Testing Tomorrow's Technology

Class 2 Permissive Change Test Report
For

Part 2, Subpart J, Paragraph 2.907 Equipment Authorization of Certification for an Intentional Radiator per Part 15, Subpart C, paragraphs 15.207, 15.209 and 15.247

For the

Clean Hand Safe Hands, LLC

Model Number: GEN4 Sensor

FCC ID: 2AHQD-SENSOR4

UST Project: 22-0199
Test Dates: June 2, 2022, July 12, 18 & 22, 2022
Issue Date: August 1, 2022

Total Pages: 26

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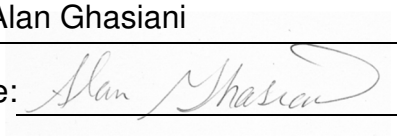
I certify that I am authorized to sign for the Test Agency and that all of the statements in this report and in the Exhibits attached hereto are true and correct to the best of my knowledge and belief:

US TECH (Agent Responsible For Test):

By: Alan Ghasiani

Name: 

Title: Compliance Engineer – President

Date: August 1, 2022

NVLAP LAB CODE 200162-0

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MEASUREMENT TECHNICAL REPORT

Company Name:	Clean Hands Safe Hands, LLC
Address:	75 Fifth St NW Suite 220 Atlanta Georgia United States 30308
Model:	GEN4 Sensor
FCC ID:	2AHQD-SENSOR4
Date:	August 1, 2022

This report concerns (check one): ☐ Original ☒ Class II Permissive Change

Equipment type: 2.4 GHz Radio Transceiver, ZigBee

Technical Information:

Radio Technology:	DTS
Frequency of Operation (MHz):	2405 – 2475
Output Power (dBm):	+6.2 dBm
Type of Modulation:	O-QPSK
Data/Bit Rate (M)bps:	250 kBPS
Antenna Gain (dBi):	+3.3 dBi
Software used to program EUT:	RAILtest
EUT firmware:	V2.12
Power setting:	+14 dBm

Report prepared by:

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1 General Information

1.1 Purpose of this Report

The purpose of this report is to file for a Class II Permissive change for the following reasons:

In this update to the design changes were to two of the data line traces on the PCBA on the ZigBee circuit. The changes are as follows: Moved the SPI_ATTN and FORCE_WAKE signal lines off of PORTC.

Change List:

1. XB_FORCE_WAKE
   previously: U12-22 (PD13), J29-5 (test point), U205-1 (PC00)
   new: U12-22 (PD13), J29-5 (test point), U205-17 (PA00)
2. XP_SPI_ATTN
   previously: U12-33 (PB13), J29-6 (test point), U205-2 (PC01)
   new: U12-33 (PB13), J29-6 (test point), U205-16 (PB00)

Component Changes: modifications to the antenna balance network for the U205 Zigbee radio.

1. C220
   previously: DNP
   new: 2.7pF Capacitor
2. L106
   previously: 0 Ohm Resistor
   new: 3.3nH Inductor
3. C221
   previously: 6.2nH Inductor
   new: 0.9pF Capacitor
4. C219
   previously: 2.2nH Inductor
   new: 2.7pF Capacitor
5. L107
   previously: 0.3nH Inductor
   new: 0 Ohm Resistor

Due to the changes above, the equipment was re-evaluated for continued compliance with Part 15.247, 15.209 requirements. Based on the changes above the following test were performed:

- Intentional Radiated emissions Part 15.247(d)- ZigBee ONLY
- Radiated Spurious emissions Part 15.209- Overall Device

All other test were deemed not to be affected by the changes. The test data has been collected and is presented herein for consideration.

1.2 Characterization of Test Sample

The samples used for testing were received by US Tech on July 22, 2021 in good operating condition.

1.3 Product Description

The EUT remains the same as previously tested: The Equipment under Test (EUT) is the Clean Hands Safe Hands, LLC Model GEN4 Sensor. The purpose of the Sensor is to monitor for sensory input and scan for Clean Hands Safe Hands Badges (BLE). This data is then transmitted back over Zigbee to a central network coordinator that processes the data and forwards it on to the cloud.

The EUT incorporates both Bluetooth LE technology and Zigbee technology.

1.4 Configuration of Tested System

The Test Sample was tested per *ANSI C63.10:2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices* for the intentional radiator aspect of the device and *ANSI C63.4:2014, Methods of Measurement of Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2014)* for the unintentional radiator aspect of the device as well as FCC subpart B and C of Part 15 and per FCC KDB Publication number 558074 v05r02 for Digital Transmission Systems Operating Under section 15.247.

Per FCC Parts 15.107 and 15.109, digital RF conducted and radiated emissions below 1 GHz were measured with the spectrum analyzer's resolution bandwidth (RBW) adjusted to 9 kHz and 120 kHz, respectively. All measurements performed above 1 GHz were made with a RBW of 1 MHz. All measurements are peak unless stated otherwise. The video filter associated with the spectrum analyzer was set to 3 times the RBW or as required per the standard throughout the evaluation process.

A list of EUT and Peripherals is found in Table 1 below. A block diagram of the tested system is shown in Figure 1. Test configuration photographs for spurious and fundamental emissions are provided in separate Appendices.

1.5 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA 30004. This site has been fully described and registered with the FCC. Its designation number is 186022. Additionally, this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1.

1.6 Related Submittal(s)/Grant(s)

The EUT is subject to the following FCC Equipment Authorizations:

a) Certification under Part 15 Subpart C as an intentional transmitter.

b) SDoC under Part 15.101 as a digital device.

