RF TEST REPORT

SIEMIC
A Bureau Veritas Group Company

Report No.: FCC_SL1610101001-SFE-020-UNII_Rev1.0
Supersede Report No.: FCC_SL1610101001-SFE-020-UNII

Applicant	:	Lighthouse AI, Inc
Product Name	:	Lighthouse
Model No.	:	A1
Test Standard	:	47 CFR 15.407
Test Method	:	ANSI C63.4: 2014 789033 D02 General UNII Test Procedures New Rules v01r02
FCC ID	:	2ALIS–A1
IC ID	:	22555-A1
Dates of test	:	02/14/2017 – 02/24/2017
Issue Date	:	05/12/2017
Test Result	:	☒ Pass ☐ Fail
Equipment complied with the specification [X] Equipment did not comply with the specification [ ]		

This Test Report is Issued Under the Authority of:	
Rachana	Chen Ge
Rachana Khanduri	Chen Ge
Test Engineer	Engineer Reviewer
This test report may be reproduced in full only Test result presented in this test report is applicable to the tested sample only	

Issued By:
SIEMIC Laboratories
775 Montague Expressway, Milpitas, 95035 CA

ilac-MRA
ACCREDITED
TESTING CERT # 2742-01

Laboratory Introduction

SIEMIC, headquartered in the heart of Silicon Valley, with superior facilities in US and Asia, is one of the leading independent testing and certification facilities providing customers with one-stop shop services for Compliance Testing and Global Certifications.

In addition to testing and certification, SIEMIC provides initial design reviews and compliance management throughout a project. Our extensive experience with China, Asia Pacific, North America, European, and International compliance requirements, assures the fastest, most cost effective way to attain regulatory compliance for the global markets.

Accreditations for Conformity Assessment

Country/Region	Accreditation Body	Scope
USA	FCC, A2LA	EMC, RF/Wireless, Telecom
Canada	IC, A2LA, NIST	EMC, RF/Wireless, Telecom
Taiwan	BSMI, NCC, NIST	EMC, RF, Telecom, Safety
Hong Kong	OFTA, NIST	RF/Wireless, Telecom
Australia	NATA, NIST	EMC, RF, Telecom, Safety
Korea	KCC/RRA, NIST	EMI, EMS, RF, Telecom, Safety
Japan	VCCI, JATE, TELEC, RFT	EMI, RF/Wireless, Telecom
Mexico	NOM, COFETEL, Caniety	Safety, EMC, RF/Wireless, Telecom
Europe	A2LA, NIST	EMC, RF, Telecom, Safety
Israel	MOC, NIST	EMC, RF, Telecom, Safety

Accreditations for Product Certifications

Country	Accreditation Body	Scope
USA	FCC TCB, NIST	EMC, RF, Telecom
Canada	IC FCB, NIST	EMC, RF, Telecom
Singapore	iDA, NIST	EMC, RF, Telecom
EU	NB	EMC & R&TTE Directive
Japan	MIC (RCB 208)	RF, Telecom
Hong Kong	OFTA (US002)	RF, Telecom

CONTENTS

1 REPORT REVISION HISTORY 4
2 EXECUTIVE SUMMARY 5
3 CUSTOMER INFORMATION 5
4 TEST SITE INFORMATION 5
5 MODIFICATION 5
6 EUT INFORMATION 6
6.1 EUT Description 6
6.2 Radio Description 6
6.3 EUT Photos - External 8
6.4 EUT Photos - Internal 10
6.5 EUT Test Setup Photos 13
7 SUPPORTING EQUIPMENT/SOFTWARE AND CABLING DESCRIPTION 14
7.1 Supporting Equipment 14
7.2 Cabling Description 14
7.3 Test Software Description 14
8 TEST SUMMARY 15
9 MEASUREMENT UNCERTAINTY 16
10 MEASUREMENTS, EXAMINATION AND DERIVED RESULTS 18
10.1 Conducted Emissions 18
10.2 26 dB Bandwidth & 6 dB Bandwidth 21
10.3 Output Power 31
10.4 Peak Spectral Density 41
10.5 Band Edge and Emission Mask Measurement 51
10.6 Radiated Emissions below 1GHz 58
10.7 Radiated Spurious Emissions above 1GHz 60
ANNEX A. TEST INSTRUMENT 69
ANNEX B. SIEMIC ACCREDITATION 70

1 Report Revision History

Report No.	Report Version	Description	Issue Date
FCC_SL16101001-SFE-020-UNII	None	Original	03/30/2017
FCC_SL16101001-SFE-020-UNII_Rev1.0	Rev1.0	Updated FCC ID	05/12/2017

2 Executive Summary

The purpose of this test program was to demonstrate compliance of following product

Company: Lighthouse AI, Inc
Product: Lighthouse
Model: A1

against the current Stipulated Standards. The specified model product stated above has demonstrated compliance with the Stipulated Standard listed on 1st page.

3 Customer information

Applicant Name	:	Lighthouse AI, Inc
Applicant Address	:	380 Portage Avenue, Palo Alto, CA
Manufacturer Name	:	Hon Hai Precision Industry CO, LTD (Foxconn)
Manufacturer Address	:	NANNING FUGUI PRECISION INDUSTRIAL CO.,LTD. B FACTORIES AREA,FOXCONN NANNING SCITECH PARK,NO.51,TONGLE, NANNING CITY, GUANGXI PROVINCE, CHINA-530031

4 Test site information

Lab performing tests	SIEMIC Laboratories
Lab Address	775 Montague Expressway, Milpitas, CA 95035
FCC Test Site No.	881796
IC Test Site No.	4842D-2
VCCI Test Site No.	A0133

5 Modification

Index	Item	Description	Note
-	-	-	-

6 EUT Information

6.1 EUT Description

Product Name	:	Lighthouse
Model No.	:	A1
Trade Name	:	Lighthouse AI
Serial No.	:	A1003170012
Input Power	:	100-240VAC,50/60Hz
Power Adapter Manu/Model	:	2ABS048F US
Power Adapter SN	:	11-16120136-00145
Product Hardware version	:	v3.2
Product Software version	:	build-alexandria-1079
Radio Hardware version	:	WCN-3660B-0-79WLNSP-TR-05-1
Radio Software version	:	CNSS.PR.2.0.1.2.c1-00021-M8936BAAAANAZW-1
Date of EUT received	:	02/06/2017
Equipment Class/ Category	:	DTS,UNII
Port/Connectors	:	None

6.2 Radio Description

Radio Type	802.11a	802.11n-20M	802.11n-40M
Operating Frequency	5180-5240MHz 5745-5825MHz	5180-5240MHz 5745-5825MHz	5190-5230MHz 5755-5795MHz
Modulation	OFDM (BPSK, QPSK, 16QAM, 64QAM)	OFDM (BPSK, QPSK, 16QAM, 64QAM)	OFDM (BPSK, QPSK, 16QAM, 64QAM)
Channel Spacing	20MHz	20MHz	40MHz
Number of Channels	9	9	4
Antenna Type	Dipole		
Antenna Gain (Peak)	5GHz: 5 dBi		
Antenna Connector Type	U.FL		
Note	2.4GHz and 5GHz Radio does not transmit simultaneously		

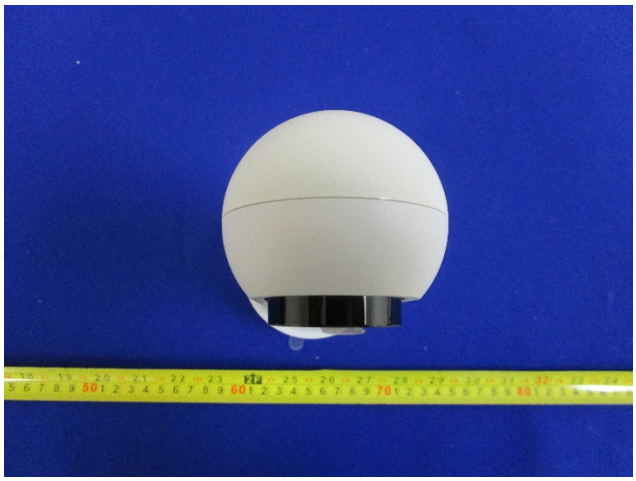
EUT Power level setting

Mode	Frequency	Power Setting
802.11-a	5180	14
802.11-a	5200	14
802.11-a	5240	14
802.11-n-20	5180	14
802.11-n-20	5200	14
802.11-n-20	5240	14
802.11-n-40	5190	14
802.11-n-40	5230	14
802.11-a	5745	14
802.11-a	5785	14
802.11-a	5825	14
802.11-n-20	5745	14
802.11-n-20	5785	14
802.11-n-20	5825	14
802.11-n-40	5755	14
802.11-n-40	5795	14

