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Test Report

Prepared for: Panasonic Corporation of North America

Model: WJ-VPU4000

Description: Network Recorder

FCC ID: ACJ9TAWJ-VPU4000
IC: 216A-WJVPU4000

To

FCC Part 15.407
ISED RSS-247

Date of Issue: March 5th 2021

On the behalf of the applicant:	**Panasonic i-PRO Sensing Solutions Corporation of America** **1701 Golf Rd., Suite 3-600** **Rolling Meadows, IL 60008**
Attention of:	**Michael Baumann, Product Manager** **Ph: 636-751-2469** **E-mail: michael.baumann@us.panasonic.com**

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Project No: p20c0005

Alex Macon
Project Test Engineer

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	March 5, 2021	Alex Macon	Original Document

Table of Contents

ANAB

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The tests results contained within this test report all fall within our scope of accreditation, unless noted below.

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FCC Site Reg. #349717

IC Site Reg. #2044A-2

Non-accredited tests contained in this report:

N/A

The applicant has been cautioned as to the following

15.21 - Information to User

The user's manual or instruction manual for an intentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

15.27(a) - Special Accessories

Equipment marked to a consumer must be capable of complying with the necessary regulations in the configuration in which the equipment is marketed. Where special accessories, such as shielded cables and/or special connectors are required to enable an unintentional or intentional radiator to comply with the emission limits in this part, the equipment must be marketed with, i.e. shipped and sold with, those special accessories. However, in lieu of shipping or packaging the special accessories with the unintentional or intentional radiator, the responsible party may employ other methods of ensuring that the special accessories are provided to the consumer without an additional charge.

Information detailing any alternative method used to supply the special accessories for a grant of equipment authorization or retained in the verification records, as appropriate. The party responsible for the equipment, as detailed in § 2.909 of this chapter, shall ensure that these special accessories are provided with the equipment. The instruction manual for such devices shall include appropriate instructions on the first page of text concerned with the installation of the device that these special accessories must be used with the device. It is the responsibility of the user to use the needed special accessories supplied with the equipment.

Standard Test Conditions Engineering Practices

Except as noted herein, the following conditions and procedures were observed during the testing:

In accordance with ANSI C63.10-2009 and unless otherwise indicated in the specific measurement results, the ambient temperature of the actual EUT was maintained within the range of 10° to 40°C (50° to 104°F) unless the particular equipment requirements specified testing over a different temperature range. Also, unless otherwise indicated, the humidity levels were in the range of 10% to 90% relative humidity.

Measurement results, unless otherwise noted, are worst-case measurements.

Environmental Conditions		
Temperature (ºC)	**Humidity (%)**	**Pressure (mbar)**
23.2 – 27.2	24 – 37.5	965– 971.8

EUT Operation during Tests

Model: WJ-VPU4000
Description: Network Recorder
Firmware: N/A
Software: N/A
Serial Number: 2S47
Additional Information:
The EUT was tested conducted mode with RF connectors mounted on the EUT at the antenna input.
The EUT is comprised of two identical 2x2 WiFi modules and a BLE radio. The modules are utilized in separate modes, with different clients and are completely uncorrelated. The module that operates in “Station” mode utilizes 2.4 GHz, 5250 – 5350, 5470 – 5725 and 5725 – 5850. The module that operates in “AP” mode utilizes 2.4 GHz and 5725 – 5850 MHz
The EUT is intended to be mounted in a vehicle and is powered by the vehicles DC voltage.
The different data rates were evaluated and the worst case data rate was chosen for all the testing.
As the modules are identical and operate in separate, non-summing modes, the data below is taken on 1 of the modules.
The EUT uses 802.11 a/n/ac All modes were investigated and it was found that ac was worst case. All data within this report, unless otherwise stated, is from ac mode

