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Test Report

Certification

FCC ID	ALZMV2
Equipment Under Test	MV-ONE
Test Report Serial No	V048809_03
Dates of Test	June 24, 2019 and July 11, 2019
Report Issue Date	August 19, 2019

Test Specifications:	**Applicant:**
FCC Part 15, Subpart C	Multi-Voice Radio LLC 266 E 900 S Mapleton, UT 84664 U.S.A.

Testing
NVLAP Lab Code 100272-0

Certification of Engineering Report

This report has been prepared by VPI Laboratories, Inc. to document compliance of the device described below with the requirements of Federal Communications Commission (FCC) Part 15, Subpart C. This report may be reproduced in full. Partial reproduction of this report may only be made with the written consent of the laboratory. The results in this report apply only to the sample tested.

Applicant	Multi-Voice Radio LLC
Manufacturer	Multi-Voice Radio LLC
Brand Name	Multi-Voice Radio
Model Number	MV-ONE
FCC ID	ALZMV2

On this 19th day of August 2019, I, individually and for VPI Laboratories, Inc., certify that the statements made in this engineering report are true, complete, and correct to the best of my knowledge, and are made in good faith.

Although NVLAP has accredited the VPI Laboratories, Inc. EMC testing facilities, this report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government.

VPI Laboratories, Inc.

Tested by: Norman P. Hansen

Reviewed by: Benjamin N. Antczak

Revision History		
Revision	**Description**	**Date**
01	Original Report Release	August 19, 2019
02	Photograph 5 replaced with correct photograph	March 19, 2020
03	Corrected NVLAP Accreditation Date on pg. 13	June 18, 2020

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1 Client Information

1.1 Applicant

Company Name	Multi-Voice Radio LLC 266 E 900 S Mapleton, UT 84664 U.S.A.
Contact Name	Dustin Fraser
Title	Vice President

1.2 Manufacturer

Company Name	Multi-Voice Radio LLC 266 E 900 S Mapleton, UT 84664 U.S.A.
Contact Name	Dustin Fraser
Title	Vice President

2 Equipment Under Test (EUT)

2.1 Identification of EUT

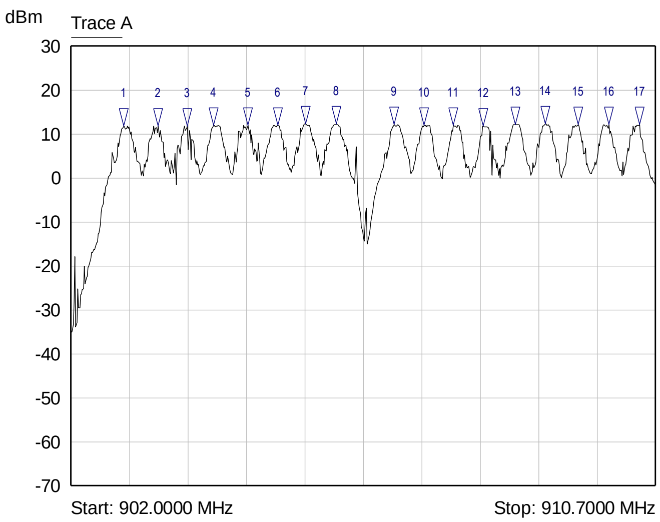
Brand Name	Multi-Voice Radio
Model Number	MV-ONE
Serial Number	None
Dimensions (cm)	14.2 x 7.6 x 25.4

2.2 Description of EUT

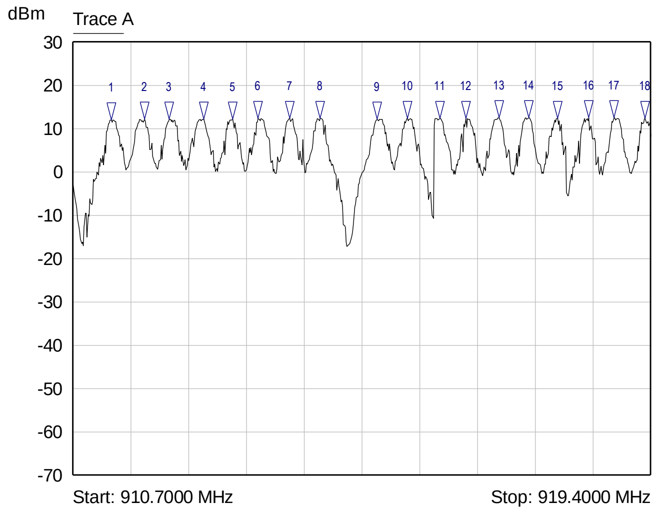
The MV-ONE is a communication headset for use for sports and industrial use. The MV-ONE has a transceiver operating in the 902-928 ISM band and a Bluetooth transceiver. The MV-ONE is powered by a Li-Po 3.7 V battery. The battery may be charged using a Monoprice ASA75a4-050500 power supply. The charging supply connects to the MV-ONE via a USB A to USB C cable.

This report covers the 902 - 928 transceiver subject to FCC Part 15, Subpart C. The circuitry of the device subject to FCC Subpart B was found to be compliant and is covered in VPI Laboratories, Inc. report V048807. The Bluetooth transceiver will be covered in a separate report.

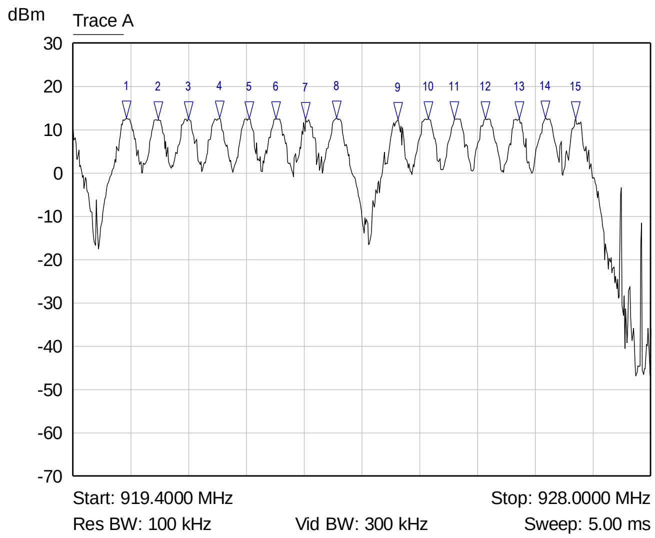
The 902 – 928 MHz transceiver uses 50 channels. The 902 – 928 MHz transceiver uses a Multi-Voice Radio OLY915 antenna with a -1.61 dBi antenna. The frequencies used are shown in the plots below.



Mkr	Trace	X-Axis	Value
1	Trace A	902.7808 MHz	11.80 dBm
2	Trace A	903.2966 MHz	11.86 dBm
3	Trace A	903.7288 MHz	11.79 dBm
4	Trace A	904.1192 MHz	12.03 dBm
5	Trace A	904.6351 MHz	11.97 dBm
6	Trace A	905.0813 MHz	12.01 dBm
7	Trace A	905.4856 MHz	12.30 dBm
8	Trace A	905.9457 MHz	12.27 dBm
9	Trace A	906.8101 MHz	12.09 dBm
10	Trace A	907.2563 MHz	12.06 dBm
11	Trace A	907.6885 MHz	12.06 dBm
12	Trace A	908.1346 MHz	11.85 dBm
13	Trace A	908.6087 MHz	12.20 dBm
14	Trace A	909.0548 MHz	12.31 dBm
15	Trace A	909.5428 MHz	12.16 dBm
16	Trace A	910.0029 MHz	12.14 dBm
17	Trace A	910.4630 MHz	12.13 dBm



Mkr	Trace	X-Axis	Value
1 ▽	Trace A	911.2716 MHz	12.02 dBm
2 ▽	Trace A	911.7736 MHz	12.14 dBm
3 ▽	Trace A	912.1500 MHz	12.17 dBm
4 ▽	Trace A	912.6659 MHz	12.22 dBm
5 ▽	Trace A	913.0981 MHz	12.22 dBm
6 ▽	Trace A	913.4885 MHz	12.29 dBm
7 ▽	Trace A	913.9625 MHz	12.39 dBm
8 ▽	Trace A	914.4226 MHz	12.28 dBm
9 ▽	Trace A	915.2731 MHz	12.25 dBm
10 ▽	Trace A	915.7332 MHz	12.36 dBm
11 ▽	Trace A	916.2212 MHz	12.39 dBm
12 ▽	Trace A	916.6115 MHz	12.38 dBm
13 ▽	Trace A	917.1135 MHz	12.49 dBm
14 ▽	Trace A	917.5596 MHz	12.55 dBm
15 ▽	Trace A	917.9918 MHz	12.28 dBm
16 ▽	Trace A	918.4659 MHz	12.42 dBm
17 ▽	Trace A	918.8423 MHz	12.49 dBm
18 ▽	Trace A	919.3163 MHz	12.28 dBm



Mkr	Trace	X-Axis	Value
1 ▽	Trace A	920.1994 MHz	12.62 dBm
2 ▽	Trace A	920.6679 MHz	12.51 dBm
3 ▽	Trace A	921.1228 MHz	12.48 dBm
4 ▽	Trace A	921.5776 MHz	12.59 dBm
5 ▽	Trace A	922.0186 MHz	12.50 dBm
6 ▽	Trace A	922.4183 MHz	12.54 dBm
7 ▽	Trace A	922.8593 MHz	12.32 dBm
8 ▽	Trace A	923.3279 MHz	12.68 dBm
9 ▽	Trace A	924.2375 MHz	12.27 dBm
10 ▽	Trace A	924.6923 MHz	12.55 dBm
11 ▽	Trace A	925.0782 MHz	12.55 dBm
12 ▽	Trace A	925.5330 MHz	12.56 dBm
13 ▽	Trace A	926.0429 MHz	12.55 dBm
14 ▽	Trace A	926.4288 MHz	12.69 dBm
15 ▽	Trace A	926.8837 MHz	12.47 dBm

2.3 EUT and Support Equipment

The EUT and support equipment used during the test are listed below.

Brand Name Model Number Serial Number	Description	Name of Interface Ports / Interface Cables
BN: Multi-Voice Radio MN: MV-ONE (Note 1) SN: None	Communication Headset	See Section 2.4

Notes: (1) EUT

2.4 Interface Ports on EUT

Name of Ports	No. of Ports Fitted to EUT	Cable Description/Length
Charging	0	USB A to USB C cable/1 meter
Note: This port is not used when the EUT is used for communication using the internal transceivers.		

2.5 Modification Incorporated/Special Accessories on EUT

There were no modifications or special accessories required to comply with the specification.

2.6 Deviation from Test Standard

There were no deviations from the test specification.

