



Shenzhen CTL Testing Technology Co., Ltd.  
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# TEST REPORT

## FCC PART 15.247

Report Reference No.....: **CTL2407153031-WF**

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**Product Name** ..... : Noah Multifunction Leak Sensor

**Model/Type reference** ..... : N2-OTAA-01

**List Model(s)**..... : N/A

**Trade Mark**..... : KAIROS

**FCC ID**..... : **2AXYM-N2OTAA01**

**Applicant's name** ..... : **Kairos Water, Inc**

**Address of applicant** ..... : 1700 Northside Drive Suite A7, Unit #5543, Atlanta, GA 30318  
United States

**Test Firm**..... : **Shenzhen CTL Testing Technology Co., Ltd.**

**Address of Test Firm** ..... : Floor 1-A, Baisha Technology Park, No.3011, Shaheji Road,  
Nanshan District, Shenzhen, China 518055

**Test specification**..... :

**Standard** ..... : **FCC Part 15.247:** Operation within the bands 902-928 MHz,  
2400-2483.5 MHz and 5725-5850 MHz.

**TRF Originator** ..... : Shenzhen CTL Testing Technology Co., Ltd.

**Master TRF**..... : Dated 2011-01

**Date of receipt of test item** ..... : Oct. 10, 2024

**Date of Test Date**..... : Oct. 10, 2024-Oct. 29, 2024

**Date of Issue** ..... : Oct. 30, 2024

**Result**..... : **Pass**

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# TEST REPORT

Test Report No. :	CTL2407153031-WF	Oct. 30, 2024
		Date of issue

Equipment under Test : Noah Multifunction Leak Sensor

Sample No : CTL2407153031

Model /Type : N2-OTAA-01

Listed Models : N/A

**Applicant** : **Kairos Water, Inc**

Address : 1700 Northside Drive Suite A7, Unit #5543, Atlanta, GA 30318  
United States

**Manufacturer** : **Kairos Water, Inc**

Address : 1700 Northside Drive Suite A7, Unit #5543, Atlanta, GA 30318  
United States

Test result	Pass *
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\*In the configuration tested, the EUT complied with the standards specified page 5.

The test results presented in this report relate only to the object tested.

This report shall not be reproduced, except in full, without the written approval of the issuing testing laboratory.

### \*\* Modified History \*\*

[illegible]

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## 1. SUMMARY

### 1.1. TEST STANDARDS

The tests were performed according to following standards:

[FCC Rules Part 15.247](#): Frequency Hopping, Direct Spread Spectrum and Hybrid Systems that are in operation within the bands of 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz

[ANSI C63.10: 2013](#): American National Standard for Testing Unlicensed Wireless Devices

### 1.2. Test Description

FCC PART 15.247		
FCC Part 15.207	AC Power Conducted Emission	N/A
FCC Part 15.247(a)(1)(i)	20dB Bandwidth	PASS
FCC Part 15.247(d)	Spurious RF Conducted Emission	PASS
FCC Part 15.247(b)	Maximum Peak Output Power	PASS
FCC Part 15.247(b)	Pseudorandom Frequency Hopping Sequence	PASS
FCC Part 15.247(a)(1)(iii)	Number of hopping frequency& Time of Occupancy	PASS
FCC Part 15.247(a)(1)	Frequency Separation	PASS
FCC Part 15.205/15.209	Radiated Emissions	PASS
FCC Part 15.247(d)	Band Edge Compliance of RF Emission	PASS
FCC Part 15.203/15.247 (b)	Antenna Requirement	PASS

### 1.3. Test Facility

#### 1.3.1 Address of the test laboratory

Shenzhen CTL Testing Technology Co., Ltd.

Floor 1-A, Baisha Technology Park, No.3011, Shahexi Road, Nanshan District, Shenzhen, China 518055

There is one 3m semi-anechoic chamber and two line conducted labs for final test. The Test Sites meet the requirements in documents ANSI C63.10 and CISPR 32/EN 55032 requirements.

