

**Advanced
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Electromagnetic Emission Compliance Test Report



Equipment Under Test (EUT)	Utility Scanner	
Model	US1	
Applicant	Earth Science Systems, LLC	
In Accordance With	FCC Part 15, Subpart F Industry Canada RSS-220 (Issue 1/2009)	
Tested by	Advanced Compliance Laboratory, Inc. 210 Cougar Court Hillsborough, New Jersey 08844	
Authorized by	Wei Li Lab Manager	Signature 
Date	October 4, 2019	
AC Lab Report Number	0048-190827-01	



Lab Code:200101-0

**The test result in this report is supported and
covered by the NVLAP accreditation.**

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Section 1. Summary of Test Results

Manufacturer: Earth Science Systems, LLC
Product Name: Utility Scanner

Model/Parts No. : US1

S/N: PT003

General: **All measurements are traceable to national standards**

These tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with FCC Part 15, Sub Part F and Industry Canada RSS-220 (Issue 1/2009).

☐ New Submission

☐ Production Unit

☐ Class I Permissive Change

☒ Pre-Production Unit

THIS TEST REPORT RELATES ONLY TO THE ITEM(S) TESTED.

THE FOLLOWING DEVIATIONS FROM, ADDITIONS TO, OR EXCLUSIONS FROM THE TEST SPECIFICATIONS HAVE BEEN MADE.

“See Summary of Test Data”



NVLAP LAB CODE: 200101-0

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Summary of Test Data

Compliance Requirement	FCC & IC Rule Part	Test No. in Section 4	Result
Cross Reference	15.505 &RSS-GEN	1	Complies
Marketing of UWB Equipment	15.507 &RSS-GEN	2	Complies
Pulse Repetition Frequency(PRF)	15.509 &RSS-220 6.2	3	Complies
UWB Bandwidth	15.509(a) &RSS-220 6.2.1(a)	4	Complies
General Operational Requirements for LF Imaging System	15.509(b) &RSS-220 6	5	Complies
Spurious Radiated Emissions≤960MHz	15.509(d) 15.209 &RSS-220 3.4, 6.2(c), 6.2(d)	6	Complies
Spurious Radiated Emissions>960MHz	15.509(d) 15.209 &RSS-220 3.4, 6.2(c), 6.2(d)	7	Complies
Radiated Emissions in GPS Bands	15.509(e) 15.209 &RSS- 220 6.2(e)	8	Complies
Highest Radiated Emission at f_M	15.509(f) 15.209 &RSS- 220 6.2(g)	9	Complies
Technical Requirements Applicable to All UWB Devices	15.521	10	Complies
Coordination Requirement	15.525	11	N/A
Antenna Requirement	15.203 &RSS-GEN 7.1.4	12	N/A
Radio Frequency Exposure	FCC OET Bulletin 65 &RSS-GEN&RSS-102	13	Complies
Conducted Emissions	15.207 &RSS-GEN	14	*
Transmission Duration	15.509(c)	15	**

* NOT APPLICABLE to the EUT as it is a battery-powered device;

** NOT APPLICABLE to the EUT as it is not a handheld device.

The estimated uncertainty of the test result is given as following. The method of uncertainty calculation is provided in Advanced Compliance Lab. Doc. No. 0048-01-01.

	Prob. Dist.	Uncertainty(dB)	Uncertainty(dB)	Uncertainty(dB)
		30-1000MHz	1-6.5GHz	Conducted
Combined Std. Uncertainty u_c	norm.	± 2.36	± 2.99	± 1.83



Wei Li
Lab Manager
Advanced Compliance Lab

Date: October 4, 2019

Section 2. General Equipment & Test Configuration

2.1. EUT Specification

EUT	Utility Scanner, Model No. US1 manufactured by Earth Science Systems, LLC. This scanner is an impulse radar system intended to be used in utility detection and geophysical surveying.	
Supply Voltage	12 VDC, provided by LiFePO4 Rechargeable Battery	
Operating Frequency		113.7MHz – 1000MHz
-10dB UWB Bandwidth	886.3MHz	
Modulation Type	Up to 1MHz Pulse Repetition Frequency (PRF)	
Peak Emissions in a 50 MHz Bandwidth	N/A. Max. peak emissions is under 1GHz	
Antenna	Dipole Antenna	
Hardware Version	NA	
Software Version	NA	

2.2. Description of Operation

The system performs time domain reflectometry by radiating a radio frequency impulse with a repetition frequency of up to 1MHz from a transmitting dipole (TX dipole). Transitions between materials exhibiting different wave impedance through which the electromagnetic wave travels cause the wave to be reflected. These reflections are received by the receiving dipole (RX dipole) and sampled by the instrument. Results may be displayed in real time on the system screen and recorded on an internal solid state disk

drive for later analysis. In the field, the system is powered from a removable rechargeable battery.

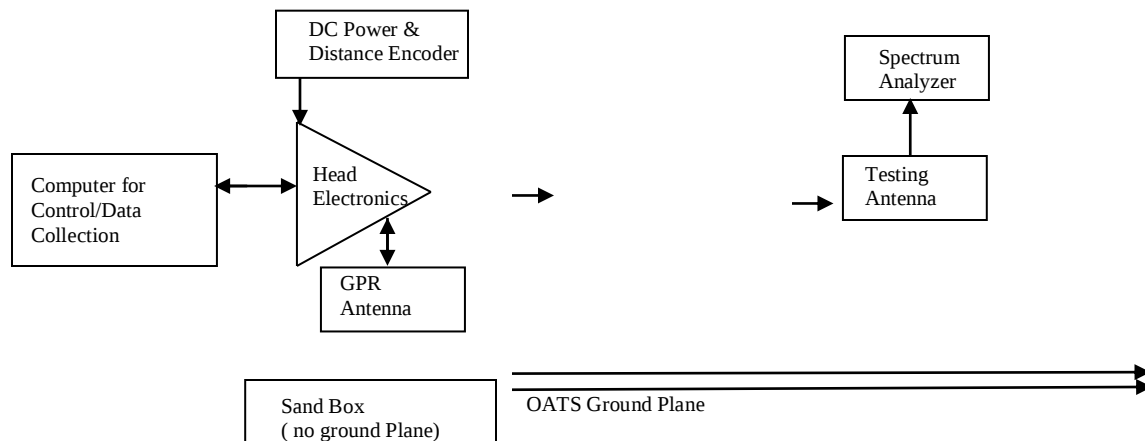
2.3. System Diagram

See Attachment provided by Applicant.

2.4. General EUT Setup

The EUT is operated in continuous transmission mode with the antennas permanently mounted in an all in one plastic housing with the controlling electronics and battery.

All measurements shall be made at room temperature and at nominal DC input voltage (provided by a battery). The EUT is placed directly on the dry sand with no ground plane under it.



2.5. Operational Frequency channel(s) for testing:

- RF Clock(s) : 250MHz
- RF antenna center frequencies: 350MHz & 750MHz

Section 3. Test Methodology & Facilities

3.1 Measurement Procedure

The tests documented in this report were performed in accordance with ANSI C63.4 /C63.10, FCC CFR 47 Part 2 & 15, Industry Canada RSS-220 (Issue 1/2009) & FCC Order, ET Docket No. 980153(FCC02-08). Test procedure described in FCC “KDB 393764, UWB Compliance Measurements” is used in this report. The test methods used to generate the data in this test report is in accordance with ANSI C63.10:2013, American National Standard for Testing Unlicensed Wireless Devices.

In accordance with ANSI C63.10:2013, Section 10.2.2, the device under test was placed on a bed of dry sand and rotated through 16 azimuth angles (Clause 5.4) to determine which produced the highest emission relative to the limit. The azimuth that produced the highest emission relative to the limit was used for all radiated emission measurements.

3.2. Facilities and Accreditation

The test sites and measurement facilities used to collect data are located at Hillsborough, New Jersey, USA. The sites are constructed in conformance with the requirements of ANSI C63.4, ANSI C63.7 and CISPR Publication 32. All receiving equipment conforms to CISPR Publication 16-1, “Radio Interference Measuring Apparatus and Measurement Methods”.