3 Test Specification, Methods and Procedures

3.1 Test Specification

Title	FCC PART 15, Subpart C (47 CFR 15) 15.203, 15.207, and 15.247 Limits and methods of measurement of radio interference characteristics of radio frequency devices.
Purpose of Test	The tests were performed to demonstrate initial compliance

3.2 Methods & Procedures

3.2.1 §15.203 Antenna Requirement

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

3.2.2 §15.207 Conducted Limits

(a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency range (MHz)	**Limit (dBμV)**	
	Quasi-peak	**Average**
0.15 to 0.50*	66 to 56*	56 to 46*
0.50 to 5	56	46
5 to 30	60	50

*Decreases with the logarithm of the frequency.

Table 1: Limits for conducted emissions at mains ports of Class B ITE.

3.2.3 §15.247 Operation within the bands 902 – 928 MHz, 2400 – 2483.5 MHz, and 5725 – 5850 MHz

a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions.

1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400 – 2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudorandomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

   i. For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

   ii. Frequency hopping systems operating in the 5725-5850 MHz band shall use at least 75 hopping frequencies. The maximum 20 dB bandwidth of the hopping channel is 1 MHz. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

   iii. Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 non-overlapping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 non-overlapping channels are used.

2) Systems using digital modulation techniques may operate in the 902 - 928 MHz, 2400 - 2483.5 MHz, and 5725 - 5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

b) The maximum peak output power of the intentional radiator shall not exceed the following:

1) For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

2) For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725 – 5850 MHz bands: 1 watt. As an alternative to a peak power measurement,

compliance with the Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

c) Operation with directional antenna gains greater than 6 dBi.

1) Fixed point-to-point operation:

i. Systems operating in the 2400-2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

ii. Systems operating in the 5725-5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.

iii. Fixed, point-to-point operation, as used in paragraphs (b)(4)(i) and (b)(4)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

2) In addition to the provisions in paragraphs (b)(1), (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400-2483.5 MHz band that emit multiple directional beams, simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:

i. Different information must be transmitted to each receiver.

ii. If the transmitter employs an antenna system that emits multiple directional beams but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, i.e., the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna /antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:

A. The directional gain shall be calculated as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

B. A lower value for the directional gain than that calculated in paragraph (c)(2)(ii)(A) of this section will be accepted if sufficient evidence is presented, e.g., due to shading of the array or coherence loss in the beamforming.

iii. If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the power limit specified in paragraph (c)(2)(ii) of this section. If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the limit specified in paragraph (c)(2)(ii) of this section. In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the limit specified in paragraph (c)(2)(ii) of this section by more than 8 dB.

iv. Transmitters that emit a single directional beam shall operate under the provisions of paragraph (c)(1) of this section.

d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

e) For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The digital modulation operation of the hybrid system, with the frequency hopping turned off, shall comply with the power density requirements of paragraph (d) of this section.

g) Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

h) The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

i) Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines. See § 1.1307(b)(1) of this Chapter.

Note: Spread spectrum systems are sharing these bands on a noninterference basis with systems supporting critical Government requirements that have been allocated the usage of these bands, secondary only to ISM equipment operated under the provisions of Part 18 of this Chapter. Many of these Government systems are airborne radiolocation systems that emit a high EIRP which can cause interference to other users. Also, investigations of the effect of spread spectrum interference to U. S. Government operations in the 902-928 MHz band may require a future decrease in the power limits allowed for spread spectrum operation.

3.3 Test Procedure

VPI Laboratories, Inc. is accredited by National Voluntary Laboratory Accreditation Program (NVLAP); NVLAP Lab Code: 100272-0, which is effective until September 30, 2020. VPI Laboratories, Inc. carries FCC Accreditation Designation Number US5263. VPI Laboratories main office is located at 313 W 12800 S, Suite 311, Draper, UT 84020. The testing was performed according to the procedures in ANSI C63.10-2013, KDB 558074, and 47 CFR Part 15. Testing was performed at the VPI Laboratories, Inc. Wanship Upper Open Area Test Site, located at 29145 Old Lincoln Highway, Wanship, UT. This location is listed on NVLAP scope under the lines for C63.4 and C63.10.

4 Operation of EUT During Testing

4.1 Operating Environment

Power Supply	3.7 VDC from LiPo battery
Note: The battery of the EUT may be recharged using an external power supply. When charging, the transceiver function is not available and the unit will not transmit.	

4.2 Operating Modes

The 902 – 928 MHz transceiver was tested on 3 orthogonal axes while in a constant transmit mode at the upper, middle, and lower channels or while hopping depending on the test requirements. The Bluetooth transceiver was active while testing. A fully charged battery was installed for testing.

4.3 EUT Exercise Software

Multi-Voice Radio FCC test software was used to control the transceiver for testing.

5 Summary of Test Results

5.1 FCC Part 15, Subpart C

5.1.1 Summary of Tests

Section	Environmental Phenomena	Frequency Range (MHz)	Result
15.203	Antenna Requirements	Structural requirement	Complied
15.207	Conducted Disturbance at Mains Ports	0.15 to 30	Not Applicable
15.247(a)	Channel Separation	902 – 928	Complied
15.247(a)	20 dB Bandwidth	902 – 928	Complied
15.247(a)	Time of Occupancy	902 – 928	Complied
15.247(b)	Peak Output Power	902 – 928	Complied
15.247(d)	Antenna Conducted Spurious Emissions	0.009 - 25000	Complied
15.247(d)	Radiated Spurious Emissions	0.009 - 25000	Complied
15.247(g)	Channel Usage	902 – 928	Complied (Note 1)
15.247(h)	Channel Intelligence/Avoidance	902 – 928	Complied (Note 1)
Note 1: Compliance with these requirements is shown in documents filed with the FCC at the time of Certification.			

5.2 Result

In the configuration tested, the EUT complied with the requirements of the specification.

6 Measurements, Examinations and Derived Results

6.1 General Comments

This section contains the test results only. Details of the test methods used and a list of the test equipment used during the measurements can be found in Section 7 of this report.

6.2 Test Results

6.2.1 §15.203 Antenna Requirements

The EUT uses a proprietary antenna that connects to the PCB via a u.fl connector that is not user accessible.

Result

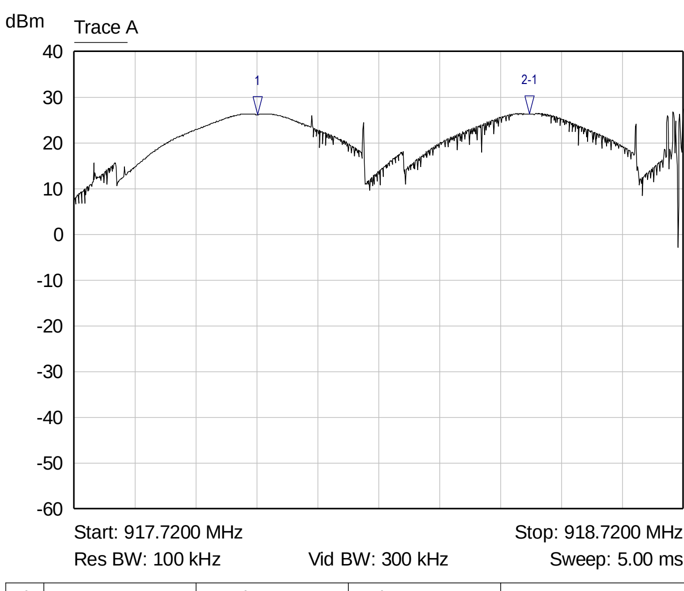
The EUT complied with the specification.

6.2.2 §15.207 Conducted Emissions at AC Mains Ports

The EUT does not transmit when connected to the AC mains via external power supply. The EUT was tested to 47 CFR 15.107 and found compliant. Those test results are reported in VPI Laboratories Inc. report V048807.

6.2.3 §15.247(a) Channel Separation

The EUT must have the hopping channel carrier frequencies separated by 25 kHz or the 20 dB bandwidth, whichever is greater. A plot showing a 446 kHz channel separation is shown below. The 20 dB bandwidth is 426 kHz and is shown in section 6.2.4.



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	918.0210 MHz	26.21 dBm	
2-1 ▽	Trace A	446.0000 kHz	0.07 dB	

Graph 1: Channel Separation Plot

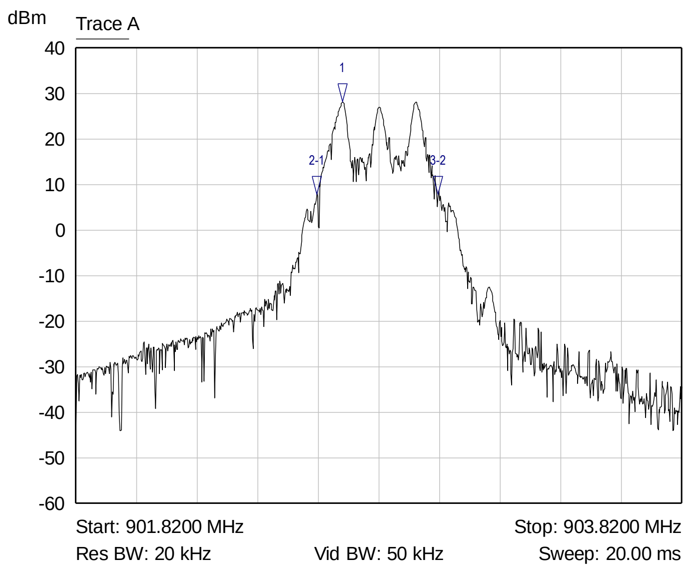
Result

The channel carrier frequency separation is 446 kHz, which is greater than the 20 dB bandwidth; therefore, the EUT complies with the specification.

6.2.4 §15.247(a)(2) Emissions Bandwidth

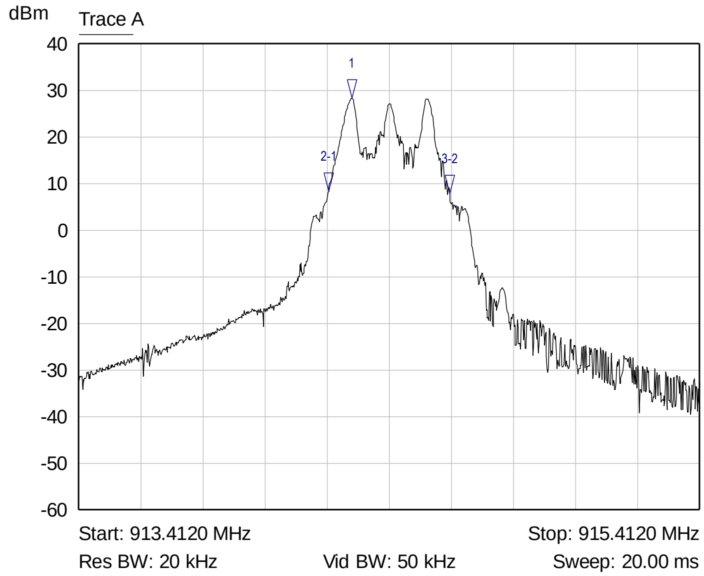
The 20 dB bandwidth of the hopping channels is shown in the table and plots below.