EUT Specifications

EUT Specifications	15.407
Equipment Code	NII
FCC ID	ACJ9TAWJ-VPU4000
Model(s)Tested	WJ-VPU4000
Model(s) Covered	WJ-VPU4000
Maximum Output Power	22.9 dBm (195 mW)
Frequency Ranges covered	5250 – 5725 MHz
EUT temperature range	-10C to 50C
Bandwidths	20/40/80 MHz
Data Rates	6, 9, 12, 18, 24, 36, 48, 54, MCS0, MCS1, MCS2, MCS3, MCS4, MCS5, MCS6, MCS7, MCS8, MCS9
Modulations	BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM

Antenna List

Model No.	Manufacturer	Antenna Type	Peak Gain
SH-IN2568	Panorama Antennas	Sharkfin	2.5

15.203: Antenna Requirement:

	The antenna is permanently attached to the EUT
X	The antenna uses a unique coupling
	The EUT must be professionally installed
	The antenna requirement does not apply

Accessories:

Qty	Description	Manufacturer	Model	S/N
1	USB to RS232 converter	US Converters	XS880	XS2018011998
1	AC/DC Adapter	Shenzhen Boshenggao Technology Co.	BX~1208000	N/A

Cables:

Qty	Description	Length (M)	Shielding Y/N	Shielded Hood Y/N	Ferrite Y/N
1	Serial cable	2	Y	Y	N

Modifications: None

Test Results Summary

Specification	RSS Standards	Test Name	Pass, Fail, N/A	Comments
§15.203	N/A	Antenna Requirements	Pass	
§15.207 §15.407(b)(6)	RSS-Gen	Line Conducted Emissions	N/A	EUT does not connect to the AC mains
§15.407(a)(2)	RSS-247 6.2.2, 6.2.3	Conducted Output Power	Pass	
§15.407(a)(2),(5)	RSS-247 6.2.2, 6.2.3	Power Spectral Density	Pass	
§15.403(i) 15.407(a)(5)	RSS-247 6.2.2, 6.2.3	26dB Occupied Bandwidth	Pass	
	RSS-247 6.2.2, 6.2.3	99% Occupied Bandwidth		
§15.407(b)(2)(3)	RSS-247 6.2.2, 6.2.3	Undesirable Emissions	Pass	
§15.205 §15.407(b)(2),(3),(5)(6)(7)	RSS-247 6.2.2, 6.2.3	General Field Strength Limits (Restricted Bands and Radiated Emission limits)	Pass	
§15.407(g)	RSS-247 6.2.2, 6.2.3	Frequency Stability	Pass	
§15.407(f)	RSS-102	RF Exposure	Pass	

References	Description
CFR47, Part 15, Subpart B	Unintentional Radiators
CFR47, Part 15, Subpart C	Intentional Radiators
CFR47, Part 15, Subpart E	Unlicensed Nation Information Infrastructure Devices (U-NII)
ANSI C63.10-2009	American National standard for testing Unlicensed Wireless Devices
ANSI C63.4-2009	Method and Measurements of Radio-Noise Emissions from low-Voltage Electrical and Electronic Equipment in the range 9kHz to 40GHz.
ISO/IEC 17025:2005	General requirements for the Competence of Testing and Calibrations Laboratories
KDB 644545 D03	Guidance for IEEE 802 11ac New Rules
KDB 789033 D02	General U-NII Test Procedures New Rules V01
KDB 926956 D01	U-NII Transition Plan

Output Power

Engineer: Alex Macon
Test Date: 1/26/2021

Test Requirements

(2) For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum conducted output power over the frequency bands of operation shall not exceed the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

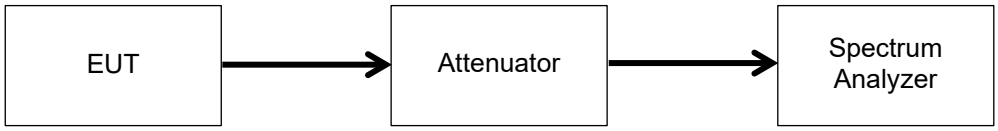
Test Procedure

The RF power was calculated using the spectrum analyzers' band power function per Method SA-1 from KDB 789033 D02 General U-NII Test Procedures New Rules v01. Measurements were made at the low, mid, and high channels of the band.

