RF TEST REPORT

FCC / ISED

APPLICANT
eero LLC

MODEL NAME
R010001

FCC ID
2AEM4-41123474

ISED ID
20631-41123474

REPORT NUMBER
HA210810-AER-001-R10

TEST REPORT

Date of Issue
January 18, 2022

Test Site
Hyundai C-Tech, Inc. dba HCT America, Inc.
1726 Ringwood Ave, San Jose, CA 95131, USA

Applicant	eero LLC
Applicant Address	660 3rd Street, 4th Floor, San Francisco, CA 94107, USA
FCC ID	2AEM4-41123474
ISED ID	20631-41123474
Model Name	R010001
EUT Type	Wireless Router / Access Point
Modulation Type	OFDM / OFDM-A
FCC Classification	Unlicensed National Information Infrastructure (NII)
FCC Rule Part(s)	Part 15.407
ISED Rule Part(s)	RSS-247 Issue 2 (February 2017) RSS-Gen Issue 5 Amd 2 (February 2021)
Test Procedure	ANSI C63.10-2013, KDB 789033 D02 v02r01, KDB 662911 D01

The device bearing the trade name and model specified above, has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures required. The results of testing in this report apply only to the product which was tested. Other similar equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

Hyundai C-Tech, Inc. dba HCT America, Inc. certifies that no party to application has been denied the FCC benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C 862

Tested By	**Reviewed By**
Yongsoo Park	Sunwoo Kim
Test Engineer	Technical Manager

REVISION HISTORY

The revision history for this document is shown in table.

TEST REPORT NO.	DATE	DESCRIPTION
HA210810-AER-001-R10	01/18/2022	Initial Issue

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Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA. TEL: +1-510-933-8848 FAX: +1-510-933-8849

1. GENERAL INFORMATION

EUT DESCRIPTION

Model	R010001
EUT Type	Wireless Router / Access Point
Serial Number	GGC1-UCD1-1416-0A1H : Radiated GGC1-UCD1-1432-0A5H : Conducted
Power Supply	5 V d.c. (USB type C - External adaptor)
RF Specification	WIFI 2.4 GHz : 802.11b/g/n(HT20/40)/ ax(HE20/40) WIFI 5 GHz : 802.11a/n(HT20/40)/ ac(VHT20/40/80/160)/ ax(HE20/40/80/160) Bluetooth 5.0 LE (1M) IEEE 802.15.4
Transmitter Chain	WIFI 2.4 GHz / 5 GHz : 2x2 MIMO Bluetooth LE / IEEE 802.15.4 : SISO
Operating Environment	Indoor
Operating Temperature	0 °C ~ +40 °C

RF SPECIFICATION SUBJECT TO THE REPORT

RF Specification	IEEE 802.11a/n (HT20/40)/ac (VHT20/40/80/160)/ ax(HE20/40/80/160)		
Transmitter Chain	2 x 2 MIMO		
Frequency Range [1)]	U-NII 2a	20 MHz BW : 5260 MHz – 5320 MHz 40 MHz BW : 5270 MHz – 5310 MHz 80 MHz BW : 5290 MHz 160 MHz BW : 5250 MHz (Straddle)	
	U-NII 2c	20 MHz BW : 5500 MHz – 5720 MHz (Straddle at 5720 MHz) 40 MHz BW : 5510 MHz – 5710 MHz (Straddle at 5710 MHz) 80 MHz BW : 5530 MHz – 5690 MHz (Straddle at 5690 MHz) 160 MHz BW : 5570 MHz	
Max. RF Output Power	U-NII 2a	23.07 dBm (0.20275 W)	
	U-NII 1/2a	21.52 dBm (0.14192 W)	
	U-NII 2c	23.46 dBm (0.22159 W)	
Modulation Type	OFDM / OFDM-A		
Operating Modes	☒ Master		
	☐ Mesh		
	☐ Slave with radar detection		
	☐ Slave without radar detection		
TPC Feature [2)]	☒ TPC function	☐ No TPC function	
Antenna Specification [3)]	Antenna Type : Internal PCB Dipole Antenna Peak Gain : 4.36 dBi Uncorrelated / 7.37 dBi Correlated		
Firmware Version [4)]	eeroOS 6.9		
Hardware Version [4)]	Rev. A		
Date(s) of Tests	October 11, 2021 ~ November 25, 2021		

Note :

1. The device cannot operate in the frequency range 5600 – 5650 MHz in Canada
2. The EUT employs the TPC mechanism having the capability to operate at least 6 dB below the highest RF output.
3. Antenna information is based on the document provided.
4. Firmware and Hardware Version are as received by the client.

ANTENNA CONFIGURATION

The device employs 2x2 MIMO technologies with possible configurations below.

Frequency	Configuration	SDM	CDD
		ANT1 + ANT2	ANT1 + ANT2
2.4 GHz	802.11b	X	O
	802.11g	X	O
	802.11n	O	O
	802.11ax	O	O
5 GHz	802.11a	X	O
	802.11n	O	O
	802.11ac	O	O
	802.11ax	O	O

The equipment under test supports Cyclic Diversity mode.
CDD mode was picked as worst case for testing even though the device support both CDD and SDM

ANTENNA DIRECTIONAL GAIN

Antenna Type	Type	RF Technology	Frequency	Gain (Ant 1)	Gain (Ant 2)
PCB	Dipole	802.11b/g/n/ax	2.4 GHz	3.69 dBi	3.06 dBi
PCB	Dipole	802.11a/n/ac/ax	5 GHz	4.50 dBi	4.22 dBi
Metal	Monopole	BLE / IEEE 802.15.4	2.4 GHz	2.90 dBi	

Ant 1 : 2.4 GHz (Chain 0) / 5 GHz (Chain 1)
Ant 2 : 2.4 GHz (Chain 1) / 5 GHz (Chain 0)

Directional Gain (2.4 GHz : Uncorrelated) = $10 \log[(10^{(3.69/10)}+10^{(3.06/10)}) / 2] = 3.39$ dBi
Directional Gain (5 GHz : Uncorrelated) = $10 \log[(10^{(4.50/10)}+10^{(4.22/10)}) / 2] = 4.36$ dBi

Directional Gain (2.4 GHz : Correlated) = $10 \log[(10^{(3.69/20)}+10^{(3.06/20)})^2 / 2] = 6.39$ dBi
Directional Gain (5 GHz : Correlated) = $10 \log[(10^{(4.50/20)}+10^{(4.22/20)})^2 / 2] = 7.37$ dBi

The device does not support beam foaming.