This site is accepted by FCC to perform measurements under Part 15 or 18 (Registration # 90601, MRA designation No. US5347) and also designated by IC as “ site IC 3130A” and accepted for wireless testing. ACL is accredited by NVLAP, Laboratory Code 200101-0. No part of this report may be used to claim or imply product endorsement by NVLAP or any agency of the US Government.

3.3. Test and Measurement Equipment

The following test and measurement equipment was utilized for the tests documented in this report:

Manufacture	Model	Serial No.	Description	Cal Due dd/mm/ yy
Hewlett-Packard	HP8546A	3448A00290	EMI Receiver	25/09/20
Agilent	E4440A	US40420700	3Hz-26.5GHz Spectrum Analyzer	17/06/20
EMCO	3104C	9307-4396	20-300MHz Biconical Antenna	15/01/20
EMCO	3146	9008-2860	200-1000MHz Log-Periodic Antenna	15/01/20
EMCO	3115	4945	Double Ridge Guide Horn Antenna	22/01/20

All Test Equipment Used is Calibrated, Traceable to NIST Standards. 2 Year Interval.

Section 4. Measurement Data

Test No.1

Name of Test:	<i>Cross Reference</i>	Test Standard:	<i>15.505 &RSS-GEN</i>
Tested By:	WEI LI	Test Date:	08/27/2019-10/01/2019

Minimum 15.505(a)

Standard: Equipment under test complies with all the relevant and applicable requirements of Subpart A, Subpart B and Section 15.201 through 15.204 and Section 15.207 of Subpart C. 15.505(b)
The Digital circuitry portion of the EUT has been tested and verified to comply with 47 CFR Part 15, subpart B.

Method of Measurement: a) Except where specifically stated otherwise within this subpart, the provisions of Subparts A and B and of Sections 15.201 through 15.204 and Section 15.207 of Subpart C of this part apply to unlicensed UWB intentional radiators. The provisions of Sections 15.35(c) and 15.205 do not apply to devices operated under this subpart. The provisions of Footnote US 246 to the Table of Frequency Allocations contained in Section 2.106 of this chapter do not apply to devices operated under this subpart.

b) The requirements of Subpart F apply only to the radio transmitter, i.e., the intentional radiator, contained in the UWB device. Other aspects of the operation of a UWB device may be subject to requirements contained elsewhere in this chapter. In particular, a UWB device that contains digital circuitry not directly associated with the operation of the transmitter also is subject to the requirements for unintentional radiators in Subpart B of this chapter. Similarly, an associated receiver that operates (tunes) within the frequency range 30 MHz to 960 MHz is subject to the requirements in Subpart B of this chapter.

Test Result:

Complies

Test Data:

Data and Plots

Project Number:	0048-190827-01
EUT:	US1
S/N:	PT003
Tested By:	David Tu
Temperature:	65° F
Humidity:	30%

Spurious Radiated Emissions from Digital Circuitry (RF off) complies with FCC Part 15.109 (Class A), measured per ANSI C63.4 with standard setup.

Freq. (MHz)	H,V	Height (m)	Angle (degree)	SA* Reading (dBuV/m)	Refer to Part 15.109 3m Limit (dBuV/m)	Margin (dB)	Result
146.3	H	1.8	000	43.7	53.1	-9.4	Pass
163.6	H	1.6	180	34.6	53.1	-18.5	Pass
169.4	H	1.6	180	40.6	53.1	-12.5	Pass
384	H	1.0	180	43.7	56.1	-12.4	Pass
432	H	1.0	045	44.2	56.1	-11.9	Pass
456	H	1.0	045	47.8	56.1	-8.3	Pass
480	H	1.0	000	47.4	56.1	-8.7	Pass
504	H	1.0	000	40.6	56.1	-15.5	Pass
960	H	1.0	180	36.3*	56.1	-19.8	Pass
1056	H	1.1	000	38.0*	59.1	-21.1	Pass
114.3	V	1.2	090	39.5	53.1	-13.6	Pass
120.0	V	1.2	100	34.5	53.1	-18.6	Pass
169.4	V	1.1	235	37.8	53.1	-15.3	Pass
190.8	V	1.1	270	37.0	53.1	-16.1	Pass
384	V	1.1	090	39.8	56.1	-16.3	Pass
432	V	1.1	090	43.4	56.1	-12.7	Pass
456	V	1.1	090	47.5	56.1	-8.6	Pass
478	V	1.1	090	43.4	56.1	-12.7	Pass
960	V	1.1	270	35.2*	56.1	-20.9	Pass
1006	V	1.1	270	39.3*	59.1	-19.8	Pass

*Quasi-peak reading. For emissions that have peak values close to (or over) the specification limit (if any) will be also measured in the quasi-peak or average mode to determine the compliance.

Test No.2

Name of Test:	<i>Marketing of UWB Equipment</i>	Test Standard:	<i>15.507 &RSS-GEN</i>
Tested By:	WEI LI	Test Date:	08/27/2019-10/01/2019

Minimum 15.507/ 2.909

Standard: The responsible party is properly informed about the responsible for ensuring that the equipment is marketed only to eligible parties, and provide correct information on the customers and users.
(See Important note for the US customers of the Installation Guide and User Manual)

Method of Measurement: In some cases, the operation of UWB devices is limited to specific parties, e.g., law enforcement, fire and rescue organizations operating under the auspices of a state or local government. The marketing of UWB devices must be directed solely to parties eligible to operate the equipment. The responsible party, as defined in Section 2.909 of this chapter, is responsible for ensuring that the equipment is marketed only to eligible parties. Marketing of the equipment in any other manner may be considered grounds for revocation of the grant of certification issued for the equipment.

Test Result:

Complies

Test Data:

NA

Test No.3

Name of Test:	<i>Pulse Repetition Frequency (PRF)</i>	Test Standard:	<i>15.509(d) &RSS-220 6.2</i>
Tested By:	WEI LI	Test Date:	08/27/2019-10/01/2019

Minimum Definition:
Standard: Pulse Repetition Frequency (PRF) is the trigger repetition frequency.

PRF declared by applicant: up to 1MHz

Method of Tested at 3-meter OATS per ANSI C63.4
Measurement: Spectrum Analyzer Settings:
RBW: 30KHz
VBW: $\geq$ RBW
Detector: Peak
Span: As required
Sweep: Auto

Test Result: **Complies**

Test Data: **PRF $\leq$ 1MHz**

Test No.4

Name of Test:	<i>UWB Bandwidth</i>	Test Standard:	<i>15.509(a) 15.503(a) &RSS-220 6.2.1(a)</i>
Tested By:	WEI LI	Test Date:	08/27/2019-10/01/2019

**Minimum
Standard:**

Definition:

The bandwidth of a UWB emission is defined by the points on the emission spectrum where the amplitude is 10 dB below the maximum emission amplitude (i.e., the -10 dB points), as based on the complete transmission system including the antenna. The upper boundary is designated f_H and the lower boundary is designated f_L . The frequency at which the highest radiated emission occurs is designated f_M . The center frequency f_C , equals $(f_H + f_L) / 2$. The fractional bandwidth equals $2 * (f_H - f_L) / (f_H + f_L)$.

In cases where the measured emission spectrum contains multiple (more than two) -10 dB points, the outermost points define the bandwidth (i.e., the widest bandwidth is assumed).

Limits:

The UWB bandwidth of an imaging system operating under the provisions of this section must be below 10.6 GHz.

Method of Measurement: Tested at 3-meter OATS per ANSI C63.4
Spectrum Analyzer Settings:
RBW: 1MHz
VBW: 3MHz
Detector: Peak
Span: As required (to display a full spectrum of the RF emission)
Sweep: Auto

Test Procedure:

- 1) The receiving antenna which varied from 1 to 4 m to find the highest emission is positioned 3 m away from the EUT.
- 2) Measure the Highest radiated emission at f_M as described in the test No. 9.
- 3) Recorded the upper and lower frequency that are at the side of the band bounded by the points at 10 dB below the highest radiated UWB emission level. Measuring the bandwidth of a UWB device using a radiated test set-up, it is imperative that appropriate adjustments be made to the measured amplitude levels to account for the frequency-dependent components of the measurement system (e.g., antenna gain or factor, pre-amplifier gain, cable loss, etc). Since UWB emissions can have bandwidths several GHz wide, these frequency-dependent characteristics can vary dramatically over the fundamental emission. According to the nature of the broadband emission characteristics, significant care must be taken to capture the true spectrum of emission, extremely narrow sweep widths is recommended.
- 4) The UWB bandwidth is the different of the upper and lower frequency recorded.