The Spectrum Analyzer was set to the following:

a. RBW = 1 MHz
b. VBW ≥ 3 MHz
c. Sweep time = auto
d. Detector = RMS
e. 100 traces in power averaging mode

Test Setup



UNII-2A Output Power Test Results using a 2.5 dBi antenna

Bandwidth	Test Frequency	Data Rate	TP	P0 Level	P1 Level	P0 Level	P1 Level	Combined Output Power	Limit	Margin
MHz	MHz			dBm	dBm	mW	mW	dBm	dBm	dB
20	5280	MCS0	14	12.07	11.87	16.1	15.4	15.0	30	-15.0
20	5300	MCS0	14	12	11.99	15.8	15.8	15.0	30	-15.0
20	5320	MCS0	12	10.43	10.8	11.0	12.0	13.6	30	-16.4
40	5310	MCS0	12	10.3	10.53	10.7	11.3	13.4	30	-16.6

UNII-2C Output Power Test Results using a 2.5 dBi antenna

Bandwidth	Test Frequency	Data Rate	TP	P0 Level	P1 Level	P0 Level	P1 Level	Combined Output Power	Limit	Margin
MHz	MHz			dBm	dBm	mW	mW	dBm	dBm	dB
20	5500	MCS0	11	7.63	9.42	5.8	8.7	11.6	30	-18.4
20	5580	MCS0	14	10.7	11.58	11.7	14.4	14.2	30	-15.8
20	5720	MCS0	14	11.77	10.78	15.0	12.0	14.3	30	-15.7
40	5510	MCS0	10	6.13	7.99	4.1	6.3	10.2	30	-19.8
40	5550	MCS0	14	10.95	12.05	12.4	16.0	14.5	30	-15.5
40	5710	MCS0	14	11.01	10.29	12.6	10.7	13.7	30	-16.3
80	5530	MCS0	9	8.65	9.72	7.3	9.4	12.2	30	-17.8
80	5690	MCS0	12	8.68	8.46	7.4	7.0	11.6	30	-18.4

Transmitter Power Spectral Density

Engineer: Alex Macon
Test Date: 1/26/2021

Test Requirements

(2) For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

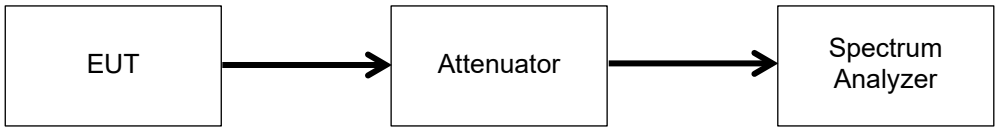
Test Procedure

The Power Spectral Density was measured using the method per SA-1 from KDB 789033 D02 General U-NII Test Procedures New Rules v01. Measurements were made at the low, mid, and high channels of the band. The maximum PSD was determine by finding the peak value across the carrier bandwidth.

The Spectrum Analyzer was set to the following:

a. RBW = 1 MHz
b. VBW ≥ 3 MHz
c. Span 1.5 * BW
d. Sweep time = auto
e. Detector = RMS
f. 100 traces in power averaging mode

Test Setup



UNII-2A Power Spectral Density Test Results for 2.5 dBi Antenna

Bandwidth	Frequency	Data Rate	TP setting	P0 Level	P1 Level	P0 Level	P1 Level	Combined Spectral Density	Limit/ 1 MHz	Margin
MHz	MHz			dBm	dBm	mW	mW	dBm	dBm	dB
20	5280	MCS0	14	1.35	1.27	1.365	1.340	4.3	11	-6.7
20	5300	MCS0	14	1.65	1.55	1.462	1.429	4.6	11	-6.4
20	5320	MCS0	12	0.37	0.35	1.089	1.084	3.4	11	-7.6
40	5310	MCS0	12	-3.01	-2.56	0.500	0.555	0.2	11	-10.8