Frequency (MHz)	Emissions 20 dB bandwidth (kHz)
902.8	402
914.4	390
926.6	426



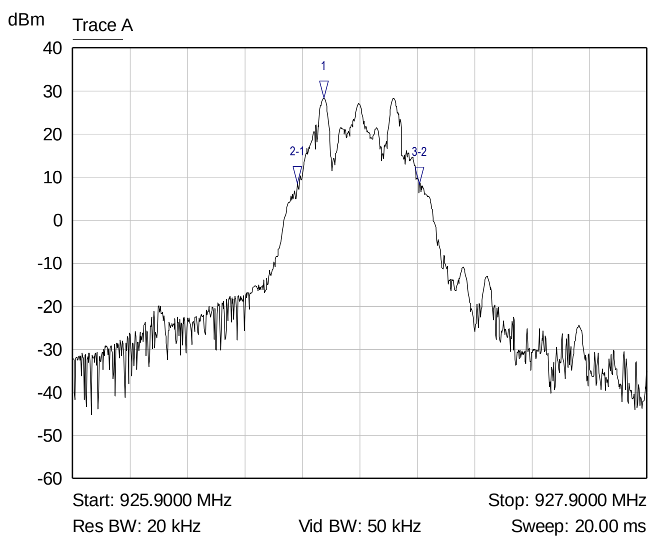
Mkr	Trace	X-Axis	Value	Notes
1	Trace A	902.7000 MHz	28.09 dBm	
2-1	Trace A	-86.0000 kHz	-20.33 dB	
3-2	Trace A	402.0000 kHz	0.13 dB	

Graph 2: Lowest Channel 20 dB Bandwidth



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	914.2920 MHz	28.26 dBm	
2-1 ▽	Trace A	-76.0000 kHz	-19.96 dB	
3-2 ▽	Trace A	390.0000 kHz	-0.40 dB	

Graph 3: Middle Channel 20 dB Bandwidth



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	926.7740 MHz	28.35 dBm	
2-1 ▽	Trace A	-92.0000 kHz	-19.84 dB	
3-2 ▽	Trace A	426.0000 kHz	-0.21 dB	

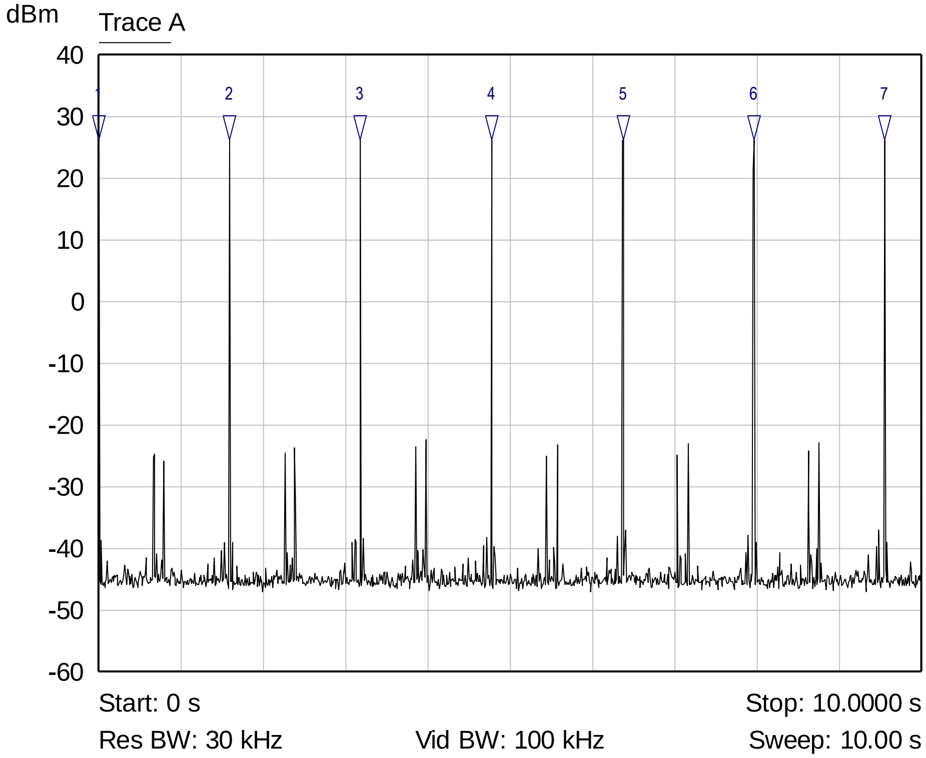
Graph 4: Highest Channel 20 dB Bandwidth

Result

In the configuration tested, the channel bandwidth is less than 500 kHz and complied with the requirements of the specification.

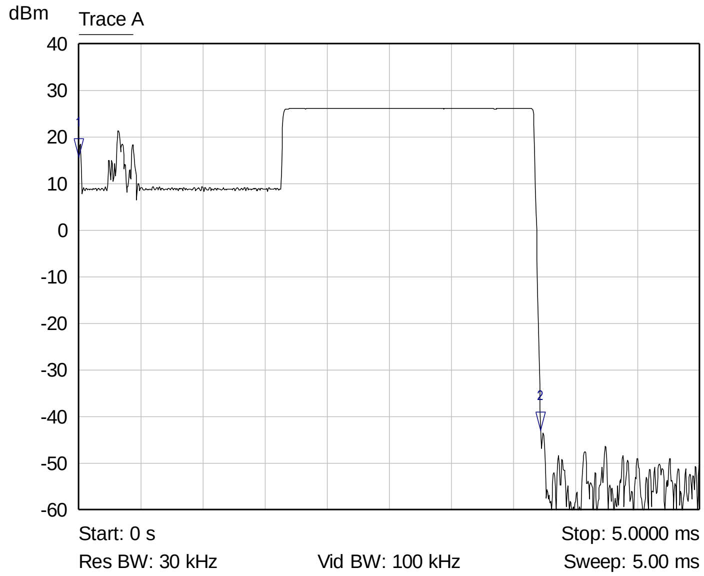
6.2.5 §15.247(a) Channel Occupancy

The EUT uses 50 channels that have a bandwidth greater than 250 kHz; therefore, the EUT must have an average time of occupancy on any frequency that is no greater than 0.4 seconds in a period of 10 seconds. See the plots and calculations below.



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	0 s	26.15 dBm	
2 ▽	Trace A	1.5900 s	26.16 dBm	
3 ▽	Trace A	3.1800 s	26.15 dBm	
4 ▽	Trace A	4.7700 s	26.15 dBm	
5 ▽	Trace A	6.3700 s	26.15 dBm	
6 ▽	Trace A	7.9600 s	26.15 dBm	
7 ▽	Trace A	9.5500 s	26.14 dBm	

Graph 5: Timing Plot Showing Channel Hits



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	0 s	15.63 dBm	
2 ▽	Trace A	3.7200 ms	-42.98 dBm	

Graph 6: Timing Plot Showing Channel Hits

From the plots, the EUT transmits up to 7 times in 10 seconds for 3.72 ms at each transmission.

Dwell time = 3.72 milliseconds/hit x 7 hits/10 seconds = 26.04 ms in a 10 second time period

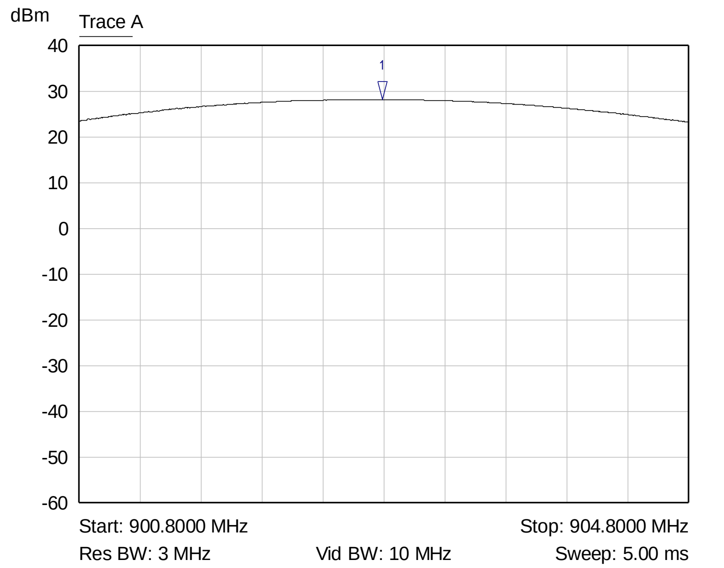
Result

The EUT complies with the specification.

6.2.6 §15.247(b)(3) Peak Output Power

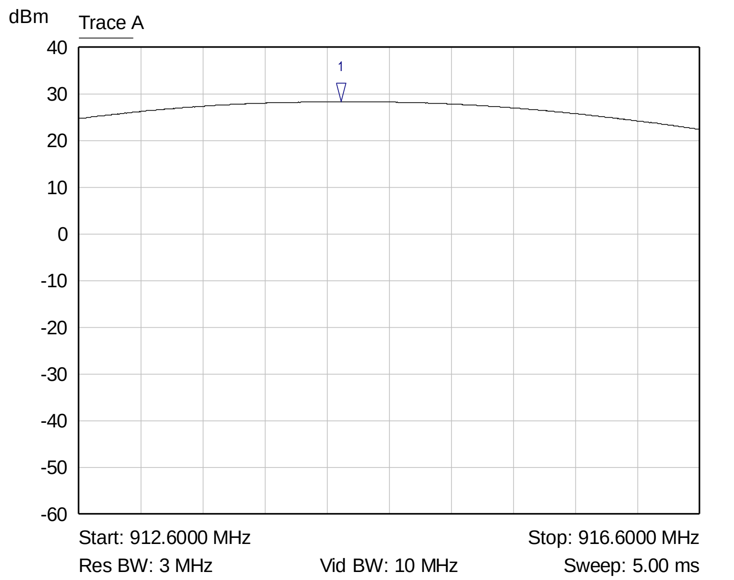
The antenna used with the EUT has a gain of -1.6 dBi. The EUT uses 50 hopping channels. The limit for this device is 30 dBm or 1 Watt. Plots are shown below and the results of this testing are summarized in the table.