Test Result: **Complies**

Test Data: **Data and Plots**

Measurement Data (Values in MHz):

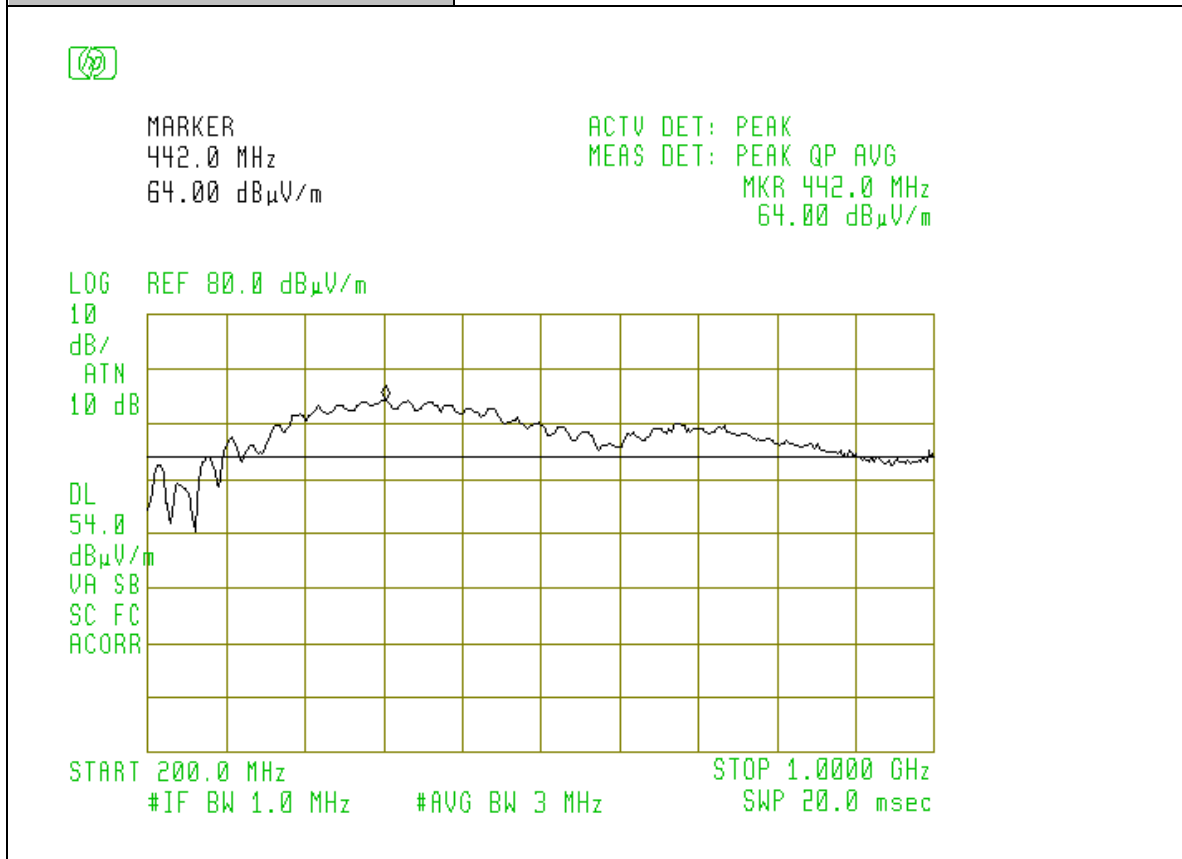
f_M	The highest emission peak	442.0
f_L	10 dB below the highest peak	113.7
f_H	10 dB above the highest peak	1000
f_C	Calculated: $(f_H + f_L)/2$	556.85
Bandwidth	Calculated: $(f_H - f_L)$	886.3
Fractional BW	Calculated: $2*(f_H - f_L)/(f_H + f_L)$	3.183

Note: The Fraction Bandwidth is greater than 0.2.

Measurement Plots:

Project Number:	0048-190827-01
EUT:	US1
S/N:	PT003
Tested By:	Wei Li
Temperature:	65°F
Humidity:	30%

Section:	UWB Bandwidth
Plot Name:	-10dB UWB Bandwidth in Anechoic Chamber
Configuration:	Stand alone, Continue operation



Project Number:	0048-190827-01
EUT:	US1
S/N:	PT003
Tested By:	Wei Li
Temperature:	65° F
Humidity:	30%

Section:	UWB Bandwidth
Plot Name:	-10dB UWB Bandwidth in Anechoic Chamber 1GHz-4GHz
Configuration:	Stand alone, Continue operation



MARKER
1.000 GHz
53.85 dB μ V/m

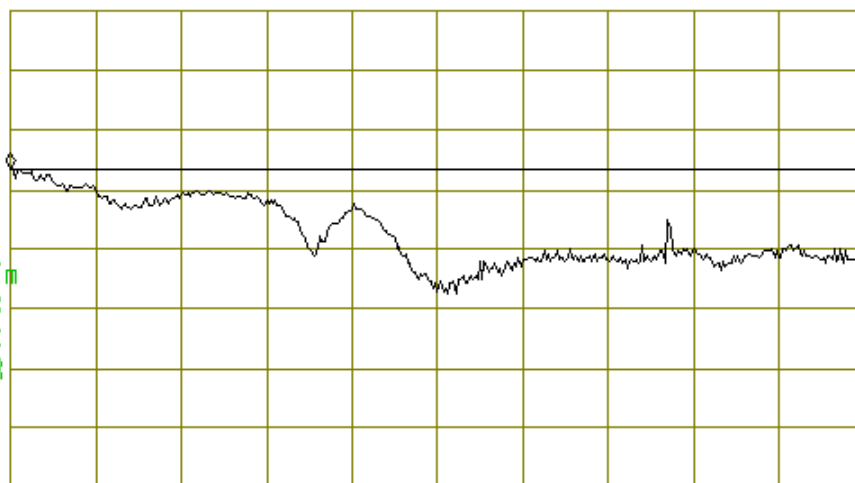
ACTV DET: PEAK
MEAS DET: PEAK QP
MKR 1.000 GHz
53.85 dB μ V/m