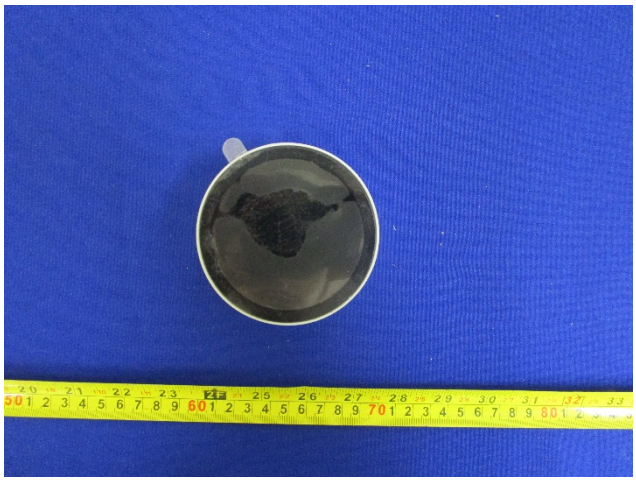
6.3 EUT Photos - External

EUT – Front View

EUT – Rear View



EUT – Top View



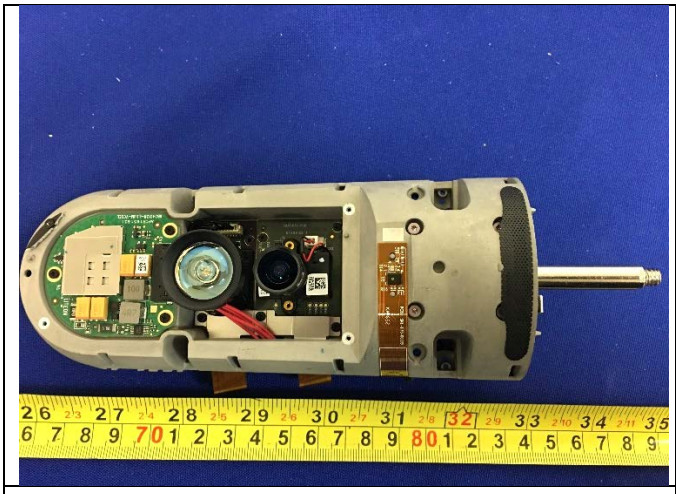
EUT – Bottom View

EUT – Left Side View

EUT – Right Side View

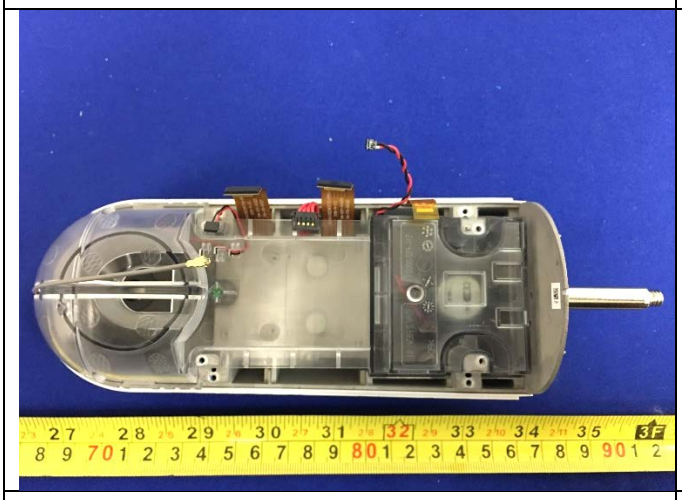
Support Equipment Power Supply Top View	Support Equipment Power Supply Bottom View