Frequency (MHz)	Measurement (dBm)	Peak Output Power (mW)
902.8	28.17	656.1
914.4	28.33	680.8
926.6	28.36	685.5



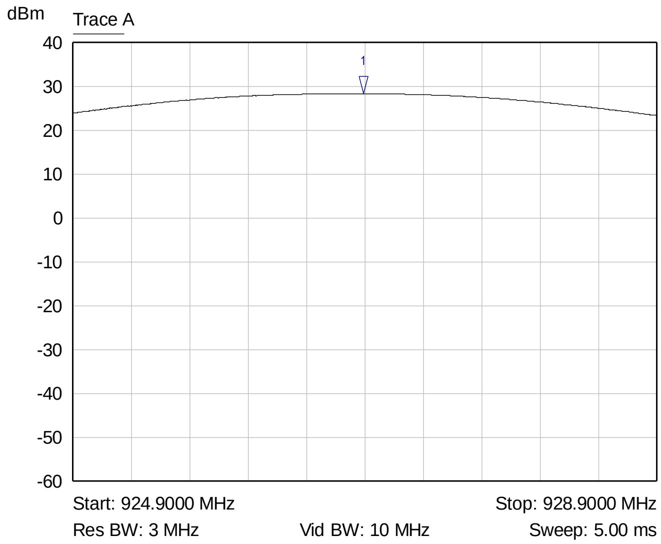
Mkr	Trace	X-Axis	Value	Notes
1 ∇	Trace A	902.7920 MHz	28.17 dBm	

Graph 7: Lowest Channel Peak Output Power



Mkr	Trace	X-Axis	Value	Notes
1 ∇	Trace A	914.2920 MHz	28.33 dBm	

Graph 8: Middle Channel Peak Output Power



Mkr	Trace	X-Axis	Value	Notes
1 ∇	Trace A	926.8920 MHz	28.36 dBm	

Graph 9: Highest Channel Peak Output Power

Result

In the configuration tested, the RF peak output power was less than 1 Watt; therefore, the EUT complied with the requirements of the specification.

6.2.7 §15.247(d) Spurious Emissions

Conducted Spurious Emissions

The frequency range from the lowest frequency generated or used in the device to the tenth harmonic of the highest fundamental frequency was investigated to measure any antenna-conducted emissions. The tables show the measurement data from spurious emissions noted across the frequency range when transmitting at the lowest frequency, middle frequency, and upper frequency. Shown below are plots with the EUT tuned to the upper and lower channels. These demonstrate compliance with the provisions of this section at the band edges.

The emissions must be attenuated 20 dB below the highest power level measured within the authorized band as measured with a 100 kHz RBW. The highest power measured in was 28.3 dBm; therefore, the criteria is 28.3 – 20 = 8.3 dBm.

Frequency (MHz)	Corrected Level (dBm)	Criteria (dBm)	Margin (dB)
1805.6	-26.0	8.3	-34.3
2708.4	-35.8	8.3	-44.1
3611.2	-35.4	8.3	-43.7
4514.0	-38.2	8.3	-46.5
5416.8	-37.5	8.3	-45.8

Frequency (MHz)	Corrected Level (dBm)	Criteria (dBm)	Margin (dB)
6319.6	-37.9	8.3	-46.2
7222.4	-36.7	8.3	-45.0
8125.2	-38.2	8.3	-46.5
9028.0	-38.5	8.3	-46.8

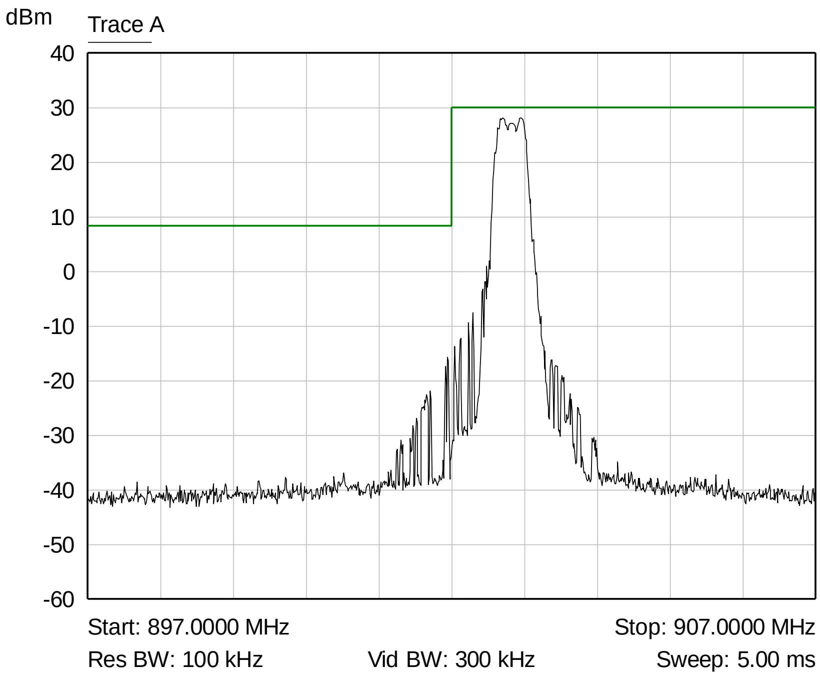
Table 2: Transmitting on the Lowest Channel

Frequency (MHz)	Corrected Level (dBm)	Criteria (dBm)	Margin (dB)
1828.8	-26.0	8.3	-34.3
2743.2	-35.1	8.3	-43.4
3657.6	-35.3	8.3	-43.6
4572.0	-38.2	8.3	-46.5
5486.4	-37.9	8.3	-46.2
6400.8	-37.5	8.3	-45.8
7315.2	-37.8	8.3	-46.1
8229.6	-37.7	8.3	-46.0
9144.0	-37.5	8.3	-45.8

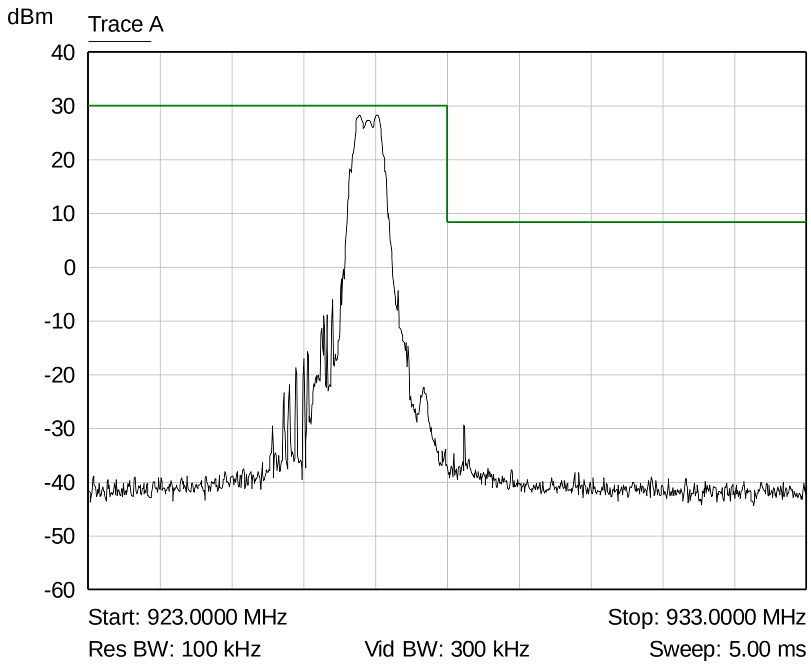
Table 3: Transmitting on the Middle Channel

Frequency (MHz)	Corrected Level (dBm)	Criteria (dBm)	Margin (dB)
1853.2	-27.2	8.3	-35.5
2779.8	-35.4	8.3	-43.7
3706.4	-35.6	8.3	-43.9
4633.0	-38.4	8.3	-46.7
5559.6	-38.5	8.3	-46.8
6486.2	-37.9	8.3	-46.2
7412.8	-38.2	8.3	-46.5
8339.4	-37.6	8.3	-45.9
9266.0	-37.9	8.3	-46.2

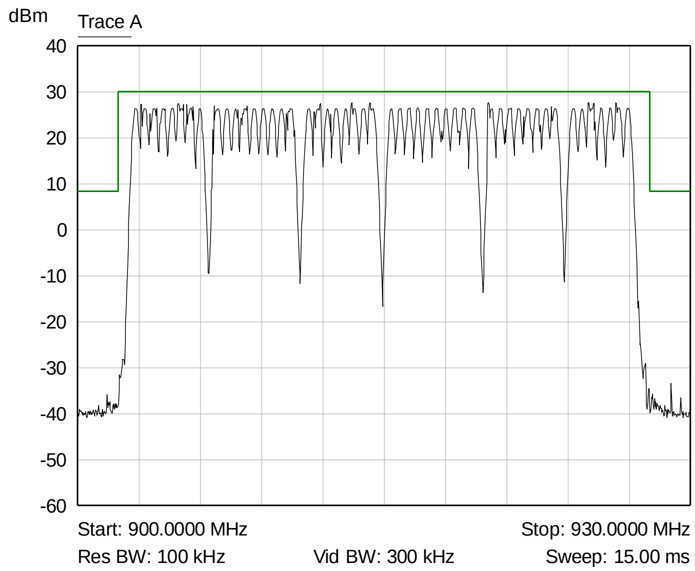
Table 4: Transmitting on the Highest Channel



Graph 10: Lower Channel Plot



Graph 11: Upper Channel Plot



Graph 12: Hopping Band Edge Plot

Result

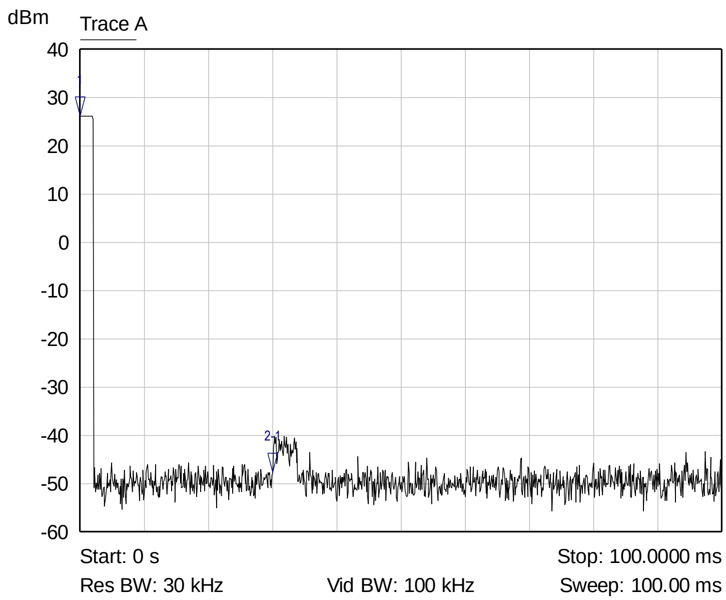
Conducted spurious emissions were attenuated 20 dB or more from the fundamental; therefore, the EUT complies with the specification.

Radiated Spurious Emissions in the Restricted Bands of §15.205

The frequency range from the lowest frequency generated or used in the device to the tenth harmonic of the highest fundamental emission was investigated to measure any radiated emissions in the restricted bands. The following tables show measurements of any emission that fell into the restricted bands of **§**15.205. The emissions in the restricted bands must meet the limits specified in **§**15.209. Tabular data for each of the spurious emissions is shown below for each of the units.