LOG REF 70.0 dB μ V/m

PREAMP ON

6
dB/
#ATN
0 dB

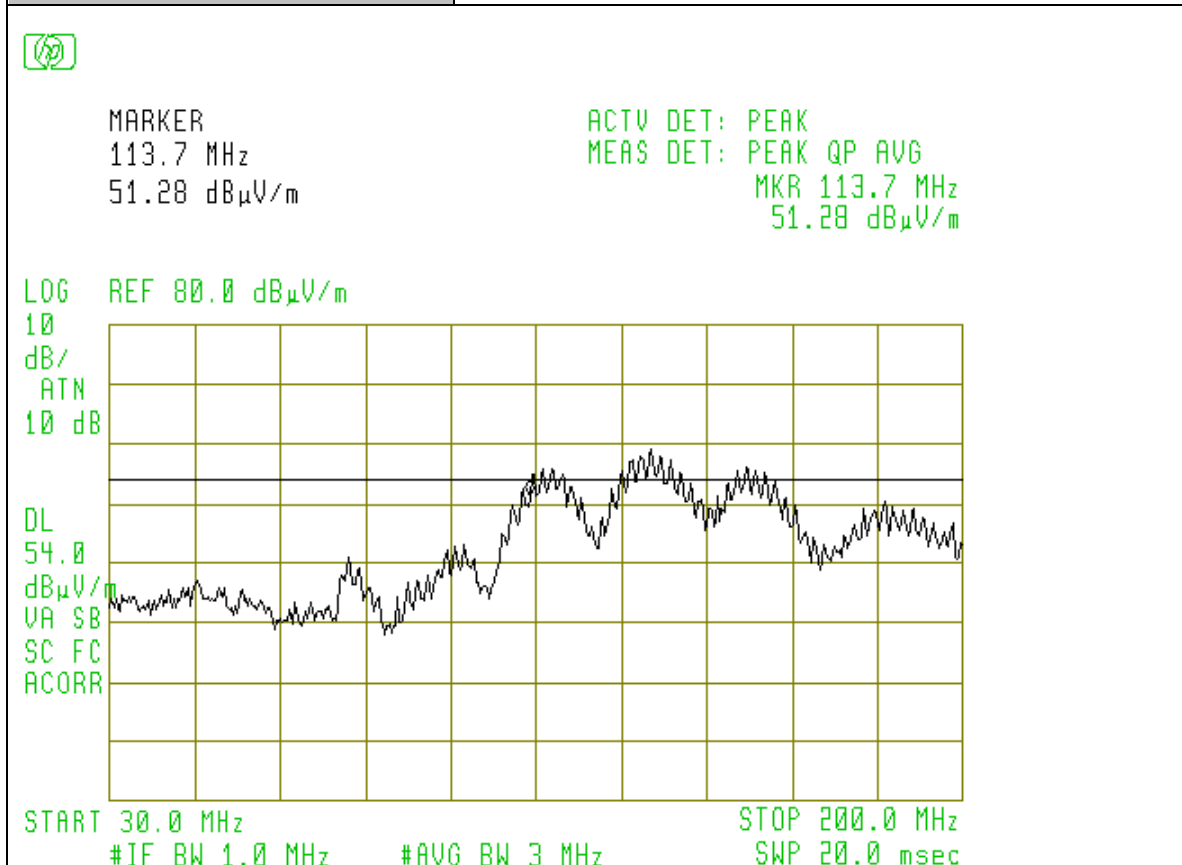
DL
54.0
dB μ V/m
VA SB
SC FC
ACORR



START 1.000 GHz STOP 2.900 GHz
#IF BW 1.0 MHz #AVG BW 3 MHz SWP 38.0 msec

Project Number:	0048-190827-01
EUT:	US1
S/N:	PT003
Tested By:	Wei Li
Temperature:	65°F
Humidity:	30%

Section:	UWB Bandwidth
Plot Name:	-10dB UWB Bandwidth in Anechoic Chamber 200MHz-1GHz
Configuration:	Stand alone, Continue operation



Test No.5

Name of Test:	<i>General Operational Requirements for LFIS</i>	Test Standard:	<i>15.509(b) &RSS-220 6</i>
Tested By:	WEI LI	Test Date:	08/27/2019-10/01/2019

Minimum 15.509(b) &RSS-220 6

Standard: Operation under the provisions of this section is limited to GPRs and wall imaging systems operated for the purposes with law enforcement, fire fighting, emergency rescue, scientific research, commercial mining, or construction.

Method of Measurement: The manufacturer Shall state that the device under test complies with the requirements outlined in section FCC Part 15.509 (b).

Test Result:

Complies

Test Data:

NA

Test No.6

Name of Test:	<i>Spurious Radiated Emissions $\leq 960\text{MHz}$</i>	Test Standard:	<i>15.509(d) 15.209 & RSS-220 3.4, 6.2(c), 6.2(d)</i>
Tested By:	David Tu	Test Date:	08/27/2019-10/01/2019

Minimum Definition:

Standard: The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in Section 15.209.

Limits:

Frequency (MHz)	Field Strengths Limits (dB μ V/m)	Measuring RBW kHz	Distance (meters)
0.009-0.490	67,6-20*Logf(kHz)	1	300
0.490-1.705	87,6-20*Logf(kHz)	9	30
1.705-30	29,5	9	30
30-88	40,0	120	3
88-216	43,5	120	3
216-960	46,0	120	3

Method of Tested at 3-meter OATS per ANSI C63.4
Measurement: Spectrum Analyzer Settings:
RBW: 120KHz
VBW: $\geq 3 \times$ RBW
Detector: Quasi-Peak
Span: As required
Sweep: Auto

Test Procedure:

- 1) The EUT was placed on sandpit area filled with dry sand initially placed in front of the ground plane (0° degree position)
- 2) The receiving antenna which varied from 1 to 4 m to find the highest emission is positioned 3 m away from the EUT.
- 3) The receiving antenna was positioned in horizontal polarization.
- 4) The measurements were made with the detector set to peak with a bandwidth of 120 kHz during monitoring the frequency range below 960 MHz.
- 5) Upon detection of a suspect emission signal, its amplitude and frequency were noted.
- 6) It is recommended to demodulate the received signals for suitable discrimination of the ambient emission from the EUT emission.
- 7) At the worst case combination of the EUT operating mode and antenna height, the field strength measure was recorded. At each of the frequencies where a field strength was recorded the final measurement was performed with a Quasi-Peak detector.
- 8) The receiving antenna was positioned in vertical polarization and the steps 2 to 6 was repeated.
- 9) The EUT was rotating from 0° to 360° degrees with 45° step increment and the steps 4 to 7 was repeated.
- 10) All the worst case combination field strength emissions founded of each EUT position and antenna polarization was recorded in the following table and compared with the applicable limits.

Test Result:

Complies

Test Data:

Data

Project Number:	0048-190827-01
EUT:	US1
S/N:	PT003
Tested By:	David Tu
Temperature:	65 ° F
Humidity:	30%

Worst Case Scenario: the worst case combination field strength emissions founded of each EUT position and antenna polarization was recorded in the following table and compared with the applicable limits.

- EUT Position (angle) : 45 ° interval.
- Antenna Polarization : Horizontal & Vertical; Antenna Height : 1-4m

Freq.* (MHz)	H,V	SA/ QP Reading (dBuV/ m)**	Height (m)	Angle (degree)	Refer to Part 15.209 3m Limit (dBuV/m)	Margin (dB)	Result
73.9	H	32.8	1.4	045	40.0	-7.2	Pass
90.8	H	33.6	1.4	000	43.5	-9.9	Pass
118.4	H	34.0	1.4	000	43.5	-9.5	Pass
141.5	H	32.2	1.3	180	43.5	-11.3	Pass
163.6	H	34.6	1.1	180	43.5	-8.9	Pass
180.0	H	36.6	1.0	180	43.5	-6.9	Pass
288	H	41.1	1.0	000	46.0	-4.9	Pass
312	H	42.2*	1.0	000	46.0	-3.8	Pass
328	H	40.2	1.0	180	46.0	-5.8	Pass
416	H	42.1*	1.0	180	46.0	-3.9	Pass
427	H	44.3*	1.0	280	46.0	-1.7	Pass
664	H	41.7	1.0	090	46.0	-4.3	Pass
56.2	V	39.0*	1.2	090	40.0	-1.0	Pass
73.9	V	38.9*	1.2	270	40.0	-1.1	Pass
114.3	V	39.5	1.1	270	43.5	-4.0	Pass
142.2	V	37.3	1.2	100	43.5	-6.2	Pass
167.0	V	32.6	1.1	100	43.5	-10.9	Pass
190.8	V	37.0	1.1	090	43.5	-6.5	Pass

331	V	42.8	1.1	090	46.0	-3.2	Pass
424	V	44.9*	1.1	090	46.0	-1.1	Pass
456	V	43.2	1.1	270	46.0	-2.8	Pass
558	V	40.5	1.1	270	46.0	-5.5	Pass
637	V	35.7	1.1	135	46.0	-10.3	Pass
758	V	41.1	1.1	090	46.0	-4.9	Pass
898	V	35.2	1.1	090	46.0	-10.8	Pass

*Emissions from Digital circuitry (identified in Test No.1 for FCC Part 15 B) excluded.

**Quasi-Peak Readings marked with *, if any.

Test No.7

Name of Test:	<i>Spurious Radiated Emissions >960MHz</i>	Test Standard:	<i>15.509(d) 15.209 &RSS-220 3.4, 6.2(c), 6.2(d)</i>
Tested By:	David Tu	Test Date:	08/27/2019-10/01/2019

Minimum Definition:
Standard: The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz.