Table 1. EUT and Peripherals

EUT MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC/IC ID	CABLES P/D
Clean Hands Safe Hands	GEN4 Sensor	N/A	2AHQD-SENSOR4	N/A
PERIPHERAL MANUFACTURER	**MODEL NUMBER**	**SERIAL NUMBER**	**FCC/IC ID**	**CABLES P/D**
Antenna See antenna details	--	--	--	--

S= Shielded, U= Unshielded, P= Power, D= Data

Table 2. Details of I/O Cables Attached to EUT

DESCRIPTION OF CABLE	DETAILS OF CABLE			CABLE LENGTH
N/A	**Manufacturer**	**Part Number**		N/A
	N/A	N/A		
	Shield Type	**Shield Termination**	**Back-shell**	
	N/A	N/A	N/A	

Shield Type
N/A = None
F = Foil
B = Braided
2B = Double Braided
CND = Could Not Determine

Shield Termination
N/A = None
360 = 360 Degrees
P = Pigtail/Drain Wire
CND = Could Not Determine
MU = Metal Unshielded

Back-shell
N/A = Not Applicable
PS = Plastic Shielded
PU = Plastic Unshielded
MS = Metal Shielded

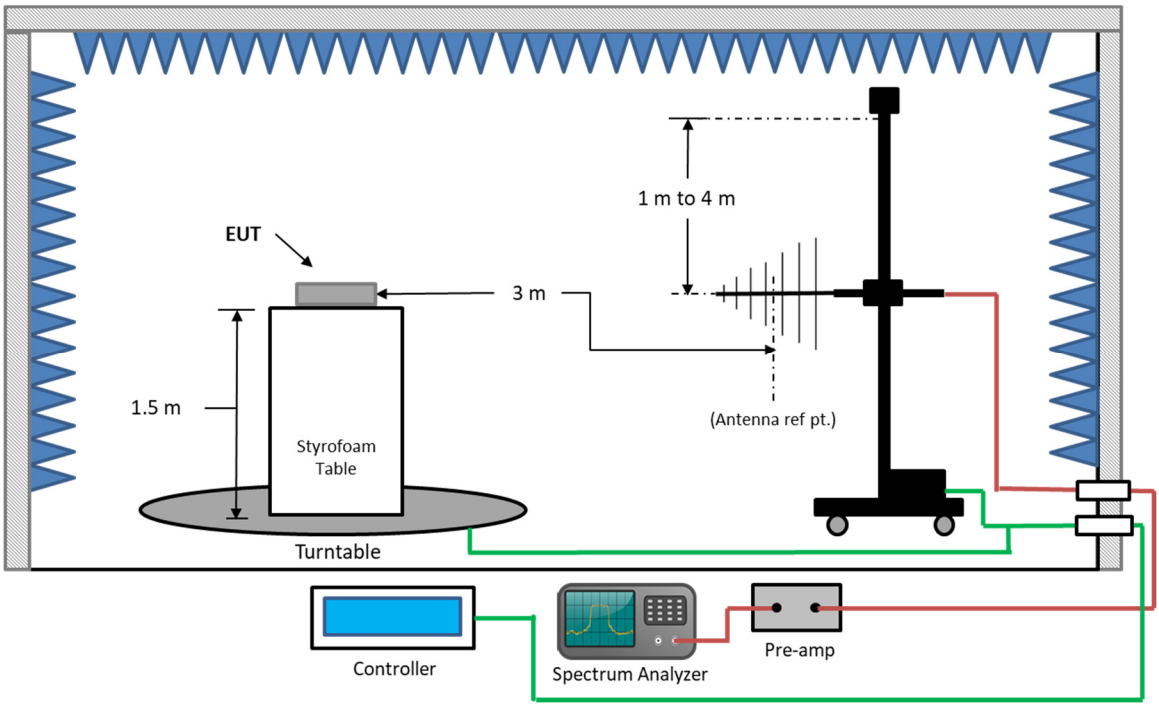


Figure 1. EUT Test Configuration Diagram

2 Tests and Measurements

2.1 Test Equipment

The table below lists test equipment used to evaluate this product.

Table 3. Test Instruments

TEST INSTRUMENT	MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	CALIBRATION DUE DATE
Spectrum Analyzer	Agilent	E4407B	US41442935	9/02/2022 2 yr.
Rf Preamp 100 kHz To 1.3 GHz	Hewlett-Packard	8447D	1937A02980	6/9/2023
Preamp 1.0 GHz To 26.0 GHz	Hewlett-Packard	8449B	3008A00914	2/11/2023
Biconical Antenna	EMCO	3110B	9306-1708	8/17/2023 2 yr.
Log Periodic Antenna	EMCO	3146	9110-3236	12/13/2023 2 yr.
Double Ridged Horn Antenna	A. H. Systems	SAS-571	605	4/28/2024 2 yr.
Filter - High Pass above 3 GHz	Microwave Circuits Inc.	H3R020G2	001DC9528	8/1/2022

Note: The calibration interval of the above test instruments are 12 months unless stated otherwise and all calibrations are traceable to NIST/USA.

2.2 Modifications to EUT Hardware

No modifications were made by US Tech to bring the EUT into compliance with FCC Part 15.209 & 15.247 requirements.

2.3 Number of Measurements for Intentional Radiators (CFR 15.31(m))

Measurements of intentional radiators or receivers shall be performed and reported for each band in which the device can be operated, with the device operating at the number of frequencies in each band specified in Table 3 as follows:

Table 4. Number of Test Frequencies for Intentional Radiators

Frequency Range over which the Device Operates	Number of Frequencies	Location in the Range of Operation
1 MHz or less	1	Middle
1 to 10 MHz	2	1 near the top 1 near the bottom
Greater than 10 MHz	3	1 near top 1 near middle 1 near bottom

The EUT operates over the range of 2405 MHz to 2475 MHz; therefore, Three (3) test frequencies were evaluated.

