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iRobot Corporation
TEST REPORT

SCOPE OF WORK
FCC PART 15.247 TRANSMITTERS CO-LOCATION

REPORT NUMBER
104798049BOX-001

ISSUE DATE | **[REVISED DATE]**
02/15/2022 | Original Issue

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DOCUMENT CONTROL NUMBER
Non-Specific Radio Report Shell Rev. December 2017

TRANSMITTERS CO-LOCATION TEST REPORT

(FULL COMPLIANCE)

Report Number: 104798049BOX-001
Project Number: G104798049

Report Issue Date: 02/15/2022

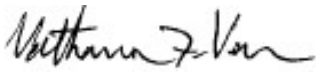
Model(s) Tested: CREATE 3
Model(s) Partially Tested: None
Model(s) Not Tested but declared equivalent by the client: None

Standards: CFR47 FCC Part 15.247 Subpart C: 02/2022,
CFR47 FCC Part 15 Subpart B: 02/2022,
RSS-247 Issue 2 February 2017,
ICES-003 Issue 7, October 2020,
RSS-Gen Issue 5 April 2018,
RSS-102 Issue 5 March 2015
(Transmitters Co-location)

Tested by:
Intertek Testing Services NA, Inc.
70 Codman Hill Road
Boxborough, MA 01719
USA

Client:
iRobot Corporation
8 Crosby Dr Mail Stop 12-2
Bedford, MA 01730
USA

Report prepared by



Vathana Ven / EMC Engineering Supervisor

Report reviewed by

Kouma Sinn / EMC Engineering Supervisor

Table of Contents

1 Introduction and Conclusion

The tests indicated in section 2.0 were performed on the product constructed as described in section 4.0. The remaining test sections are the verbatim text from the actual data sheets used during the investigation. These test sections include the test name, the specified test Method, a list of the actual Test Equipment Used, documentation Photos, Results and raw Data. No additions, deviations, or exclusions have been made from the standard(s) unless specifically noted.

Based on the results of our investigation, we have concluded the product tested **complies** with the requirements of the standard(s) indicated. The results obtained in this test report pertain only to the item(s) tested. Intertek does not make any claims of compliance for samples or variants which were not tested.

2 Test Summary

Section	Test full name	Result
3	Client Information	--
4	Description of Equipment Under Test and Variant Models	--
5	System Setup and Method	--
6	Human RF exposure CFR47 FCC Part 15 Subpart C:01/2022, Section 15.247 (b)(3) RSS-247 Issue 2 February 2017, RSS-102 Issue 5 March 2015	Pass
7	Transmitter spurious emissions CFR47 FCC Part 15 Subpart C: 01/2022, Section 15.247 (d) RSS-247 Issue 2 February 2017	Pass
8	Band Edge Compliance CFR47 FCC Part 15 Subpart C: 01/2022, Section 15.247 (d) RSS-247 Issue 2: 02/2017)	Pass
9	Revision History	--

*Notes: Co-location testing with two radios incorporated in the EUT.

3 Client Information

This EUT was tested at the request of:

Client: iRobot Corporation
8 Crosby Dr Mail Stop 12-2
Bedford, MA 01730
USA

Contact: Kyle Neffendorf
Telephone: +1 (781) 430-3061
Fax: None
Email: kneffendorf@irobot.com

4 Description of Equipment Under Test and Variant Models

Manufacturer: iRobot Corporation
8 Crosby Dr Mail Stop 12-2
Bedford, MA 01730
USA

Equipment Under Test			
Description	Manufacturer	Model Number	Serial Number
Robot	iRobot Corporation	CREATE 3	RCI3020J210813E102219

Receive Date:	09/14/2021
Received Condition:	Good
Type:	Production

Description of Equipment Under Test (provided by client)
The EUT is robot which has the following pre-approved transmitters incorporated. 1) Bluetooth BLE Module 2402.0MHz - 2480.0MHz TX +7.76dBm (Conducted) 0.008W (EIRP) Laird Technologies, Inc. FCC ID: SQGBT850 IC: Not available Antenna : Antegral antenna, Peak Gain: 2dBi . 2) WiFi Module 2412.0MHz - 2462.0MHz TX +25.02dBm 0.80W EIRP iRobot Corporation FCC ID: UFE-AXFY1 IC: Not available Antenna: Antegral antenna, Peak Gain: 4dBi

Equipment Under Test Power Configuration			
Rated Voltage	Rated Current	Rated Frequency	Number of Phases
Internal Battery	N/A	N/A	N/A

Operating modes of the EUT:

No.	Descriptions of EUT Exercising
1	All transmitters transmit simultaneously

Software used by the EUT:

No.	Descriptions of EUT Exercising
1	Each radio was pre-programmed to transmit low, mid, high channels using Tera Term

Variant Models:

The following variant models were not tested as part of this evaluation, but have been identified by the manufacturer as being electrically identical models, depopulated models, or with reasonable similarity to the model(s) tested. Intertek does not make any claims of compliance for samples or variants which were not tested.

None

5 System Setup and Method

Cables					
ID	Description	Length (m)	Shielding	Ferrites	Termination
--	None	--	--	--	--

Support Equipment			
Description	Manufacturer	Model Number	Serial Number
None	--	--	--

5.1 Method:

Configuration as required by Configuration as required by FCC Part 15 Subpart C 15.247: 01/2022, FCC Part 15 Subpart B: 01/2022, RSS 247 Issue 2: 02/2017, ISED ICES-003 Issue 7, October 2020, ANSI C 63.10: 2013, ANSI C 63.4: 2014 and KDB 551693 Grant Comments DR02-42299.

5.2 EUT Block Diagram:

6 Human RF exposure

6.1 Results:

The sample tested was found to Comply. The calculated maximum power density at 20 cm distance is less than the limits for general population / uncontrolled exposure.

6.2 Human RF Exposure Calculation

The EUT incorporated two radios as indicated below.

FCC §1.1310 Radiofrequency radiation exposure limits

Table 1 below sets forth limits for Maximum Permissible Exposure (MPE) to radiofrequency electromagnetic field.

Table 1 – Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power Density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	*100	6
3.0-30	1842/f	4.89/f	$*900/f^2$	6
30-300	61.4	0.163	1.0	6
300-1,500			f/300	6
1,500-100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*100	30
1.34-30	842/f	2.19/f	$*180/f^2$	30
30-300	27.5	0.073	0.2	30
300-1,500			f/1500	30
1,500-100,000			1.0	30

F = frequency in MHz * = Plane-wave equivalent power density

ISED RSS-102 Issue 5

Table 2 below sets forth limits for the RF field strength.

Table 2 – RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)

Frequency range (MHz)	Electric field strength (V/m rms)	Magnetic field strength (A/m rms)	Power Density (W/m^2)	Reference Period (minutes)
0.003-10	83	90	-	Instantaneous*
0.1-10	-	$0.73/f$	-	6**
1.1-10	$87/f^{0.5}$	-	-	6**
10-20	27.46	0.0728	-2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142 f^{0.3417}$	$0.008335 f^{0.3417}$	$0.02619 f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158 f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000/f^{1.2}$

Note: f is frequency in MHz. *Based on nerve stimulation (NS) **Based on specific absorption rate (SAR)

6.3 Method

An MPE evaluation was performed in order to show that the device was compliant with FCC §2.1091 and ISED RSS-102. The maximum power density was calculated for each transmitter at a separation distance of 20 cm. The calculation was performed using the maximum gain from the internal and external antennas declared by the manufacturer.

The maximum permissible exposure (MPE) is predicted by using the following equation:

$$S = PG/4\pi R^2$$

where: S = power density (in appropriate units, e.g. mW/cm^2)
P = power input to the antenna (in appropriate units, e.g., mW)
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

Technology	Frequency (MHz)	Conductied Power (dBm)	Antenna Gain (dBi)	EIRP Power (dBm)	EIRP Power (mW)	PD @ 20cm (mW/cm^2)	FCC PD Limits (mW/cm^2)	% of FCC Limit
2.4 GHz WiFi Radio	2442	25.02	4.00	29.02	797.99	0.1588	1	15.88
BLE	2441	7.76	2.00	9.02	7.98	0.0016	1	0.16
							Total %:	**16.03**

*Output power data were taken from Intertek test report #104076035BOX-001c
and International Certification Corp. test report #FR791801AD

Technology	Frequency (MHz)	Conductied Power (dBm)	Antenna Gain (dBi)	EIRP Power (dBm)	EIRP Power (mW)	PD @ 20cm (W/cm^2)	ISED PD Limits (W/cm^2)	% of FCC Limit
2.4 GHz WiFi Radio	2442	25.02	4.00	29.02	797.99	1.5876	5.41	29.34
BLE	2441	7.76	2.00	9.02	7.98	0.0159	5.41	0.29
							Total %:	**29.64**

*Output power data were taken from Intertek test report #104076035BOX-001c
and International Certification Corp. test report #FR791801AD

Using the following equation to calculate total power density:

$$\sum_{i=1}^{n} \frac{S_i}{(MPE)_i} \leq 1$$

Where S_i – power density for i = 1, 2,…, n
n – number of antennas transmitting simultaneously,
$(MPE)_i$ – limit of MPE for i = 1, 2,…, n

FCC: $\Sigma(S_i/MPE_i) = 15.88 + 0.16 = 16.03\ \% < 100\ \%$
ISED Canada: $\Sigma(S_i/MPE_i) = 29.34 + 0.29 = 29.64\ \% < 100\ \%$

Test Personnel:	Vathana Ven VJV	Test Date:	02/02/2022
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	FCC Part 15.247, RSS-247 RSS-102	Limit Applied:	Per Co-location Requirements
Input Voltage:	Internal Battery Powered	Ambient Temperature:	N/A
Pretest Verification w/ Ambient Signals or BB Source:	N/A	Relative Humidity:	N/A
		Atmospheric Pressure:	N/A

Deviations, Additions, or Exclusions: None

7 Transmitter spurious emissions

7.1 Method

Tests are performed in accordance with FCC Part 15 Subpart C 15.247, FCC Part 15 Subpart B, RSS 247 ICES 003, ANSI C 63.10, and ANSI C 63.4.