Limits:

Frequency (MHz)	EIRP @ 3 meters (1 MHz BW) (dBm)	Field strength @ 3 meters (1 MHz BW) (dBμV/m)	Field strength @ 1 meters (1 MHz BW) (dBμV/m)
960-1610	-	29,9	39,4
1610-1990	-	41,9	51,4
1990-3100	-	43,9	53,4
3100-10600	-	53,9	63,4
Above 10600	-	43,9	53,9

Remark: The limits were converted from EIRP to field strength at 3 and 1 meter according to FCC 15.503(k).

Method of Tested at 3-meter OATS per ANSI C63.4
Measurement: Spectrum Analyzer Settings:
RBW: 1MHz
VBW: $\geq 3 \times$ RBW
Detector: RMS Average Detector
Span: As required
Sweep: Auto

Test Procedure:

- 1) The EUT was placed on sandpit area filled with dry sand initially placed in front of the ground plane (0° degree position)
- 2) The receiving antenna is placed at 1 meter away from the EUT and it is pointed in the direction of the radiating head with an inclination of -10° to find the highest emission.
- 3) The receiving antenna was positioned in horizontal polarization.
- 4) The measurements were made with the detector set to RMS with a bandwidth of 1 MHz during monitoring the frequency range above 960 MHz.
- 5) Upon detection of a suspect emission signal, its amplitude and frequency were noted.
- 6) It is recommended to demodulate the received signals for suitable discrimination of the ambient emission from the EUT emission.
- 7) At the worst case combination of the EUT operating mode and antenna height, the field strength measure was recorded.
- 8) The receiving antenna was positioned in vertical polarization and the steps 2 to 6 were repeated.
- 9) The EUT was rotating from 0° to 360° degrees with 45° step increment and the steps 4 to 7 was repeated.
- 10) All the worst case combination field strength emissions founded of each EUT position and antenna polarization was recorded in the following table and compared with the applicable limits.

Test Result:

Complies

Test Data:

Data

Project Number:	0048-190827-01
EUT:	US1
S/N:	PT003
Tested By:	David Tu
Temperature:	65° F
Humidity:	30%

Worst Case Scenario: the worst case combination field strength emissions founded of each EUT position and antenna polarization was recorded in the following table and compared with the applicable limits.

- EUT Position (angle) : 45 ° interval.
- Antenna Polarization : Horizontal & Vertical; Antenna Height: 1m-4m.

Freq.* (MHz)	H,V	SA** Average Reading @1m (dBuV/m)	Height (m)	Angle (degree)	Refer to 15.509(d) 15.209 & RSS- 220 3.4, 6.2(c), 6.2(d) Limit (dBuV/m)	Margin (dB)	Result
1020	H	38.3	1.0	180	39.4	-1.1	Pass
1064	H	36.5	1.0	180	39.4	-2.9	Pass
1099	H	38.0	1.0	000	39.4	-1.4	Pass
1118	H	37.9	1.0	000	39.4	-1.5	Pass
1888	H	37.1	1.0	000	39.4	-2.3	Pass
1056	V	38.0	1.0	090	39.4	-1.4	Pass
1211	V	38.2	1.0	090	39.4	-1.2	Pass
1315	V	34.2	1.0	135	39.4	-5.2	Pass
1336	V	34.9	1.0	135	39.4	-4.5	Pass
1485	V	34.1	1.0	090	39.4	-5.3	Pass

NOTE:

* Emissions from Digital circuitry (identified in Test No.1 for FCC Part 15B) are excluded.

**SA (Spectrum Analyzer) Reading Setup: Average Reading for above 960MHz; 1m/3m distance factor applied if needed.

Test No.8

Name of Test:	<i>Radiated Emissions in GPS Bands</i>	Test Standard:	<i>15.509(e) 15.209 & RSS-220 6.2(e)</i>
Tested By:	David Tu	Test Date:	08/27/2019- 10/01/2019

Minimum Definition:

Standard: In addition to the radiated emission limits specified for frequency above 960 MHz, UWB transmitters operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz in the GPS frequency bands.

Limits:

Frequency (MHz)	EIRP @ 3 meters (1 MHz BW) (dBm)	Field strength @ 3 meters (1 MHz BW) (dBµV/m)	Field strength @ 1 meter (1 MHz BW) (dBµV/m)
1164-1240	-75.3	19.9	29.4
1559-1610	-75.3	19.9	29.4

Remark: The limits were converted from EIRP to field strength at 3 and 1 meter according to FCC 15.503(k).

Method of Tested at 3-meter OATS per ANSI C63.4
Measurement: Spectrum Analyzer Settings:
RBW: 1KHz
VBW: >3xRBW
Detector: RMS Average Detector
Span: As required
Sweep: Auto

Test Procedure:

- 1) The EUT was placed on sandpit area filled with dry sand initially placed in front of the ground plane (0° degree position)
- 2) The receiving antenna is placed at 1 meter away from the EUT and it is pointed in the direction of the radiating head with an inclination of -10° to find the highest emission.
- 3) The receiving antenna was positioned in horizontal polarization.
- 4) The measurements were made with the detector set to RMS during monitoring the frequency range above 960 MHz.
- 5) Upon detection of a suspect emission signal, its amplitude and frequency were noted.
- 6) It is recommended to demodulate the received signals for suitable discrimination of the ambient emission from the EUT emission.
- 7) At the worst case combination of the EUT operating mode and antenna height, the field strength measure was recorded.
- 8) The receiving antenna was positioned in vertical polarization and the steps 2 to 6 were repeated.
- 9) The EUT was rotating from 0° to 360° degrees with 45° step increment and the steps 4 to 7 was repeated.
- 10) All the worst case combination field strength emissions founded of each EUT position and antenna polarization was recorded in the following table and compared with the applicable limits.

Test Result:

Complies

Test Data:

Data and Plot

Project Number:	0048-190827-01
EUT:	US1
S/N:	PT003
Tested By:	David Tu
Temperature:	65° F
Humidity:	30%

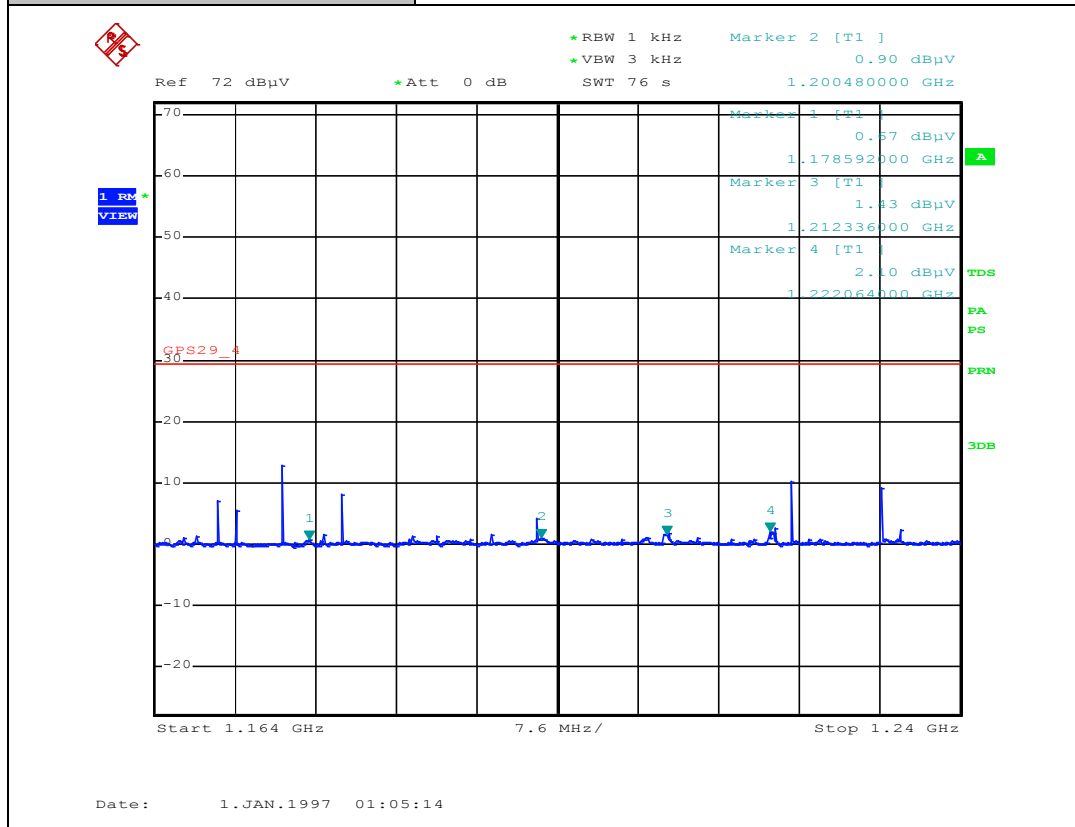
Worst Case Scenario: All maximum Field strength emissions were found at the following test set-up conditions:

Freq. (MHz)	H,V	SA Reading (dBuV/m)	Height (m)	Angle (degree)	1m Limit (dBuV/m)	Margin (dB)	Result
1178.6	H	0.7	1.0	090	29.4	-28.7	Pass
1200.8	H	0.9	1.0	090	29.4	-28.5	Pass
1212.3	H	1.4	1.0	090	29.4	-28.0	Pass
1222.1	H	2.1	1.0	090	29.4	-27.3	Pass
1567.8	H	1.93	1.0	090	29.4	-27.5	Pass
1577.4	H	2.07	1.0	090	29.4	-27.3	Pass
1586.8	H	2.5	1.0	090	29.4	-26.9	Pass
1601.8	H	2.6	1.0	090	29.4	-26.8	Pass
1178.9	V	1.5	1.0	180	29.4	-27.9	Pass
1187.4	V	2.5	1.0	180	29.4	-26.9	Pass
1207.6	V	1.3	1.0	180	29.4	-28.1	Pass
1221.1	V	2.2	1.0	180	29.4	-27.2	Pass
1560.6	V	1.7	1.0	180	29.4	-27.7	Pass
1576.7	V	2.1	1.0	180	29.4	-27.3	Pass
1582.0	V	3.0	1.0	180	29.4	-26.4	Pass
1604.8	V	2.2	1.0	180	29.4	-27.2	Pass

There were no significant broadband emissions related to the UWB transmitter. Most measured signals were narrowband and related to the microprocessor / clocks and do not fall under the requirements of this section.

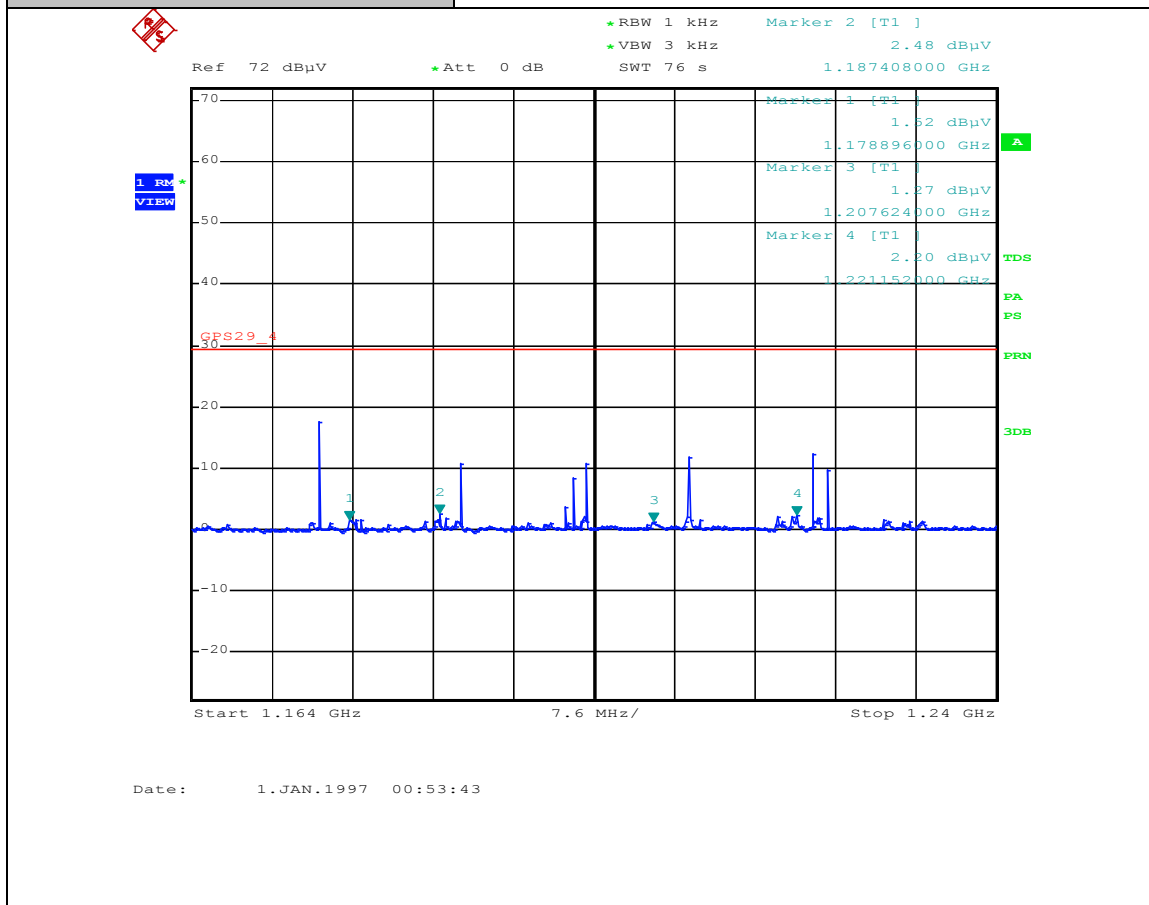
Project Number:	0048-190827-01
EUT:	US1
S/N:	PT003
Tested By:	Wei Li
Temperature:	65°F
Humidity:	30%

Section:	<i>Radiated Emissions in GPS Bands</i>
Plot Name:	Radiated Emissions in 1164-1240MHz Band H Polarity
Configuration:	Stand alone, Continue operation



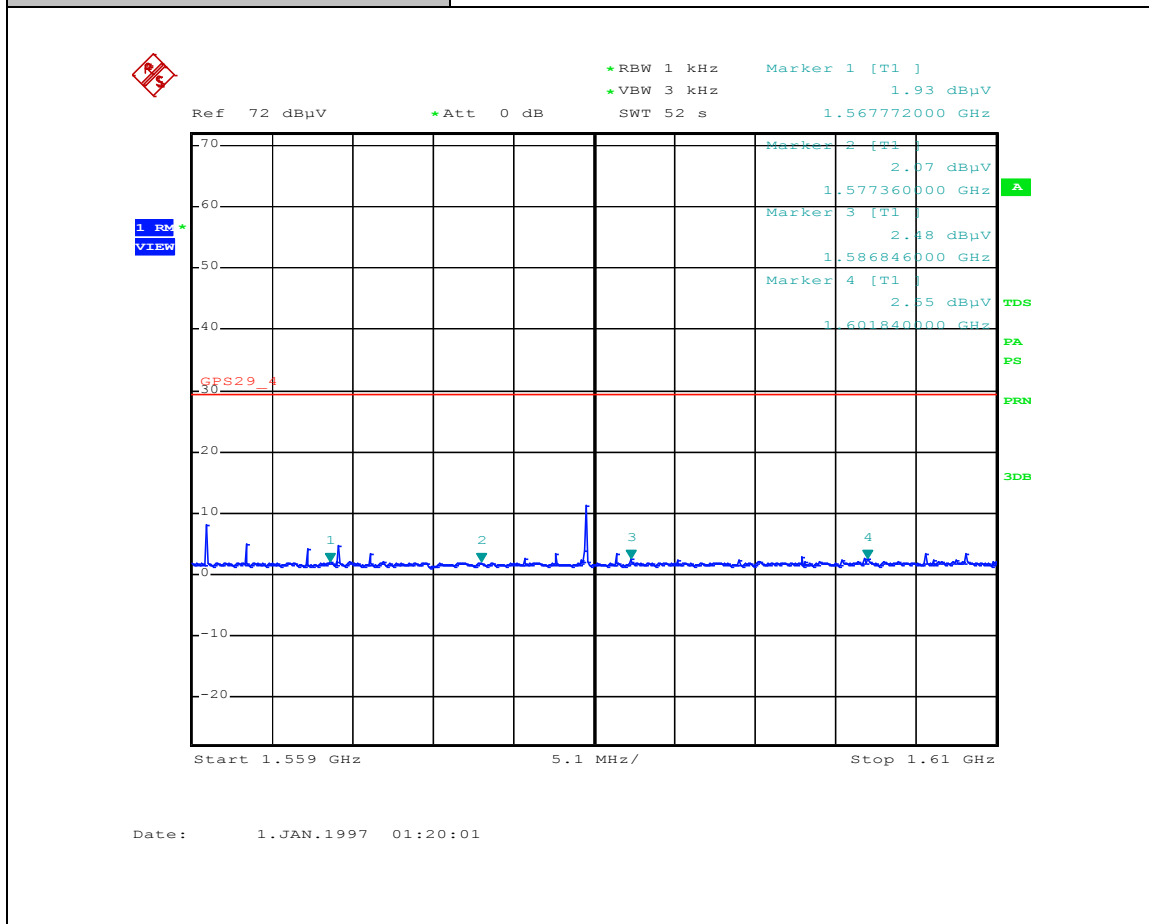
Project Number:	0048-190827-01
EUT:	US1
S/N:	PT003
Tested By:	Wei Li
Temperature:	65°F
Humidity:	30%