#### 1.3.2 Laboratory accreditation

The test facility is recognized, certified, or accredited by the following organizations:

##### **CNAS-Lab Code: L7497**

Shenzhen CTL Testing Technology Co., Ltd. has been assessed and proved to be in compliance with CNAS-CL01 Accreditation Criteria for Testing and Calibration Laboratories (identical to ISO/IEC 17025: 2017 General Requirements) for the Competence of Testing and Calibration Laboratories.

##### **A2LA-Lab Cert. No. 4343.01**

Shenzhen CTL Testing Technology Co., Ltd, EMC Laboratory has been accredited by A2LA for technical competence in the field of electrical testing, and proved to be in compliance with ISO/IEC 17025: 2017 General Requirements for the Competence of Testing and Calibration Laboratories and any additional program requirements in the identified field of testing.

##### **IC Registration No.: 9618B**

##### **CAB identifier: CN0041**

The 3m alternate test site of Shenzhen CTL Testing Technology Co., Ltd. EMC Laboratory has been registered by Innovation, Science and Economic Development Canada to test to Canadian radio equipment requirements with Registration No.: 9618B .

##### **FCC-Registration No.: 399832**

##### **Designation No.: CN1216**

Shenzhen CTL Testing Technology Co., Ltd. EMC Laboratory has been registered and fully described in a report filed with the (FCC) Federal Communications Commission. The acceptance letter from the FCC is maintained in our files. Registration 399832.

### 1.4. Statement of the measurement uncertainty

The data and results referenced in this document are true and accurate. The reader is cautioned that there may be errors within the calibration limits of the equipment and facilities. The measurement uncertainty was calculated for all measurements listed in this test report acc. to CISPR 16 - 4 "Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainty in EMC Measurements" and is documented in the Shenzhen CTL Testing Technology Co., Ltd. quality system acc. to DIN EN ISO/IEC 17025. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

Hereafter the best measurement capability for CTL laboratory is reported:

Test	Measurement Uncertainty	Notes
Transmitter power Radiated	±2.20 dB	(1)
Occupied Bandwidth	±0.02ppm	(1)
Radiated Emission 30~1000MHz	±4.08dB	(1)
Radiated Emission Above 1GHz	±4.32dB	(1)

Conducted Disturbance0.15~30MHz	$\pm 2.96\text{dB}$	(1)
20dB Emission Bandwidth	$\pm 1.9\%$	(1)
Carrier Frequency Separation	$\pm 1.9\%$	(1)
Maximum Power Spectral Density Level	$\pm 0.98\text{ dB}$	(1)
Number of Hopping Channel	$\pm 1.9\%$	(1)
Time of Occupancy	$\pm 0.11\%$	(1)
Max Peak Conducted Output Power	$\pm 0.98\text{ dB}$	(1)
Band-edge Spurious Emission	$\pm 1.21\text{dB}$	(1)
Conducted RF Spurious Emission	9kHz-7GHz: $\pm 1.09\text{dB}$ 7GHz-26.5GHz: $\pm 3.27\text{dB}$	(1)

- (1) This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of  $k=1.96$ .

## 2. GENERAL INFORMATION

### 2.1. Environmental conditions

During the measurement the environmental conditions were within the listed ranges:

Normal Temperature:	25°C
Relative Humidity:	55 %
Air Pressure:	101 kPa

### 2.2. General Description of EUT

Product Name:	Noah Multifunction Leak Sensor
Model/Type reference:	N2-OTAA-01
Power supply:	DC 3.6V battery power supply
<b>SRD:</b>	
Modulation:	Lora-FHSS
Operation frequency:	902.3MHz~914.9MHz
Channel number:	64
Channel separation:	0.2MHz
Antenna type:	PCB Antenna
Antenna gain:	2.47dBi

Note1: For more details, please refer to the user's manual of the EUT.

Note2: Antenna gain provided by the applicant.



## 2.3. Description of Test Modes and Test Frequency

The Applicant provides communication tools software to control the EUT for staying in continuous transmitting and receiving mode for testing. There are 64 channels provided to the EUT and Channel 00/32/63 were selected to test.

### Operation Frequency :

Channel	Frequency (MHz)
<b>00</b>	<b>902.3</b>
01	902.5
⋮	⋮
31	908.5
<b>32</b>	<b>908.7</b>
33	908.9
⋮	⋮
62	914.7
<b>63</b>	<b>914.9</b>

Preliminary tests were performed in each mode and packet length of Lora, and found worst case as bellow, finally test were conducted at those mode and recorded in this report.