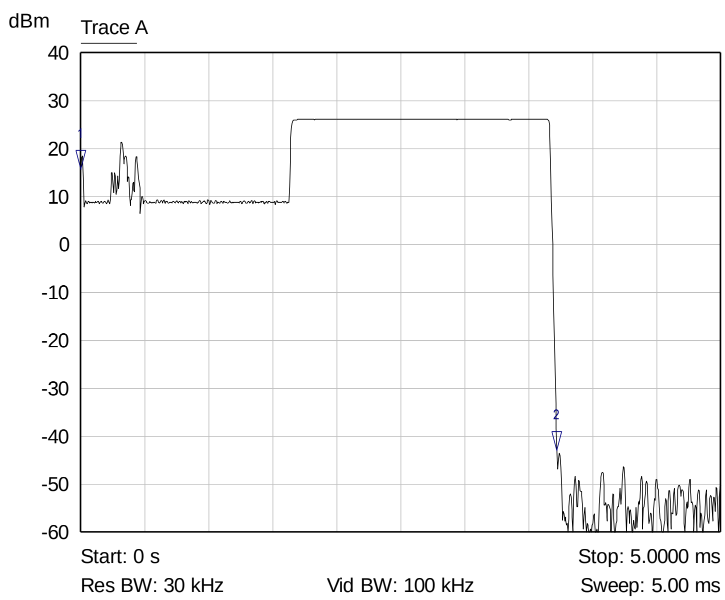
Average Factor

An average factor was calculated for correcting the peak measurement to average for comparison to the Average limit. The plots below show the dwell time per channel hop. The duty cycle correction factor calculations are shown below the plot.



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	0 s	26.12 dBm	
2-1	Trace A	30.0000 ms	-73.77 dB	

Graph 13: Plot Showing the EUT Transmit, Receive, and Transmit Next Channel



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	0 s	15.63 dBm	
2	Trace A	3.7200 ms	-42.98 dBm	

Graph 14: Transmit Duration

From the plots above, the EUT transmits once in a 30 ms period. The duration is 3.72 ms.

Duty Cycle Correction Factor = 20 log (dwell time / 100 ms)

= 20 log (3.72 ms / 30 ms) = -18.1 dB

Frequency (MHz)	Detector	Antenna Polarity	Receiver Reading (dBµV)	Correction Factor (dB)	Duty Cycle Correction Factor (dB)	Field Strength (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2708.4	Peak	Vertical	28.8	33.3	0.0	62.1	74.0	-11.9
2708.4	Average	Vertical	28.8	33.3	-18.1	44.0	54.0	-10.0
2708.4	Peak	Horizontal	25.4	33.3	0.0	0.0	74.0	-74.0
2708.4	Average	Horizontal	25.4	33.3	-18.1	0.0	54.0	-54.0
3611.2	Peak	Vertical	16.8	36.4	0.0	53.2	74.0	-20.8
3611.2	Average	Vertical	16.8	36.4	-18.1	35.1	54.0	-18.9
3611.2	Peak	Horizontal	15.1	36.4	0.0	51.5	74.0	-22.5
3611.2	Average	Horizontal	15.1	36.4	-18.1	33.4	54.0	-20.6
4514.0	Peak	Vertical	14.1	38.0	0.0	52.1	74.0	-21.9
4514.0	Average	Vertical	14.1	38.0	-18.1	34.0	54.0	-20.0
4514.0	Peak	Horizontal	16.0	38.0	0.0	54.0	74.0	-20.0
4514.0	Average	Horizontal	16.0	38.0	-18.1	35.9	54.0	-18.1
5416.8	Peak	Vertical	26.3	40.1	0.0	66.4	74.0	-7.6
5416.8	Average	Vertical	26.3	40.1	-18.1	48.3	54.0	-5.7
5416.8	Peak	Horizontal	28.7	40.1	0.0	68.8	74.0	-5.2
5416.8	Average	Horizontal	28.7	40.1	-18.1	50.7	54.0	-3.3
7222.6	Peak	Vertical	24.7	42.9	0.0	67.6	74.0	-6.4
7222.6	Average	Vertical	24.7	42.9	-18.1	49.5	54.0	-4.5
7222.6	Peak	Horizontal	24.7	42.9	0.0	67.6	74.0	-6.4
7222.6	Average	Horizontal	24.7	42.9	-18.1	49.5	54.0	-4.5
8125.4	Peak	Vertical	19.6	44.5	0.0	64.1	74.0	-9.9
8125.4	Average	Vertical	19.6	44.5	-18.1	46.0	54.0	-8.0
8125.4	Peak	Horizontal	19.4	44.5	0.0	63.9	74.0	-10.1
8125.4	Average	Horizontal	19.4	44.5	-18.1	45.8	54.0	-8.2
9028.0	Peak	Vertical	13.7	45.5	0.0	59.2	74.0	-14.8
9028.0	Average	Vertical	13.7	45.5	-18.1	41.1	54.0	-12.9
9028.0	Peak	Horizontal	14.5	45.5	0.0	60.0	74.0	-14.0
9028.0	Average	Horizontal	14.5	45.5	-18.1	41.9	54.0	-12.1

Table 5: Transmitting at the Lowest Frequency

Frequency (MHz)	Detector	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Duty Cycle Correction Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2743.2	Peak	Vertical	29.8	33.5	0.0	63.3	74.0	-10.7
2743.2	Average	Vertical	29.8	33.5	-18.1	45.2	54.0	-8.8
2743.2	Peak	Horizontal	28.8	33.5	0.0	62.3	74.0	-11.7
2743.2	Average	Horizontal	28.8	33.5	-18.1	44.2	54.0	-9.8
3657.6	Peak	Vertical	13.7	36.6	0.0	50.3	74.0	-23.7
3657.6	Average	Vertical	13.7	36.6	-18.1	32.2	54.0	-21.8
3657.6	Peak	Horizontal	15.7	36.6	0.0	52.3	74.0	-21.7
3657.6	Average	Horizontal	15.7	36.6	-18.1	34.2	54.0	-19.8
4572.0	Peak	Vertical	19.8	38.2	0.0	58.0	74.0	-16.0
4572.0	Average	Vertical	19.8	38.2	-18.1	39.9	54.0	-14.1
4572.0	Peak	Horizontal	20.5	38.2	0.0	58.7	74.0	-15.3
4572.0	Average	Horizontal	20.5	38.2	-18.1	40.6	54.0	-13.4
5486.4	Peak	Vertical	14.9	40.3	0.0	55.2	74.0	-18.8
5486.4	Average	Vertical	14.9	40.3	-18.1	37.1	54.0	-16.9
5486.4	Peak	Horizontal	15.3	40.3	0.0	55.6	74.0	-18.4
5486.4	Average	Horizontal	15.3	40.3	-18.1	37.5	54.0	-16.5
7315.2	Peak	Vertical	13.1	43.2	0.0	56.3	74.0	-17.7
7315.2	Average	Vertical	13.1	43.2	-18.1	38.2	54.0	-15.8
7315.2	Peak	Horizontal	10.6	43.2	0.0	53.8	74.0	-20.2
7315.2	Average	Horizontal	10.6	43.2	-18.1	35.7	54.0	-18.3
8229.6	Peak	Vertical	18.8	44.6	0.0	63.4	74.0	-10.6
8229.6	Average	Vertical	18.8	44.6	-18.1	45.3	54.0	-8.7
8229.6	Peak	Horizontal	15.8	44.6	0.0	60.4	74.0	-13.6
8229.6	Average	Horizontal	15.8	44.6	-18.1	42.3	54.0	-11.7
9144.0	Peak	Vertical	11.6	45.6	0.0	57.2	74.0	-16.8
9144.0	Average	Vertical	11.6	45.6	-18.1	39.1	54.0	-14.9
9144.0	Peak	Horizontal	12.7	45.6	0.0	58.3	74.0	-15.7
9144.0	Average	Horizontal	12.7	45.6	-18.1	40.2	54.0	-13.8

Table 6: Transmitting at the Middle Frequency

Frequency (MHz)	Detector	Antenna Polarity	Receiver Reading (dBμV)	Correction Factor (dB)	Duty Cycle Correction Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2780.7	Peak	Vertical	30.2	33.6	0.0	63.8	74.0	-10.2
2780.7	Average	Vertical	30.2	33.6	-18.1	45.7	54.0	-8.3
2780.7	Peak	Horizontal	28.6	33.6	0.0	62.2	74.0	-11.8
2780.7	Average	Horizontal	28.6	33.6	-18.1	44.1	54.0	-9.9
3707.6	Peak	Vertical	13.1	36.7	0.0	49.8	74.0	-24.2
3707.6	Average	Vertical	13.1	36.7	-18.1	31.7	54.0	-22.3
3707.6	Peak	Horizontal	11.2	36.7	0.0	47.9	74.0	-26.1
3707.6	Average	Horizontal	11.2	36.7	-18.1	29.8	54.0	-24.2
4634.5	Peak	Vertical	9.6	38.3	0.0	47.9	74.0	-26.1
4634.5	Average	Vertical	9.6	38.3	-18.1	29.8	54.0	-24.2
4634.5	Peak	Horizontal	8.6	38.3	0.0	46.9	74.0	-27.1
4634.5	Average	Horizontal	8.6	38.3	-18.1	28.8	54.0	-25.2
5561.4	Peak	Vertical	12.7	40.3	0.0	53.0	74.0	-21.0
5561.4	Average	Vertical	12.7	40.3	-18.1	34.9	54.0	-19.1
5561.4	Peak	Horizontal	7.7	40.3	0.0	48.0	74.0	-26.0
5561.4	Average	Horizontal	7.7	40.3	-18.1	29.9	54.0	-24.1
7415.2	Peak	Vertical	9.0	43.5	0.0	52.5	74.0	-21.5
7415.2	Average	Vertical	9.0	43.5	-18.1	34.4	54.0	-19.6
7415.2	Peak	Horizontal	7.9	43.5	0.0	51.4	74.0	-22.6
7415.2	Average	Horizontal	7.9	43.5	-18.1	33.3	54.0	-20.7
8342.1	Peak	Vertical	15.3	44.8	0.0	60.1	74.0	-13.9
8342.1	Average	Vertical	15.3	44.8	-18.1	42.0	54.0	-12.0
8342.1	Peak	Horizontal	14.7	44.8	0.0	59.5	74.0	-14.5
8342.1	Average	Horizontal	14.7	44.8	-18.1	41.4	54.0	-12.6
9269.0	Peak	Vertical	17.0	45.7	0.0	62.7	74.0	-11.3
9269.0	Average	Vertical	17.0	45.7	-18.1	44.6	54.0	-9.4
9269.0	Peak	Horizontal	11.7	45.7	0.0	57.4	74.0	-16.6
9269.0	Average	Horizontal	11.7	45.7	-18.1	39.3	54.0	-14.7

Table 7: Transmitting at the Highest Frequency

Result

The radiated spurious emissions in the restricted bands met the limits specified in §15.209; therefore, the EUT complies with the specification.