2.4 Frequency Range of Radiated Measurements (CFR 15.33)

2.4.1 Intentional Radiator

The spectrum shall be investigated for the intentional radiator from the lowest RF signal generated in the EUT, without going below 9 kHz to the 10th harmonic of the highest fundamental frequency generated or 40 GHz, whichever is the lowest.

2.4.2 Unintentional Radiator

For the digital device, an unintentional radiator, the frequency range shall be 30 MHz to 1000 MHz, or to the range specified in 2.4.1 above; whichever is the higher range of investigation.

2.5 Measurement Detector Function and Bandwidth (CFR 15.35)

The radiated and conducted emissions limits shown herein are based on the parameters listed in the following paragraphs.

2.5.1 Detector Function and Associated Bandwidth

On frequencies below 1000 MHz, the limits herein are based upon measurement equipment employing a CISPR quasi-peak detector function and related measurement bandwidths (i.e. 9 kHz from 150 kHz to 30 MHz and 120 kHz from 30 MHz to 1000 MHz). Alternatively, measurements may be made with equipment employing a peak detector function as long as the same bandwidths specified for the quasi-peak device are used.

2.5.2 Corresponding Peak and Average Requirements

Above 1000 MHz, radiated limits are based on measuring instrumentation employing an average detector function. When average radiated emissions are specified there is also a corresponding peak requirement that is measured using a peak detector. The peak limit shall be 20 dB greater than the average limit. For all measurements above 1000 MHz, the Resolution Bandwidth shall be at least 1 MHz.

2.5.3 Pulsed Transmitter Averaging

When the radiated emissions limit is expressed as an average value, and the transmitter is pulsed, the measured field strength shall be determined by applying a Duty Cycle Correction Factor based upon dividing the total ON time during the first 100 ms period by 100 ms (or by the period if less than 100 ms). The duty cycle may also be expressed logarithmically in dB. In this case, the Duty Cycle Correction Factor was determined from the manufacturer's claim.

2.6 Transmitter Duty Cycle (Part 15.35(c))

The Duty Cycle calculations are confidential and can be provided upon request by contacting Clean Hands Safe Hands

2.7 Restricted Bands of Operation (Part 15.205)

Only spurious emissions can fall in the frequency bands of CFR 15.205. The field strength of these emissions cannot exceed the limits of 15.209. Radiated harmonics and other spurious emissions are examined for this requirement see paragraph 2.10.

2.8 EUT Antenna Requirements (CFR 15.203)

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The antenna details are as follows:

Table 5. Antenna 1

Manufacturer	Model	Type	Gain (dBi)	Connector
Clean Hands Safe Hands, LLC	Inverted F type	PCB Trace	+3.3	PCB Trace

2.9 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.247(d))

For radiated measurements, the EUT was set into a collocated continuous transmission mode. Below 1 GHz, the RBW of the measuring instrument was set equal to 120 kHz. Peak measurements above 1 GHz were measured using a RBW = 1 MHz, with a VBW ≥ 3 x RBW. The results of peak radiated spurious emissions falling within restricted bands are given in Table 5 below. For average measurements above 1 GHz, the emissions were measured using an average detector. The measurement of each signal detected was maximized by rotating the turntable 360° clockwise and counterclockwise and raising and lowering the receive antenna between 1 and 4 meters in height while monitoring the ever changing spectrum analyzer display with Trace A in the Max-Hold mode and Trace B in the Clear-Write mode for the largest signal visible. The emission from the EUT was measured and recorded when both maxima were simultaneously satisfied.

2.9.1 EUT Worst Case Test Configuration

On the test site, the EUT was placed on top of a polystyrene table above the ground plane inside a semi-anechoic test chamber. The EUT was evaluated in each of its three axes (X/Y/Z) while transmitting on the channel that produced the highest output power for worst case condition. The position of the EUT determined to be worst case was with the EUT positioned along its Y axis (EUT on its side). The worst case test results of the fundamental and harmonics are presented in the table below.