TEST SITE: 10m ALSE

The 10m ALSE is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A Styrofoam table 80 cm high is used for table-top equipment.

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucispr
Radiated Emissions, 10m	30-1000 MHz	4.6dB	6.3 dB
Radiated Emissions, 3m	30-1000 MHz	5.3 dB	6.3 dB
Radiated Emissions, 3m	1-6 GHz	4.5 dB	5.2 dB
Radiated Emissions, 3m	6-15 GHz	5.2 dB	5.5 dB
Radiated Emissions, 3m	15-18 GHz	5.0 dB	5.5 dB
Radiated Emissions, 3m	18-40 GHz	5.0 dB	5.5 dB

As shown in the table above our radiated emissions U_{lab} is less than the corresponding U_{CISPR} reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required, based on CISPR 22 and CISPR 11 (for 2006 and later revisions) Clause 11.

Sample Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF - AG
Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

Assume a receiver reading of 52.0 dBμV is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dBμV/m. This value in dBμV/m was converted to its corresponding level in μV/m.

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

To convert from dBμV to μV or mV the following was used:

$UF = 10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

Example:

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
$UF = 10^{(32\ dB\mu V / 20)}$ = 39.8 μV/m

Alternately, when BAT-EMC Emission Software is used, the “Level” includes all losses and gains and is compared directly in the “Margin” column to the “Limit”. The “Correction” includes Antenna Factor, Preamp, and Cable Loss. These are already accounted for in the “Level” column.

7.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV007`	Weather Station Vantage Vue	Davis	6250	MS191212003	03/22/2021	03/22/2022
145108`	EMI Test Receiver (20Hz – 40GHz)	Rohde & Schwarz	ESIB40	100209	06/22/2021	06/22/2022
145-406'	10m Track A In-floor Cable #1	Huber + Suhner	sucoflex 160-19220mm	001	07/22/2021	07/22/2022
HS002`	DC-18GHz cable 1.4m long	Huber & Suhner	SucoFlex 106A	HS002	11/25/2020	11/25/2021
PRE10'	30-1000MHz pre-amp	ITS	PRE10	PRE10	02/17/2021	02/17/2022
IW006'	DC-18GHz cable 8.4m long	Insulated Wire	2800-NPS	IW006	11/25/2020	11/25/2021
145145'	Broadband Hybrid Antenna 30 MHz - 3 GHz	Sunol Sciences Corp.	JB3	A122313	06/09/2021	06/09/2022
PRE12`	500MHz – 18GHz 40dB Gain Preamp	COM-POWER	PAM-118A	18040117	12/07/2020	12/07/2021
ETS002'	1-18GHz DRG Horn Antenna	ETS Lindgren	3117	00143260	08/24/2021	08/24/2022
145-420'	Receiver to floor cable	Utiflex	UFB311A-2-0591-70070	145-420	02/17/2021	02/17/2022
145-422'	10Amp Pre-amp to under floor	Utiflex	UFB311A-0-2756-70070	145-422	02/17/2021	02/17/2022
REA004'	3GHz High Pass Filter	Reactel, Inc	7HSX-3G/18G-S11	06-1	02/19/2021	02/19/2022
HS003'	10m under floor cable	Huber-Schuner	10m-1	HS003	02/17/2021	02/17/2022
REA008'	band reject filter 2.4GHz	Reactel, Inc	12RX7-2441.75-x140 S	17-01	07/28/2021	07/28/2022
PRE9'	100MHz-40GHz Preamp	MITEQ	NSP4000-NFG	1260417	09/24/2020	09/24/2021
CBLHF2012-5M-2'	5m 9kHz-40GHz Coaxial Cable - SET2	Huber & Suhner	SF102	252676002	02/19/2021	02/19/2022
IW001'	2 meter cable	Insulated Wire	2801-NPS	001	01/08/2020	10/08/2021
145-424'	9kHz to 40GHz Cable	Huber and Suhner	Sucoflex	145-424	02/17/2021	02/17/2022
ROS005-1'	Signal and Spectrum Analyzer	Rohde and Shwartz	FSW43	100646	10/27/2020	10/27/2021
CBLSHF204'	Cable, SMA - SMA, 9kHz -40GHz, (Cable Kit 5)	Huber + Suhner	Sucoflex 102EA	234714001	12/10/2020	12/10/2021

Software Utilized:

Name	Manufacturer	Version
BAT-EMC	Nexio	3.17.0.3
EMI Boxborough.xls	Intertek	08/27/2010

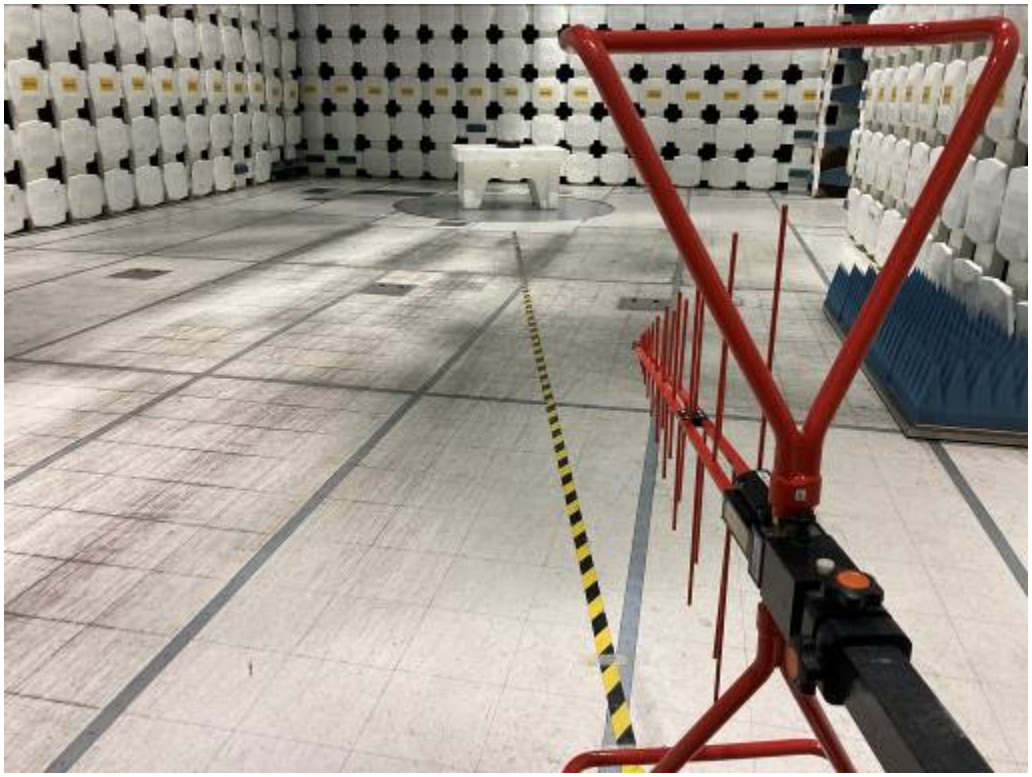
7.3 Results:

The sample tested was found to Comply.

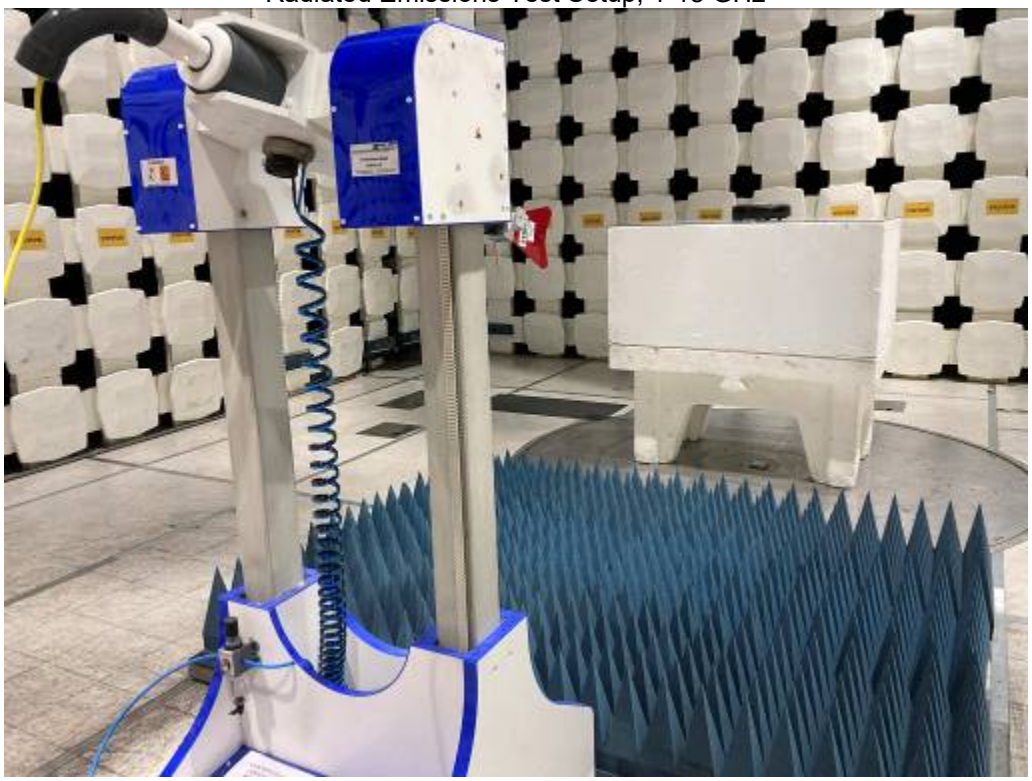
15.247 (d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that 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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c))