OPERATING FREQUENCY CHANNELS

Band	Frequency (MHz)	Channel	802.11a	802.11n HT20	802.11ac VHT20	802.11ax HE20
U-NII 2a	5260	52	O	O	O	O
	5280	56	O	O	O	O
	5300	60	O	O	O	O
	5320	64	O	O	O	O
U-NII 2c	5500	100	O	O	O	O
	5520	104	O	O	O	O
	5540	108	O	O	O	O
	5560	112	O	O	O	O
	5580	116	O	O	O	O
	5600	120	O	O	O	O
	5620	124	O	O	O	O
	5640	128	O	O	O	O
	5660	132	O	O	O	O
	5680	136	O	O	O	O
	5700	140	O	O	O	O
Straddle	5720 (1)	144	O	O	O	O

Band	Frequency (MHz)	Channel	802.11n HT40	802.11ac VHT40	802.11ax HE40
U-NII 2a	5270	54	O	O	O
	5310	62	O	O	O
U-NII 2c	5510	102	O	O	O
	5550	110	O	O	O
	5590	118	O	O	O
	5630	126	O	O	O
	5670	134	O	O	O
Straddle	5710 (1)	142	O	O	O

Band	Frequency (MHz)	Channel	802.11ac VHT80	802.11ax HE80
U-NII 2a	5290	58	O	O
U-NII 2c	5530	106	O	O
	5610	122	O	O
Straddle	5690 (1)	138	O	O

Band	Frequency (MHz)	Channel	802.11ac VHT160	802.11ax HE160
Straddle	5250 (2)	50	O	O
U-NII 2c	5570	114	O	O

Note :

1. Straddle channels between U-NII 2c and U-NII 3
2. Straddle channel between U-NII 2a and U-NII 1
3. The device cannot operate in the frequency range 5600 – 5650 MHz in Canada

2. METHODOLOGY

The measurement procedure described in FCC KDB 789033 D02 General UNII Test Procedures New Rules v02r01 dated December 14, 2017 entitled “Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices Part15, Subpart E” and ANSI C63.10(Version : 2013) ‘the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices’ were used in the measurement.

EUT CONFIGURATION

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner that intends to maximize its emission characteristics in a continuous normal application.

EUT EXERCISE

The EUT was operated in the engineering mode to fix the Tx frequency that was for the purpose of the measurements. According to its specifications, the EUT must comply with the requirements of the Section 15.207, 15.209 and 15.407 under the FCC Rules Part 15 Subpart E. / RSS-Gen issue 5, RSS-247 issue 2.

GENERAL TEST PROCEDURES

Conducted Emissions

The EUT is placed on the turntable, which is 0.8 m above ground plane. According to the requirements in Section 6.2 of ANSI C63.10. (Version :2013) Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30MHz using CISPR Quasi-peak and average detector modes.

Radiated Emissions

The EUT is placed on a turn table, which is 0.8 m above ground plane below 1GHz. Above 1GHz with 1.5m using absorbers between the EUT and receive antenna. The turntable shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3 m away from the receiving antenna, which varied from 1 m to 4 m to find out the highest emission. Also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the maximum emission, the relative positions of this hand-held transmitter (EUT) were rotated through three orthogonal axes according to the requirements in Section 8 of ANSI C63.10. (Version: 2013)

DESCRIPTION OF TEST MODES

The EUT has been tested at 5 GHz WLAN test mode. Qualcomm Radio Control Tool was used to control the channels, power level setting at continuous TX and normal RX mode for each 802.11a/n (HT20/40) /ac (VHT20/40/80/160).

3. INSTRUMENT CALIBRATION

The measuring equipment, which was utilized in performing the tests documented herein, has been calibrated in accordance with the manufacturer's recommendations for utilizing calibration equipment’s, which is traceable to recognized national standards. Especially, all antenna for measurement is calibrated in accordance with the requirements of C63.5 (Version : 2017).

4. FACILITIES AND ACCREDITATIONS

FACILITIES

The SAC (Semi-Anechoic Chamber) and conducted measurement facility used to collect the radiated data are located at 1726 Ringwood Avenue, San Jose, California 95131, USA.
The site is constructed in conformance with the requirements of ANSI C63.4. (Version :2014) and CISPR Publication 22.

EQUIPMENT

Radiated emissions are measured with one or more of the following types of Linearly polarized antennas: tuned dipole, bi-conical, log periodic, bi-log, and/or ridged waveguide, horn. Spectrum analyzers with pre-selectors and quasi-peak detectors are used to perform radiated measurements.

Conducted emissions are measured with Line Impedance Stabilization Networks and EMI Test Receivers. Calibrated wideband preamplifiers, coaxial cables, and coaxial attenuators are also used for making measurements.

All receiving equipment conforms to CISPR Publication 16-1, “Radio Interference Measuring Apparatus and Measurement Methods.”

5. ANTENNA REQUIREMENTS

According to FCC 47 CFR §15.203:

"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can 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."

(1) The antenna of this E.U.T is permanently attached and there is no provision for connection to an external antenna.
(2) The E.U.T Complies with the requirement of §15.203

According to RSS-Gen Issue 5 (Section 6.8) :
The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report (and in the notice to be included in the user manual, provided below).

When measurements at the antenna port are used to determine the RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer.

The test report shall state the RF power, output power setting and spurious emission measurements with each antenna type that is used with the transmitter being tested.

6. MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013.

All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95 % level of confidence. The measurement data shown herein meets or exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Parameter	Expanded Uncertainty
Output Power, Conducted	± 0.35 dB
Occupied Bandwidth	± 12.4 kHz
Unwanted Emissions, Conducted	± 0.46 dB
Radiated Emissions (below 1 GHz)	± 6.09 dB
Radiated Emissions (Above 1 GHz)	± 5.23 dB

7. DESCRIPTION OF TESTS

7.1. DUTY CYCLE

TEST SETUP

TEST PROCEDURE

The transmitter output is connected to the Spectrum Analyzer.
Measurement is performed in accordance with the section B.2 in KDB 789033 D02 v02r01.

The largest available value of RBW is 8 MHz and VBW is 50 MHz.
The zero-span method of measuring duty cycle shall not be used if T ≤ 6.25 microseconds. (50/6.25 = 8)
The zero-span method was used because all measured T data are > 6.25 microseconds and both RBW and VBW are > 50/*T*.