Test Items	Worst case
Conducted Emissions	Lora-FHSS
Radiated Emissions and Band Edge	Lora-FHSS
Maximum Conducted Output Power	Lora-FHSS
20dB Bandwidth	Lora-FHSS
Frequency Separation	Lora-FHSS
Number of hopping frequency	Lora-FHSS
Time of Occupancy (Dwell Time)	Lora-FHSS
Out-of-band Emissions	Lora-FHSS

## 2.4. Equipments Used during the Test

Test Equipment	Manufacturer	Model No.	Serial No.	Calibration Date	Calibration Due Date
LISN	R&S	ESH2-Z5	860014/010	2024/04/30	2025/04/29
Limitator	ROHDE & SCHWARZ	ESH3-Z2	100408	2024/04/30	2025/04/29
EMI Test Receiver	ROHDE & SCHWARZ	ESCI	1166.5950.03	2024/04/30	2025/04/29
Double cone logarithmic antenna	Schwarzbeck	VULB 9168	824	2023/02/13	2026/02/12
EMI Test Receiver	R&S	ESCI	1166.5950.03	2024/04/30	2025/04/29
Spectrum Analyzer	Agilent	N9020A	US46220290	2024/05/02	2025/05/01
Spectrum Analyzer	Keysight	N9020A	MY53420874	2024/05/02	2025/05/01
Horn Antenna	Sunol Sciences Corp.	DRH-118	A062013	2021/12/23	2024/12/22
Active Loop Antenna	Da Ze	ZN30900A	/	2024/04/30	2025/04/29
Amplifier	Agilent	8449B	3008A02306	2024/04/30	2025/04/29
Amplifier	Brief&Smart	LNA-4018	2104197	2024/05/03	2025/05/02
Temperature/Humidity Meter	Ji Yu	MC501	/	2024/05/04	2025/05/03
Power measurement module	TSTPASS	TSPS2023R	TSCB220016	2024/05/03	2025/05/02
Power Sensor	Agilent	U2021XA	MY53340004	2024/05/04	2025/05/03
Power Sensor	Agilent	U2021XA	MY54080012	2024/05/03	2025/05/02
Spectrum Analyzer	RS	FSP	1164.4391.38	2024/05/03	2025/05/02
Test Software					
Name of Software			Version		
TST-PASS			V2.0		
EZ_EMC(Below 1GHz)			V1.1.4.2		
EZ_EMC((Above 1GHz)			V1.1.4.2		

## 2.5. Related Submittal(s) / Grant (s)

This submittal(s) (test report) is intended to comply with Section 15.247 of the FCC Part 15, Subpart C Rules.

## 2.6. Modifications

No modifications were implemented to meet testing criteria.

### 3. TEST CONDITIONS AND RESULTS

#### 3.1. Conducted Emissions Test

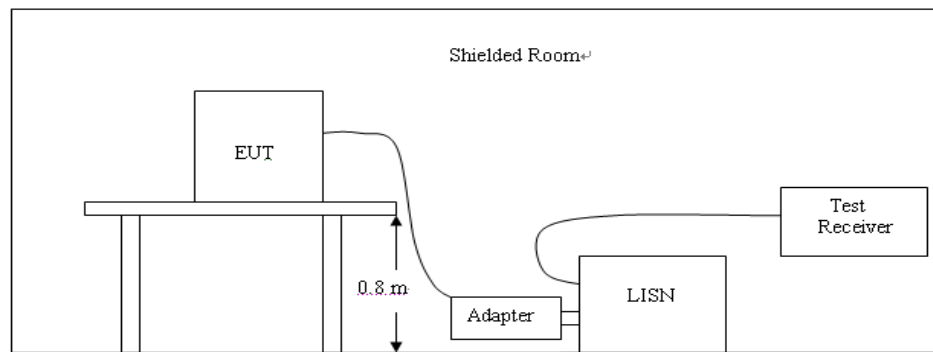
##### LIMIT

FCC CFR Title 47 Part 15 Subpart C Section 15.207

Frequency range (MHz)	Limit (dBuV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

\* Decreases with the logarithm of the frequency.