UNII-2C Power Spectral Density Test Results for 2.5 dBi Antenna

Bandwidth	Frequency	Data Rate	TP setting	P0 Level	P1 Level	P0 Level	P1 Level	Combined Spectral Density	Limit/ 1 MHz	Margin
MHz	MHz			dBm	dBm	mW	mW	dBm	dBm	dB
20	5500	MCS0	11	-2.65	-0.88	0.543	0.817	1.3	11	-9.7
20	5580	MCS0	14	0.57	1.47	1.140	1.403	4.1	11	-6.9
20	5720	MCS0	14	1.49	0.27	1.409	1.064	3.9	11	-7.1
40	5510	MCS0	10	-7.08	-4.96	0.196	0.319	-2.9	11	-13.9
40	5550	MCS0	14	-2.8	-1.36	0.525	0.731	1.0	11	-10.0
40	5710	MCS0	14	-2.3	-2.69	0.589	0.538	0.5	11	-10.5
80	5530	MCS0	9	-7.7	-6.77	0.170	0.210	-4.2	11	-15.2
80	5690	MCS0	12	-7.9	-8.3	0.162	0.148	-5.1	11	-16.1

Undesirable Emissions Conducted

Engineer: Alex Macon
Test Date: 2/04/2021

Test Requirements

Unwanted Emissions that fall Outside Restricted Bands

For transmitters operating in the 5.25-5.35 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

For transmitters operating in the 5.47-5.725 GHz band: All emissions outside of the 5.47-5.725 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

As specified in § 15.407(b), emissions above 1000 MHz that are outside of the restricted bands are subject to a maximum emission limit of -27 dBm/MHz. However, an out-of-band emission that complies with both the peak and average limits of § 15.209 is not required to satisfy the -27 dBm/MHz maximum emission limit.

The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz

The provisions of §15.205 apply to intentional radiators operating under this section

Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in §15.209.

For Conducted Unwanted Emissions in the Restricted Bands

For conducted measurements above 1000 MHz, EIRP was determined and then the field strength computed by the following:
E[dBµV/m] = EIRP[dBm] - 20 log(d[meters]) + 104.77, where E = field strength and d = 3m
E[dBµV/m] = EIRP[dBm] + 95.2, for d = 3 meters.

Test Procedure

Per KDB 789033 D02 General U-NII Test Procedures New Rules v01 conducted RF port measurements were made in lieu of radiated. In addition, Cabinet Emissions measurements were performed in a semi-anechoic chamber with the antenna port terminated by a matching load. See additional section for Radiated Emissions.

The following criteria were addressed:

The Spectrum Analyzer was set to the following for emissions > 1000MHz:

a. RBW = 1 MHz
b. VBW ≥ 3 MHz
c. Detector = Peak.
d. Sweep time = auto
e. Trace mode = max hold
    1. Note: For emissions where the peak exceeded that of the average 15.209 emission limit the following was performed.
f. VBW ≤ RBW/100 (i.e., 10 kHz) but not less than 10 Hz

For emissions below 1000MHz the Spectrum Analyzer settings were as follows:

a. RBW = 100 kHz
b. VBW ≥ 300 kHz
c. Detector = Peak
d. Sweep time = auto
e. Trace mode = max hold

Test Setup

Test Results: **See Annex B: Undesirable Emissions Conducted**

Note:
Conducted spurious emissions were investigated from 30 -1000 MHz for all BW at low, mid, high channels at P0 and P1 ports.
No emissions other than noise floor were observed.
A sample plot is provided in Annex B.

Undesirable Emissions Radiated

Engineer: Alex Macon
Test Date: 2/16/2021

Test Requirements

The provision of §15.209 were applied. In addition the requirements of §15.407 were also applied.

FCC Part 15 Subpart C Paragraph 15.209(a) Limits

Frequency (MHz)	Frequency (microvolts/meter)	Frequency (meter)
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

Remarks: E field strength (dBµV/m) = 20 log E field strength (uV/m)

Test Procedure

The EUT was setup in accordance with ANSI C63.10. 2013 and tested per KDB 789033. The antenna was replaced with non-radiating matched load. The EUT is placed on non-conductive platform at a height of 0.8 meters above the ground plane of the semi-anechoic chambers. The EUT was rotated 360 degrees and the receive antenna raised and lowered to find the maximum emissions from 30MHz to the 10th harmonic of the fundamental. The EUT was set to the maximum power level allowed and the low, mid, and high channels were investigated for emissions. No spurious emissions were observed below 1 GHz. An example plot is included in annex C.