7 Test Procedures and Test Equipment

7.1 Direct Connection at the Antenna Port Test

Type of Equipment	Manufacturer	Model Number	Asset Number	Date of Last Calibration	Due Date of Calibration
Spectrum Analyzer/Receiver	Rohde & Schwarz	ESU40	V033119	07/16/2018	07/16/2019
6 dB Attenuator	Pasternack	PE7004-6	V033645	01/08/2019	01/08/2020
Low Loss Cable	N/A	N/A	V034173	01/08/2019	01/08/2020

Figure 1: Direct Connection at the Antenna Port Test

7.2 Radiated Emissions

The radiated emissions from the EUT were measured using a spectrum analyzer with a quasi-peak adapter for peak and quasi-peak readings.

A preamplifier with a fixed gain of 51 dB was used to increase the sensitivity of the measuring instrumentation. The quasi-peak adapter uses a bandwidth of 120 kHz, with the spectrum analyzer's resolution bandwidth set at 1 MHz, for readings in the 30 to 1000 MHz frequency ranges. For frequencies below 30 MHz, a 9 kHz resolution Bandwidth was used.

A loop antenna was used to measure frequencies below 30 MHz. A biconilog antenna was used to measure the frequency range of 30 to 1000 MHz, at a distance of 3 meters from the EUT. The readings obtained by these antennas are correlated to the levels obtained with a tuned dipole antenna by adding antenna factors. A double-ridged guide antenna was used to measure the emissions at frequencies above 1000 MHz at a 3 meter or 1 meter distance from the EUT.

The configuration of the EUT was varied to find the maximum radiated emission. The EUT was connected to the peripherals listed in Section 2.3 via the interconnecting cables listed in Section 2.4. A technician manually manipulated these interconnecting cables to obtain worst-case radiated emissions. The EUT was rotated 360 degrees, and the antenna height was varied from 1 to 4 meters to find the maximum radiated emission. Where there were multiple interface ports all of the same type, cables are either placed on all of the ports or cables added to these ports until the emissions do not increase by more than 2 dB.

Desktop EUT are measured on a non-conducting table 0.8 meters above the ground plane. For frequencies above 1000 MHz, the EUT is placed on a table 1.5 meters above the ground plane. The table is placed on a turntable, which is level with the ground plane. For equipment normally placed on floors, the equipment shall be placed directly on the turntable.

For radiated emissions testing that is performed at distances closer than the specified distance; an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

Type of Equipment	Manufacturer	Model Number	Asset Number	Date of Last Calibration	Due Date of Calibration
Spectrum Analyzer/Receiver	Rohde & Schwarz	ESU40	V033119	07/16/2018	07/16/2019
Spectrum Analyzer	Hewlett Packard	8566B	V048078	05/26/2019	05/26/2020
Quasi-Peak Detector	Hewlett Packard	85650A	V039474	05/02/2018	05/02/2020
Loop Antenna	EMCO	6502	V034216	02/11/2019	02/11/2021
Biconilog Antenna	EMCO	3142E-PA	V035736	07/05/2018	07/05/2020
Double Ridged Guide Antenna	EMCO	3115	V033469	04/13/2018	04/13/2020
Standard Gain Horn	ETS-Lindgren	3160-09	V034223	ICO	ICO
High Frequency Amplifier	Miteq	AFS4-001018000-35-10P-4	V033997	01/08/2019	01/08/2020
900 MHz High Pass Filter	Micro-Tronics	HPM50108-03	V034185	01/08/2019	01/08/2020
6’ High Frequency Cable	Microcoax	UFB197C-0-0720-000000	V033638	01/08/2019	01/08/2020
20’ High Frequency Cable	Microcoax	UFB197C-1-3120-000000	V033979	01/08/2019	01/08/2020
3 Meter Radiated Emissions Cable Wanship Upper Site	Microcoax	UFB205A-0-4700-000000	V033639	01/08/2019	01/08/2020
Test Software (FCC)	VPI Labs	Revision 01	V035673	N/A	N/A

Table 8: List of equipment used for radiated emissions testing.

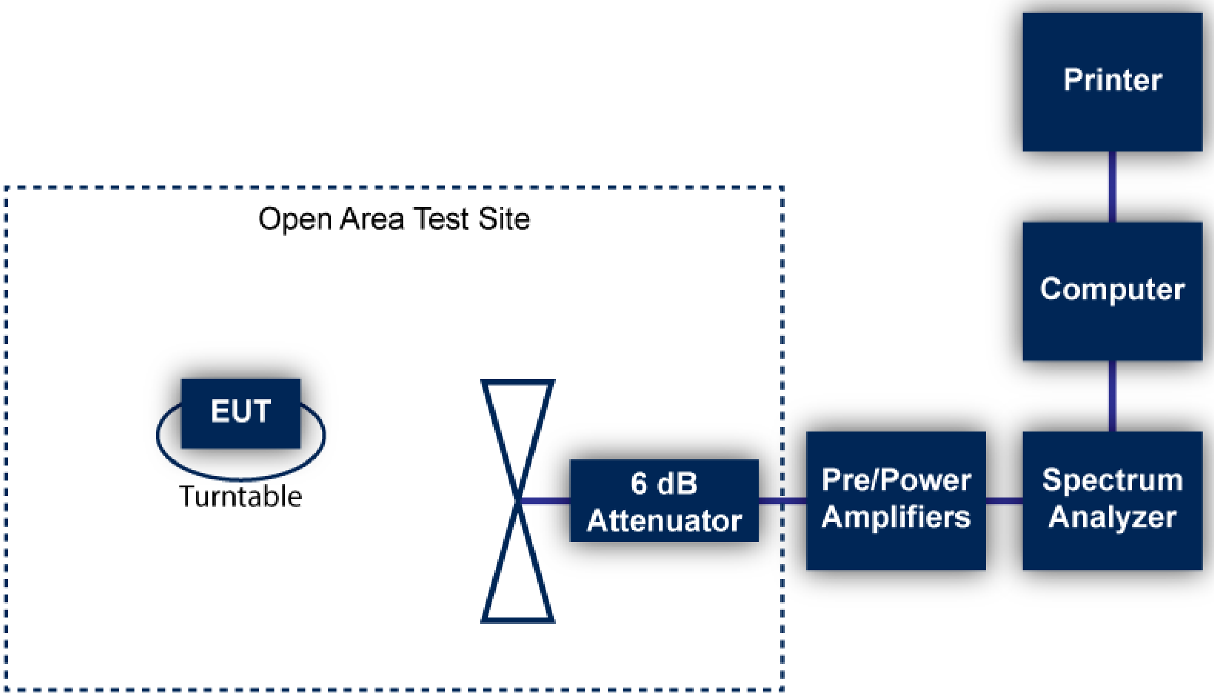


Figure 2: Radiated Emissions Test

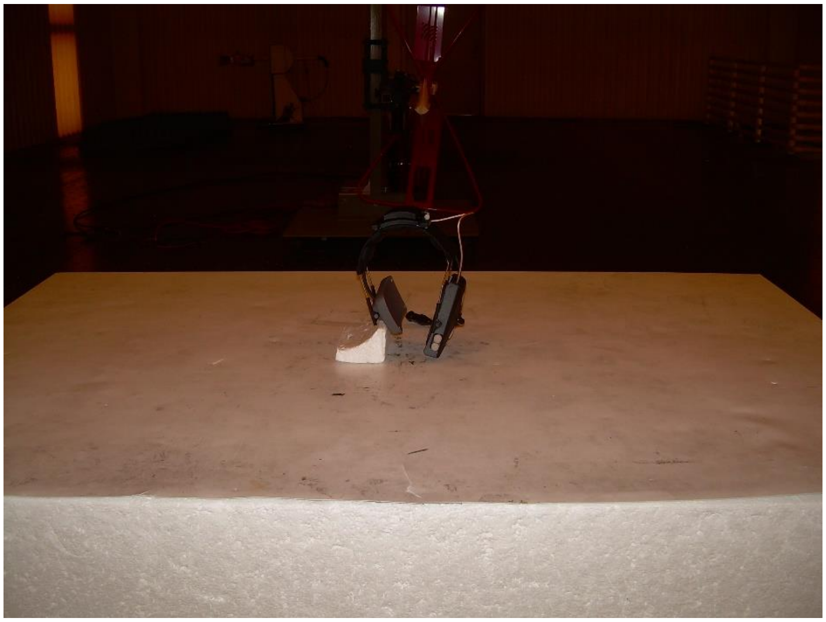
7.3 Equipment Calibration

All applicable equipment is calibrated using either an independent calibration laboratory or VPI Laboratories, Inc. personnel at intervals defined in ANSI C63.4:2014 following outlined calibration procedures. All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Supporting documentation relative to tractability is on file and is available for examination upon request.

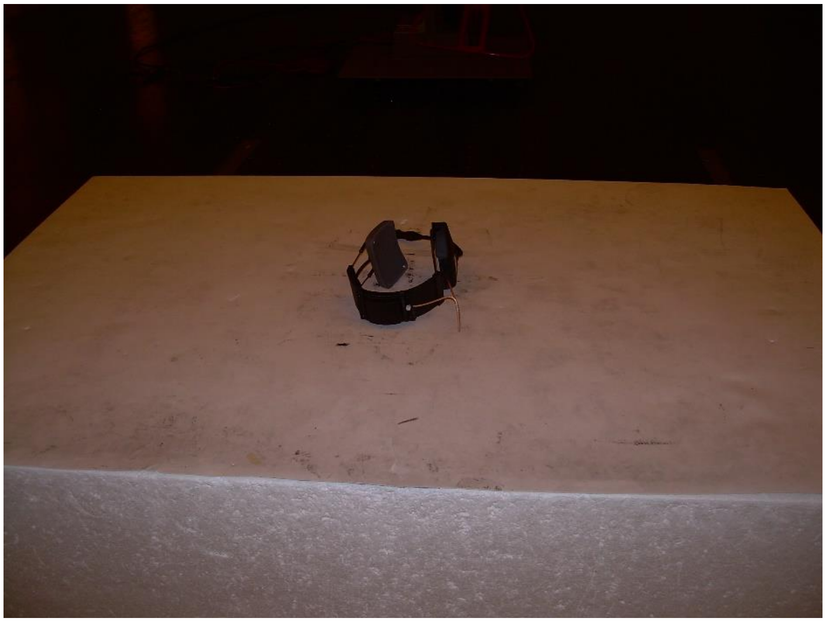
7.4 Measurement Uncertainty

Test	Uncertainty (±dB)	Confidence (%)
Conducted Emissions	2.8	95
Radiated Emission (9 kHz to 30 MHz)	3.3	95
Radiated Emissions (30 MHz to 1 GHz)	3.4	95
Radiated Emissions (1 GHz to 18 GHz)	5.0	95
Radiated Emissions (18 GHz to 40 GHz)	4.1	95