Section:	<i>Radiated Emissions in GPS Bands</i>
Plot Name:	Radiated Emissions in 1164-1240MHz Band V Polarity
Configuration:	Stand alone, Continue operation



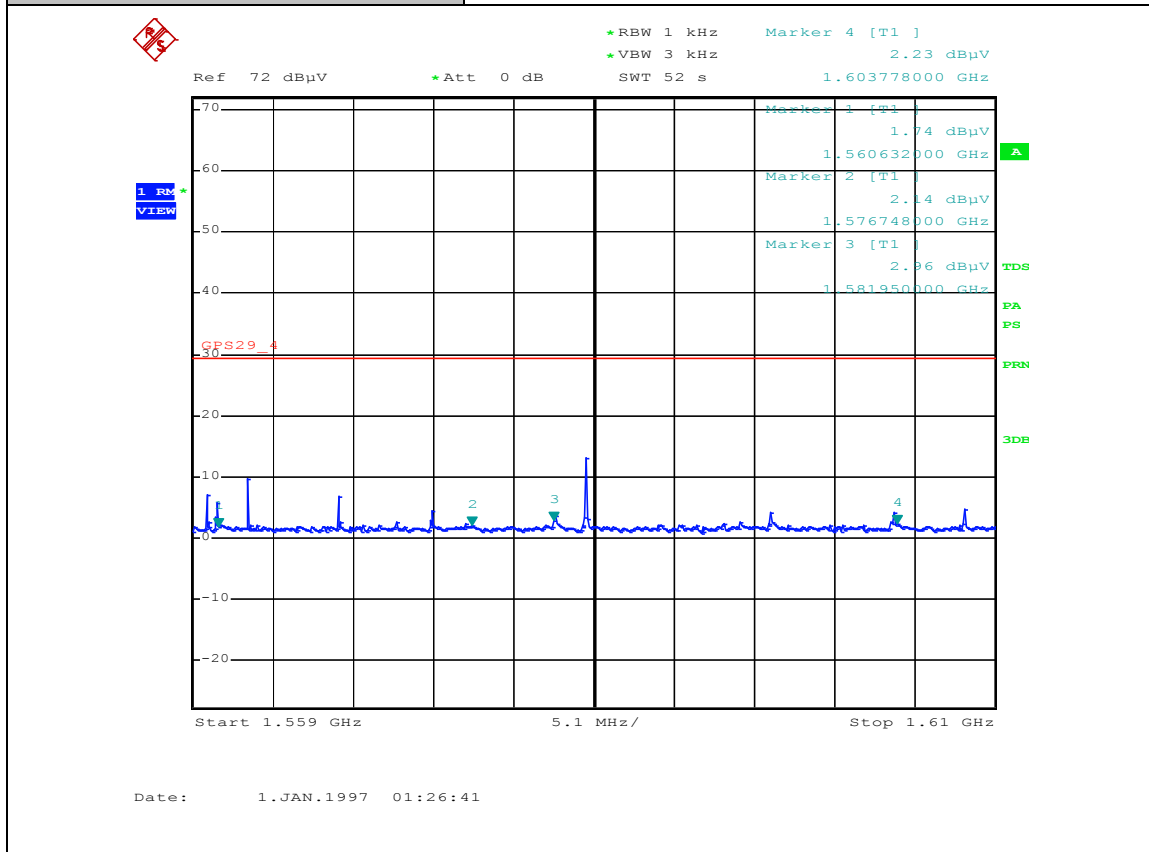
Project Number:	0048-190827-01
EUT:	US1
S/N:	PT003
Tested By:	Wei Li
Temperature:	65° F
Humidity:	30%

Section:	<i>Radiated Emissions in GPS Bands</i>
Plot Name:	Radiated Emissions in 1559-1610MHz Band H Polarity
Configuration:	Stand alone, Continue operation



Project Number:	0048-190827-01
EUT:	US1
S/N:	PT003
Tested By:	Wei Li
Temperature:	65°F
Humidity:	30%

Section:	<i>Radiated Emissions in GPS Bands</i>
Plot Name:	Radiated Emissions in 1559-1610MHz Band V Polarity
Configuration:	Stand alone, Continue operation



Test No.9

Name of Test:	<i>Highest Radiated Emission at f</i>	Test Standard:	15.509(f) 15.209 & RSS-220 6.2(g)
Tested By:	David Tu	Test Date:	08/27/2019-10/01/2019

Minimum Definition:

Standard: For UWB devices where the frequency at which the highest radiated emission occurs, f_M , is above 960 MHz, there is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on f_M .

Limits:

The peak emission level contained within a 50 MHz bandwidth centered on f_M must be limited to a maximum of 0 dBm EIRP.

EIRP limit (dBm)	Field strength limit @ 3 meters for 50MHz RBW (dBuV/m)	Field strength limit @ 3 meters (measured with 1 MHz RBW) (dBuV/m)
0	95.2	61.23

The limits were converted from EIRP to field strength at 3 meter according to FCC 15.503(k).

As the measurement was employed with a 1 MHz resolution bandwidth the applicable limit is adjusted with a $20\log(1/50)$ dB factor.

$$20 \log (1/50)\text{dBm} = -33.97 \text{ dBm. } -33.97 \text{ dBm} = 61.23 \text{ dBuV/m.}$$

Method of Tested at 3-meter OATS per ANSI C63.4
Measurement: Spectrum Analyzer Settings:
RBW: 1MHz
VBW: $\geq 3 \times$ RBW
Detector: Peak
Span: As required
Sweep: Auto

Test Procedure:

- 1) The EUT was placed on sandpit area filled with dry sand initially placed in front of the ground plane (0° degree position).
- 2) The receiving antenna which varied from 1 to 4 m to find the highest emission is positioned 3 m away from the EUT.
- 3) The receiving antenna was positioned in horizontal polarization.
- 4) The measurements were made with the detector set to peak with a bandwidth of 1 MHz during monitoring the frequency range inside the UWB of the EUT.
- 5) At the worst case combination of the EUT operating mode and antenna height, the field strength measure was recorded.
- 6) The receiving antenna was positioned in vertical polarization and the steps 4 to 6 were repeated.
- 7) The EUT was rotating from 0° to 360° degrees with 45° step increment and the steps 4 to 7 was repeated.
- 8) Record the peak emission from the EUT.