- RBW = 8 MHz (the largest available value)
- VBW = 8 MHz (≥ RBW)
- SPAN = 0 Hz
- Detector = Peak
- Number of points in sweep > 100
- Trace mode = Clear write
- Measure T_{total} and T_{on}
- Calculate Duty Cycle = T_{on}/ T_{total} and Duty Cycle Factor = 10*log(1/Duty Cycle)

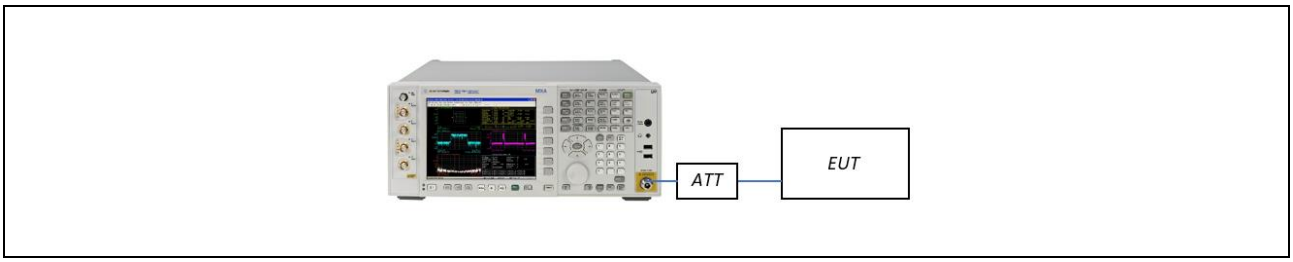
7.2. 6 dB BANDWIDTH / 26 dB BANDWIDTH / 99 % OCCUPIED BANDWIDTH

LIMIT

Emission bandwidth was measured to define the minimum frequency range which the spectrum is integrated for maximum conducted output power measurement.

Within the 5.725-5.85 GHz band, the minimum 6 dB bandwidth of U-NII devices shall be at least 500 kHz.

TEST SETUP



TEST PROCEDURE (26 dB Bandwidth)

Testing was performed according to the section C.1 in KDB 789033 D02 v02r01.
The transmitter output is connected to the spectrum analyzer.

- RBW = Approximately 1 % of the emission bandwidth
- VBW > RBW
- Detector = Peak
- Trace mode = max hold
- Sweep = auto couple
- Measure the maximum width of the emission that is 26 dB down from the maximum of the emission. Compare this with the RBW setting of the analyzer. Readjust RBW and repeat measurement as needed until the RBW/EBW ratio is approximately 1 %.

TEST PROCEDURE (99% Bandwidth)

Testing was performed according to the section D in KDB 789033 D02 v02r01.
The transmitter output is connected to the spectrum analyzer.

- RBW = 1% ~ 5% of the occupied bandwidth
- VBW ≒ 3 x RBW
- Detector = Peak
- Trace mode = max hold
- Sweep = auto couple
- Allow the trace to stabilize

Note:
1. The bandwidth measurement function from the spectrum analyzer is used to measure X dB bandwidth.
2. 26 dB bandwidth is used to determine the conducted power limits.

TEST PROCEDURE (6 dB Bandwidth)

6 dB bandwidth requirement is for the straddle channels spanning over both U-NII 2c and U-NII 3 bands
Testing was performed according to the procedure C.1 in KDB 789033 D02 v02r01.
The transmitter output is connected to the Spectrum Analyzer.

- RBW = 100 kHz
- VBW ≥ 3*RBW
- Detector = Peak
- Trace mode = Max hold
- Allow the trace to stabilize
- Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points(upper and lower frequencies) that are attenuated by 6 dB relative to the maximum lever measured in the fundamental emission.

7.3. OUTPUT POWER

LIMIT

Band	47 CFR §15.407(a)(2)	RSS-247, 6.2.2.1 / 6.2.3.1
U-NII 2a	≤ 250 mW or ≤ 11 dBm + 10 log (B) Whichever is less (where B is the 26 dB Emission BW in MHz)	≤ 250 mW or ≤ 11 dBm + 10 log (B) ≤ 1 W e.i.r.p. or ≤ 17 dBm + 10 log (B) e.i.r.p. Whichever power is less (where B is 99% BW in MHz)
U-NII 2c		

TEST SETUP

TEST PROCEDURE

Refer to the section E.2.d) in KDB 789033 D02 v02r01
The transmitter output is connected to the Spectrum Analyzer.
Spectrum analyzer's integrated band power measurement function was used.

- Measure the duty cycle.
- Set span to encompass the 26 dB EBW of the signal.
- RBW = 1 MHz
- VBW ≥ 3 MHz
- Number of points in sweep ≥ 2*span/RBW.
- Sweep time = auto.
- Detector = RMS.
- Do not use sweep triggering. Allow the sweep to "free run".
- Trace average at least 100 traces in power averaging (RMS) mode
- Integrated bandwidth = EBW

Add 10log(1/x), where x is the duty cycle, to the measured power in order to compute the average power during the actual transmission times

Sample Calculation

- Conducted Output Power (Average) = Reading Value + ATT loss + Cable loss + Duty Cycle Factor

7.4. POWER SPECTRAL DENSITY

LIMIT

Band	47 CFR §15.407(a)(2)	RSS-247, 6.2.2.1 / 6.2.3.1
U-NII 2a	≤ 11 dBm/MHz	≤ 11 dBm/MHz
U-NII 2c		

TEST SETUP

TEST PROCEDURE

Refer to the section F in KDB 789033 D02 v02r01.

- Set span to encompass the entire emission bandwidth (EBW) of the signal.
- RBW = 1 MHz (510 kHz for UNII 3)
- VBW ≥ 3 MHz
- Number of points in sweep ≥ 2*span/RBW.
- Sweep time = auto.
- Detector = RMS (i.e., power averaging), if available. Otherwise, use sample detector mode.
- Do not use sweep triggering. Allow the sweep to “free run”.
- Trace average at least 100 traces in power averaging (RMS) mode
- Use the peak search function on the spectrum analyzer to find the peak of the spectrum.
- If Method SA-2 was used, add 10 log(1/x), where x is the duty cycle, to the peak of the spectrum.

Sample Calculation

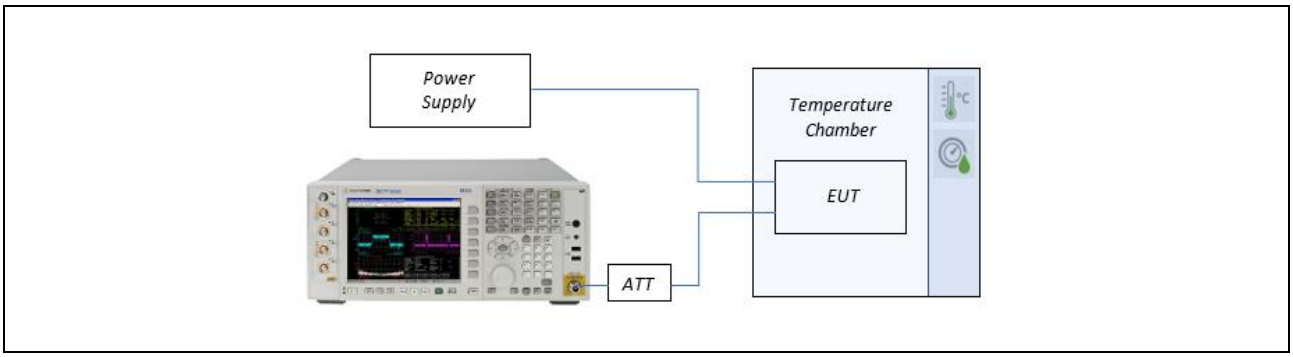
Total PSD (Average) = Reading Value + ATT loss + Cable loss + Duty Cycle Factor

7.5. FREQUENCY STABILITY

LIMIT

§15.407(g) / RSS-Gen, 8.8
Fundamental emissions of the radio devices should be kept within at least the central 80% of its permitted operating frequency band to minimize the possibility of out of band operation.