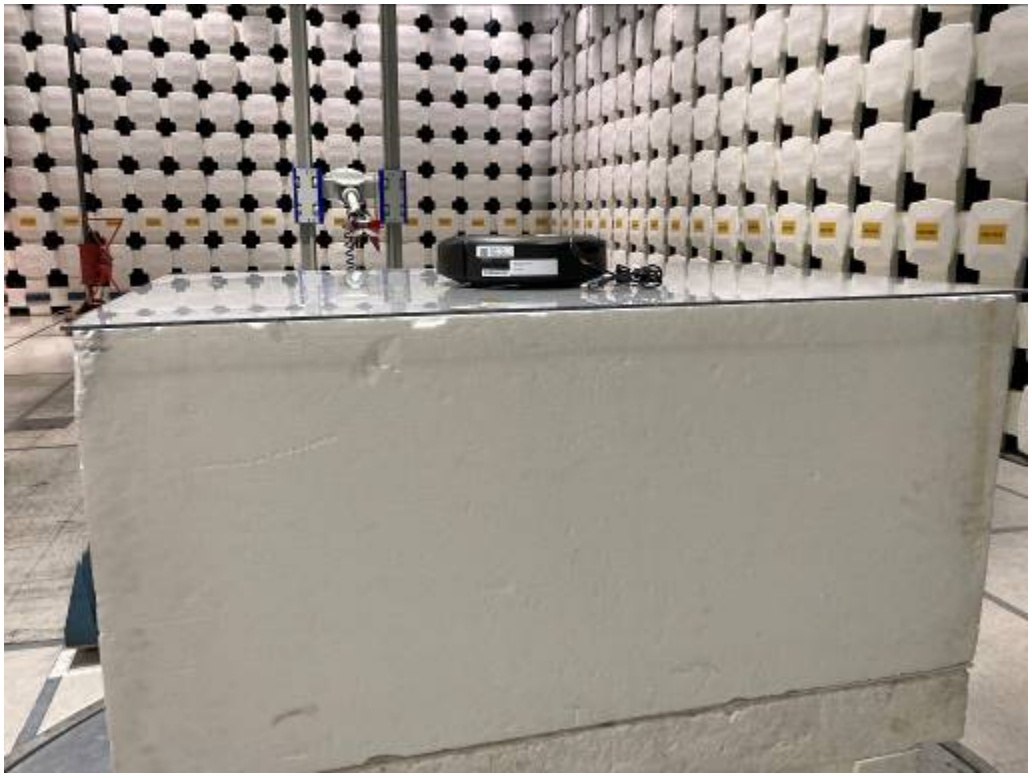
7.4 Setup Photographs:

Radiated Emissions Test Setup, Below 1000 MHz



Radiated Emissions Test Setup, 1-18 GHz





Radiated Emissions Test Setup, 18-26 GHz

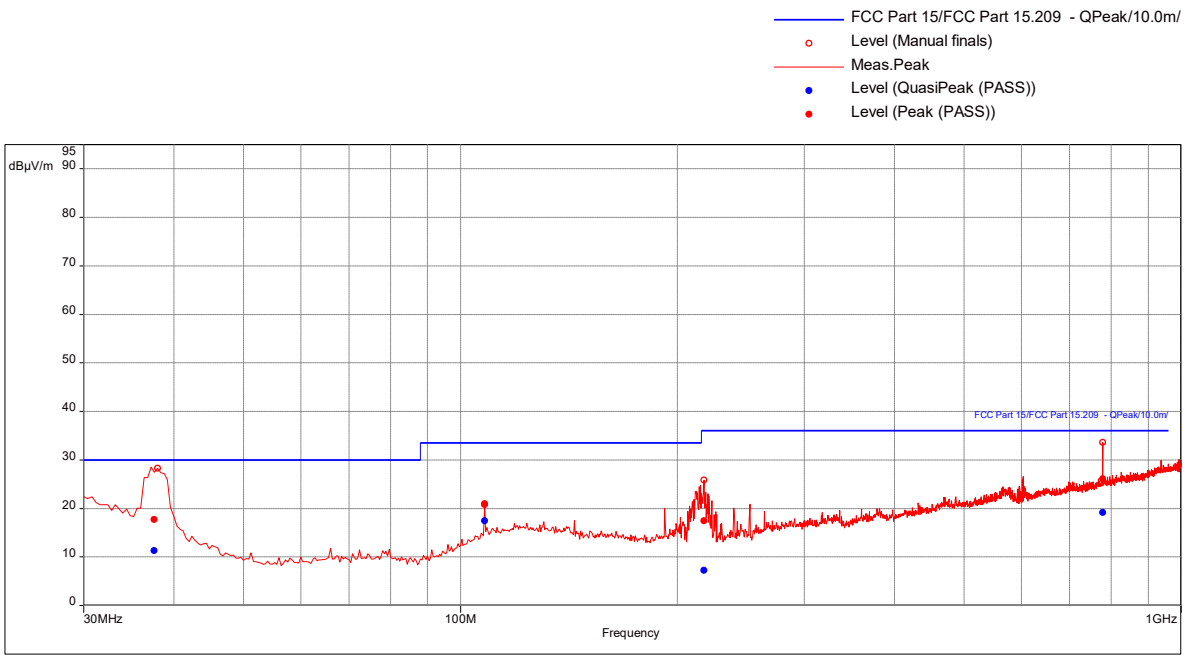
7.5 Plots/Data:

All Radios Transmit @ Low Channel, 30-1000 MHz

Test Information:

Date and Time	9/14/2021 5:47:41 PM
Client and Project Number	iRobot_G104798049
Engineer	Vathana Ven
Temperature	24 deg C
Humidity	38%
Atmospheric Pressure	1008 mB
Comments	RE 30-1000MHz_Battery_802.11n HT40, MCS6, 40MHz BW_Low CH (2412MHz), BLE Tx Low CH (2412MHz)

Graph:



Results:

QuasiPeak (PASS) (4)

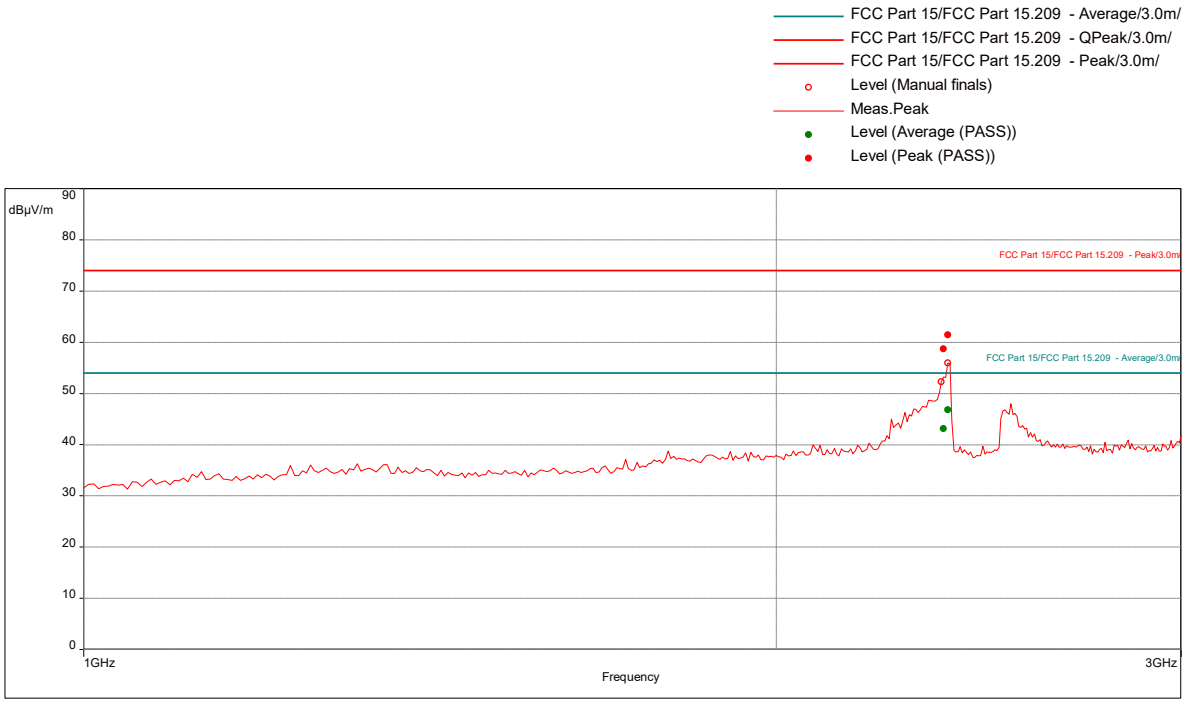
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
37.74736842	11.27	30.00	-18.73	118.00	3.68	Vertical	120000.00	-17.98
108	17.43	33.50	-16.07	69.00	2.62	Horizontal	120000.00	-20.17
217.7894737	7.19	36.00	-28.81	233.00	1.36	Vertical	120000.00	-21.33
778.3473684	19.18	36.00	-16.82	359.00	2.75	Horizontal	120000.00	-8.12

All Radios Transmit @ Low Channel, 1-3 GHz

Test Information:

Date and Time	9/14/2021 10:44:40 PM
Client and Project Number	iRobot_G104798049
Engineer	Vathana Ven
Temperature	24 deg C
Humidity	38%
Atmospheric Pressure	1008 mB
Comments	RE 1 to 3GHz_Battery_802.11n HT40, MCS6, 40MHz BW_Low CH (2412MHz), BLE Tx Low CH (2412MHz)

Graph:



Results:

Peak (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2364.210526	58.68	74.00	-15.32	157.00	3.30	Vertical	1000000.00	-3.29
2376.578947	61.46	74.00	-12.54	152.00	3.74	Vertical	1000000.00	-3.24

Average (PASS) (2)