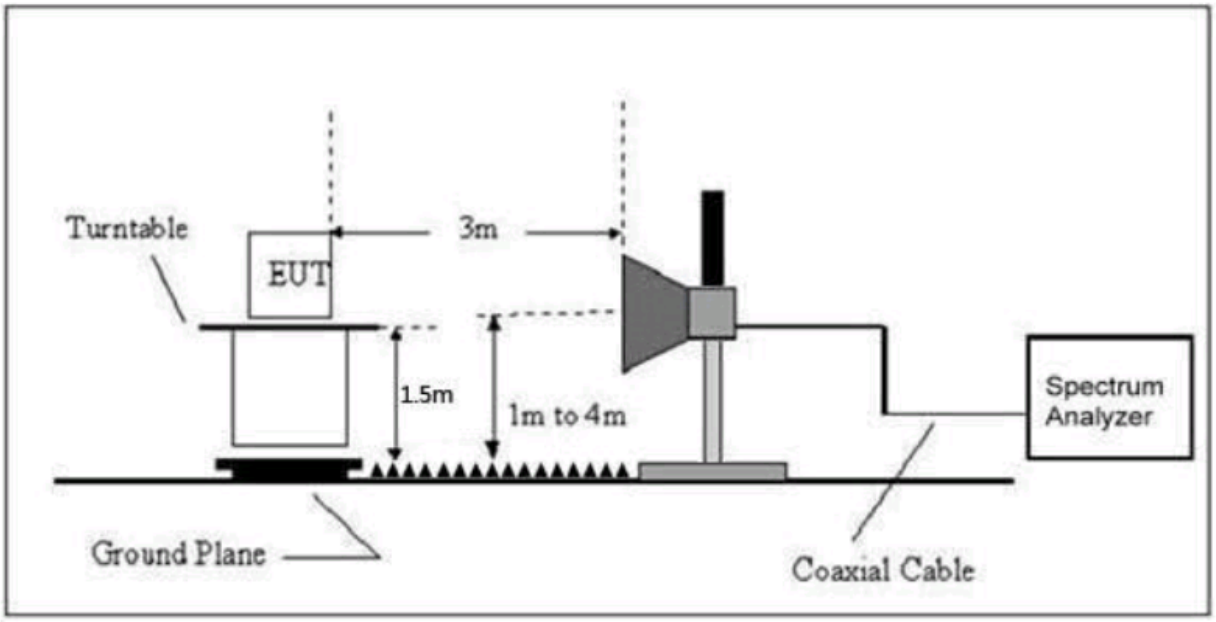


Figure 2. Above 1 GHz Radiated Emissions Test Setup

Table 6. Peak Radiated Fundamental and Harmonic Emissions

Test: FCC Part 15.247 / 15.209								
Frequency (MHz)	**Test Data (dBuV)**	**Additional Factor**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detector**
Low Channel								
2404.00	110.10	--	-6.23	103.87	--	3.0m/HORZ	--	**PK**
4810.00	52.36	--	-1.35	51.01	74	3.0m/HORZ	23.0	**PK**
7216.00	57.54	-9.50	7.02	55.06	74	3.0m/VERT	18.9	**PK**
Note 1	--	--	--	--	--	--	--	**--**
Mid Channel								
2440.00	112.00	--	-6.19	105.81	--	3.0m/VERT	--	**PK**
4878.00	52.05	--	1.88	53.93	74	3.0m./HORZ	20.1	**PK**
7321.00	52.77	-9.50	8.44	51.71	74	1.0m/VERT	22.3	**PK**
Note 1	--	--	--	--	--	--	--	**--**
High Channel								
2475.00	111.90	--	-6.01	105.89	--	3.0m/VERT	--	**PK**
4949.00	52.46	--	-0.82	51.64	74	3.0m/HORZ	22.4	**PK**
7426.00	53.15	-9.50	7.02	50.67	74	1.0m/VERT	23.3	**PK**
Note 1	--	--	--	--	--	--	--	**--**

Notes:
1. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic

Sample Calculation at 911.07 MHz:

Magnitude of Measured Frequency	110.10	dBuV
+Additional Factor	0.00	dB
+Antenna Factor + Cable Loss - Amplifier Gain	-6.23	dB/m
Corrected Result	103.87	dBuV/m

Test Date: July 22, 2022

Tested by
Signature:  Test Engineer: Gabriel Medina

Table 7. Average Radiated Fundamental and Harmonic Emissions

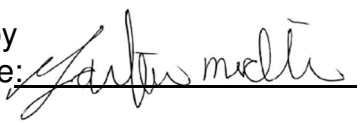
Test: FCC Part 15.247 / 15.209								
Frequency (MHz)	**Test Data (dBuV)**	**Additional Factor**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detector**
Low Channel								
2404.00	110.10	--	-6.23	103.87	--	3.0m/HORZ	--	**PK**
4810.00	52.36	--	-1.35	51.01	54	3.0m/HORZ	3.0	**PK**
7216.00	44.19	-9.50	7.02	41.71	54	3.0m/VERT	12.3	**AVG**
Note 1	--	--	--	--	--	--	--	**--**
Mid Channel								
2440.00	112.00	--	-6.19	105.81	--	3.0m/VERT	--	**PK**
4878.00	35.49	--	1.88	37.37	54	3.0m./HORZ	16.6	**AVG**
7321.00	52.77	-9.50	7.30	50.57	54	1.0m./VERT	3.4	**PK**
Note 1	--	--	--	--	--	--	--	**--**
High Channel								
2475.00	111.90	--	-6.01	105.89	--	3.0m/VERT	--	**PK**
4949.00	36.98	--	-0.82	36.16	54.0	3.0m./HORZ	17.8	**AVG**
7426.00	39.18	-9.50	7.02	36.70	54.0	1.0m./VERT	17.3	**AVG**
Note 1	--	--	--	--	--	--	--	**--**

Notes:
1. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic.

Sample Calculation at 911.07 MHz:

Magnitude of Measured Frequency	110.10	dBuV
+Additional Factor (Duty cycle correction)	0.00	dB
+Antenna Factor + Cable Loss - Amplifier Gain	-6.23	dB/m
Corrected Result	103.87	dBuV/m

Test Date: July 22, 2022

Tested by
Signature:  Test Engineer: Gabriel Medina

2.10 Intentional Radiator Power Line Conducted Emissions (CFR 15.207)

The EUT is battery powered; therefore, this test is not applicable.

2.11 Unwanted Emissions of the Intentional Radiator, (CFR 15.109, 15.209 and 15.33(a))

The test data provided herein is to support the verification requirement for radiated emissions coming for the EUT in a transmitting state per 15.209 and were investigated from 9kHz or the lowest operating clock frequency to 25 GHz and tested as detailed in ANSI C63.10:2013, Clause 6.4-6.6.

Measurements were made with the analyzer's resolution bandwidth set to 120 kHz for measurements made below 1 GHz and 1 MHz for measurements made above 1 GHz. The video bandwidth was set to three times the resolution bandwidth; 1 MHz RBW and 3 MHz VBW. The test data were maximized for magnitude by rotating the turn-table through 360 degrees and raising and lowering the receiving antenna between 1 to 4 meters in height as a part of the measurement procedure.