TEST SETUP



TEST PROCEDURE

- The EUT was placed inside an environmental chamber as the temperature in the chamber was varied between -30 ℃ and 50 ℃.
- The temperature was incremented by 10 ℃ intervals and the unit was allowed to stabilize at each temperature before each measurement. The center frequency of the transmitting channel was evaluated at each temperature and the frequency deviation from the channel's center frequency was recorded.
- The primary supply voltage is varied from 85% to 115% of the nominal value for non-hand carried battery and AC powered equipment. For hand-carried, battery-powered equipment, primary supply voltage is reduced to the battery operating end point which shall be specified by the manufacturer.
- While maintaining a constant temperature inside the environmental chamber, turn the EUT ON and record the operating frequency at startup, and at 2 minutes, 5 minutes, and 10 minutes after the EUT is energized. Four measurements in total are made.

7.6. UNDESIRABLE EMISSION

LIMIT

Frequency Band		Limit
U-NII 2a	☒	In accordance with **47 CFR § 15.407(b)(2) / RSS-247, 6.2.2.2** All emissions outside the 5.15-5.35 GHz band shall not exceed an −27 dBm/MHz e.i.r.p.
U-NII 2c	☒	In accordance with **47 CFR § 15.407(b)(3) / RSS-247, 6.2.3.2** All emissions outside the 5.47-5.725 GHz band shall not exceed an −27 dBm/MHz e.i.r.p.

Emissions at the straddle channels comply with the rules for the band which the signal spans over.

7.7. RADIATED EMISSIONS

RADIATION EMISSION LIMIT

FCC : 47 CFR § 15.209		
Frequency (MHz)	**Field Strength (uV/m)**	**Measurement Distance (m)**
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

ISED : RSS-GEN Section 8.9		
Frequency (MHz)	**Field Strength (uV/m)**	**Measurement Distance (m)**
0.009 – 0.490	6.37/F(kHz)	300
0.490 – 1.705	63.7/F(kHz)	30
1.705 – 30	0.08	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

RECEIVER RADIATED EMISSION LIMIT

ISED : RSS-GEN Section 7.3		
Frequency (MHz)	**Field Strength (uV/m)**	**Measurement Distance (m)**
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

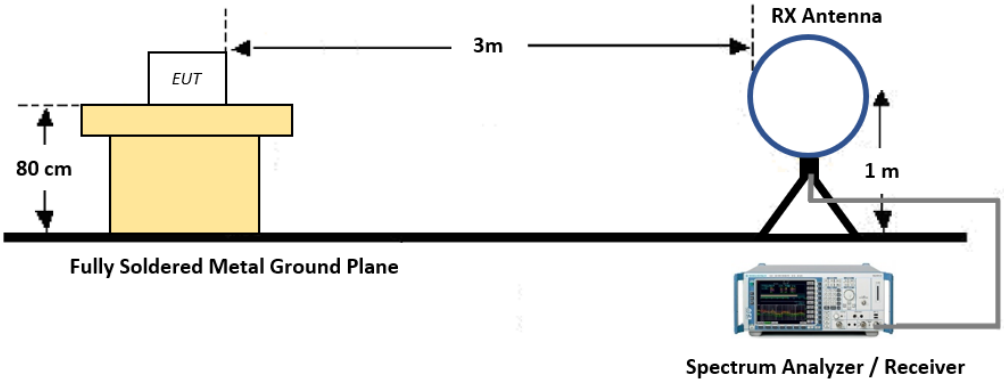
RESTRICTED BANDS OF OPERATION

FCC : 47 CFR § 15.205(a)				
Frequency (MHz)	**Frequency (MHz)**	**Frequency (MHz)**	**Frequency (MHz)**	**Frequency (MHz)**
0.090 – 0.110	12.29 - 12.293	149.9 - 150.05	1660.0 - 1710.0	8025 - 8500
0.495 - 0.505	12.51975 - 12.52025	156.52475 - 156.52525	1718.8 - 1722.2	9000 - 9200
2.1735 - 2.1905	12.57675 - 12.57725	156.7 - 156.9	2200.0 - 2300.0	9300 - 9500
4.125 - 4.128	13.36 - 13.41	162.0125 - 167.17	2310.0 - 2390.0	10600 - 12700
4.17725 - 4.17775	16.42 - 16.423	167.72 - 173.2	2483.5 - 2500.0	13250 - 13400
4.20725 - 4.20775	16.69475 - 16.69525	240.0 - 285.0	2690.0 - 2900.0	14470 - 14500
6.215 - 6.218	16.80425 - 16.80475	322.0 - 335.4	3260.0 - 3267.0	15350 - 16200
6.26775 - 6.26825	25.5 - 25.67	399.9 - 410.0	3332.0 - 3339.0	17700 - 21400
6.31175 - 6.31225	37.5 - 38.25	608.0 - 614.0	3345.8 - 3358.0	22010 - 23120
8.291 - 8.294	73 - 74.6	960.0 - 1240.0	3600.0 - 4400.0	23600 - 24000
8.362 - 8.366	74.8 - 75.2	1300.0 - 1427.0	4500.0 - 5150.0	31200 - 31800
8.37625 - 8.38675	108 - 121.94	1435.0 - 1626.5	5350.0 - 5460.0	36430 - 36500
8.41425 - 8.41475	123 - 138	1645.5 - 1646.5	7250.0 - 7750.0	Above 38600