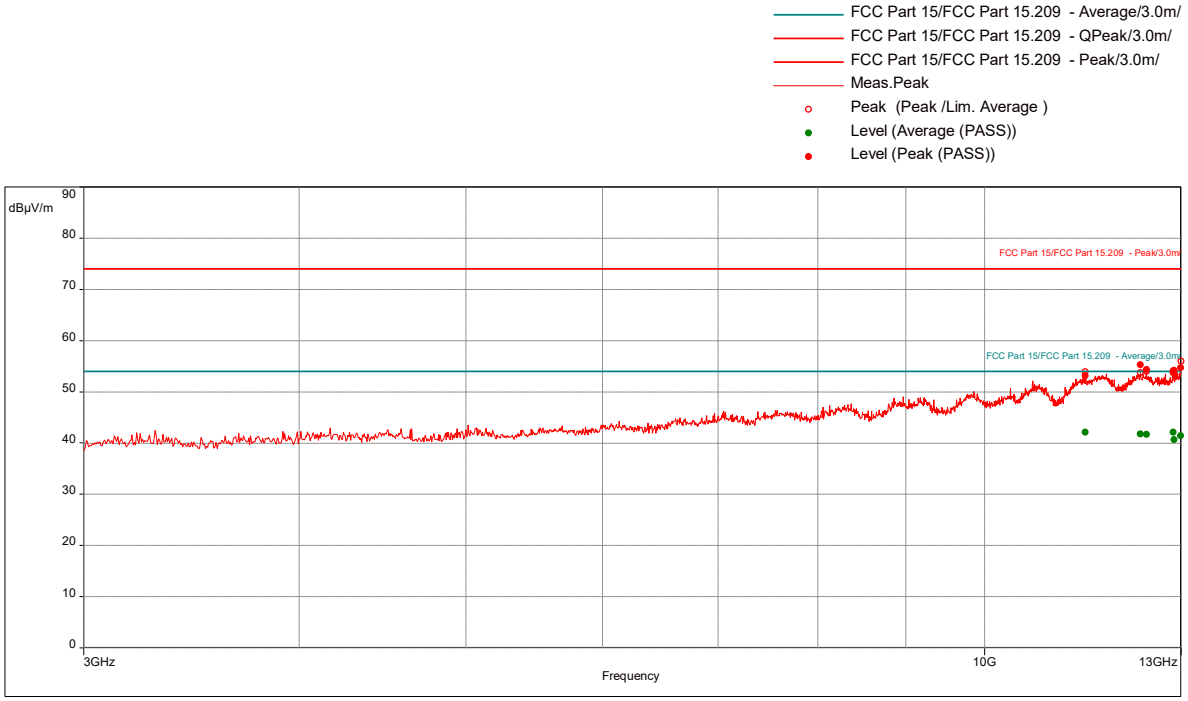
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2364.210526	43.09	54.00	-10.91	157.00	3.30	Vertical	1000000.00	-3.29
2376.578947	46.84	54.00	-7.16	152.00	3.74	Vertical	1000000.00	-3.24

All Radios Transmit @ Low Channel, 3-13 GHz

Test Information:

Date and Time	9/14/2021 10:56:21 PM
Client and Project Number	iRobot_G104798049
Engineer	Vathana Ven
Temperature	24 deg C
Humidity	38%
Atmospheric Pressure	1008 mB
Comments	RE 3 to 13GHz_Battery_802.11n HT40, MCS6, 40MHz BW_Low CH (2412MHz), BLE Tx Low CH (2412MHz)

Graph:



Results:

Peak (PASS) (6)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
11433.94737	53.09	74.00	-20.91	350.00	2.30	Horizontal	1000000.00	12.51
12313.68421	55.28	74.00	-18.72	39.00	2.45	Horizontal	1000000.00	13.42
12412.10526	54.33	74.00	-19.67	0.00	1.35	Horizontal	1000000.00	13.50
12864.21053	54.09	74.00	-19.91	82.00	1.15	Horizontal	1000000.00	14.90
12879.73684	54.15	74.00	-19.85	204.00	3.89	Horizontal	1000000.00	14.95
12995.78947	54.65	74.00	-19.35	4.00	2.85	Vertical	1000000.00	15.19

Average (PASS) (6)

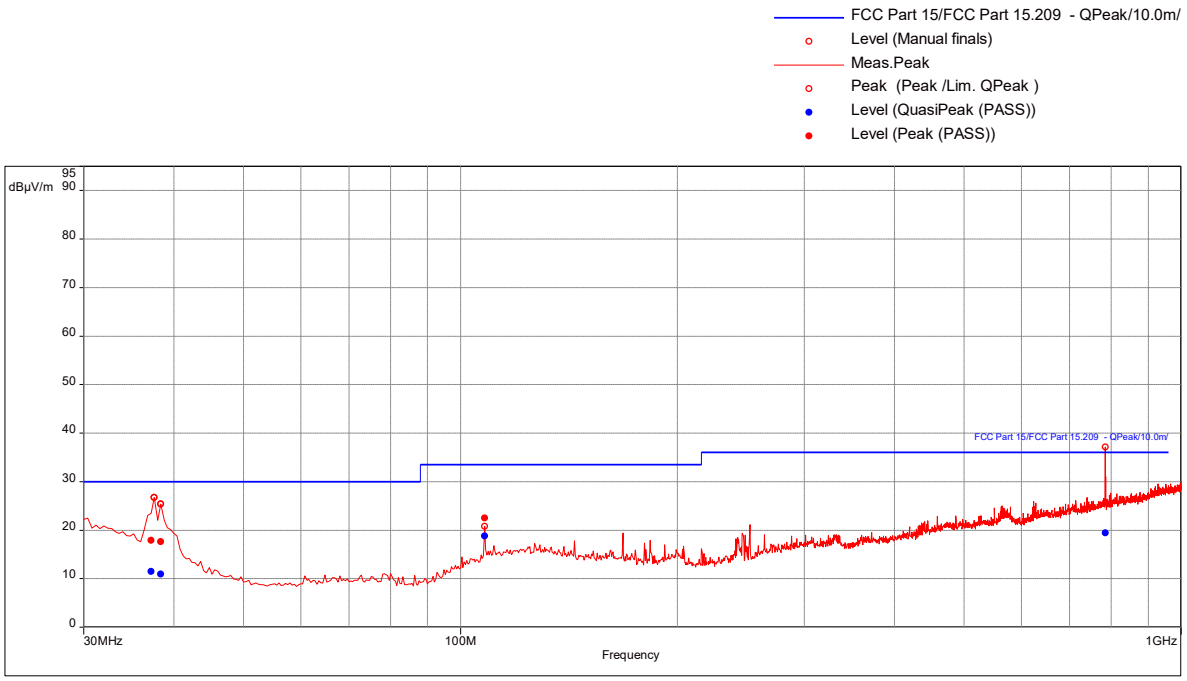
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
11433.94737	42.09	54.00	-11.91	350.00	2.30	Horizontal	1000000.00	12.51
12313.68421	41.71	54.00	-12.29	39.00	2.45	Horizontal	1000000.00	13.42
12412.10526	41.63	54.00	-12.37	0.00	1.35	Horizontal	1000000.00	13.50
12864.21053	42.13	54.00	-11.87	82.00	1.15	Horizontal	1000000.00	14.90
12879.73684	40.68	54.00	-13.32	204.00	3.89	Horizontal	1000000.00	14.95
12995.78947	41.43	54.00	-12.57	4.00	2.85	Vertical	1000000.00	15.19

All Radios Transmit @ Mid Channel, 30-1000 MHz

Test Information:

Date and Time	9/14/2021 6:46:41 PM
Client and Project Number	iRobot_G104798049
Engineer	Vathana Ven
Temperature	24 deg C
Humidity	38%
Atmospheric Pressure	1008 mB
Comments	RE 30-1000MHz_Battery_802.11n HT40, MCS6, 40MHz BW_Mid CH (2442MHz), BLE Tx Mid CH (2442MHz)

Graph:



Results:

QuasiPeak (PASS) (4)

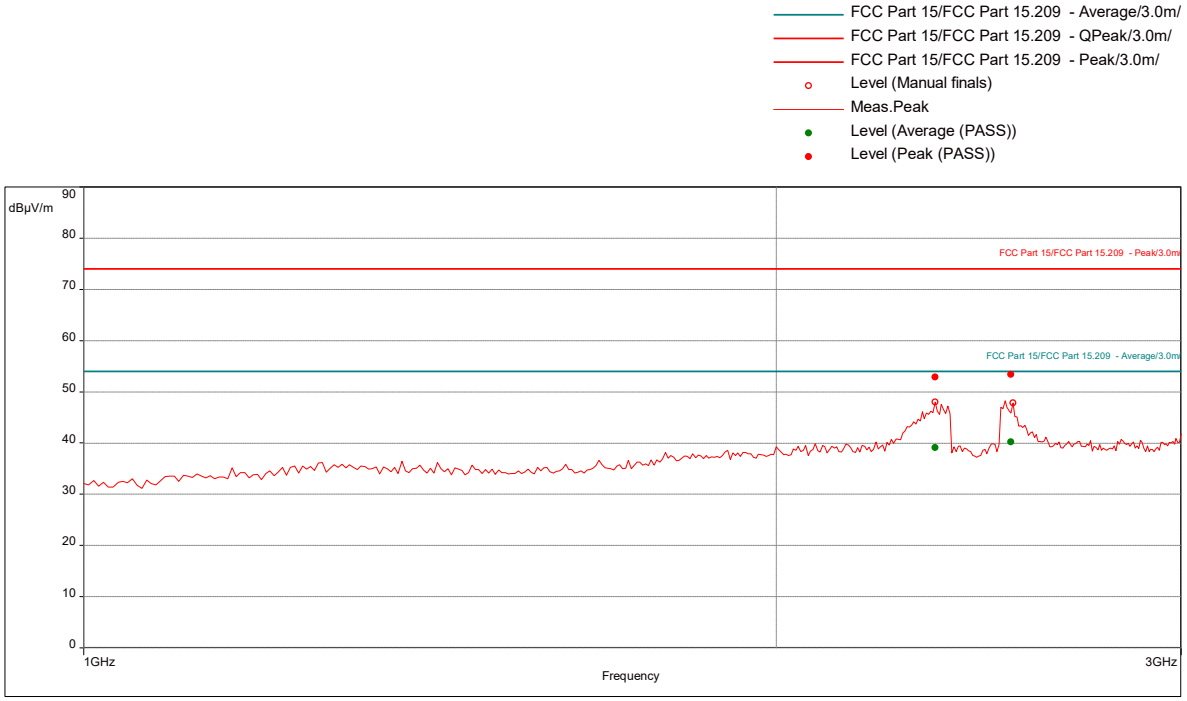
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
37.31578947	11.48	30.00	-18.52	119.00	3.41	Vertical	120000.00	-17.72
38.30526316	10.91	30.00	-19.09	52.00	1.55	Vertical	120000.00	-18.34
108	18.84	33.50	-14.66	125.00	3.31	Horizontal	120000.00	-20.17
785.2736842	19.40	36.00	-16.60	355.00	1.80	Horizontal	120000.00	-7.90