2.11 Unwanted Emissions of the Intentional Radiator, (CFR 15.109, 15.209 and 15.33(a)), cont'd

The radiated emissions generated by this modified version of the EUT were equal to or less than the originally recorded emissions levels. The originally recorded emissions levels are presented here as the representative levels for this modified EUT.

Table 8. Spurious Radiated Emissions (30 MHz – 1 GHz)

Test: FCC Part 15.209							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**DETECTOR PK / QP/AVG**
78.54	41.15	-18.22	22.93	40.0	3m./HORZ	17.1	**PK**
139.04	41.16	-15.05	26.11	43.5	3m./HORZ	17.4	**PK**
425.06	41.23	-10.07	31.16	46.0	3m./HORZ	14.8	**PK**
595.64	41.62	-6.81	34.81	46.0	3m./HORZ	11.2	**PK**
833.08	41.42	-3.68	37.74	46.0	3m./HORZ	8.3	**PK**
89.88	41.56	-17.27	24.29	43.5	3m./VERT	19.2	**PK**
157.44	40.77	-13.57	27.20	43.5	3m./VERT	16.3	**PK**
399.56	41.35	-11.59	29.76	46.0	3m./VERT	16.2	**PK**
628.58	41.81	-7.57	34.24	46.0	3m./VERT	11.8	**PK**
851.28	41.39	-5.41	35.98	46.0	3m./VERT	10.0	**PK**

AF is antenna factor.
CL is cable loss.
PA is preamplifier gain.

Sample Calculation at 78.54 MHz:

Magnitude of Measured Frequency	41.15	dBuV
+Antenna Factor + Cable Loss - Amplifier Gain	-18.22	dB/m
Corrected Result	22.93	dBuV/m

Test Date: June 2 2022

Tested By
Signature:  Name: Gabriel Medina

Table 9. Spurious Radiated Emissions (1 GHz – 10 GHz)

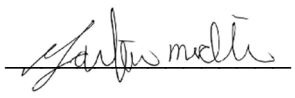
Test: FCC Part 15.209							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**DETECTOR PK / QP/AVG**
5767.00	31.63	-1.78	29.85	54.0	3.0m./HORZ	24.1	**AVG**
7423.00	45.53	3.62	49.15	54.0	1.0m./HORZ	4.8	**AVG**
5758.00	31.08	-1.13	29.95	54.0	3.0m./VERT	24.0	**AVG**
7423.00	45.35	3.48	48.83	54.0	1.0m./VERT	5.2	**AVG**

AF is antenna factor.
CL is cable loss.
PA is preamplifier gain.

Sample Calculation at 5767.00 MHz:

Magnitude of Measured Frequency	31.63	dBuV
+Antenna Factor + Cable Loss - Amplifier Gain	-1.78	dB/m
Corrected Result	29.85	dBuV/m