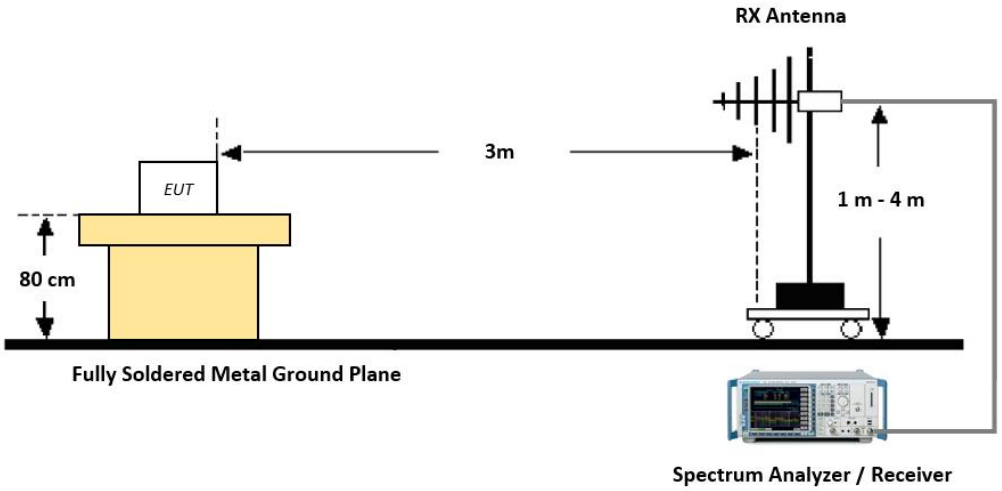
ISED : RSS-GEN Section 8.10				
Frequency (MHz)	**Frequency (MHz)**	**Frequency (MHz)**	**Frequency (MHz)**	**Frequency (MHz)**
0.090 - 0.110	8.37625 - 8.38675	108 – 138	1660 - 1710	8025 - 8500
0.495 - 0.505	8.41425 - 8.41475	149.9 - 150.05	1718.8 - 1722.2	9000 - 9200
2.1735 - 2.1905	12.29 - 12.293	156.52475 - 156.52525	2200 - 2300	9300 - 9500
3.020 - 3.026	12.51975 - 12.52025	156.7 - 156.9	2310 - 2390	10600 - 12700
4.125 - 4.128	12.57675 - 12.57725	162.0125 - 167.17	2483.5 - 2500	13250 - 13400
4.17725 - 4.17775	13.36 - 13.41	167.72 - 173.2	2655 - 2900	14470 - 14500
4.20725 - 4.20775	16.42 - 16.423	240 - 285	3260 - 3267	15350 - 16200
5.677 - 5.683	16.69475 - 16.69525	322 - 335.4	3332 - 3339	17700 - 21400
6.215 - 6.218	16.80425 - 16.80475	399.9 - 410	3345.8 - 3358	22010 - 23120
6.26775 - 6.26825	25.5 - 25.67	608 - 614	3500 - 4400	23600 - 24000
6.31175 - 6.31225	37.5 - 38.25	960 - 1427	4500 - 5150	31200 - 31800
8.291 - 8.294	73 - 74.6	1435 - 1626.5	5350 - 5460	36430 - 36500
8.362 - 8.366	74.8 - 75.2	1645.5 - 1646.5	7250 - 7750	Above 38600

TEST SETUP

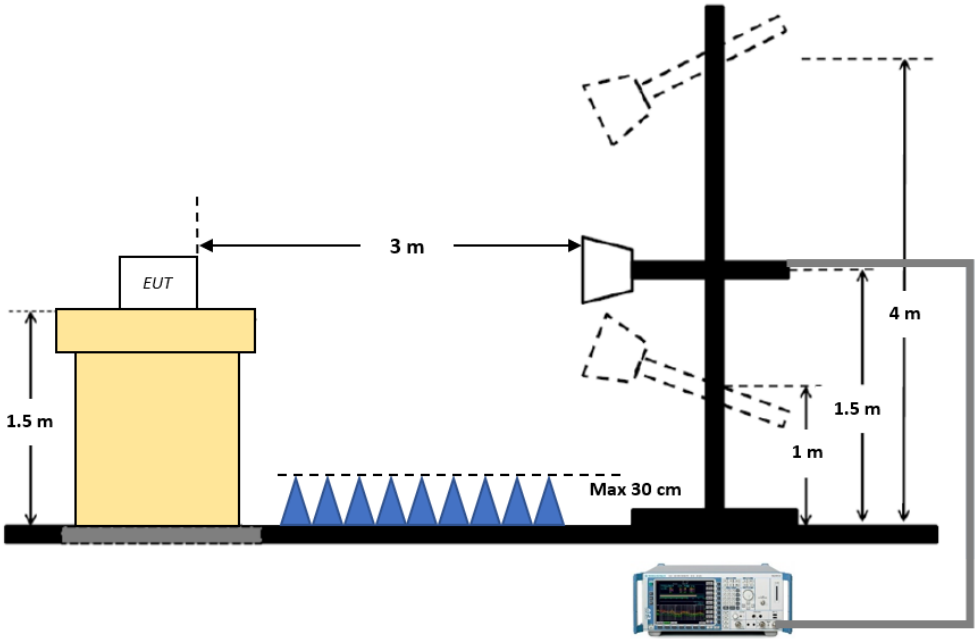
Below 30 MHz



30 MHz - 1 GHz



Above 1 GHz



TEST PROCEDURE OF RADIATED SPURIOUS EMISSION (BELOW 30 MHz)

1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
2. The loop antenna was placed at a location 3m from the EUT
3. The EUT is placed on a turntable, which is 0.8m above ground plane.
4. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
5. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
6. Distance Correction Factor (0.009 MHz – 0.490 MHz) = 40*log(3 m/300 m) = - 80 dB
   Measurement Distance: 3 m
7. Distance Correction Factor (0.490 MHz – 30 MHz) = 40*log(3 m/30 m) = - 40 dB
   Measurement Distance: 3 m
8. Spectrum Setting

   - Frequency Range = 9 kHz ~ 30 MHz
   - Detector = Peak
   - Trace = Max hold
   - RBW = 9 kHz
   - VBW ≥ 3*RBW

9. Total = Reading Value + Antenna Factor (A.F) + Cable Loss (C.L)
10. There is a comparison data both open-field test site and alternative test site – semi-Anechoic chamber according to 414788 D01. And the results are properly calibrated.

TEST PROCEDURE OF RADIATED SPURIOUS EMISSION (30 MHz – 1 GHz)

1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
2. The EUT is placed on a turntable, which is 0.8 m above ground plane.
3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
5. Spectrum Setting

   (1) Measurement Type (Peak):
   - Measured Frequency Range: 30 MHz – 1 GHz
   - Detector = Peak
   - Trace = Max hold
   - RBW = 100 kHz
   - VBW ≥ 3*RBW

   (2) Measurement Type(Quasi-peak):
   - Measured Frequency Range: 30 MHz – 1 GHz
   - Detector = Quasi-Peak
   - RBW = 120 kHz

6. Total = Reading Value + Antenna Factor (A.F) + Cable Loss (C.L)

TEST PROCEDURE OF RADIATED SPURIOUS EMISSION (ABOVE 1 GHz)

1. The EUT is placed on a turntable, which is 1.5 m above ground plane.
2. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
3. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
4. EUT is set 3 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
5. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
6. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
7. The unit was tested with its standard battery.
8. Spectrum Setting

   (1) Measurement Type(Peak, G.5 in KDB 789033 v02r01):
   - RBW = 1 MHz
   - VBW ≥ 3 MHz
   - Detector = Peak
   - Sweep Time = auto
   - Trace mode = Max hold
   - Allow sweeps to continue until the trace stabilizes.
   - Note that if the transmission is not continuous, the time required for the trace to stabilize will increase by a factor of approximately 1/x, where x is the duty cycle.