All Radios Transmit @ Mid Channel, 1-3 GHz

Test Information:

Date and Time	9/14/2021 10:15:10 PM
Client and Project Number	iRobot_G104798049
Engineer	Vathana Ven
Temperature	24 deg C
Humidity	38%
Atmospheric Pressure	1008 mB
Comments	RE 1 to 3GHz_Battery_802.11n HT40, MCS6, 40MHz BW_Mid CH (2442MHz), BLE Tx Mid CH (2442MHz)

Graph:



Results:

Peak (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2344.210526	52.88	74.00	-21.12	147.00	3.35	Vertical	1000000.00	-3.39
2531.052632	53.39	74.00	-20.61	146.00	3.64	Vertical	1000000.00	-3.16

Average (PASS) (2)

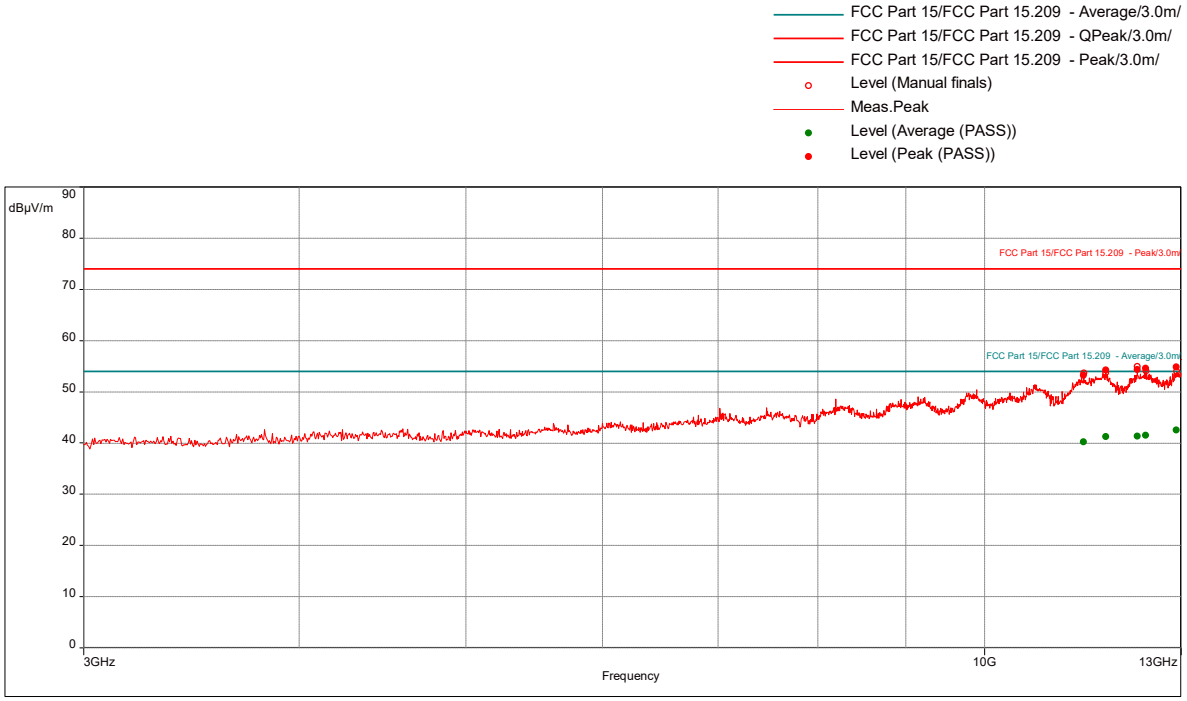
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2344.210526	39.14	54.00	-14.86	147.00	3.35	Vertical	1000000.00	-3.39
2531.052632	40.20	54.00	-13.80	146.00	3.64	Vertical	1000000.00	-3.16

All Radios Transmit @ Mid Channel, 3-13 GHz

Test Information:

Date and Time	9/14/2021 9:47:50 PM
Client and Project Number	iRobot_G104798049
Engineer	Vathana Ven
Temperature	24 deg C
Humidity	38%
Atmospheric Pressure	1008 mB
Comments	RE 3 to 13GHz_Battery_802.11n HT40, MCS6, 40MHz BW_Mid CH (2442MHz), BLE Tx Mid CH (2442MHz)

Graph:



Results:

Peak (PASS) (5)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
11412.36842	53.23	74.00	-20.77	24.00	3.84	Vertical	1000000.00	12.40
11752.89474	54.23	74.00	-19.77	290.00	1.00	Vertical	1000000.00	13.16
12258.68421	54.35	74.00	-19.65	248.00	3.69	Horizontal	1000000.00	13.39
12401.05263	54.57	74.00	-19.43	31.00	3.89	Vertical	1000000.00	13.50
12922.36842	54.88	74.00	-19.12	291.00	1.00	Horizontal	1000000.00	15.06

Average (PASS) (5)

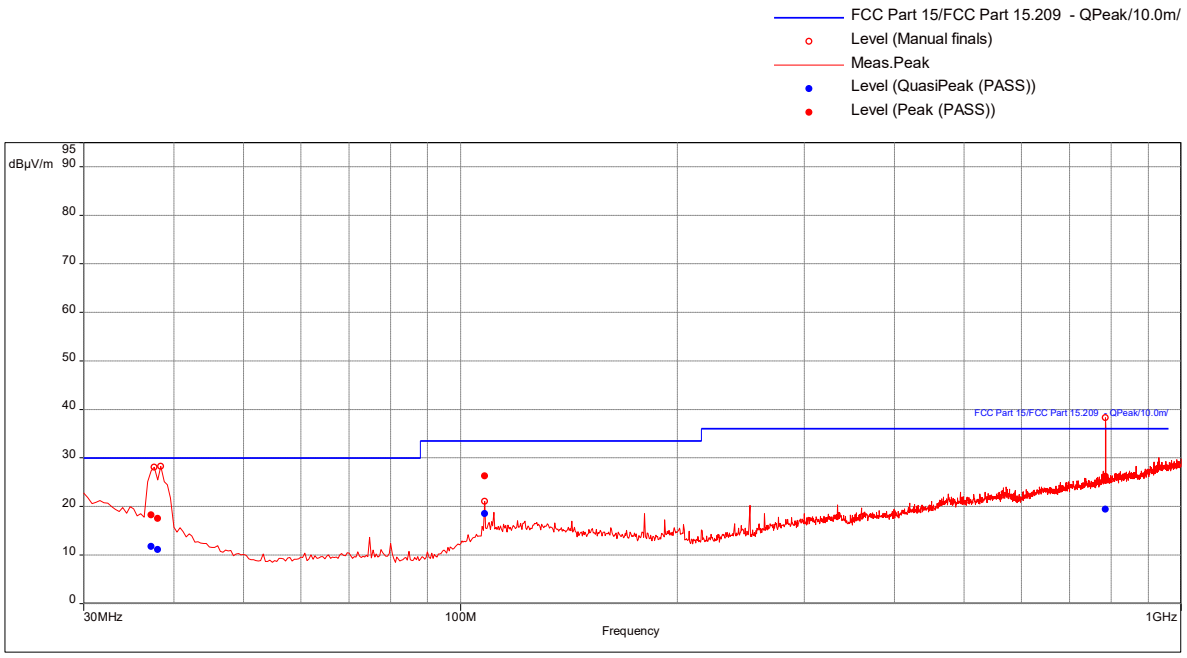
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
11412.36842	40.19	54.00	-13.81	24.00	3.84	Vertical	1000000.00	12.40
11752.89474	41.23	54.00	-12.77	290.00	1.00	Vertical	1000000.00	13.16
12258.68421	41.35	54.00	-12.65	248.00	3.69	Horizontal	1000000.00	13.39
12401.05263	41.46	54.00	-12.54	31.00	3.89	Vertical	1000000.00	13.50
12922.36842	42.54	54.00	-11.46	291.00	1.00	Horizontal	1000000.00	15.06

All Radios Transmit @ High Channel, 30-1000 MHz

Test Information:

Date and Time	9/14/2021 7:52:27 PM
Client and Project Number	iRobot_G104798049
Engineer	Vathana Ven
Temperature	24 deg C
Humidity	38%
Atmospheric Pressure	1008 mB
Comments	RE 30-1000MHz_Battery_802.11n HT40, MCS6, 40MHz BW_High CH (2462MHz), BLE Tx High CH (2462MHz)

Graph:



Results:

QuasiPeak (PASS) (4)

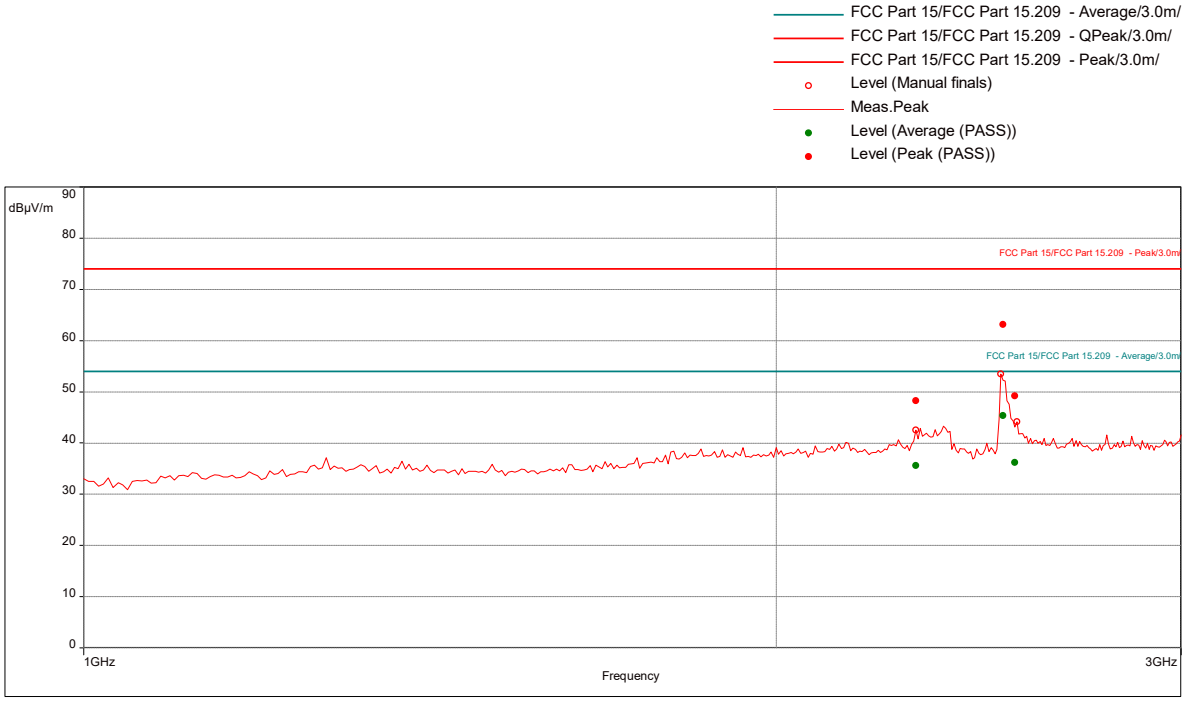
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
37.06315789	11.73	30.00	-18.27	111.00	2.57	Vertical	120000.00	-17.57
37.98947368	11.12	30.00	-18.88	118.00	2.90	Vertical	120000.00	-18.13
108	18.56	33.50	-14.94	96.00	2.50	Horizontal	120000.00	-20.17
785.1894737	19.41	36.00	-16.59	24.00	1.30	Vertical	120000.00	-7.88