##### TEST CONFIGURATION



##### TEST PROCEDURE

1. The equipment was set up as per the test configuration to simulate typical actual usage per the user's manual. The EUT is a tabletop system; a wooden table with a height of 0.8 meters is used and is placed on the ground plane as per ANSI C63.10:2013.
2. Support equipment, if needed, was placed as per ANSI C63.10:2013.
3. All I/O cables were positioned to simulate typical actual usage as per ANSI C63.10:2013.
4. The adapter received AC120V/60Hz power through a Line Impedance Stabilization Network (LISN) which supplied power source and was grounded to the ground plane.
5. All support equipments received AC power from a second LISN, if any.
6. The EUT test program was started. Emissions were measured on each current carrying line of the EUT using a spectrum Analyzer / Receiver connected to the LISN powering the EUT. The LISN has two monitoring points: Line 1 (Hot Side) and Line 2 (Neutral Side). Two scans were taken: one with Line 1 connected to Analyzer / Receiver and Line 2 connected to a 50 ohm load; the second scan had Line 1 connected to a 50 ohm load and Line 2 connected to the Analyzer / Receiver.
7. Analyzer / Receiver scanned from 150 KHz to 30MHz for emissions in each of the test modes.
8. During the above scans, the emissions were maximized by cable manipulation.

##### TEST RESULTS

Battery powered products do not require this test.

### 3.2. Radiated Emissions and Band Edge

#### Limit

For intentional device, according to § 15.209(a), the general requirement of field strength of radiated emission out of authorized band shall not exceed the following table at a 3 meters measurement distance.

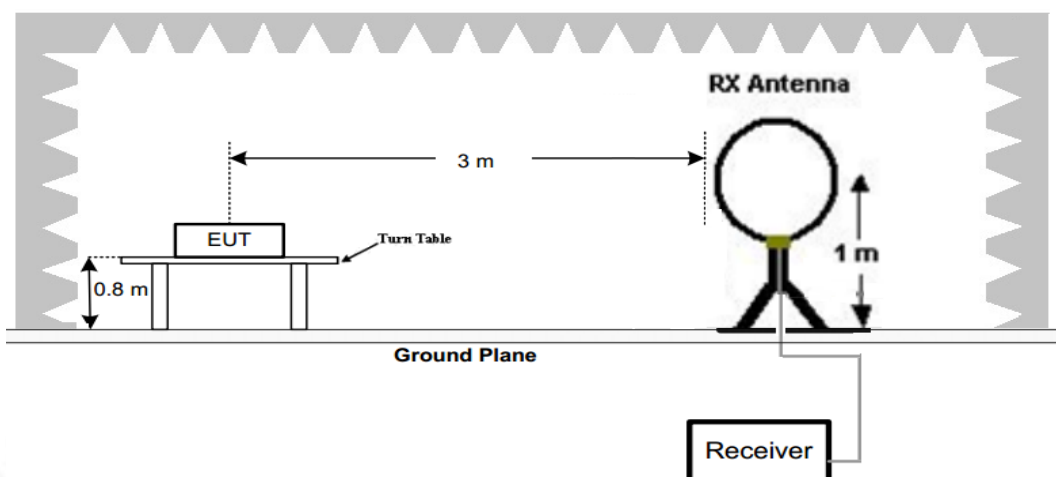
In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a)