6.4 EUT Photos - Internal

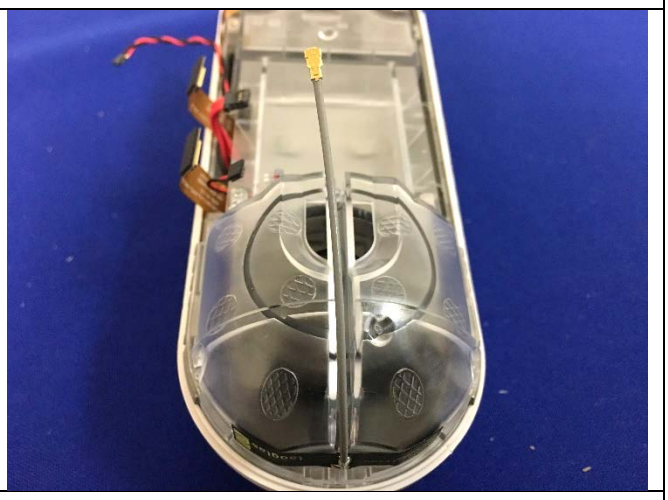


EUT: Cover Off Front View

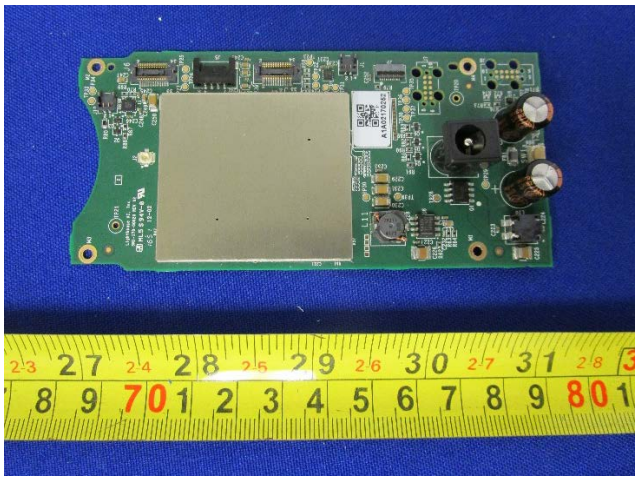
EUT: Cover Off Rear View



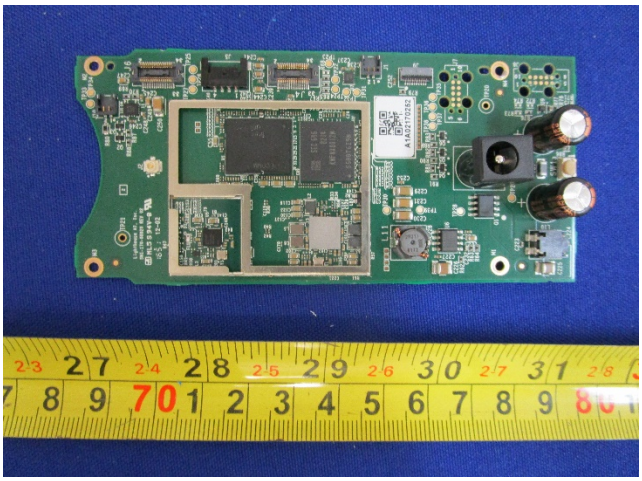
Internal Cover Off View



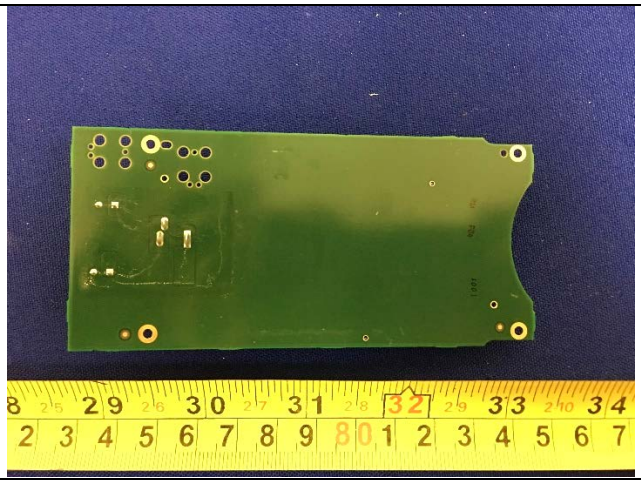
Internal Antenna View



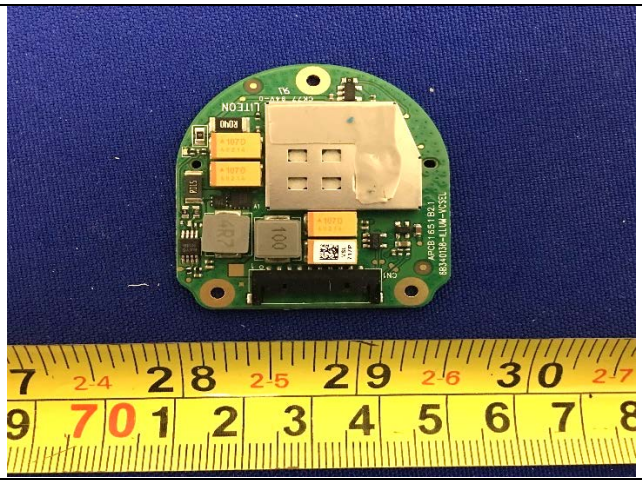
Radio Board with Shielding – Top View



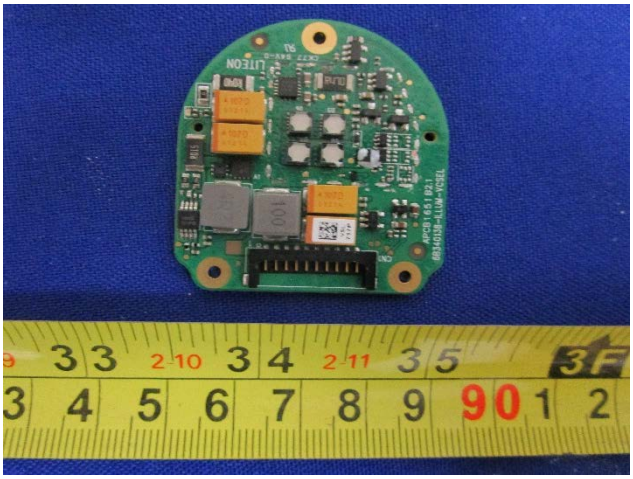
Radio Board without Shielding – Top View



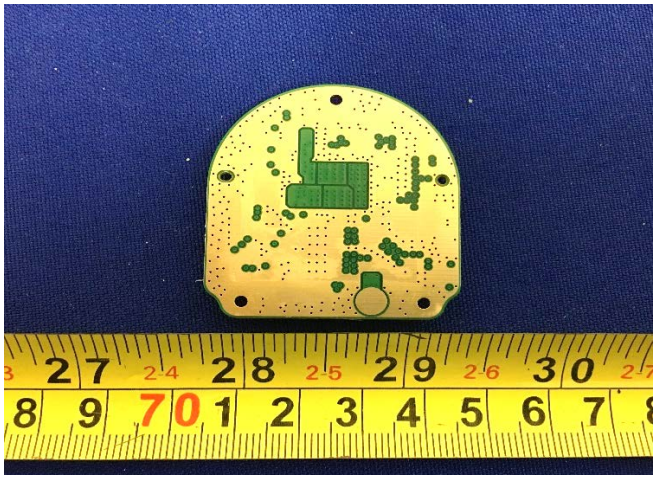
Radio Board without Shielding – Bottom View



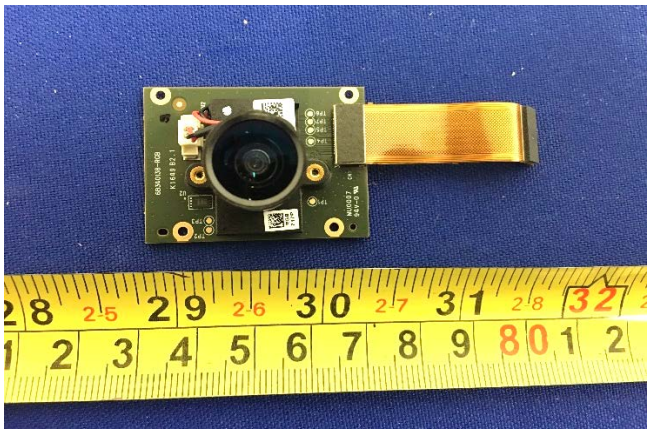
Internal PCBA 1 with Shielding Top View



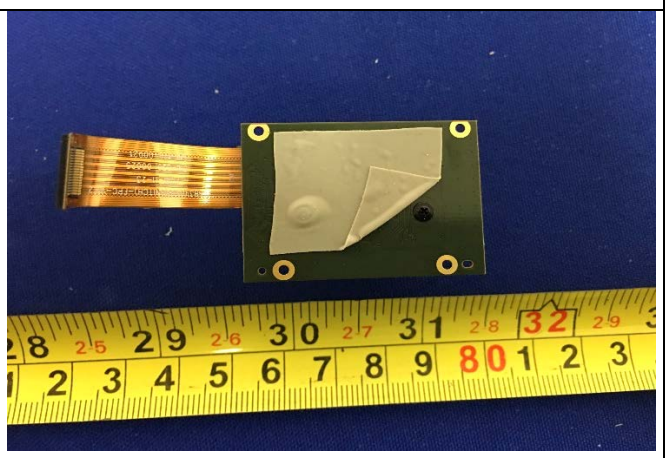
Internal PCBA 1 without Shielding Top View



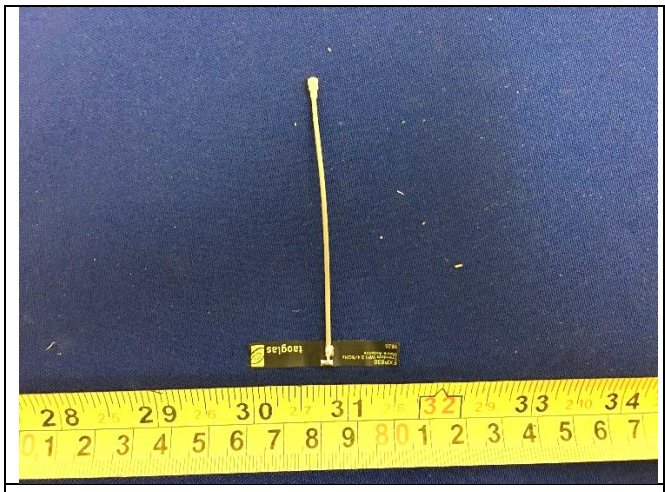
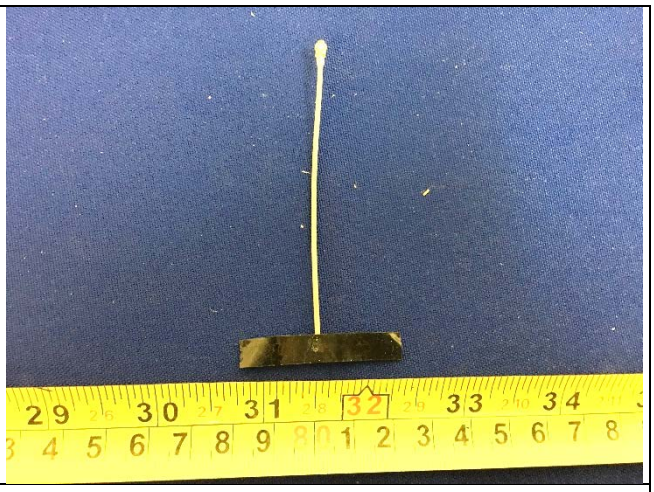
Internal PCBA 1 Bottom View