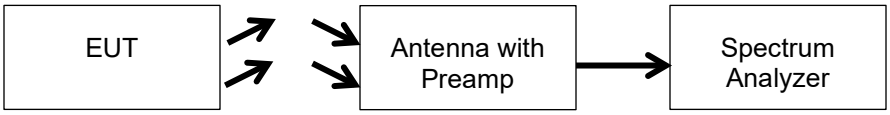
The Spectrum Analyzer was set to the following for emissions > 1000MHz:

a. (RBW = 1 MHz
b. VBW ≥ 3 MHz
c. Detector = Peak
d. Sweep time = auto
e. Trace mode = max hold
    1. Note: For emissions where the peak exceeded that of the average 15.209 emission limit the following was performed.
f. RBW = 1 MHz
g. VBW ≤ RBW/100 (i.e., 10 kHz) but not less than 10Hz

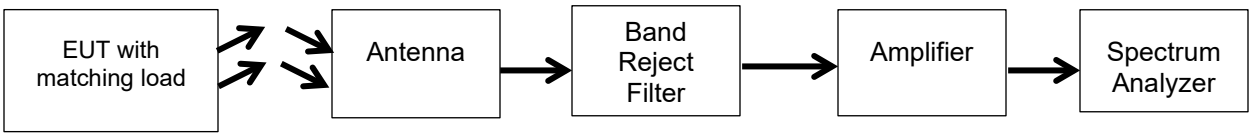
For emissions below 1000MHz the Spectrum Analyzer settings were as follows:

a. RBW = 100 kHz
b. VBW ≥ 300 kHz
c. Detector = Peak
d. Sweep time = auto
e. Trace mode = max hold
    1. Note: A quasi peak detector was used for emissions where the peak exceeded that of the average 15.209 emission limits

Test Setup below 1000MHz



Test Setup above 1000MHz



Test Results: **See Annex C: Undesirable Emission Radiated**

Occupied Bandwidth

Engineer: Alex Macon
Test Date: 1/26/2021

Test Requirement

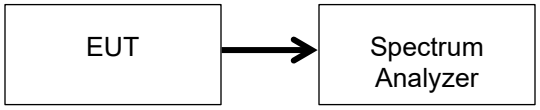
The emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolution bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement

Test Procedure

The Spectrum Analyzer was set to the following parameters:

a. RBW = approximately 1 to 5% of the emission bandwidth.
b. VBW > RBW.

Test Setup



Test Results: **See Annex D: Occupied Bandwidth**

Frequency Stability

Engineer: Alex Macon
Test Date: 3/5/21

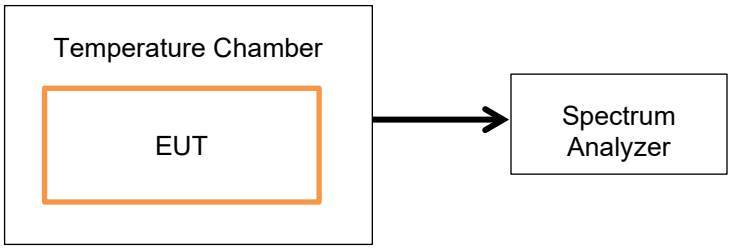
Test Requirement

Manufacturers of U-NII devices are responsible for ensuring frequency stability such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the user's manual.

Test Procedure

a. The EUT was placed into a temperature chamber and the temperature ranges were set to the manufacturer's specifications.
b. The RF output of the EUT was connected to a spectrum analyzer
c. The lowest and highest channels of the band were set to transmit
d. The carrier plots were measured to insure that the 26dB band width remained within the band over the prescribed temperature extremes.