   (2) Measurement Type(Average, G.6.d in KDB 789033 v02r01):
   - RBW = 1 MHz
   - VBW(Duty cycle ≥ 98 percent) = VBW ≤ RBW/100(i.e., 10 kHz) but not less than 10 Hz.
   - VBW(Duty cycle is < 98 percent) = VBW ≥ 1/T, where T is the minimum transmission duration.
   - The analyzer is set to linear detector mode.
   - Detector = Peak.
   - Sweep time = auto.
   - Trace mode = Max hold.
   - Allow max hold to run for at least 50 traces if the transmitted signal is continuous or has at least 98 percent duty cycle. For lower duty cycles, increase the minimum number of traces by a factor of 1/x, where x is the duty cycle.

9. Measurement value only up to 6 maximum emissions noted or would be lesser if no specific emissions from the EUT are recorded (i.e.: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor

10. Measuring frequencies from 1 GHz to the 10th harmonic of highest fundamental frequency (or 40 GHz whichever comes first)

11. Sample Calculation

    (1) Total (Peak) = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G)
    (2) Total (Average, Duty ≥ 98%) = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G)
    (3) Total (Average, Duty < 98%) = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G) + Duty Cycle Factor

TEST PROCEDURE OF RADIATED RESTRICTED BAND EDGE

1. Radiated test is performed with hopping off (if there is any)
2. The EUT is placed on a turntable, which is 1.5 m above ground plane.
3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
5. EUT is set 3 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
6. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
7. The unit was tested with its standard battery.
8. Spectrum Setting

(1) Measurement Type(Peak, G.5 in KDB 789033 v02r01):

- RBW = 1 MHz
- VBW ≥ 3 MHz
- Detector = Peak
- Sweep Time = auto
- Trace mode = Max hold
- Allow sweeps to continue until the trace stabilizes.
- Note that if the transmission is not continuous, the time required for the trace to stabilize will increase by a factor of approximately 1/x, where x is the duty cycle.

(2) Measurement Type(Average, G.6.d in KDB 789033 v02r01):

- RBW = 1 MHz
- VBW(Duty cycle ≥ 98 percent) = VBW ≤ RBW/100(i.e., 10 kHz) but not less than 10 Hz.
- VBW(Duty cycle is < 98 percent) = VBW ≥ 1/T, where T is the minimum transmission duration.
- The analyzer is set to linear detector mode.
- Detector = Peak.
- Sweep time = auto.
- Trace mode = Max hold.
- Allow max hold to run for at least 50 traces if the transmitted signal is continuous or has at least 98 percent duty cycle. For lower duty cycles, increase the minimum number of traces by a factor of 1/x, where x is the duty cycle.

9. Sample Calculation

(1) Total (Peak) = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L)
(2) Total (Average, Duty ≥ 98%) = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G)
(3) Total (Average, Duty < 98%) = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G) + Duty Cycle Factor

7.8. AC POWER LINE CONDUCTED EMISSIONS

LIMIT

47 CFR § 15.207 / RSS-GEN Section 8.8

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).

Frequency Range (MHz)	Limits (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.

Compliance with this provision shall be based on the measurement of the radio frequency.
voltage between each power line (LINE and NEUTRAL) and ground at the power terminals.

TEST SETUP

See test photographs attached in Annex A for the actual connections between EUT and support equipment.

TEST PROCEDURE

1. The EUT is placed on a wooden table 80 cm above the reference ground plane.
2. The EUT is connected via LISN to a test power supply.
3. The measurement results are obtained as described below:
4. Detectors : Quasi Peak and Average Detector.

According to FCC KDB 174176 D01 Line Conducted FAQ v01r01 :

Devices Operating Above 30 MHz

For a device with a permanent or detachable antenna operating above 30 MHz, measurements must be performed with the antenna connected as specified in clause 6.2 of ANSI C63.10-2013.

Devices Operating Below 30 MHz

For a device with a permanent or detachable antenna operating at or below 30 MHz, the FCC will accept measurements performed with a suitable dummy load in lieu of the antenna under the following conditions:

(1) Perform the AC power-line conducted tests with the antenna connected to determine compliance with Section 15.207 limits outside the transmitter's fundamental emission band;

(2) Retest with a dummy load in lieu of the antenna to determine compliance with Section 15.207 limits within the transmitter's fundamental emission band. For a detachable antenna, remove the antenna and connect a suitable dummy load to the antenna connector. For a permanent antenna, remove the antenna and terminate the RF output with a dummy load or network which simulates the antenna in the fundamental frequency band. All measurements must be performed as specified in clause 6.2 of ANSI C63.10-2013.

Sample Calculation

Quasi-peak(Final Result) = Reading Value + Correction Factor

8. SUMMARY OF TEST RESULTS

Test Description	FCC Part Section(s)	Test Limit	Test Condition	Test Result
26 dB Bandwidth	§15.407	N/A (For power measurement)	Conducted	-
6 dB Bandwidth (1)	§15.407(e)	≥ 500 kHz		PASS
Maximum Conducted Output Power	§15.407(a)(2)	≤ 250 mW or 11dBm+10log(B) Whichever is less (B: Emission BW)		PASS
Power Spectral Density	§15.407(a)(2)	≤ 11 dBm/MHz		PASS
Frequency Stability	§15.407(g) §2.1055	Maintained within the band		PASS
AC Power line Conducted Emissions	§15.207 §15.407(b)(9)	cf. Section 7.8		PASS
Undesirable Emissions	§15.407(b)(2) §15.407(b)(3)	cf. Section 7.6	Radiated	PASS
Radiated Spurious Emissions	§15.209 §15.407(b)(9)	cf. Section 7.7		PASS
Radiated Restricted Band Edge	§15.407(b)(7) §15.205(a)	cf. Section 7.7		PASS

Note :

1. 6 dB bandwidth was measured for the straddle channels spanning between U-NII 2c and U-NII 3 bands

Test Description	ISED Part Section(s)	Test Limit	Test Condition	Test Result
6 dB Bandwidth (1)	RSS-247, 6.2.4.1	≥ 500 kHz	Conducted	PASS
Occupied bandwidth	RSS-Gen, 6.7	N/A		-
Maximum Conducted Output Power	RSS-247, 6.2.2 1 a RSS-247, 6.2.3.1 a	≤ 250 mW or ≤ 11 dBm + 10 log B Whichever is less (B : 99% BW in MHz)		PASS
Maximum e.i.r.p.	RSS-247, 6.2.2.1 b RSS-247, 6.2.3.1 b	≤ 1 W e.i.r.p. or ≤ 17 dBm + 10 log B e.i.r.p. Whichever is less (B : 99% BW in MHz)		PASS
Power Spectral Density	RSS-247, 6.2.4.1	≤ 11 dBm/ MHz EIRP		PASS
Frequency Stability	RSS-Gen, 8.11	should be kept within at least the central 80% of its permitted operating frequency band in order to minimize the possibility of out-of-band operation.		PASS
AC Power line Conducted Emissions	RSS-Gen, 8.8	cf. Section 7.8		PASS
Undesirable Emissions	RSS-247, 6.2.2.2 RSS-247, 6.2.3 2	cf. Section 7.6	Radiated	PASS
Radiated Spurious Emissions	RSS-Gen, 8.9	cf. Section 7.7		PASS
Radiated Restricted Band Edge	RSS-Gen, 8.10	cf. Section 7.7		PASS
Receiver Spurious Emissions	RSS-Gen, 7.3	cf. Section 7.7		PASS