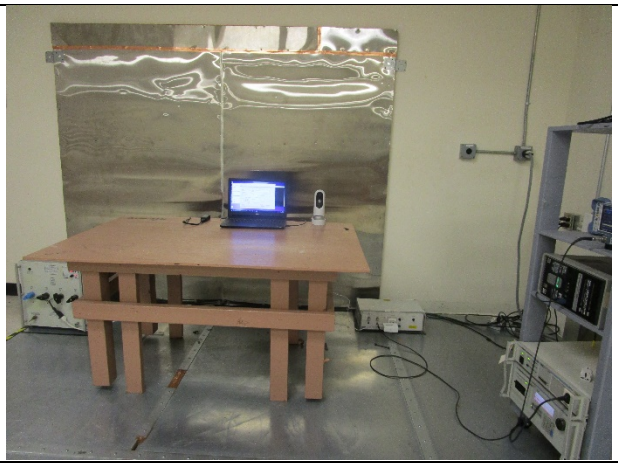
Internal PCBA 2 Top View



Internal PCBA 2 Bottom View

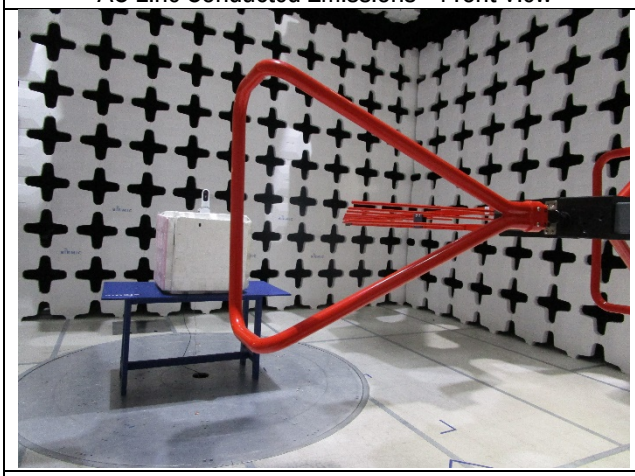
	
Antenna Top View	Antenna Bottom View

6.5 EUT Test Setup Photos

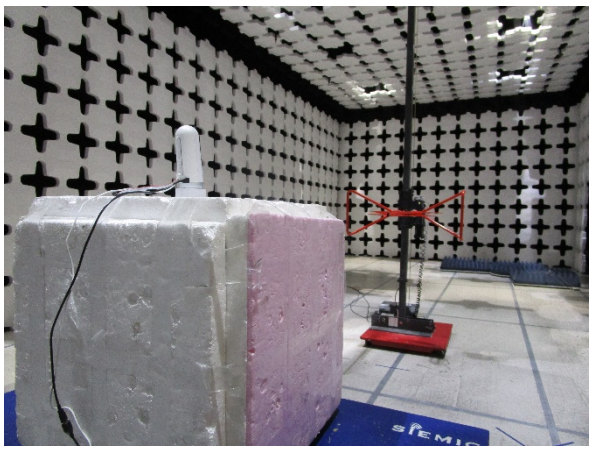


AC Line Conducted Emissions – Front View

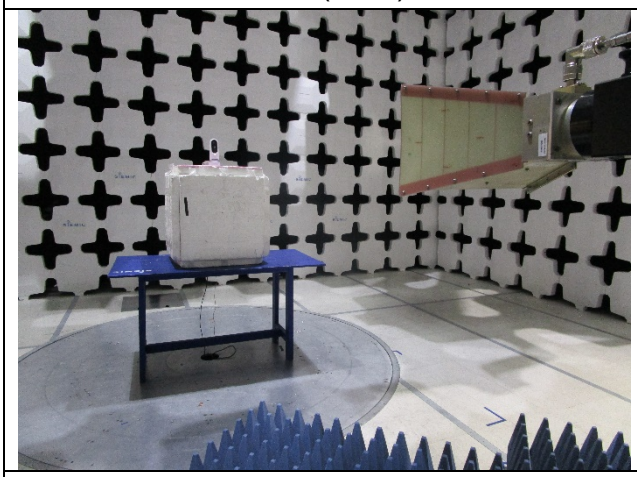
AC Line Conducted Emissions – Rear View



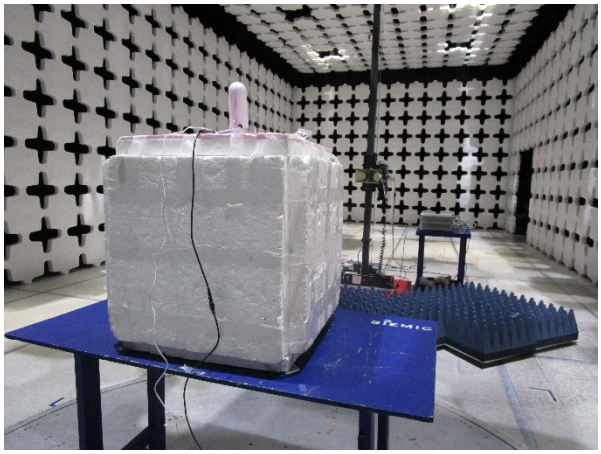
Radiated Emissions (<1GHz) – Front View



Radiated Emissions (<1GHz) – Rear View



Radiated Emissions (>1GHz) – Front View



Radiated Emissions (>1GHz) – Rear View

7 Supporting Equipment/Software and cabling Description

7.1 Supporting Equipment

Item	Supporting Equipment Description	Model	Serial Number	Manufacturer	Note
1	Laptop	N/A	3YZQ162	Dell	-

7.2 Cabling Description

Name	Connection Start		Connection Stop		Length / shielding Info		Note
	From	I/O Port	To	I/O Port	Length (m)	Shielding	
USB	USB	EUT	USB	Laptop	USB	1	Unshielded

7.3 Test Software Description

Test Item	Software	Description
RF Testing	QRCT	Set the EUT to transmit continuously in diferent test modes and channels

8 Test Summary

Test Item	Test standard		Test Method/Procedure	Pass / Fail
Restricted Band of Operation	FCC	15.205	ANSI C63.4 – 2014 789033 D02 General UNII Test Procedures New Rules v01r02	☒ Pass ☐ N/A
AC Conducted Emissions Voltage	FCC	15.207(a)	ANSI C63.4 – 2014	☒ Pass ☐ N/A

Test Item	Test standard		Test Method/Procedure	Pass / Fail
26 & 6 dB Emission Bandwidth	FCC	15.407 (a) (2)	789033 D02 General UNII Test Procedures New Rules v01r02	☒ Pass ☐ N/A
Maximum conducted Output Power	FCC	15.407 (a) (2)	789033 D02 General UNII Test Procedures New Rules v01r02	☒ Pass ☐ N/A
Power reduction (Antenna Gain > 6 dBi)	FCC	15.407 (a) (2)	-	☐ Pass ☒ N/A
Band Edge and Radiated Spurious Emissions	FCC	15.407(b)(2), 15.407(b)(6)	ANSI C63.4 – 2014 789033 D02 General UNII Test Procedures New Rules v01r02	☒ Pass ☐ N/A
Power Spectral Density	FCC	15.407 (a) (2)	789033 D02 General UNII Test Procedures New Rules v01r02	☒ Pass ☐ N/A
Frequency Stability	FCC	15.407 (g)	-	☐ Pass ☒ N/A
Transmit Power Control (TPC)	FCC	15.407 (h)(1)	-	☐ Pass ☒ N/A
User Manual	FCC	-	-	☒ Pass ☐ N/A
Remark	1. All measurement uncertainties are not taken into consideration for all presented test result. 2. The applicant shall ensure frequency stability by showing that an emission is maintained within the band of operation under all normal operating conditions as specified in the user's manual.			

9 Measurement Uncertainty

9.1 Conducted Emissions

The test is to measure the conducted emissions to the mains port of the EUT.

Some error sources that can contribute to the total uncertainty:

- Uncertainty of the receiver
- Uncertainty of the LISN
- Uncertainty of cables
- Uncertainty due to the mismatches
- Etc, see the below table for details

Source of Uncertainty	Value (dB)	Probability Distribution	Division	Sensitivity Coefficient	Expanded Uncertainty
Receiver Reading	0.12	Rectangular	1.732	1	0.069284
Cable Insertion Loss	0.21	Normal	2	1	0.105
Filter Insertion Loss	0.25	Normal	2	1	0.125
LISN Insertion Loss	0.40	Normal	2	1	0.20
Receiver CW accuracy	0.5	Rectangular	1.732	1	0.2886836
Pulse Amplitude Response	1.5	Rectangular	1.732	1	0.86605081
PRF Response	1.5	Rectangular	1.732	1	0.86605081
Mismatch LISN - Receiver	0.25	U-Shape	1.414	1	0.1768033
LISN Impedance	2.5	Triangular	2.449	1	1.0208248
Combined Standard Uncertainty					1.928133
Expanded Uncertainty (K=2)					3.856266

The total derived measurement uncertainty is +/- 3.86 dB.

9.2 Radiated Emissions (30MHz to 1GHz)

The test is to measure the radiated emissions of the EUT.

Some error sources that can contribute to the total uncertainty:

- Uncertainty of the receiver
- Uncertainty of the antenna
- Uncertainty of cables
- Uncertainty due to the mismatches
- NSA Calibration
- Etc., details see the below table

Source of Uncertainty	Value (dB)	Probability Distribution	Division	Sensitivity Coefficient	Expanded Uncertainty
Receiver Reading	0.12	Rectangular	1.732	1	0.069284
Cable Insertion Loss	0.21	Normal	2	1	0.105
Filter Insertion Loss	0.25	Normal	2	1	0.125
Antenna Factor	0.65	Normal	2	1	0.325
Receiver CW accuracy	0.5	Rectangular	1.732	1	0.2886836
Pulse Amplitude Response	1.5	Rectangular	1.732	1	0.86605081
PRF Response	1.5	Rectangular	1.732	1	0.86605081
Mismatch Filter - Receiver	0.25	U-Shape	1.414	1	0.1768033
NSA Calibration	4.0	U-Shape	1.414	1	2.8288543
Combined Standard Uncertainty					3.0059131
Expanded Uncertainty (K=2)					6.0118262

The total derived measurement uncertainty is +/- 6.00 dB.