All Radios Transmit @ High Channel, 1-3 GHz

Test Information:

Date and Time	9/14/2021 8:54:56 PM
Client and Project Number	iRobot_G104798049
Engineer	Vathana Ven
Temperature	24 deg C
Humidity	38%
Atmospheric Pressure	1008 mB
Comments	RE 1 to 3GHz_Battery_802.11n HT40, MCS6, 40MHz BW_High CH (2462MHz), BLE Tx High CH (2462MHz)

Graph:



Results:

Peak (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2300	48.25	74.00	-25.75	182.00	3.74	Vertical	1000000.00	-3.76
2507.894737	63.12	74.00	-10.88	189.00	3.59	Vertical	1000000.00	-3.17
2540.263158	49.16	74.00	-24.84	191.00	3.49	Vertical	1000000.00	-3.15

Average (PASS) (3)

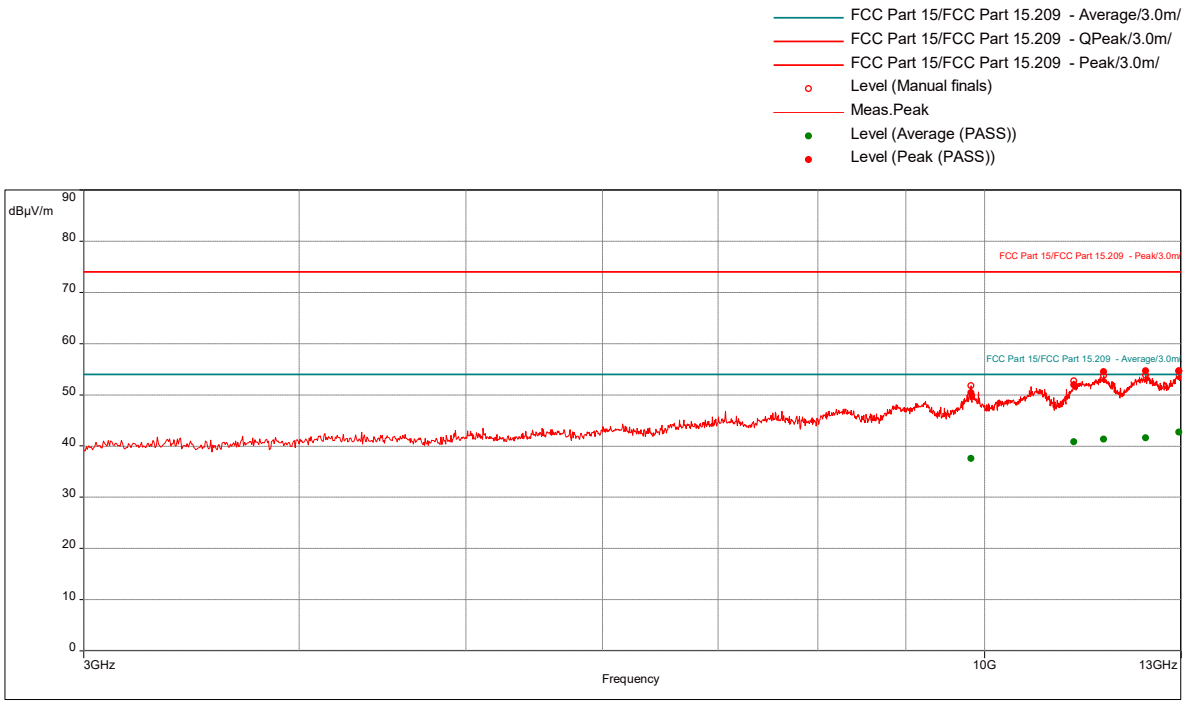
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2300	35.56	54.00	-18.44	182.00	3.74	Vertical	1000000.00	-3.76
2507.894737	45.38	54.00	-8.62	189.00	3.59	Vertical	1000000.00	-3.17
2540.263158	36.20	54.00	-17.80	191.00	3.49	Vertical	1000000.00	-3.15

All Radios Transmit @ High Channel, 3-13 GHz

Test Information:

Date and Time	9/14/2021 9:16:01 PM
Client and Project Number	iRobot_G104798049
Engineer	Vathana Ven
Temperature	24 deg C
Humidity	38%
Atmospheric Pressure	1008 mB
Comments	RE 3 to 13GHz_Battery_802.11n HT40, MCS6, 40MHz BW_High CH (2462MHz), BLE Tx High CH (2462MHz)

Graph:



Results:

Peak (PASS) (5)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
9818.684211	50.41	74.00	-23.59	262.00	3.69	Horizontal	1000000.00	7.84
11265	51.97	74.00	-22.03	133.00	3.10	Horizontal	1000000.00	11.75
11719.21053	54.49	74.00	-19.51	198.00	3.79	Vertical	1000000.00	13.16
12401.31579	54.71	74.00	-19.29	104.00	3.94	Vertical	1000000.00	13.50
12961.84211	54.69	74.00	-19.31	211.00	3.30	Vertical	1000000.00	15.14

Average (PASS) (5)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
9818.684211	37.53	54.00	-16.47	262.00	3.69	Horizontal	1000000.00	7.84
11265	40.80	54.00	-13.20	133.00	3.10	Horizontal	1000000.00	11.75
11719.21053	41.29	54.00	-12.71	198.00	3.79	Vertical	1000000.00	13.16
12401.31579	41.57	54.00	-12.43	104.00	3.94	Vertical	1000000.00	13.50
12961.84211	42.68	54.00	-11.32	211.00	3.30	Vertical	1000000.00	15.14

13-25 GHz on Low, Mid, and High Channels Radiated Emissions

Company:	iRobot Corporation			Antenna & Cables:	LF	Bands: N, LF, HF, SHF	
Model #:				Antenna:	EMC04	ETS002	
Serial #:	RCI3020J210813E102219			Cable(s):	CBLHF2012-5M-2	CBLSHF204	
Engineers:	Vathana Ven	Location:	10m Chamber	Barometer:	DAV007	Filter:	REA004 REA005
Project #:	G103836530	Date(s):	09/14/21				
Standard:	FCC Part 15.247 & 15.209			Temp/Humidity/Pressure:	24C	38%	1008mbar
Receiver:	ROS005-1	Limit Distance (m):	3				
PreAmp:	PRE9	Test Distance (m):	3				

PreAmp Used? (Y or N): Y Voltage/Frequency: Internal Battery Frequency Range: 13-25 GHz

Net = Reading (dBuV/m) + Antenna Factor (dB1/m) + Cable Loss (dB) - Preamp Factor (dB) - Distance Factor (dB)

Peak: PK Quasi-Peak: QP Average: AVG RMS: RMS; NF = Noise Floor, RB = Restricted Band; Bandwidth denoted as RBW/VBW

Detector Type	Ant. Pol. (V/H)	Frequency MHz	Reading dB(uV)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Distance Factor dB	Net dB(uV/m)	Limit dB(uV/m)	Margin dB	Bandwidth
Testing was performed manually at 10cm from the EUT. No emissions were detected at low, mid, and high channels on all axis											

Test Personnel:	Vathana Ven VSV	Test Date:	09/14/2021
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	CFR47 FCC Part 15.247 RSS-247	Limit Applied:	See report section 7.3
Input Voltage:	Internal Battery Powered		
Pretest Verification w/ Ambient Signals or BB Source:	BB Source	Ambient Temperature:	24 ºC
		Relative Humidity:	38 %
		Atmospheric Pressure:	1008 mbars

Deviations, Additions, or Exclusions: None

8 Band Edge Compliance

8.1 Method

Tests are performed in accordance with FCC Part 15 Subpart C 15.247 RSS 247, ANSI C 63.10, and ANSI C 63.4.

TEST SITE: 10m ALSE

The 10m ALSE is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A Styrofoam table 80 cm high is used for table-top equipment.

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucispr
Radiated Emissions, 10m	30-1000 MHz	4.6dB	6.3 dB
Radiated Emissions, 3m	30-1000 MHz	5.3 dB	6.3 dB
Radiated Emissions, 3m	1-6 GHz	4.5 dB	5.2 dB
Radiated Emissions, 3m	6-15 GHz	5.2 dB	5.5 dB
Radiated Emissions, 3m	15-18 GHz	5.0 dB	5.5 dB
Radiated Emissions, 3m	18-40 GHz	5.0 dB	5.5 dB

As shown in the table above our radiated emissions U_{lab} is less than the corresponding U_{CISPR} reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required, based on CISPR 22 and CISPR 11 (for 2006 and later revisions) Clause 11.

Sample Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF - AG
Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

Assume a receiver reading of 52.0 dBμV is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dBμV/m. This value in dBμV/m was converted to its corresponding level in μV/m.