Test Date: June 2 2022

Tested By
Signature:  Name: Gabriel Medina

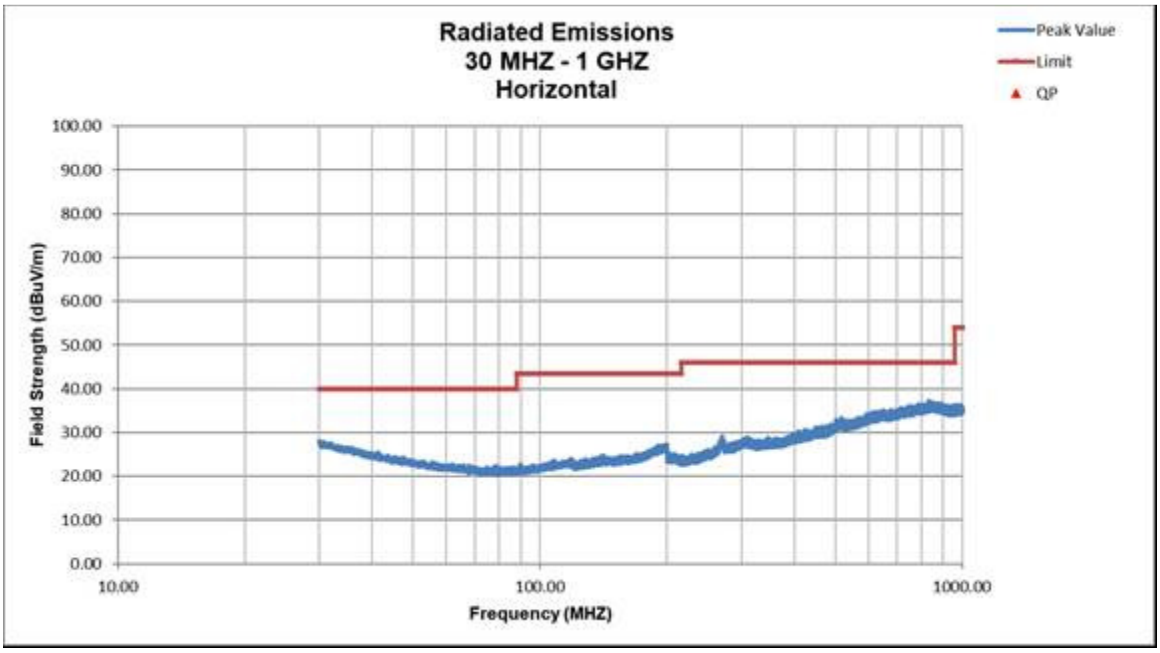


Figure 3. Radiated Emissions, Horizontal 30 MHz – 1 GHz

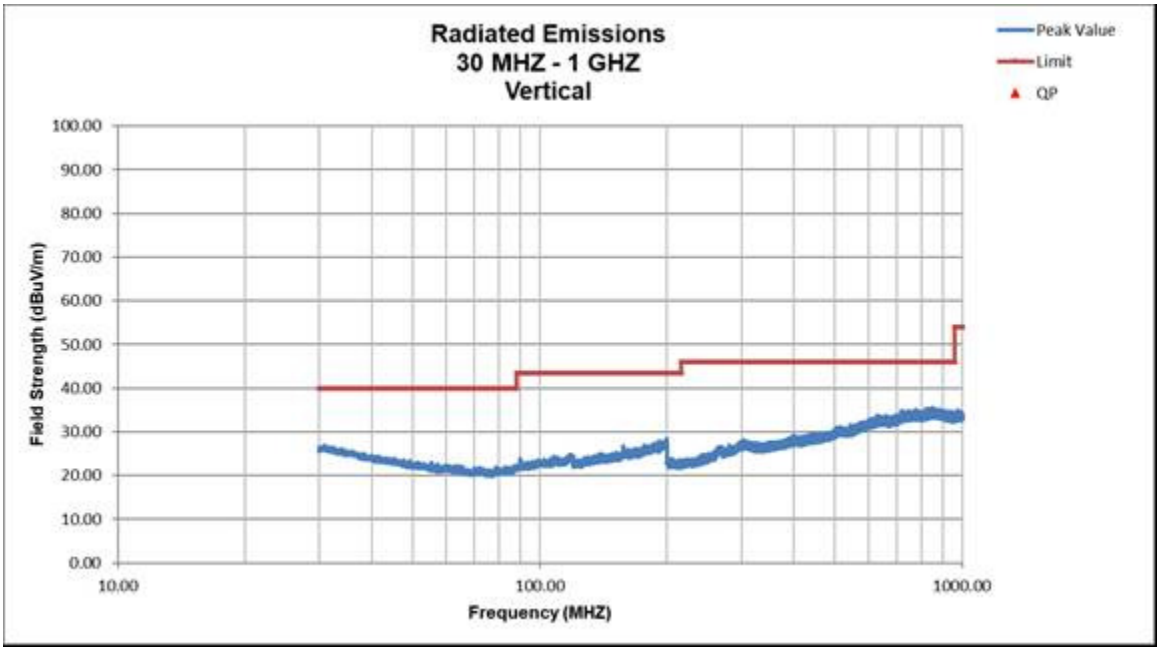


Figure 4. Radiated Emissions, Vertical 30 MHz – 1 GHz

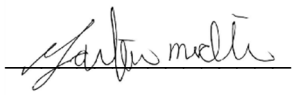
Table 10. Spurious Radiated Emissions (10 GHz – 25 GHz)

Test: FCC Part 15.209							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**DETECTOR PK / QP/AVG**
All emissions where either less than 6 dB above the noise-floor or more than 20 dB below the applicable limit.							

AF is antenna factor.
CL is cable loss.
PA is preamplifier gain.