9.3 Radiated Emissions (1GHz to 40GHz)

The test is to measure the radiated emissions of the EUT.

Some error sources that can contribute to the total uncertainty:
- Uncertainty of the receiver
- Uncertainty of the antenna
- Uncertainty of cables
- Uncertainty due to the mismatches
- VSWR Calibration
- Etc., details see the below table

Source of Uncertainty	Value (dB)	Probability Distribution	Division	Sensitivity Coefficient	Expanded Uncertainty
Receiver Reading	0.12	Rectangular	1.732	1	0.0692840
Cable Insertion Loss	0.21	Normal	2	1	0.1050000
Filter Insertion Loss	0.25	Normal	2	1	0.1250000
Antenna Factor	0.65	Normal	2	1	0.3250000
Receiver CW accuracy	0.5	Rectangular	1.732	1	0.2886836
Pulse Amplitude Response	1.5	Rectangular	1.732	1	0.8660508
PRF Response	1.5	Rectangular	1.732	1	0.8660508
Mismatch Filter - Receiver	0.25	U-Shape	1.414	1	0.1768033
VSWR Calibration	2.0	U-Shape	1.414	1	1.4144272
Combined Standard Uncertainty					4.2363
Expanded Uncertainty (K=2)					8.4726

The total derived measurement uncertainty is +/- 8.47 dB.

9.4 RF conducted measurement

The test is to measure the RF output power from the EUT.

Some error sources that can contribute to the total uncertainty:

- Uncertainty of the Reference Level Uncertainty
- Uncertainty of variable attenuators
- Uncertainty of cables
- Uncertainty due to the mismatches

Source of Uncertainty	Value (dB)	Probability Distribution	Division	Sensitivity Coefficient	Expanded Uncertainty
Reference Level	0.12	Rectangular	1.732	1	0.069284
Cable Insertion Loss	0.21	Normal	2	1	0.105
Attenuator	0.25	Normal	2	1	0.125
Mismatch	0.25	U-Shape	1.414	1	0.1768033
Combined Standard Uncertainty					0.476087
Expanded Uncertainty (K=2)					0.952174

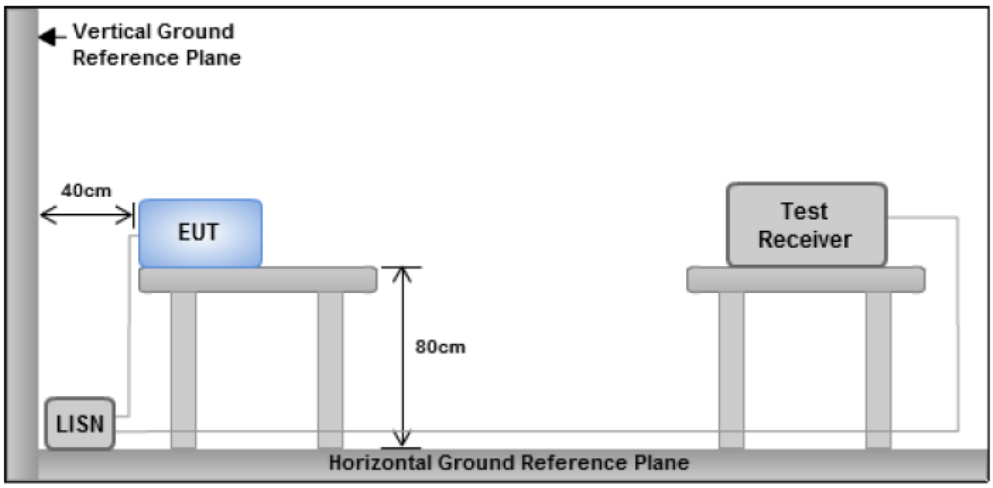
The total derived measurement uncertainty is +/- 0.95 dB.

10 Measurements, Examination and Derived Results

10.1 Conducted Emissions

Conducted Emission Limit

Frequency ranges (MHz)	Limit (dBuV)	
	QP	Average
0.15 ~ 0.5	66 – 56	56 – 46
0.5 ~ 5	56	46
5 ~ 30	60	50

Spec	Item	Requirement	Applicable
RSS247(A8.1)	a)	For Low-power radio-frequency devices 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). The lower limit applies at the boundary between the frequency ranges.	☒
Test Setup	 Note: 1. Support units were connected to second LISN. 2. Both of LISNs (AMN) are 80 cm from EUT and at least 80 cm from other units and other metal planes	
Procedure	- The EUT and supporting equipment were set up in accordance with the requirements of the standard on top of a 1.5m x 1m x 0.8m high, non-metallic table, as shown in Annex B. - The power supply for the EUT was fed through a 50Ω/50µH EUT LISN, connected to filtered mains. - The RF OUT of the EUT LISN was connected to the EMI test receiver via a low-loss coaxial cable. - All other supporting equipment was powered separately from another main supply.	
Remark	EUT was tested at 120VAC, 60Hz	
Result	☒ Pass ☐ Fail	

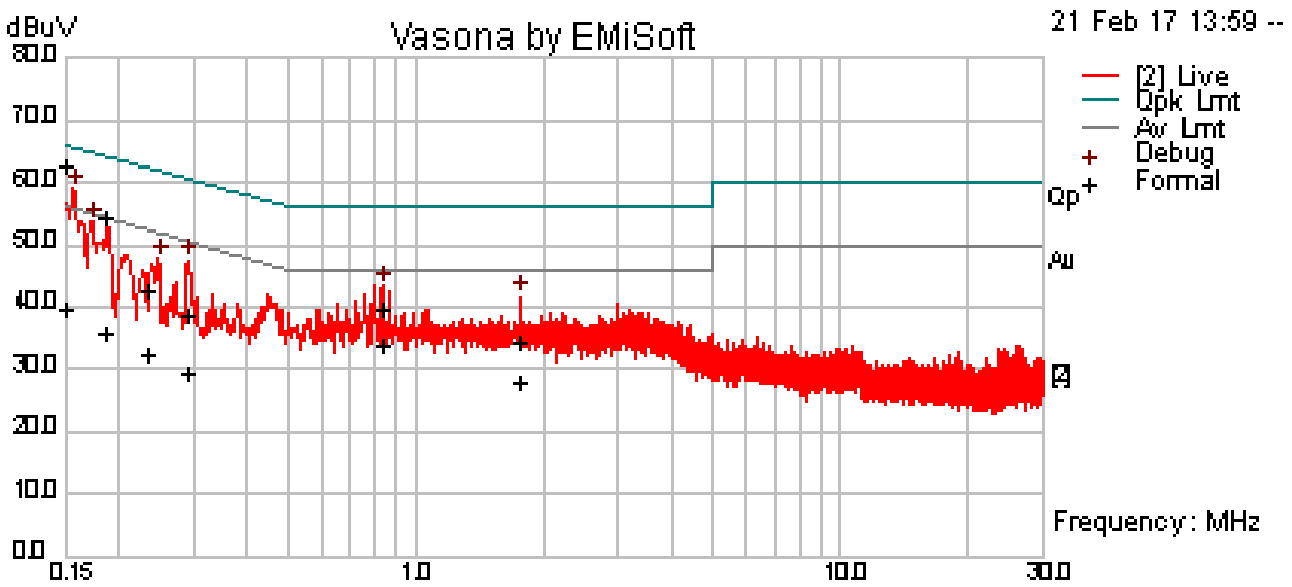
Test Data ☒ Yes ☐ N/A

Test Plot ☒ Yes (See below) ☐ N/A

Test was done by Rachana Khanduri at Conducted Emission test site.