Note :
1. 6 dB bandwidth was measured for the straddle channels spanning between U-NII 2c and U-NII 3 bands
2. The device cannot operate in the frequency range 5600 – 5650 MHz in Canada

WORST CASE CONFIGURATION

RADIATED TEST

1. EUT Axis

- All X, Y, and Z positions for horizontal / vertical antenna polarization were investigated to find the worst-case position.
- X position was selected for the final evaluation.

2. Operations with all the data rates available were investigated for each different channel BW mode. Lowest datarate was selected as the worst case.

3. Radiated test was performed at the worst case 2 x TX CDD mode
   - Radiated band edge test was conducted for each different mode and bandwidth. 802.11a/n(HT20/40)/ac(VHT80/160)/ac(HE20/40/80/160) modes were reported as the worst case
   - Radiated spurious emission test was performed for each different bandwidth. 802.11a, 802.11n (HT40), 802.11ac (VHT80/160) modes were reported as the worst-case spurious emission.
   - Receiver spurious emission test was performed for each mode and 802.11a mode was reported as the worst case.

CONDUCTED TEST

1. AC line conducted emission test was performed at the worst case transmission mode.
2. RF conducted emissions were measured for each different bandwidth modes. 802.11a, 802.11n (HT20/40), 802.11ac (VHT80/160), 802.11ax (HE20/40/80/160).

WORST CASE DATA RATE

Mode	Worst Case Data Rate
802.11a	6 Mbps
802.11n	MCS0
802.11ac	MCS0
802.11ax	MCS0

CHANNEL UNDER TEST

Mode (U-NII 2a)	Bandwidth (MHz)	Low Channel (MHz)	Mid Channel (MHz)	High Channel (MHz)
802.11a	20	5260	5300	5320
802.11n	20	5260	5300	5320
	40	5270	-	5310
802.11ac	80	5290		
802.11ax	20	5260	5300	5320
	40	5270	-	5310
	80	5290		

Mode (U-NII 2c)	Bandwidth (MHz)	Low Channel (MHz)	Mid Channel (MHz)	High Channel (MHz)
802.11a	20	5500	5580	5700
802.11n	20	5500	5580	5700
	40	5510	5590	5670
802.11ac	80	5530	-	5610
	160	5570		
802.11ax	20	5500	5580	5700
	40	5510	5590	5670
	80	5530	-	5610
	160	5570		

Mode (Straddle)	Bandwidth (MHz)	Low Channel (MHz)	Mid Channel (MHz)	High Channel (MHz)
802.11a	20	5720 (1)		
802.11n	20	5720 (1)		
	40	5710 (1)		
802.11ac	80	5690 (1)		
	160	5250 (2)		
802.11ax	20	5720 (1)		
	40	5710 (1)		
	80	5690 (1)		
	160	5250 (2)		

Note :
1. Straddle channels : U-NII 2c and U-NII 3 bands
2. Straddle channel : U-NII 1 and U-NII 2a bands

SUMMARY OF OUTPUT POWER

FCC			
Frequency (MHz)	**Bandwidth**	**Max Output Power (dBm)**	**Max Output Power (W)**
5260 - 5320	20/40/80 MHz	23.07	0.20275
5250	160 MHz	21.52	0.14192
5500 - 5720	20/40/80/160 MHz	23.46	0.22159

ISED			
Frequency (MHz)	**Bandwidth**	**Max Output Power (dBm)**	**Max Output Power (W)**
5260 - 5320	20/40/80 MHz	23.07	0.20275
5250	160 MHz	20.80	0.12024
5500 - 5720	20/40/80/160 MHz	23.46	0.22159

Note :

1. The device cannot operate in the frequency range 5600 – 5650 MHz for Canada

SUMMARY OF POWER LEVEL SETTING : FCC

U-NII 2 Band (20 MHz)			Power Level setting / Chain			
Band	Frequency (MHz)	Channel	802.11a	802.11n HT20	802.11ac VHT20	802.11ax HE20
U-NII 2a	5260	52	17	17.5	17.5	17.5
	5280	56	17	17.5	17.5	17.5
	5300	60	17.5	17.5	17.5	18
	5320	64	17.5	18	18	18
U-NII 2c	5500	100	17	17.5	17.5	18
	5520	104	17.5	18	18	18
	5540	108	17.5	18	18	18
	5560	112	17.5	18	18	18
	5580	116	18	18.5	18.5	18.5
	5600	120	17.5	18	18	18
	5620	124	17	17.5	17.5	17.5
	5640	128	17	17.5	17.5	17.5
	5660	132	17	17.5	17.5	17.5
	5680	136	17	17.5	17.5	17.5
	5700	140	16.5	17	17	17.5
U-NII 2c/3	5720	144	18	18	18	18.5

U-NII 2 Band (40 MHz)			Power Level setting / Chain		
Band	Frequency (MHz)	Channel	802.11n HT40	802.11ac VHT40	802.11ax HE40
U-NII 2a	5270	54	18	18	18.5
	5310	62	17.5	17.5	17.5
U-NII 2c	5510	102	19	19	19
	5550	110	19.5	19.5	19.5
	5590	118	19.5	19.5	19.5
	5630	126	19.5	19.5	19.5
	5670	134	19	19	19.5
U-NII 2c/3	5710	142	19	19	19

U-NII 2 Band (80 MHz)			Power Level setting / Chain	
Band	Frequency (MHz)	Channel	802.11ac VHT80	802.11ax HE80
U-NII 2a	5290	58	17	17
U-NII 2c	5530	106	19	19
	5610	122	20	20
U-NII 2c/3	5690	138	20	20

U-NII 2 Band (160 MHz)			Power Level setting / Chain	
Band	Frequency (MHz)	Channel	802.11ac VHT160	802.11ax HE160
U-NII 1/2a	5250	50	17.5	17.5
U-NII 2c	5570	114	18	18