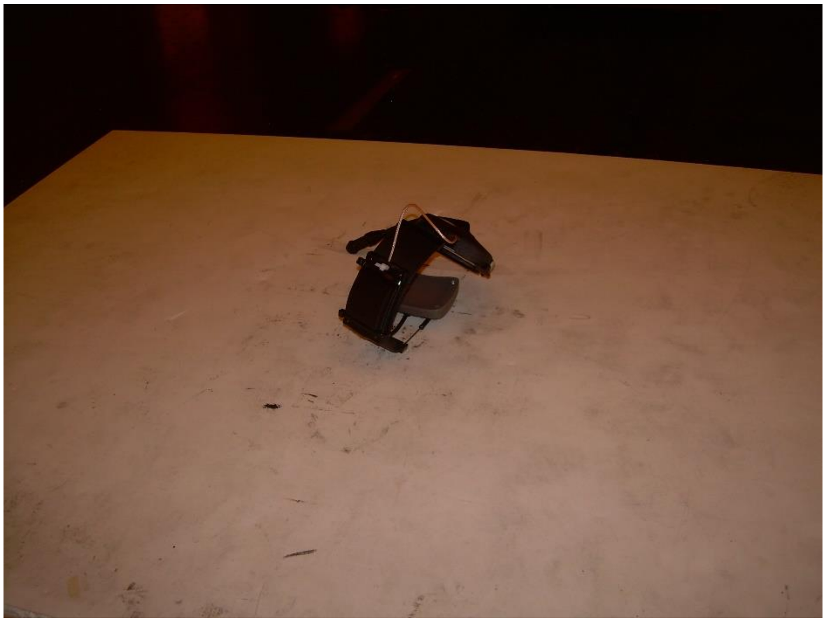
8 Photographs



Photograph 1: View Radiated Emissions Worst-Case Configuration – Vertical



Photograph 2: Front View Radiated Emissions – Flat Configuration



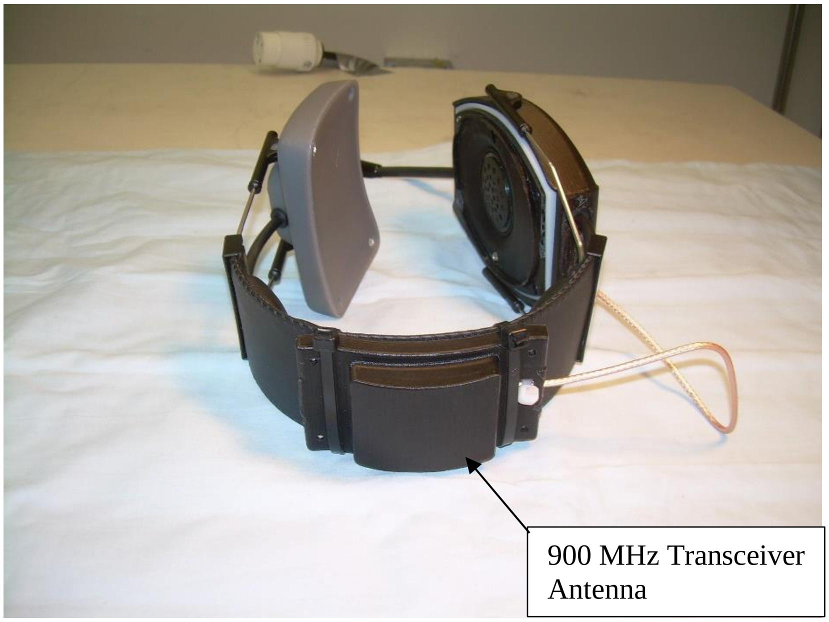
Photograph 3: Front View Radiated Emissions – On Edge Configuration

Photograph 4: Front View Radiated Emissions Worst-Case Configuration – Above 1000 MHz

Photograph 5 – Back View Radiated Emissions Configuration – Above 1000 MHz

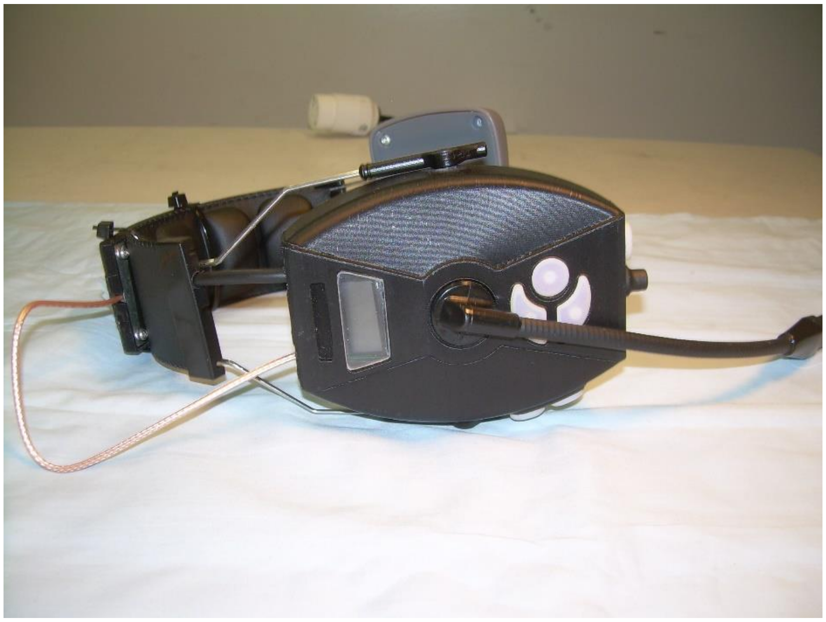
Photograph 6 - Front View of the EUT

Photograph 7 - Back View of the EUT

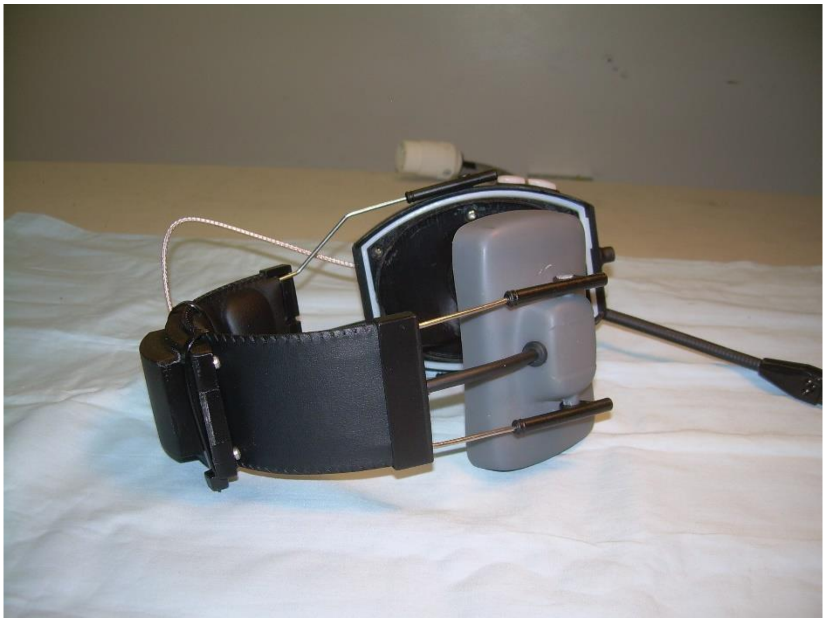


Photograph 8 – Top View of the EUT

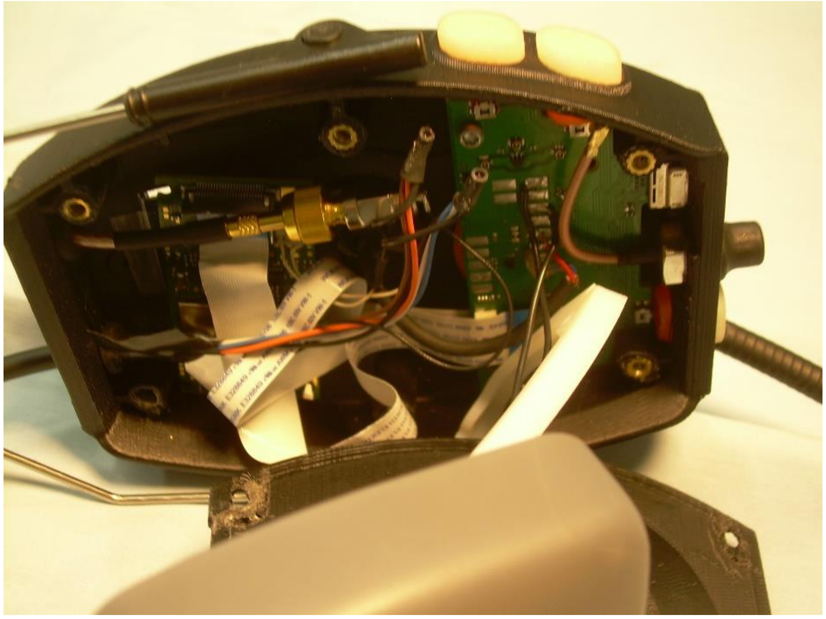
Photograph 9 - Bottom View of the EUT



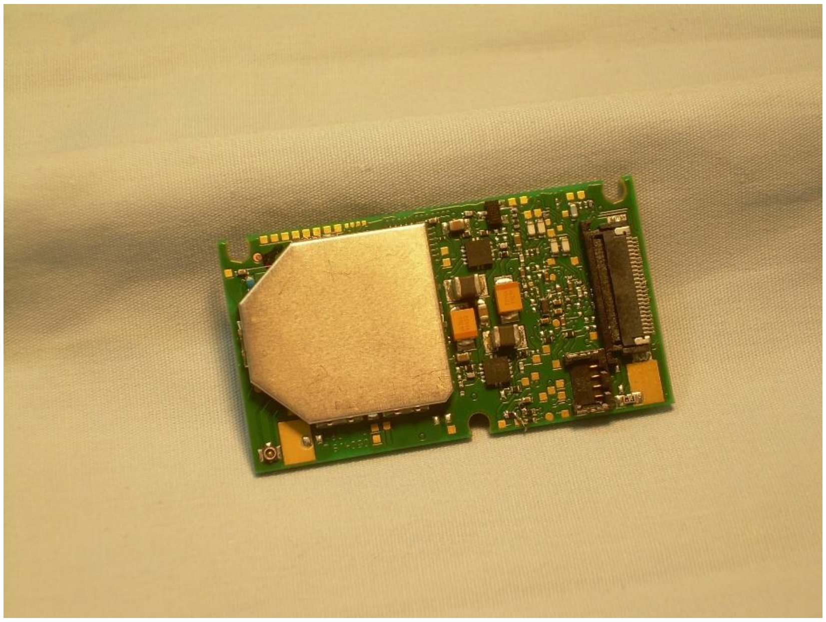
Photograph 10 – Display/Keypad Side View of the EUT