Conducted Emission Test Results

Test specification:	Conducted Emissions			
Environmental Conditions:	Temp(°C):	21	Result:	☒ Pass ☐ Fail
	Humidity (%):	42		
	Atmospheric(mbar):	1021		
Mains Power:	120Vac, 60Hz			
Tested by:	Rachana Khanduri			
Test Date:	02/21/2017			
Remarks	conducted @ Line			

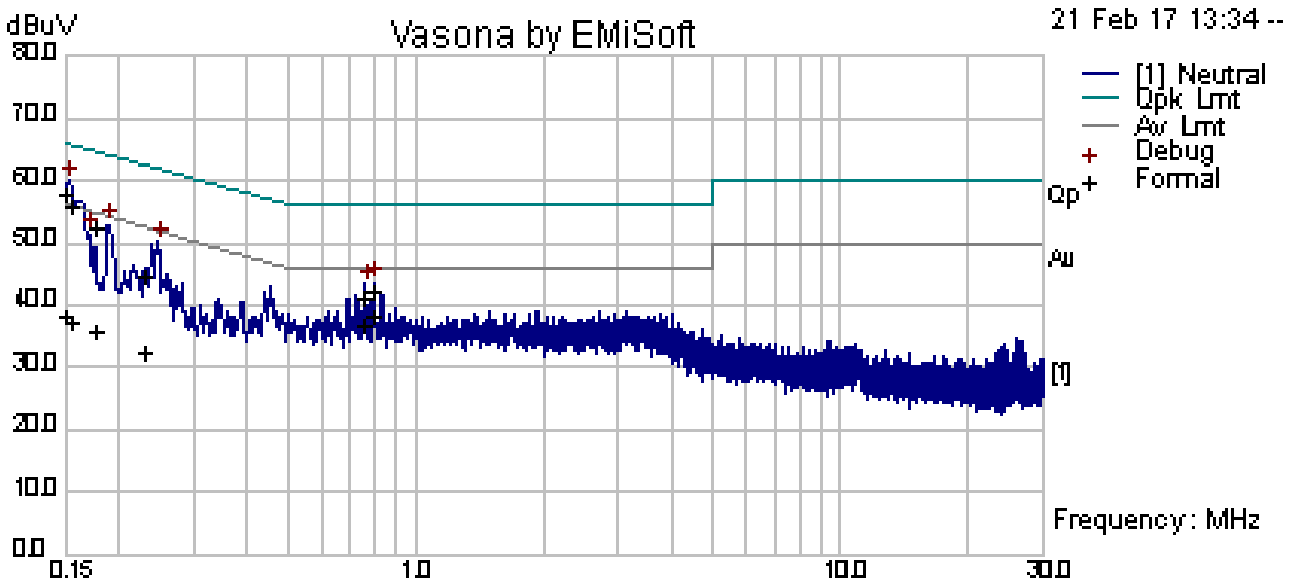


Line Plot at 120Vac, 60Hz

Frequency (MHz)	Raw (dBuV)	Cable Loss (dB)	Factors (dB)	Level (dBuV)	Measurement Type	Line / Neutral	Limit (dBuV)	Margin (dB)	Pass /Fail
0.15	50.97	10.00	1.74	62.71	Quasi Peak	Live	66.00	-3.29	Pass
0.19	43.26	10.00	1.36	54.63	Quasi Peak	Live	64.22	-9.59	Pass
0.83	29.27	10.01	0.54	39.83	Quasi Peak	Live	56.00	-16.17	Pass
0.29	28.05	10.00	0.88	38.94	Quasi Peak	Live	60.58	-21.65	Pass
0.24	31.78	10.00	1.07	42.84	Quasi Peak	Live	62.24	-19.40	Pass
1.75	24.03	10.02	0.50	34.56	Quasi Peak	Live	56.00	-21.44	Pass
0.15	27.83	10.00	1.74	39.57	Average	Live	56.00	-16.43	Pass
0.19	24.44	10.00	1.36	35.81	Average	Live	54.22	-18.41	Pass
0.83	23.48	10.01	0.54	34.03	Average	Live	46.00	-11.97	Pass
0.29	18.78	10.00	0.88	29.67	Average	Live	50.58	-20.92	Pass
0.24	21.31	10.00	1.07	32.37	Average	Live	52.24	-19.87	Pass
1.75	17.59	10.02	0.50	28.12	Average	Live	46.00	-17.88	Pass

Conducted Emission Test Results

Test specification:	Conducted Emissions			
Environmental Conditions:	Temp(°C):	21	Result:	☒ Pass ☐ Fail
	Humidity (%):	42		
	Atmospheric(mbar):	1021		
Mains Power:	120Vac, 60Hz			
Tested by:	Rachana Khanduri			
Test Date:	02/21/2017			
Remarks	conducted @ Neutral			



Neutral Plot at 120Vac, 60Hz

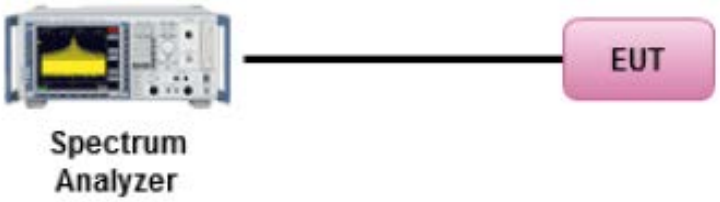
Frequency (MHz)	Raw (dBuV)	Cable Loss (dB)	Factors (dB)	Level (dBuV)	Measurement Type	Line / Neutral	Limit (dBuV)	Margin (dB)	Pass /Fail
0.15	46.09	10.00	1.74	57.83	Quasi Peak	Neutral	66.00	-8.17	Pass
0.18	40.88	10.00	1.45	52.33	Quasi Peak	Neutral	64.67	-12.34	Pass
0.23	33.29	10.00	1.09	44.39	Quasi Peak	Neutral	62.45	-18.06	Pass
0.80	31.69	10.01	0.55	42.25	Quasi Peak	Neutral	56.00	-13.75	Pass
0.76	30.56	10.01	0.55	41.13	Quasi Peak	Neutral	56.00	-14.87	Pass
0.16	44.44	10.00	1.68	56.12	Quasi Peak	Neutral	65.74	-9.62	Pass
0.15	26.62	10.00	1.74	38.36	Average	Neutral	56.00	-17.64	Pass
0.18	24.41	10.00	1.45	35.86	Average	Neutral	54.67	-18.82	Pass
0.23	21.34	10.00	1.09	32.44	Average	Neutral	52.45	-20.01	Pass
0.80	27.56	10.01	0.55	38.13	Average	Neutral	46.00	-7.87	Pass
0.76	26.15	10.01	0.55	36.71	Average	Neutral	46.00	-9.29	Pass
0.16	25.48	10.00	1.68	37.16	Average	Neutral	55.74	-18.58	Pass

10.2 26 dB Bandwidth & 6 dB Bandwidth

Requirement(s):

Spec	Item	Requirement	Applicable
§ 15.407	-	26 dB Emission BW: Report only for reference.	☒
	a) (2)	26 dB Emission BW: Report only for power limit calculation.	☐
	e)	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

789033 D02 General UNII Test Procedures New Rules v01r02

26dB Emission bandwidth measurement procedure (Other than 5.725-5.85 GHz)

- Allow the trace to stabilize.
- Use the spectrum analyzer built-in measurement function to determine the 26dB BW.
  - Set RBW = around 1% of emission bandwidth
  - Set VBW > RBW
  - Detector = Peak
  - Trace mode = max hold
- Capture the plot.
- Repeat above steps for different test channel and other modulation type.

6 dB Minimum emission bandwidth measurement procedure (for 5.725-5.85 GHz)

- Allow the trace to stabilize.
- Use the spectrum analyzer built-in measurement function to determine the 6dB BW.
  - Set RBW = 100 KHz
  - Set VBW ≥ 3 x RBW
  - Detector = Peak
  - Trace mode = max hold
  - Sweep = auto couple
- Capture the plot.
- Repeat above steps for different test channel and other modulation type.

Test Date	02/14/2017	Environmental condition	Temperature 22ºC Relative Humidity 38% Atmospheric Pressure 1020mbar
Remark	-		
Result	☒ Pass ☐ Fail		

Test Data ☒ Yes ☐ N/A

Test Plot ☒ Yes ☐ N/A

Test was done by Rachana Khanduri at RF test site.