Sample Calculation: N/A

Test Date: June 2 2022

Tested By
Signature:  Name: Gabriel Medina

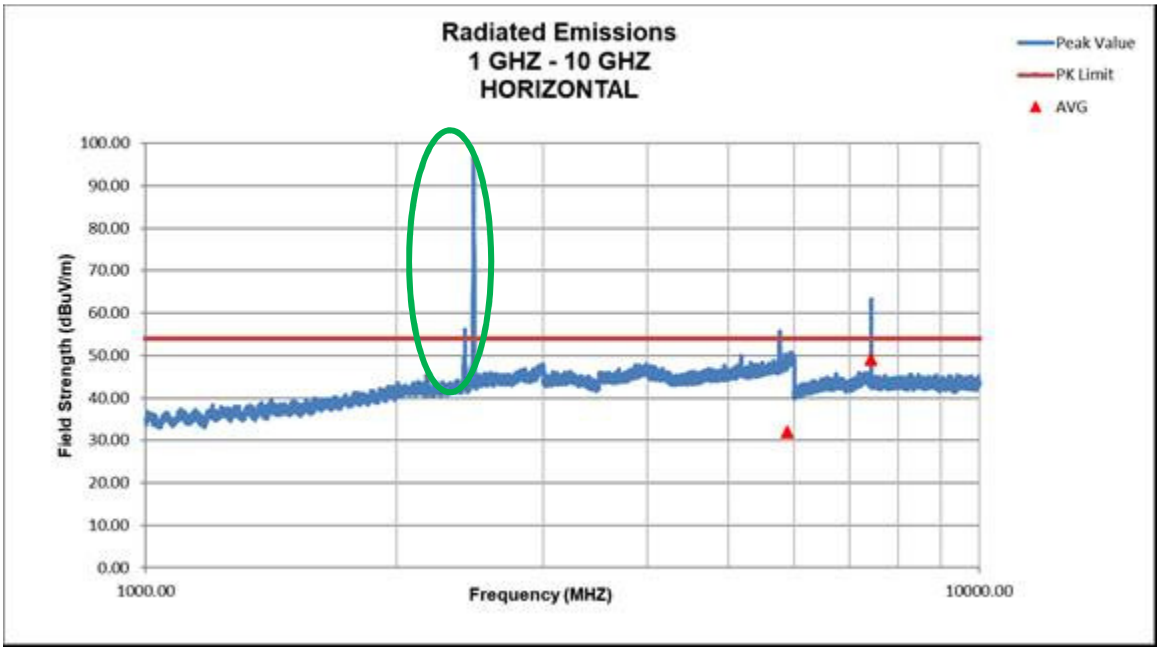


Figure 5. Radiated Emissions, Horizontal 1 GHz – 10 GHz

Note: fundamental emission is encircled in green

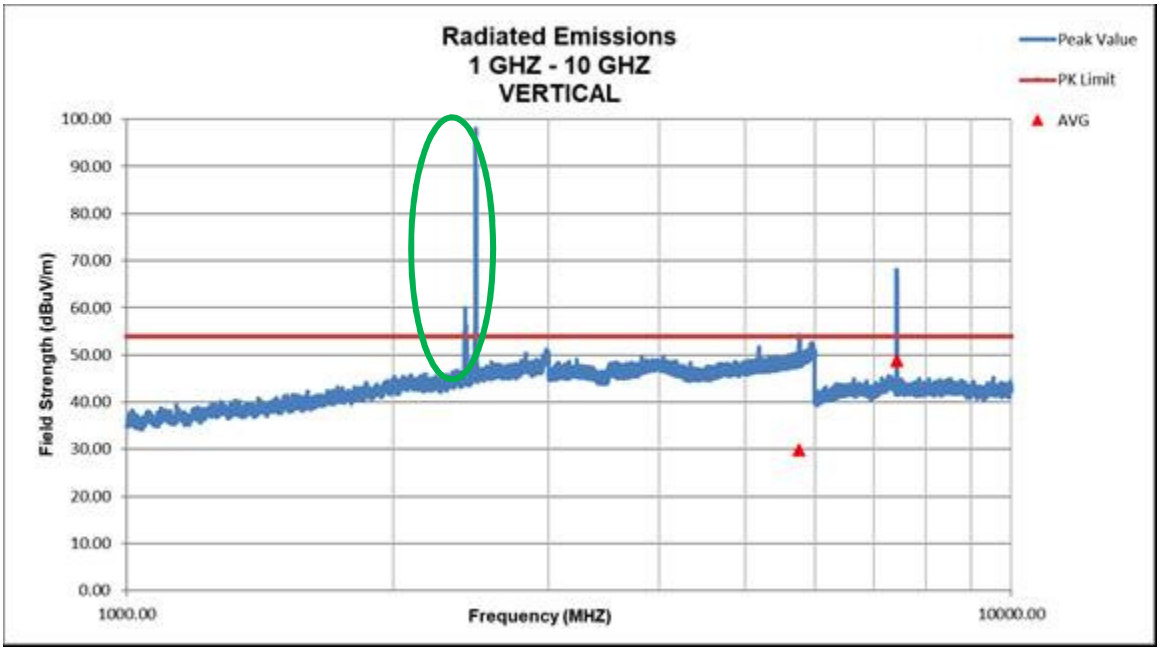


Figure 6. Radiated Emissions, Vertical 1 GHz – 10 GHz

Note: fundamental emission is encircled in green

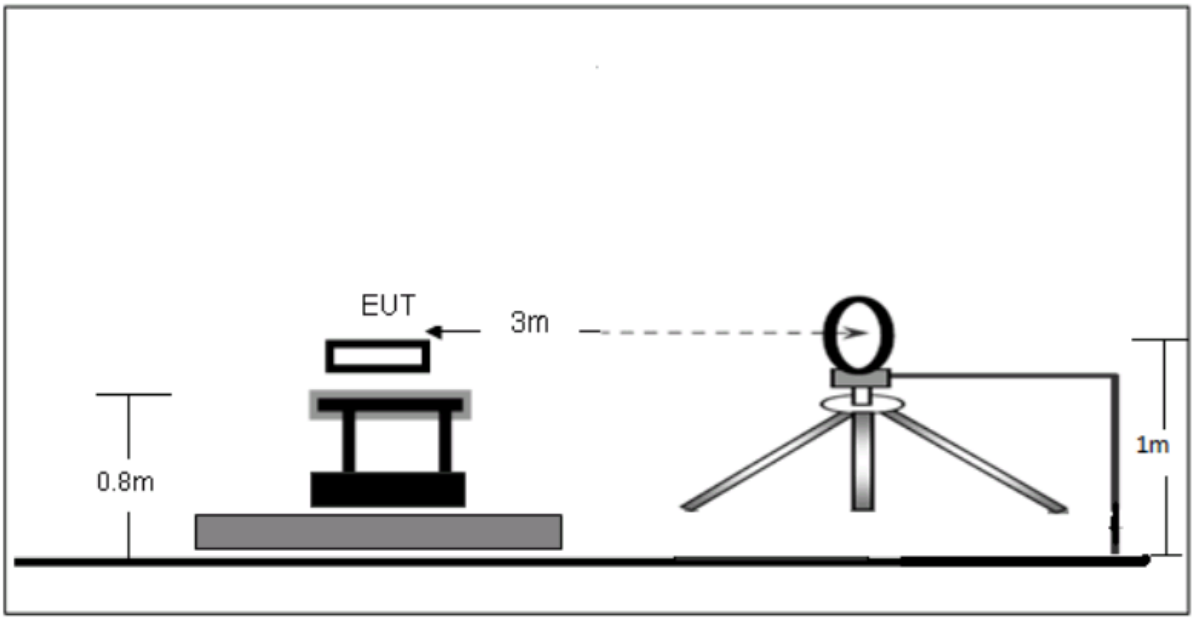


Figure 7. Block Diagram below 30 MHz Radiated Emissions Test Setup

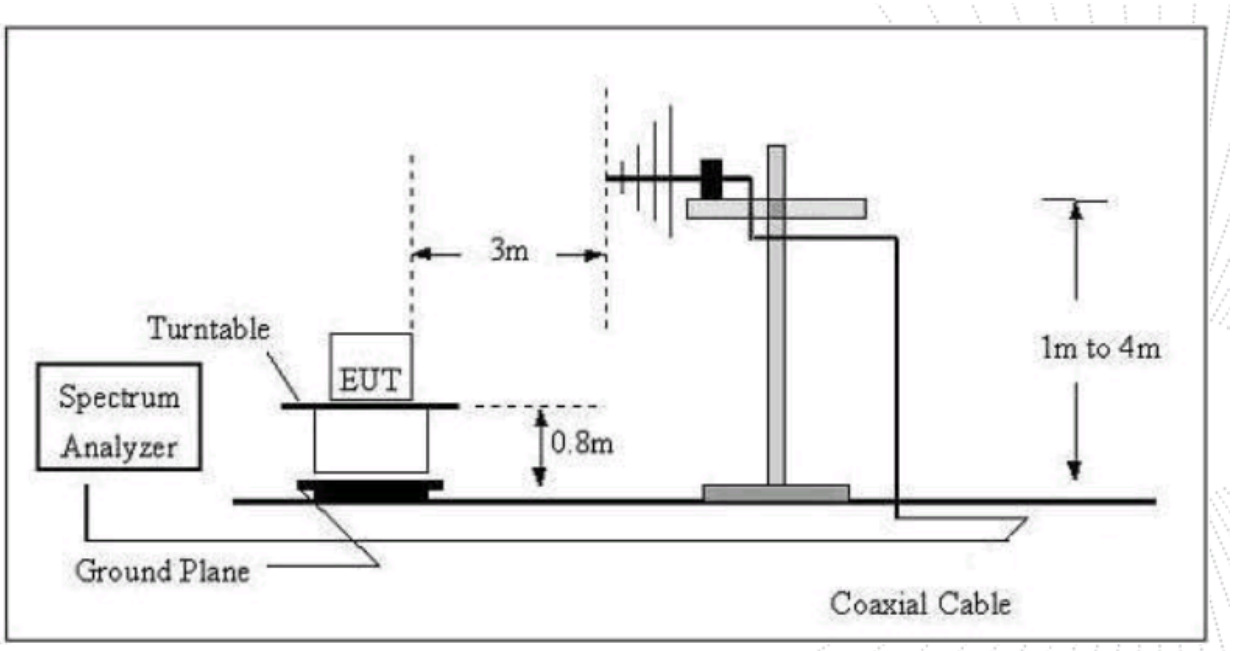


Figure 8. Block Diagram 30- 1000 MHz Radiated Emissions Test Setup

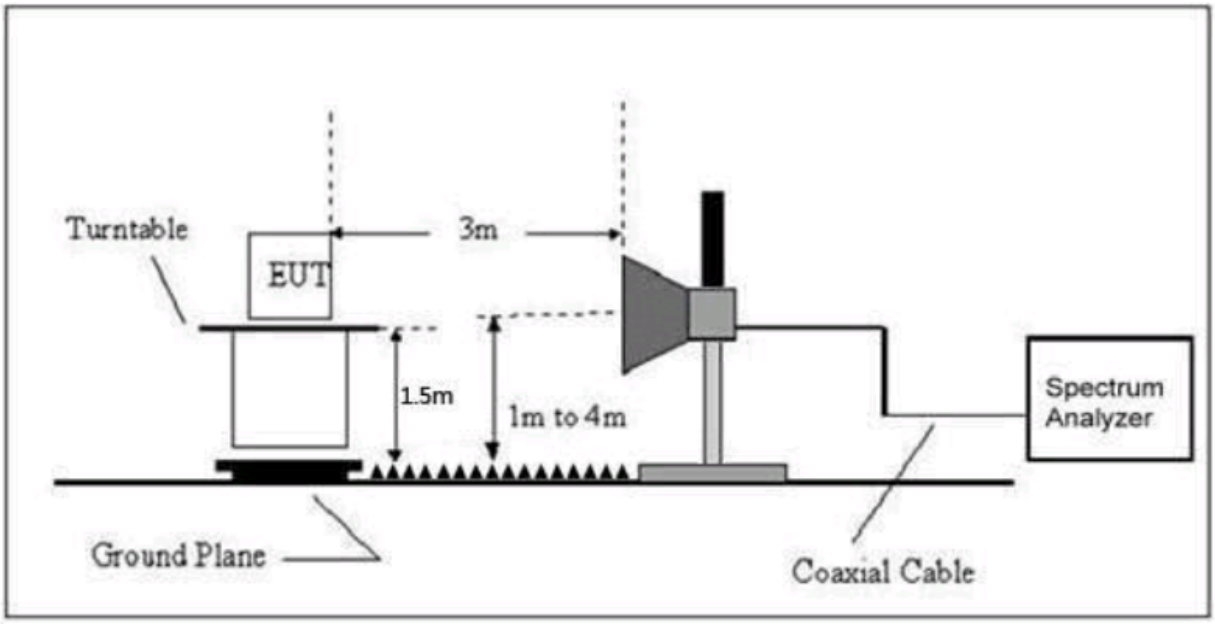


Figure 9. Block Diagram above 1 GHz Radiated Emissions Test Setup

2.12 Measurement Uncertainty

The measurement uncertainties given were calculated using the method detailed in CISPR 16-4-2:2011. A coverage factor of k=2 was used to give a level of confidence of approximately 95%.

2.12.1 Conducted Emissions Measurement Uncertainty

Measurement Uncertainty (within a 95% confidence level) for this test is ±2.78 dB.

2.12.2 Radiated Emissions Measurement Uncertainty

For a measurement distance of 3 m the measurement uncertainty (with a 95% confidence level) for this test using a Biconical Antenna (30 MHz to 200 MHz) is ±5.3 dB. This value includes all elements of measurement.

The measurement uncertainty (with a 95% confidence level) for this test using a Log Periodic Antenna (200 MHz to 1000 MHz) is ±5.1 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna (Above 1000 MHz) is ±5.1 dB.

3 Test Results

The EUT is deemed to have met the requirements of the standards cited within the test report when tested as detailed in the test report.