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

To convert from dBμV to μV or mV the following was used:

$UF = 10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

Example:

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
$UF = 10^{(32\ dB\mu V / 20)}$ = 39.8 μV/m

8.2 Test Equipment Used:

Test equipment used on 09/17/2021

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV007`	Weather Station Vantage Vue	Davis	6250	MS191212003	03/22/2021	03/22/2022
HS002`	DC-18GHz cable 1.4m long	Huber & Suhner	SucoFlex 106A	HS002	11/25/2020	11/25/2021
IW006`	DC-18GHz cable 8.4m long	Insulated Wire	2800-NPS	IW006	11/25/2020	11/25/2021
ETS002'	1-18GHz DRG Horn Antenna	ETS Lindgren	3117	00143260	08/24/2021	08/24/2022
145-420'	Receiver to floor cable	Utiflex	UFB311A-2-0591-70070	145-420	02/17/2021	02/17/2022
ROS005-1'	Signal and Spectrum Analyzer	Rohde and Shwartz	FSW43	100646	10/27/2020	10/27/2021

Test equipment used on 11/05/2021

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV007`	Weather Station Vantage Vue	Davis	6250	MS191212003	03/22/2021	03/22/2022
145108`	EMI Test Receiver (20Hz – 40GHz)	Rohde & Schwarz	ESIB40	100209	06/22/2021	06/22/2022
145-420'	Receiver to floor cable	Utiflex	UFB311A-2-0591-70070	145-420	02/17/2021	02/17/2022
145-414'	Cables 145-400 145-403 145-405 145-409	Huber + Suhner	3m Track A cables	multiple	07/09/2021	07/09/2022
145-422'	10Amp Pre-amp to under floor	Utiflex	UFB311A-0-2756-70070	145-422	02/17/2021	02/17/2022
145-421'	10m Ant to Pre-amp	Utiflex	UFB311A-0-3346-50050	145-421	02/16/2021	02/16/2022
ETS002'	1-18GHz DRG Horn Antenna	ETS Lindgren	3117	00143260	08/24/2021	08/24/2022

Software Utilized:

Name	Manufacturer	Version
None	--	--

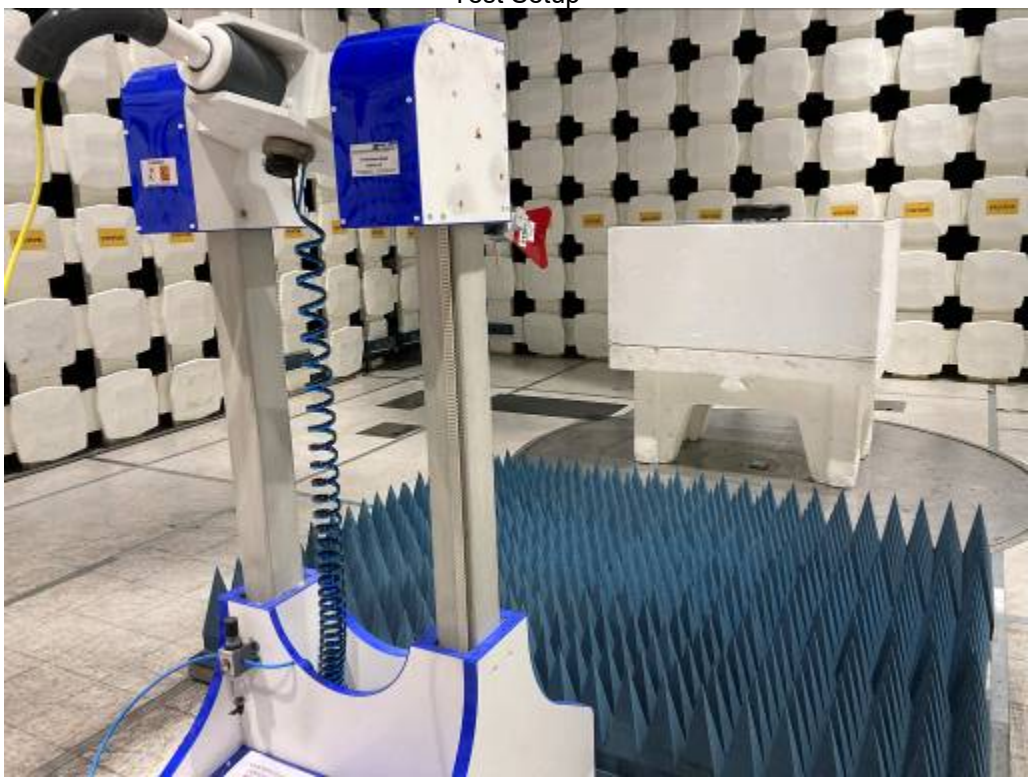
8.3 Results:

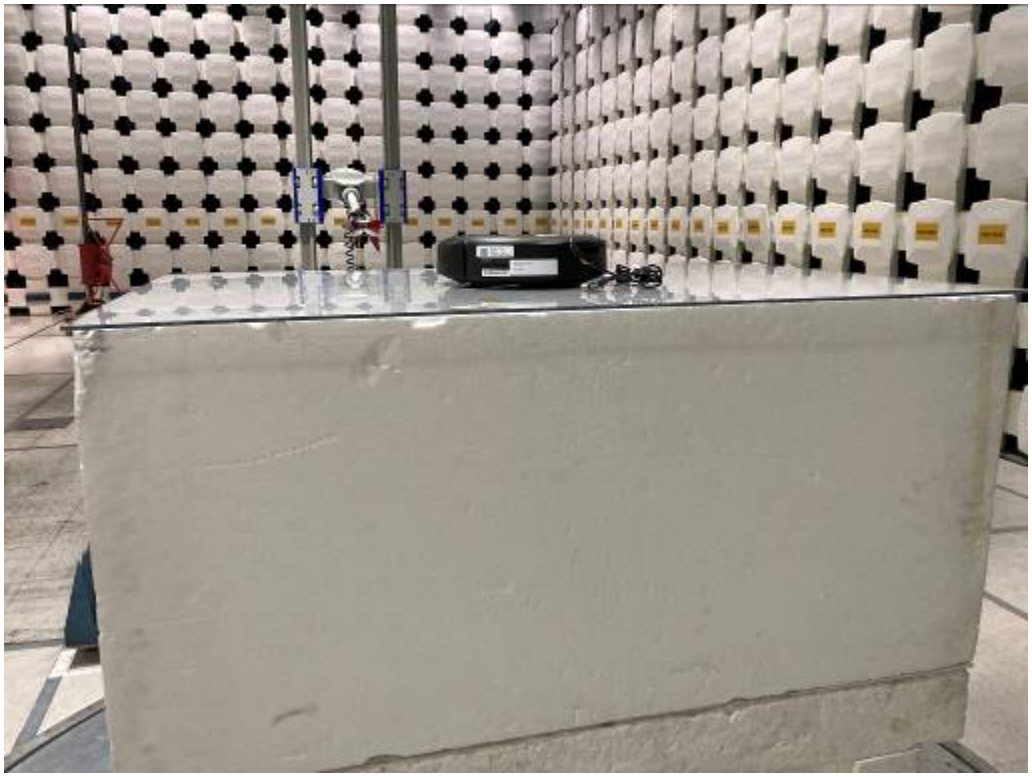
The sample tested was found to Comply.

15.247 (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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c))