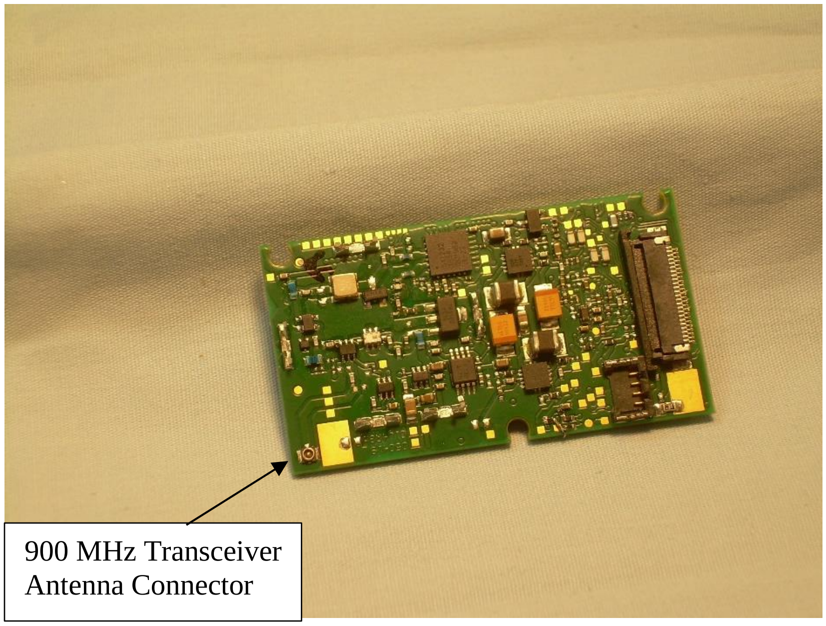
Photograph 11 – Side View of the EUT



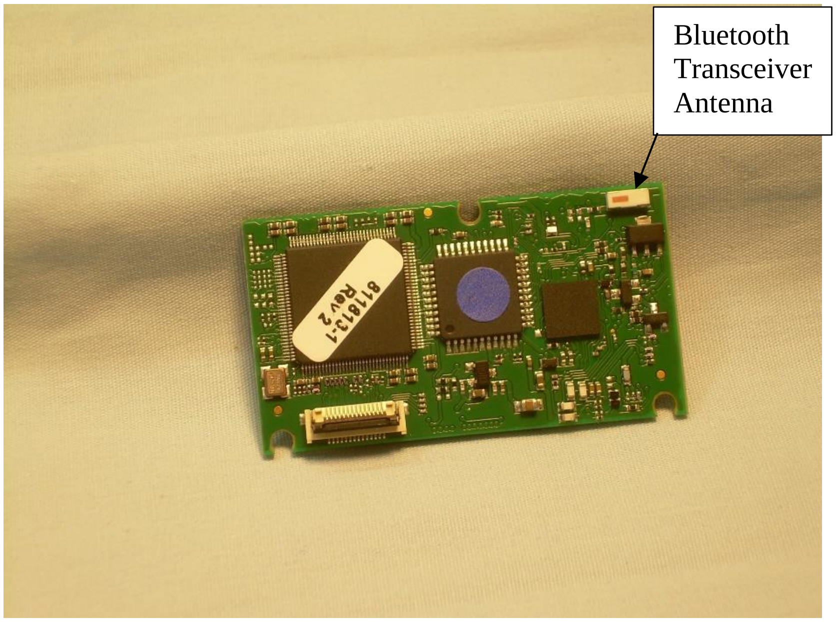
Photograph 12 – Cover Removed Showing PCB Placement



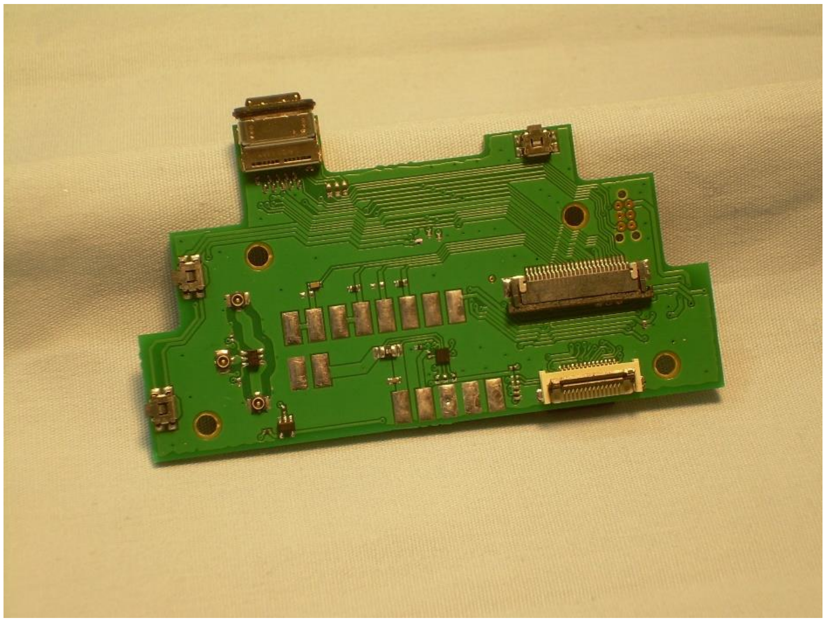
Photograph 13 – Front Side of the Main PCB



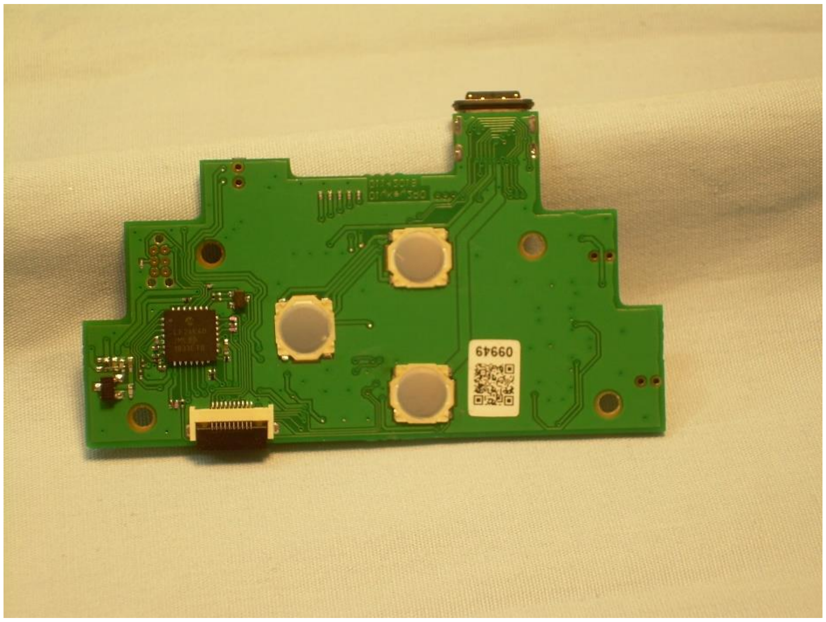
Photograph 14 – Front Side of the Main PCB with RF Shield Removed



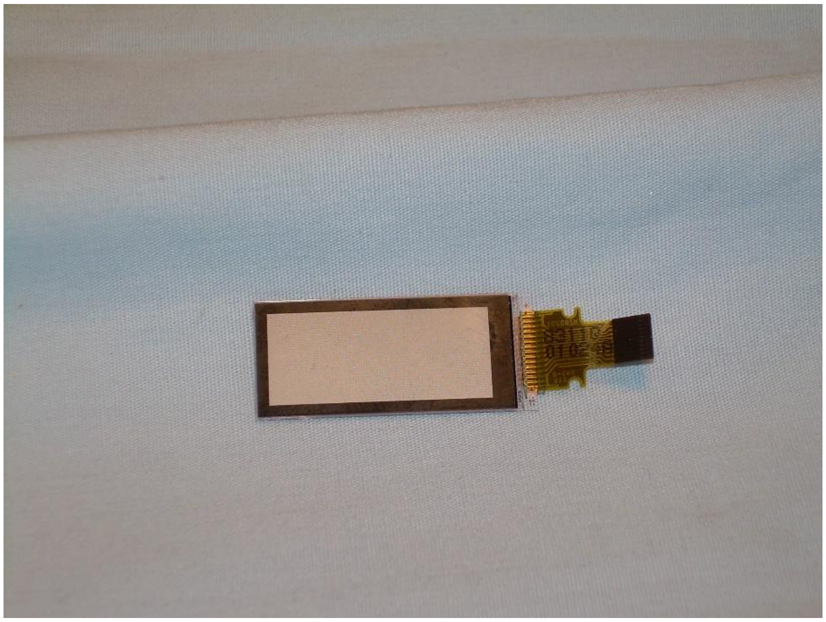
Photograph 15 – Back Side of the Main PCB



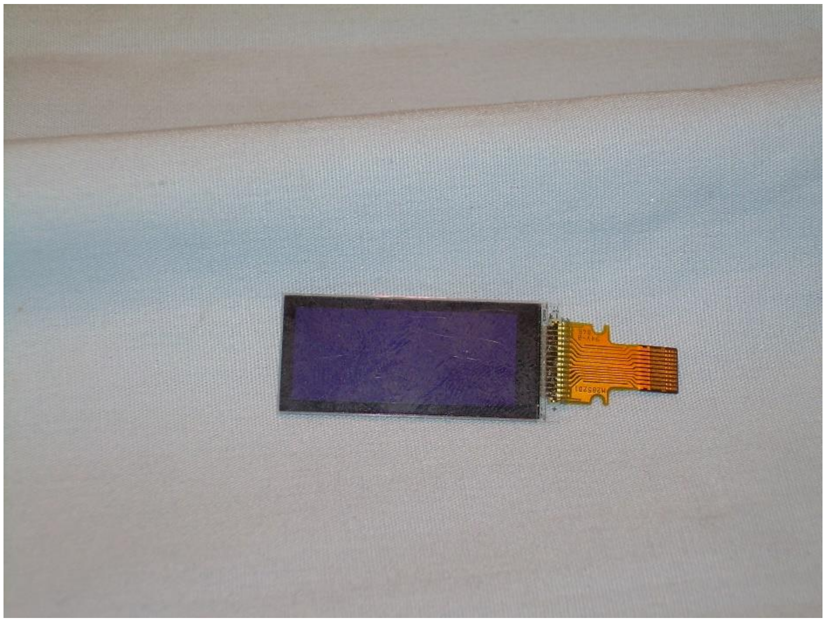
Photograph 16 – Back Side of the Keypad PCB



Photograph 17 – Button Side of the Keypad PCB



Photograph 18 – Back View of the Display



Photograph 19 – Front View of the Display

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