Test Setup



Test Results: **See Annex E: Frequency Stability**

RF Exposure

Engineer: Alex Macon
Test Date: 2/28/2021

Requirements

U-NII devices are subject to the radio frequency radiation exposure requirements specified in §1.1307(b), §2.1091 and §2.1093 of this chapter, as appropriate. All equipment shall be considered to operate in a "general population/uncontrolled" environment. Applications for equipment authorization of devices operating under this section must contain a statement confirming compliance with these requirements for both fundamental emissions and unwanted emissions. In addition, systems operating under the provisions of this section shall be operated in a manner that insures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

Exposure Limits

At operating frequencies less than or equal to 6 GHz, the limits for maximum permissible exposure (MPE) shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Section 1.1307(b), except for portable devices as defined in §2.1093 as these evaluations shall be performed according to the SAR provisions in §2.1093 of this chapter.

MPE Limit Calculations

Exposure Limit 1mW/cm^2

Source Based Time Averaged Power Calculation

Average Power Calculations

Average Power = Peak Power * duty-cycle%

Band	Tuned Frequency (MHz)	Peak Conducted Output Power (mW)	Duty Cycle (%)	Average Power (mW)
UNII-2A	5300	31.62	100	31.62
UNII-2C	5550	28.18	100	28.18

MPE Evaluation

This is a **fixed** device used in uncontrolled /general population exposure environment.

Limits Uncontrolled Exposure	0.3-1.234 MHz	Limit [mW/cm²] = 100
47 CFR 1.1310	1.34-30 MHz	Limit [mW/cm²] = (180/f²)
Table 1, (B)	30-300 MHz	Limit [mW/cm²] = 0.2
	300-1500 MHz	Limit [mW/cm²] = f/1500
	1500-100,000 MHz	Limit [mW/cm²] = 1.0

UNII-2A Test Data

Test Frequency, MHz	5300
Power, Conducted, mW (P)	31.62
Antenna Gain Isotropic	2.5
Antenna Gain Numeric (G)	1.78
Antenna Type	Omni
Distance (R)	20

$$S = \frac{P * G}{4\pi r^2}$$

Power Density (S) mw/cm²	Power mW (P)	Numeric Gain (G)	Distance (r^2) cm
0.011	31.62	1.78	20

Power Density (S) = 0.011 mw/cm²
Limit =(from above table) = 1.0 mw/cm²

UNII-2C Test Data

Test Frequency, MHz	5550
Power, Conducted, mW (P)	28.18
Antenna Gain Isotropic	2.5
Antenna Gain Numeric (G)	1.78
Antenna Type	Omni
Distance (R)	20

$$S = \frac{P * G}{4\pi r^2}$$

Power Density (S) mw/cm^2	Power mW (P)	Numeric Gain (G)	Distance (r^2) cm
0.0099	28.18	1.78	20

Power Density (S) = 0.0099 mw/cm^2
Limit =(from above table) = 1.0 mw/cm^2

Test Equipment Utilized

Description	Manufacturer	Model #	CT Asset #	Last Cal Date	Cal Due Date
Temperature Chamber	Tenney	Tenney Jr	i00027	NCR	NCR
Horn Antenna	EMCO	3116	i00085	2/22/21	2/22/23
Bi-Log Antenna	Schaffner	CBL611C	i00267	8/28/20	8/28/22
Horn Antenna	ARA	DRG-118/A	i00271	8/3/20	8/3/22
Humidity / Temp Meter	Newport	IBTHX-W-5	i00282	8/28/20	8/28/21
Spectrum Analyzer	Agilent	E4407B	i00331	12/28/20	12/28/21
Data Logger	Fluke	Hydra Data Bucket	i00343	6/10/20	6/10/21
Signal Generator	HP	83650A	i00353	12/7/20	12/7/22
EMI Analyzer	Agilent	E7405A	i00379	12/29/20	12/29/21
3 Meter Semi-Anechoic Chamber	Panashield	3 Meter Semi-Anechoic Chamber	i00428	7/17/20	7/17/21
EMI Receiver	Keysight	N9038A	i00552	1/12/21	1/21/22
Spectrum Analyzer	Agilent	E4445A	i00471	12/23/20	12/23/21

In addition to the above listed equipment standard RF connectors and cables were utilized in the testing of the described equipment. Prior to testing these components were tested to verify proper operation.

END OF TEST REPORT