8.4 Setup Photograph:

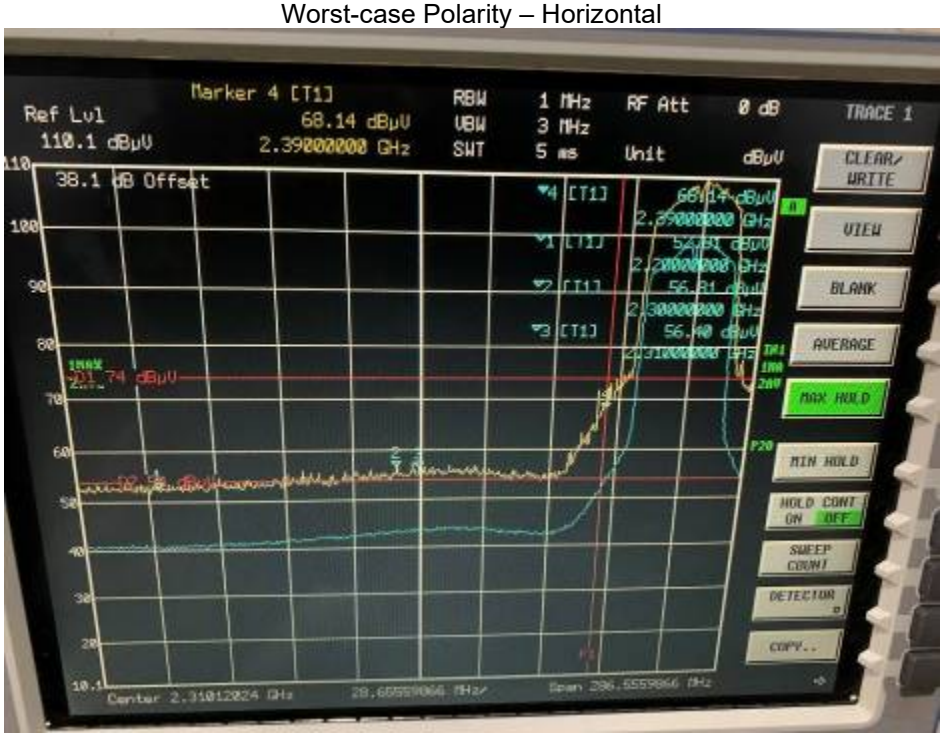
Test Setup



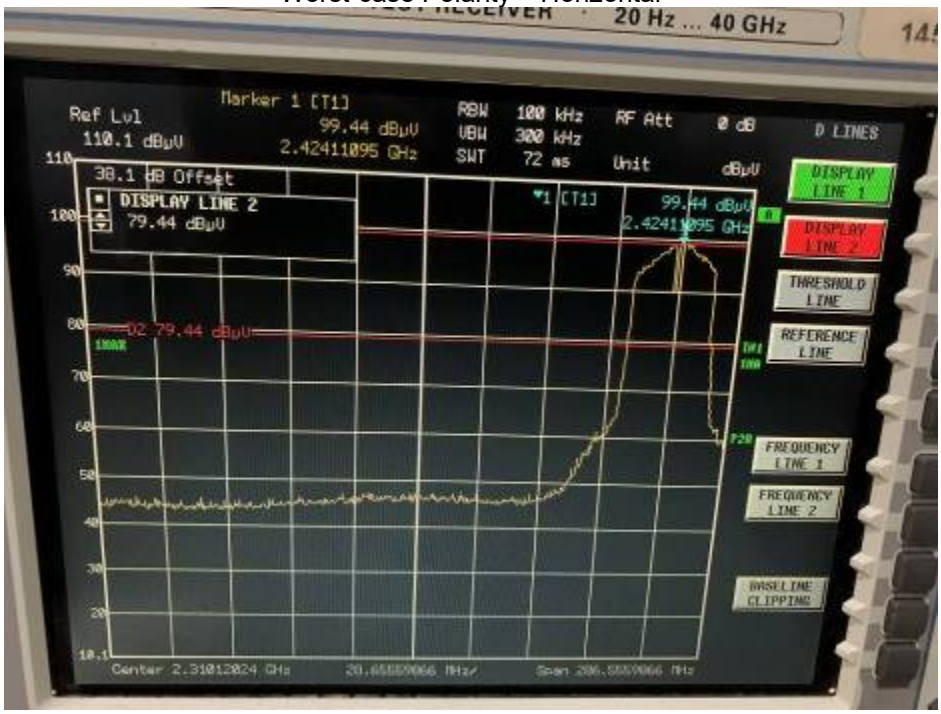


8.5 Plots/Data:

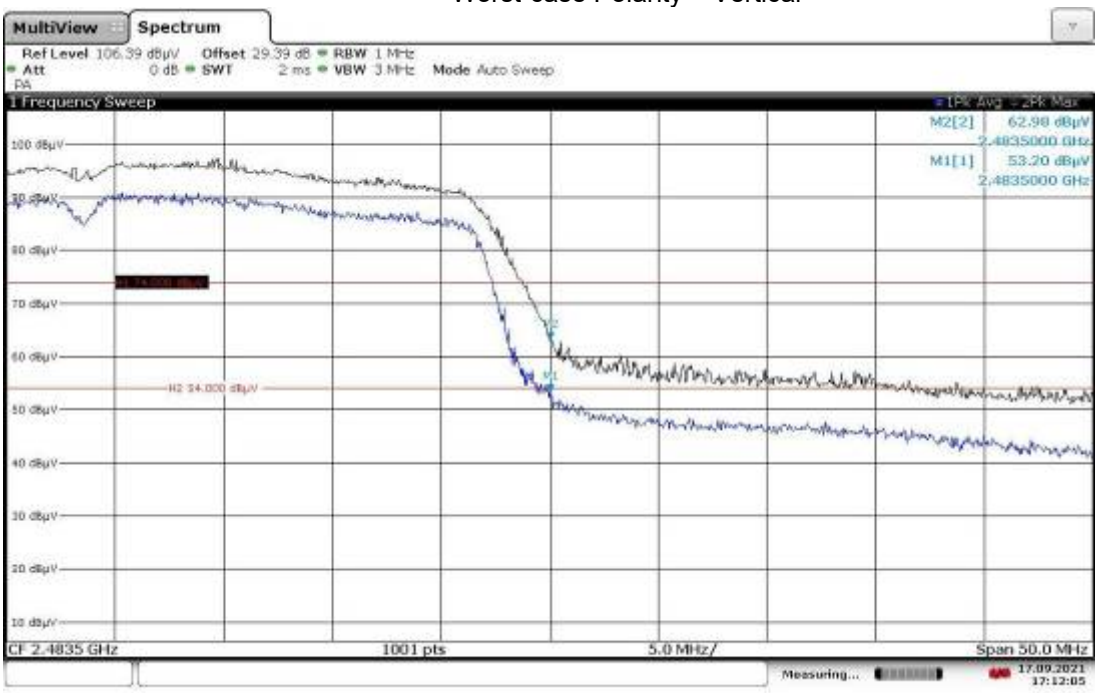
Lower Band Edge With FCC 15.209 limits (74 dBµV/m Peak and 54 dBµV/m Average), Worst-case Polarity – Horizontal



Upper Band Edge With FCC § 15.247 (d), 20 dB down from the peak carrier Worst-case Polarity – Horizontal

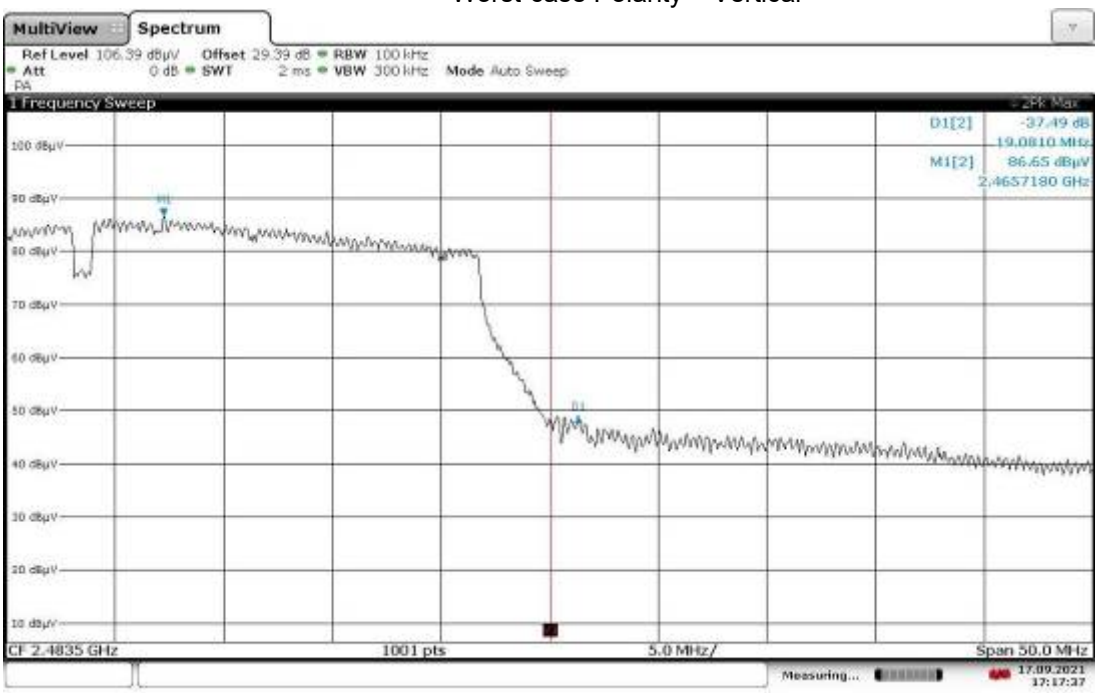


Upper Band Edge With FCC 15.209 limits (74 dBµV/m Peak and 54 dBµV/m Average),
Worst-case Polarity – Vertical



17:12:06 17.09.2021

Upper Band Edge With FCC § 15.247 (d), 20 dB down from the peak carrier
Worst-case Polarity – Vertical



17:17:37 17.09.2021

Radiated Emissions

Company: iRobot Corporation
Model #: CREATE 3
Serial #: RCI3020J210813E102219
Engineers: Vathana Ven
Project #: G104798049
Standard: FCC Part 15C, 15.247
Receiver: R & S ESI (145-108) 06-22-2022
PreAmp: NONE.
PreAmp Used? (Y or N): N
Antenna & Cables: HF Bands: N, LF, HF, SHF
Antenna: 2021-3MH 08_24_2022.txt 2021-3MH 08_24_2022.txt
Cable(s): 145-416 3mTrkB 10-03-2014.txt NONE.
Location: 10M Chamber Barometer: DAV007 Filter: NONE
Date(s): 09/17/2021, 11/05/2021
Temp/Humidity/Pressure: 21, 21 deg C 22, 23% 1008, 986 mB
Limit Distance (m): 3
Test Distance (m): 3
Voltage/Frequency: Battery power Frequency Range: See below

Net = Reading (dBuV/m) + Antenna Factor (dB1/m) + Cable Loss (dB) - Preamp Factor (dB) - Distance Factor (dB)
Peak: PK Quasi-Peak: QP Average: AVG RMS: RMS; NF = Noise Floor, RB = Restricted Band; Bandwidth denoted as RBW/VBW

Detector Type	Ant. Pol. (V/H)	Frequency MHz	Reading dB(uV)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Distance Factor dB	Net dB(uV/m)	Limit dB(uV/m)	Margin dB	Bandwidth	FCC	IC
Lower Band Edge Compliance													
PK	H	2390.000	28.04	31.80	7.10	0.00	0.00	66.94	74.00	-7.06	1/3 MHz	RB	RB
AVG	H	2390.000	11.90	31.80	7.10	0.00	0.00	50.80	54.00	-3.20	1/3 MHz	RB	RB
Upper Band Edge Compliance													
PK	V	2483.500	23.51	32.51	6.99	0.00	0.00	63.01	74.00	-10.99	1/3 MHz	RB	
AVG	V	2483.500	13.81	32.51	6.99	0.00	0.00	53.31	54.00	-0.69	1/3 MHz	RB	

Test Personnel: Kouma Sinn KPS
Supervising/Reviewing Engineer: (Where Applicable) Vathana Ven VSV
Product Standard: CFR47 FCC Part 15.247 RSS-247
Input Voltage: Internal Battery Powered
Pretest Verification w/ Ambient Signals or BB Source: BB Source

Test Date: 09/17/2021, 11/05/2021
Limit Applied: See report section 8.3
Ambient Temperature: 21, 21 ºC
Relative Humidity: 22, 23 %
Atmospheric Pressure: 1008, 986 mbars

Deviations, Additions, or Exclusions: None

9 Revision History

Revision Level	Date	Report Number	Prepared By	Reviewed By	Notes
0	02/15/2022	104798049BOX-001	VFV	KPS	Original Issue