SUMMARY OF POWER LEVEL SETTING : ISED

U-NII 2 Band (20 MHz)			Power Level setting / Chain			
Band	Frequency (MHz)	Channel	802.11a	802.11n HT20	802.11ac VHT20	802.11ax HE20
U-NII 2a	5260	52	17	17.5	17.5	17.5
	5280	56	17	17.5	17.5	17.5
	5300	60	17.5	17.5	17.5	18
	5320	64	17.5	18	18	18
U-NII 2c	5500	100	17	17.5	17.5	18
	5520	104	17.5	18	18	18
	5540	108	17.5	18	18	18
	5560	112	17.5	18	18	18
	5580	116	18	18.5	18.5	18.5
	5600	120	17.5	18	18	18
	5620	124	17	17.5	17.5	17.5
	5640	128	17	17.5	17.5	17.5
	5660	132	17	17.5	17.5	17.5
	5680	136	17	17.5	17.5	17.5
	5700	140	16.5	17	17	17.5
U-NII 2c/3	5720	144	18	18	18	18.5

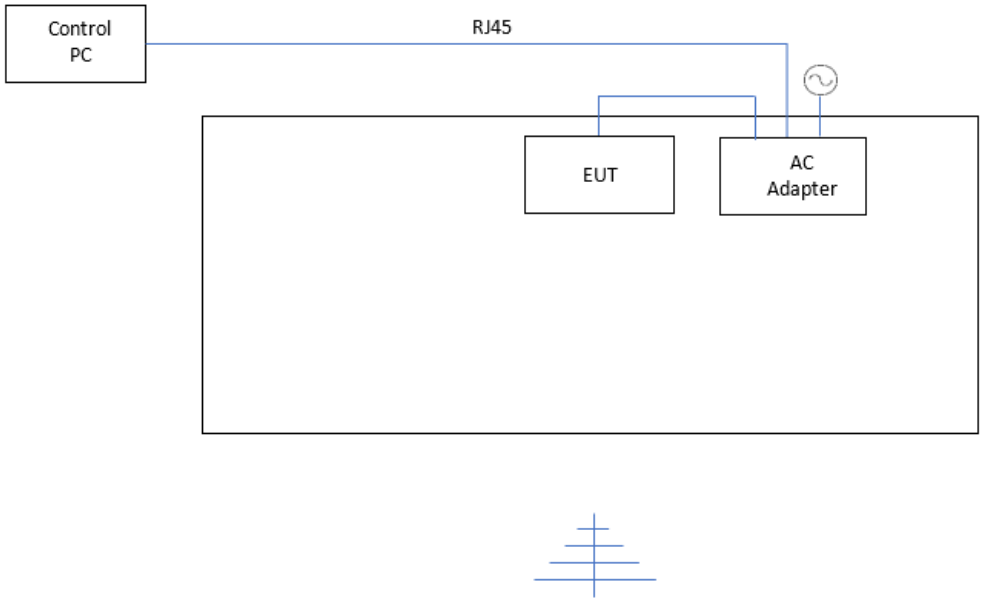
U-NII 2 Band (40 MHz)			Power Level setting / Chain		
Band	Frequency (MHz)	Channel	802.11n HT40	802.11ac VHT40	802.11ax HE40
U-NII 2a	5270	54	18	18	18.5
	5310	62	17.5	17.5	17.5
U-NII 2c	5510	102	19	19	19
	5550	110	19.5	19.5	19.5
	5590	118	19.5	19.5	19.5
	5630	126	19.5	19.5	19.5
	5670	134	19	19	19.5
U-NII 2c/3	5710	142	19	19	19

U-NII 2 Band (80 MHz)			Power Level setting / Chain	
Band	Frequency (MHz)	Channel	802.11ac VHT80	802.11ax HE80
U-NII 2a	5290	58	17	17
U-NII 2c	5530	106	19	19
	5610	122	20	20
U-NII 2c/3	5690	138	20	20

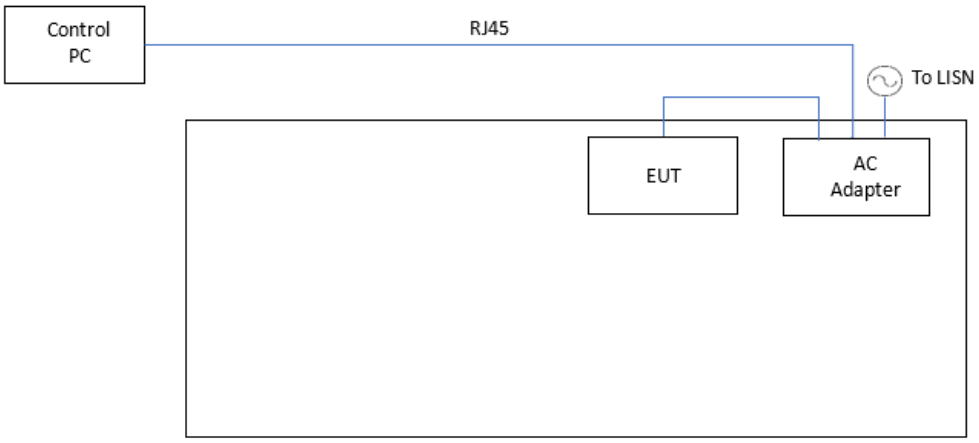
U-NII 2 Band (160 MHz)			Power Level setting / Chain	
Band	Frequency (MHz)	Channel	802.11ac VHT160	802.11ax HE160
U-NII 1/2a	5250	50	17	17
U-NII 2c	5570	114	18	18

TEST CONFIGURATION

Radiated Emission



Conducted Emission



LIST OF SUPPORT EQUIPMENT

Equipment Type	Model No.	Serial Number	Manufacturer	Qty	Note
PoE Adapter	G0566-500-120	-	Shenzhen Gospell Digital Tech.	1	100-240 VAC, 1.5 A 50/60Hz (50 VDC)
Laptop	TP00076A	R9-0NUJ14 17/08	Lenovo	1	-

9. TEST RESULT

9.1 DUTY CYCLE

Mode	Data Rate	T_{on} (ms)	T_{total} (ms)	Duty Cycle	Duty Factor (dB)	VBW(1/T) (Hz)
802.11a	6 Mbps	1.98	2.34	0.85	0.72	505.31
802.11n HT20	MCS0	5.43	5.94	0.91	0.39	184.16
802.11ax HE20	MCS0	5.44	5.70	0.96	0.20	183.75
802.11n HT40	MCS0	5.43	5.91	0.92	0.37	184.16
802.11ax HE40	MCS0	5.44	5.70	0.96	0.20	183.75
802.11ac VHT80	MCS0	5.43	5.95	0.91	0.40	184.16
802.11ax HE80	MCS0	5.44	5.77	0.94	0.25	183.66
802.11ac VHT160	MCS0	5.42	5.82	0.93	0.31	184.67
802.11ax HE160	MCS0	5.42	5.72	0.95	0.23	184.67

Note :
The result of the duty cycle measurement was reused from the UNII-1 and U-NII 2 test report.