26dB Bandwidth measurement result for 5.2GHz

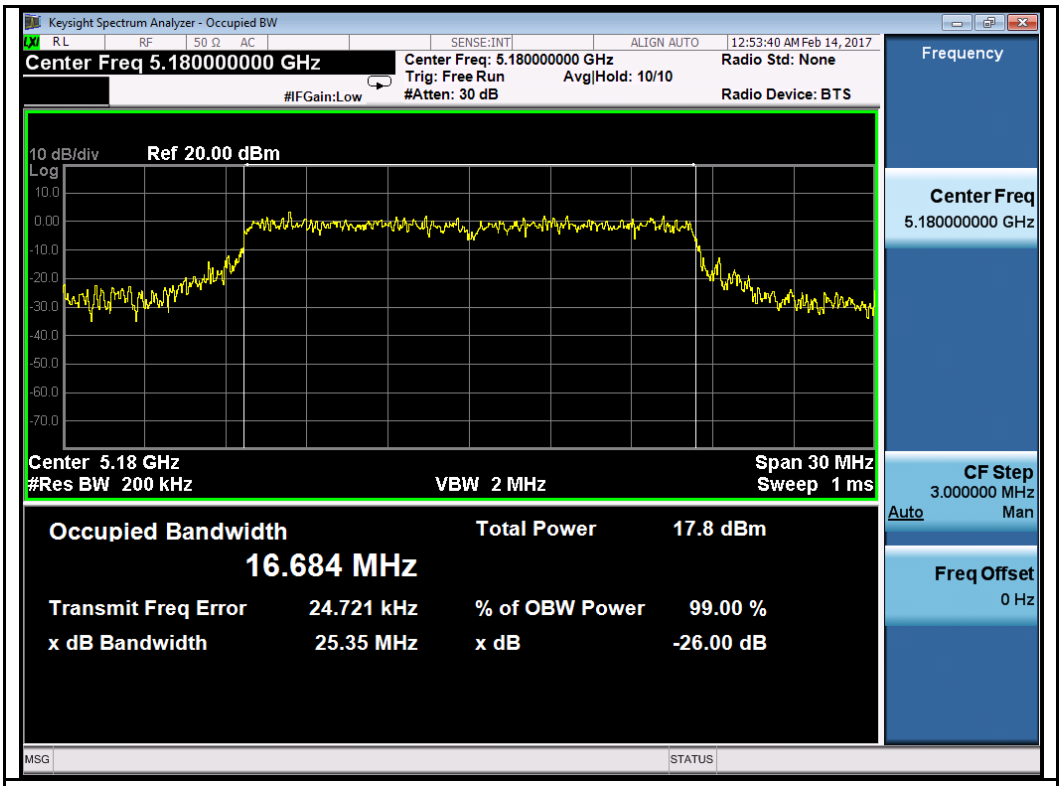
Type	Test mode	Freq (MHz)	CH	Result (MHz)	Limit (MHz)
26dB BW	802.11a	5180	Low	25.35	-
		5200	Mid	27.28	-
		5240	High	27.37	-
	802.11n-20	5180	Low	26.44	-
		5200	Mid	28.57	-
		5240	High	25.81	-
	802.11n-40	5190	Low	48.44	-
		5230	High	49.05	-

6dB Bandwidth measurement result for 5.8GHz

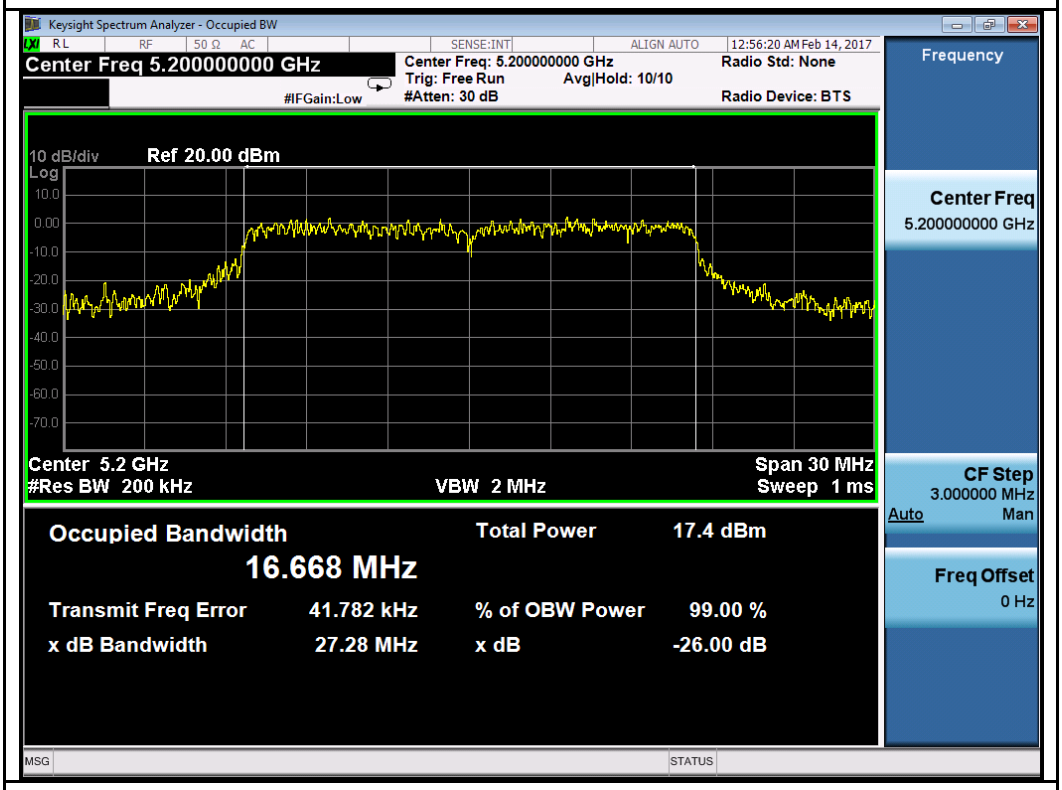
Type	Test mode	Freq (MHz)	CH	Result (MHz)	Limit (MHz)	Result
6dB BW	802.11a	5745	Low	16.35	≥0.5	Pass
		5785	Mid	16.52	≥0.5	Pass
		5825	High	16.70	≥0.5	Pass
	802.11n-20	5745	Low	17.53	≥0.5	Pass
		5785	Mid	17.60	≥0.5	Pass
		5825	High	17.71	≥0.5	Pass
	802.11n-40	5755	Low	34.87	≥0.5	Pass
		5795	High	33.10	≥0.5	Pass

26dB Bandwidth Test Plots

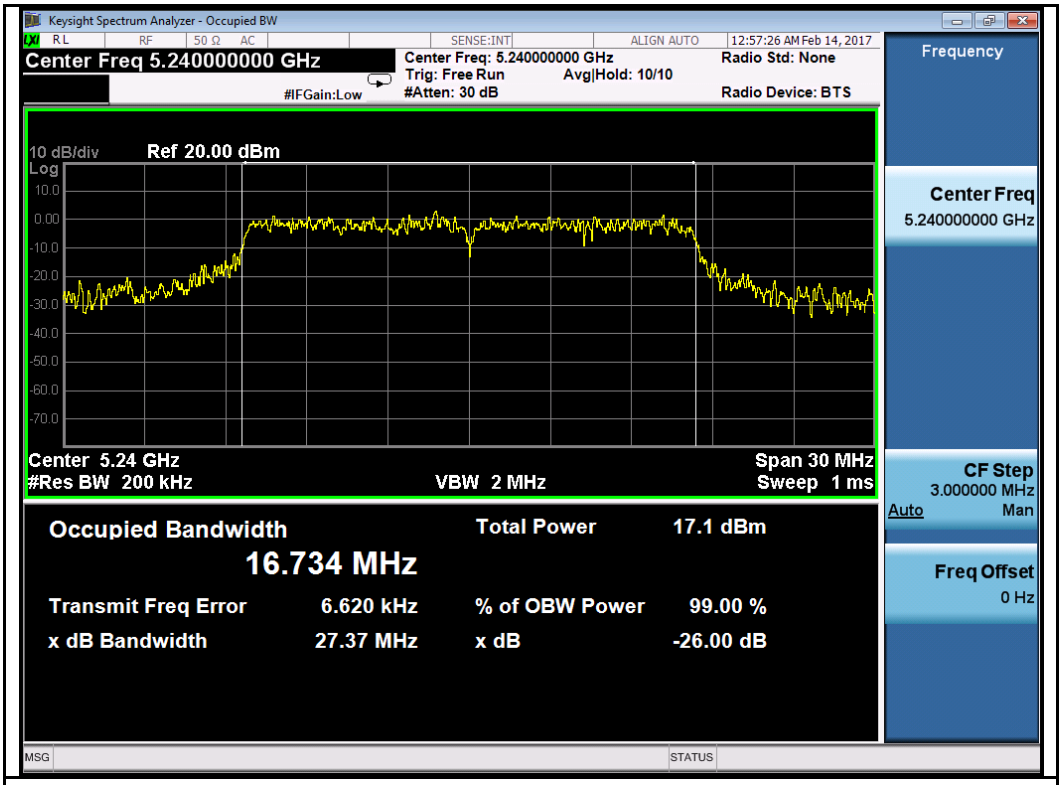
W52:



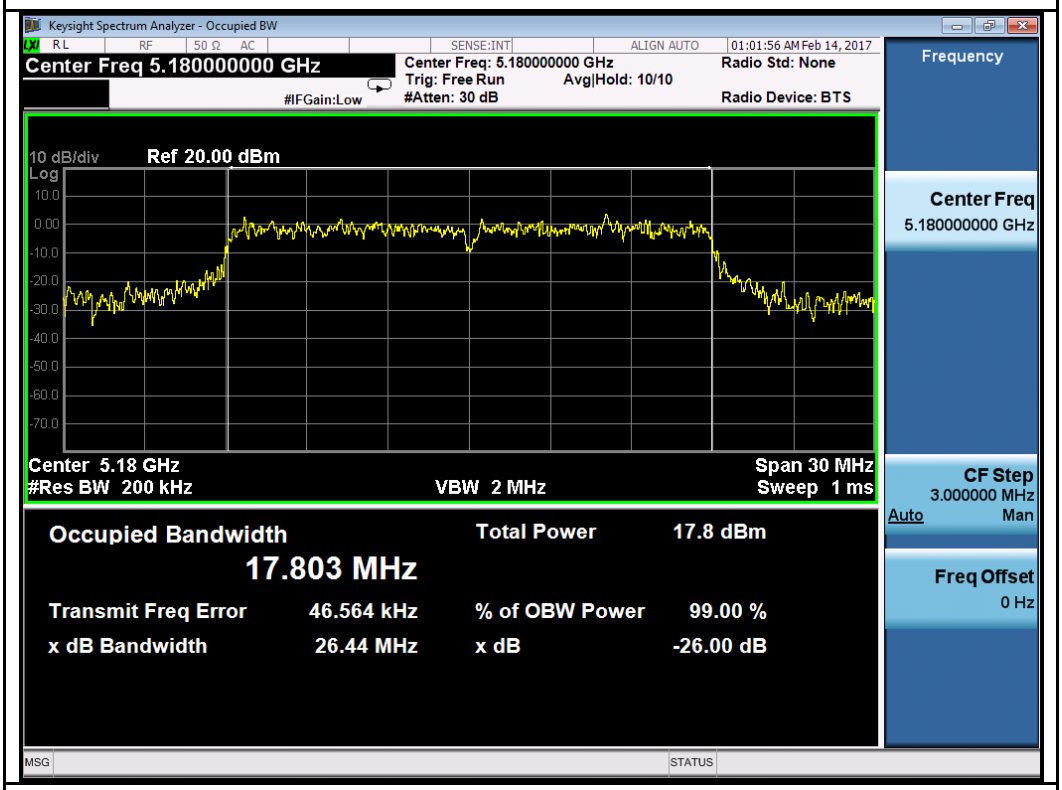
802.11a-5180MHz



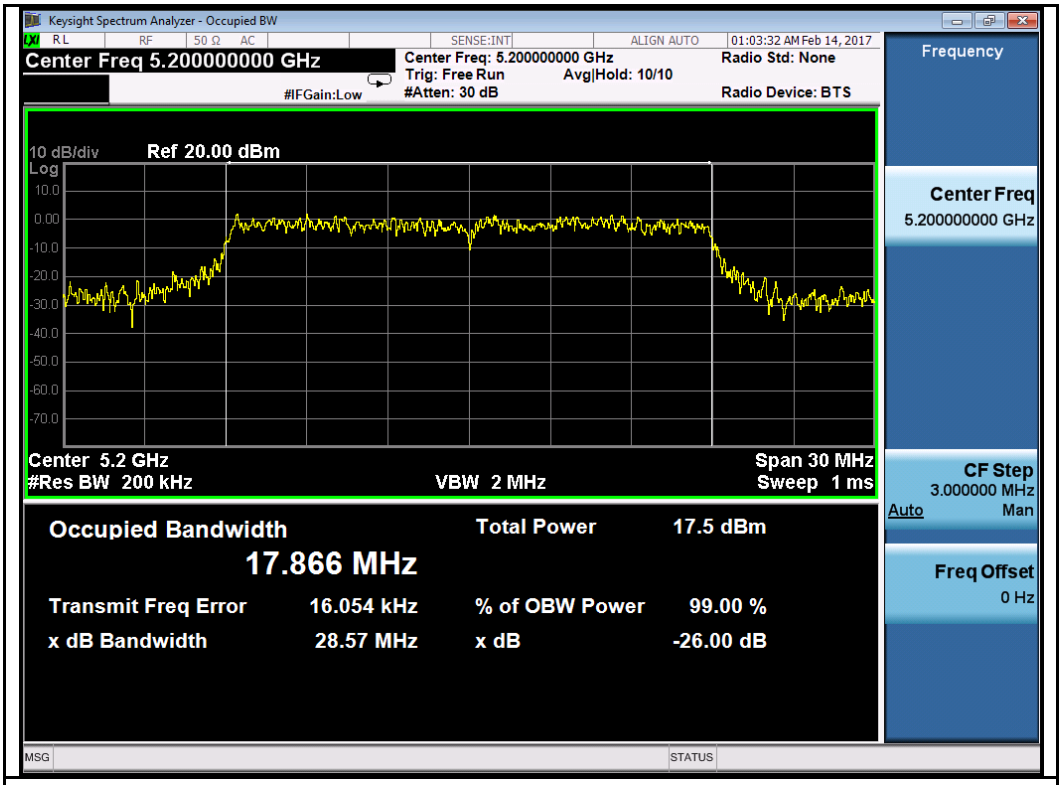
802.11a-5200MHz



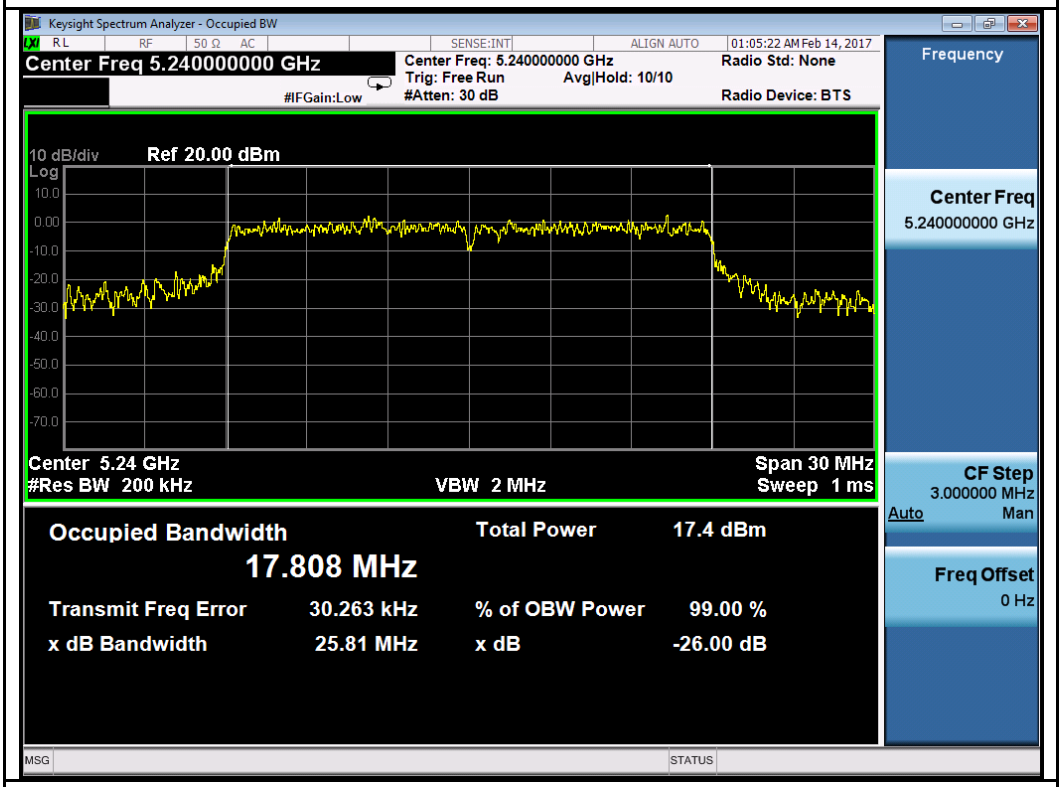
802.11a-5240MHz



802.11n-HT20-5180MHz



802.11n-HT20-5200MHz



802.11n-HT20-5240MHz