575	H	0.0	2.0	44.0	-7.9	36.1	-59.1	-13.0	-46.1	Peak	NF
454.290	H	0.0	2.0	38.0	-6.0	32.0	-63.2	-13.0	-50.2	Peak	
530.005	H	90.0	2.0	36.6	-4.2	32.4	-62.8	-13.0	-49.8	Peak	NF
605.720	H	0.0	2.0	54.0	-3.1	50.9	-44.3	-13.0	-31.3	Peak	
681.435	H	0.0	2.0	30.0	-0.9	29.1	-66.1	-13.0	-53.1	Peak	Ambient
757.150	H	0.0	2.0	41.0	0.6	41.6	-53.6	-13.0	-40.6	Peak	NF

NF: Noise floor

4.1.3 Co-location

The device includes a 2.4GHz transmitter (separately certified as a Limited Modular Approval FCC ID: UYXRSK2020-02) as well, so co-location measurements were made at frequencies related to the sum and differences of the two radiators. The data were collected in the same manner as the transmitter harmonics and the emissions compared to the FCC 15.209 Class B limit.

4.1.4 Test Data

The EUT complied with the Radiated Emissions requirements. Table 7 provides the test results for radiated emissions.

Co-location was assessed as a radiated test in an operational OCU3. The 75 MHz transmitter was set to maximum permissible power and the Payload Module was set to center channel and set to transmit a CW signal.

Measurements were performed of the 2440 MHz +/- 75.71 MHz up to 3 harmonics of the 75.71 MHz signal. Results are in the following table.

Table 8. Co-Location Results

Frequency (MHz)	Pol (H/V)	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Corr. Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Peak or Average
FLAT									
2028.45	V	90.0	1.8	44.8	3.0	47.8	54.0	-6.2	Peak
2179.87	V	0.0	1.8	26.2	3.8	30.0	54.0	-24.0	Peak
2331.29	V	45.0	1.6	31.9	3.8	35.7	54.0	-18.3	Peak
2482.71	V	45.0	2.1	43.0	5.1	48.2	54.0	-5.8	Peak
2634.13	V	90.0	1.7	41.7	6.4	48.1	54.0	-5.9	Peak
2028.45	H	90.0	2.0	49.2	3.0	52.2	54.0	-1.8	Peak
2179.87	H	90.0	2.0	47.9	3.8	51.6	54.0	-2.4	Peak
2331.29	H	0.0	2.0	42.8	3.8	46.6	54.0	-7.4	Peak
2482.71	H	90.0	1.5	40.5	5.1	45.6	54.0	-8.4	Peak
2634.13	H	45.0	2.0	44.0	6.4	50.4	54.0	-3.6	Peak
VERTICAL									
2028.45	H	45.0	1.5	45.0	3.0	48.0	54.0	-6.0	Peak
2179.87	H	0.0	1.8	33.1	3.8	36.8	54.0	-17.2	Peak
2331.29	H	90.0	2.0	40.0	3.8	43.8	54.0	-10.2	Peak
2482.71	H	180.0	2.0	38.5	5.1	43.7	54.0	-10.3	Peak
2634.13	H	90.0	2.0	43.0	6.4	49.4	54.0	-4.6	Peak
2028.45	V	0.0	2.2	48.5	3.0	51.4	54.0	-2.6	Peak
2179.87	V	45.0	1.9	47.8	3.8	51.6	54.0	-2.4	Peak
2331.29	V	180.0	2.3	45.7	3.8	49.5	54.0	-4.5	Peak
2482.71	V	0.0	1.8	38.7	5.1	43.9	54.0	-10.1	Peak
2634.13	V	0.0	2.7	33.5	6.4	40.0	54.0	-14.0	Peak