Test Result:

Complies

Test Data:

Project Number:	0048-190827-01
EUT:	US1
S/N:	PT003
Tested By:	David Tu
Temperature:	65° F
Humidity:	30%

Worst Case Scenario: The maximum peak level of emission is found at the following test set-up conditions:

Freq. (MHz)	H,V	SA Peak Reading At 1 meter (dBuV/m)	RBW	Peak Reading (or corrected) for 3 meter		Limit (dBuV/m)	Margin (dB)	Result
1020*	V	47.84	1MHz	37.34		61.23	-23.96	Pass
424**	V		1MHz	50.70		N/A		

* measured at 1m due to low signal level

** max. emission @3m, but under 1GHz.

Test No.10

Name of Test:	<i>Technical Requirements Applicable to ALL UWB Devices</i>	Test Standard:	15.521
Tested By:	WEI LI	Test Date:	08/27/2019-10/01/2019

Requirement **Description**

15.521(a)	The EUT is not employed for the operation of toys, operation onboard an aircraft, ship and satellite.
15.521(b)	Permanent attached antenna, no External radio frequency power amplifiers and antenna modifications are permitted.
15.521(c)	The Digital circuitry portion of the EUT has been tested and verified to comply with 47 CFR Part 15, subpart B.
15.521(d)	Considered
15.521(e)	The f_M , frequency at which the highest radiated emission occurs is contained within the measured UWB bandwidth.
15.521(f)	The EUT is not intended to detection of tags or the transfer or data or voice information.
15.521(g)	Considered
15.521(h)	Considered
15.521(i)	Prohibition in Sections 2.201(f) and 15.5(d) of this chapter against Class B (damped wave) emissions is not applied.
15.521(j)	Battery operating device not connected to AC power lines.
15.521(a)	The EUT is not employed for the operation of toys, operation onboard an aircraft, ship and satellite.

Test Result:

Complies

Test Data:

NA

Test No.11

Name of Test:	<i>Coordination Requirement</i>	Test Standard:	15.525
Tested By:	Wei Li	Test Date:	08/27/2019-10/01/2019

Minimum Standard: The responsible party is properly informed about the required coordination requirement and provide correct information to the customers and users about their specific care and legislative obligations.

(See Important note for the US customers of the Installation Guide and User Manual)

Method of Measurement: (a) UWB imaging systems require coordination through the FCC before the equipment may be used. The operator shall comply with any constraints on equipment usage resulting from this coordination.

(b) The users of UWB imaging devices shall supply operational areas to the FCC Office of Engineering and Technology, which shall coordinate this information with the Federal Government through the National Telecommunications and Information Administration.

(c) The manufacturers, or their authorized sales agents, must inform purchasers and users of their systems of the requirement to undertake detailed coordination of operational areas with the FCC prior to the equipment being operated.

(d) Users of authorized, coordinated UWB systems may transfer them to other qualified users and to different locations upon coordination of change of ownership or location to the FCC and coordination with existing authorized operations.

(e) The FCC/NTIA coordination report shall identify those geographical areas within which the operation of an imaging system requires additional coordination or within which the operation of an imaging system is prohibited.

(f) The coordination of routine UWB operations shall not take longer than 15 business days from the receipt of the coordination request by NTIA.

Test Result:

Test Data: NA

Test No. 12

Name of Test:	<i>Antenna Requirement</i>	Test Standard:	<i>15.203 &RSS-GEN 7.1.4</i>
Tested By:	WEI LI	Test Date:	

Minimum Standard: 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.

Method of Measurement: The antenna utilized by the device under test is an internal, non user replaceable unit.

Test Result:

Test Data: NA

Test No.13

Name of Test:	Radio Frequency Exposure	Test Standard:	FCC OET Bulletin 65 & RSS-GEN & RSS-102
Tested By:	WEI LI	Test Date:	08/27/2019-10/01/2019

Minimum Standard: For FCC, per Public Exposure to Radio Frequency Energy Levels (1.1307 (b)(1)) Limits:

From §1.1310 Table 1 (B), for Public $S = 1.0 \text{ mW/cm}^2$;
for Professional, $S = 5.0 \text{ mW/cm}^2$.

For IC: per RSS-102, Sec. 2.5.2, Exemption Limits for Routine Evaluation, with formula of $1.31 \times 10^{-2} f^{0.6834} \text{ W}$, more restricted EIRP limit value are 1.37W at 902MHz, 2.67W at 2400MHz, 4.52W at 5180MHz.

Method of Measurement: $d = 0.282 * 10^{\frac{(P + G)}{20}} / \sqrt{S}$ Equation (1)
 $S = 0.0795 * 10^{\frac{(P + G)}{10}} / d^2$ Equation (2)

where

d = MPE distance in cm

P = Power in dBm

G = Antenna Gain in dBi

S = Power Density Limit in mW/cm^2

Equation (1) and the measured peak power is used to calculate the MPE distance.

Equation (2) and the measured peak power is used to calculate the Power density.

Test Result: **Complied with MPE limit**

Test Data: **NA**

Calculation:

A. For FCC MPE compliance:

1) For GPR alone , max emission level is under the limit set in Section 15.209. No RF hazard need to be concerned.

2) With co-location of GPR and pre-certified RF module, the following calculation shows total RF exposure is still under the MPE limit:

For GPR Tx, max. level measured at 3m distance: 44.9 dBμV/m, i.e. P+G= -50.3dBm

Plug all three items into equation (2), yielding,

Power Density Limit (mW/cm ²)	Output Power (dBm)	Antenna Gain (dBi)	Power Density at 20cm (mW/ cm ²)	Max. EIRP (W)
1.0			1.6E-9	9E-9

For RF module, made by Texas Instruments Inc., WiFi and BT Module, Model # WL18MODGI. (FCC ID: Z64-WL18DBMOD, IC: 451I-WL18DBMOD). Worst case MPE per report #FA4O0971:

Power Density Limit (mW/cm ²)	Output Power (dBm)	Antenna Gain (dBi)	Power Density at 20cm (mW/ cm ²)	Max. EIRP (W)
1.0	19.5	4.5	0.050	0.251

Thus, co-location calculations:

$$\Sigma \text{MPE} = 1.6\text{E-}9 \text{ mW/cm}^2 + 0.251 \text{ mW/cm}^2 = 0.251 \text{ mW/cm}^2 \text{ which is less than the limit } 1.0 \text{ mW/cm}^2$$

Additionally,

$$\Sigma \text{SeqnSlimn} = \text{Seq1Slim1} + \text{Seq2Slim2} \leq 1$$

$$\text{Herein } \Sigma \text{SeqnSlimn} = 1.6\text{E-}9/1.0 + 0.251/1.0 = 0.251 \leq 1$$

B. For IC ISSED MPE compliance:

GPR max. EIRP = 9E-9W and RF module EIRP = 0.251W. Thus co-location max. EIRP = 0.251W < limit 1.37W / 2.67W / 4.52W.

NOTE: For mobile or fixed location transmitters, the minimum separation distance between the antenna & radiating structures of the device and nearby persons is 20 cm, even if calculations indicate that the MPE distance would be less.

Test No.14

Name of Test:	<i>Conducted Emissions</i>	Test Standard:	<i>15.507 &RSS-GEN</i>
Tested By:	-	Test Date:	-

Minimum Standard: 15.507 &RSS-GEN
Limit

Frequency Range (MHz)	Limits (dBµV)	
	Quasi-Peak	Average
0.15 to 0.50	66 to 56*	56 to 46*
0.50 to 5.0	56	46
5.0 to 30.0	60	50
* Decreases with the logarithm of the frequency.		

Method of Measurement: Test measurements were made in accordance with ANSI C63.4-2003, Standard Methods of Measurement of Radio Noise Emissions from Low-Voltage Electrical and Electronics Equipment in the Range of 9 kHz to 40 GHz.

Spectrum Analyzer Setting:
Frequency Range: 150KHz to 30MHz
RBW: 9KHz
VBW: 30KHz
Detector: Peak/QP/Average

Test Result: **NA**
(The EUT is only powered via a lithium-ion battery which is remotely recharged)

Test Data: **NA**

Test No.15

Name of Test:	<i>Transmission Duration</i>	Test Standard:	<i>15.509(c)</i>
Tested By:	-	Test Date:	-

Minimum 15.509 (c)

Standard: A GPR that is designed to be operated while being hand held and a wall imaging system shall contain a manually operated switch that causes the transmitter to cease operation within 10 seconds of being released by the operator. In lieu of a switch located on the imaging system, it is permissible to operate an imaging system by remote control provided the imaging system ceases transmission within 10 seconds of the remote switch being released by the operator.

Method of NA
Measurement:

Test Result: NA

Test Data: NA