Radiated emission limits

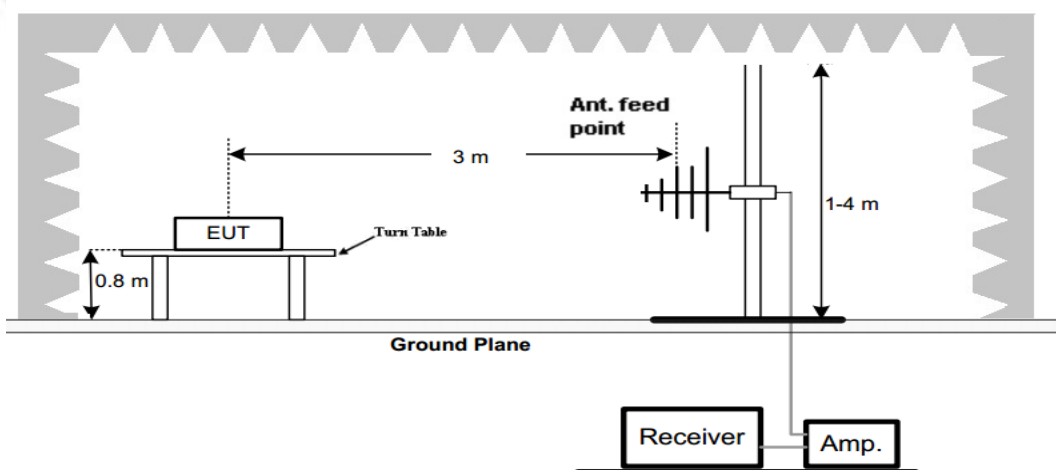
Frequency (MHz)	Distance (Meters)	Radiated (dB $\mu$ V/m)	Radiated ( $\mu$ V/m)
0.009-0.49	3	$20\log(2400/F(\text{KHz}))+40\log(300/3)$	$2400/F(\text{KHz})$
0.49-1.705	3	$20\log(24000/F(\text{KHz}))+40\log(30/3)$	$24000/F(\text{KHz})$
1.705-30	3	$20\log(30)+40\log(30/3)$	30
30-88	3	40.0	100
88-216	3	43.5	150
216-960	3	46.0	200
Above 960	3	54.0	500

#### TEST CONFIGURATION

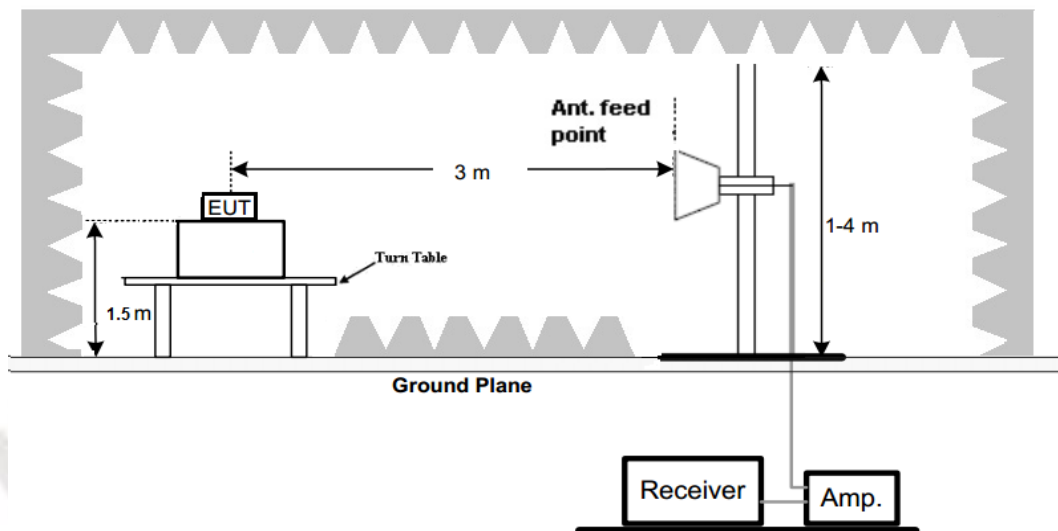
(A) Radiated Emission Test Set-Up, Frequency Below 30MHz



(B) Radiated Emission Test Set-Up, Frequency below 1000MHz



## (C) Radiated Emission Test Set-Up, Frequency above 1000MHz

**Test Procedure**

1. Below 1GHz measurement the EUT is placed on a turntable which is 0.8m above ground plane, and above 1GHz measurement EUT was placed on a low permittivity and low loss tangent turn table which is 1.5m above ground plane.
2. Maximum procedure was performed by raising the receiving antenna from 1m to 4m and rotating the turn table from 0° to 360° to acquire the highest emissions from EUT
3. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
4. Repeat above procedures until all frequency measurements have been completed.
5. The EUT was pretested with 3 orientations placed on the table for the radiated emission measurement –X, Y, and Z-plane. The X-plane results were found as the worst case and were shown in this report.

**TEST RESULTS**

Remark:

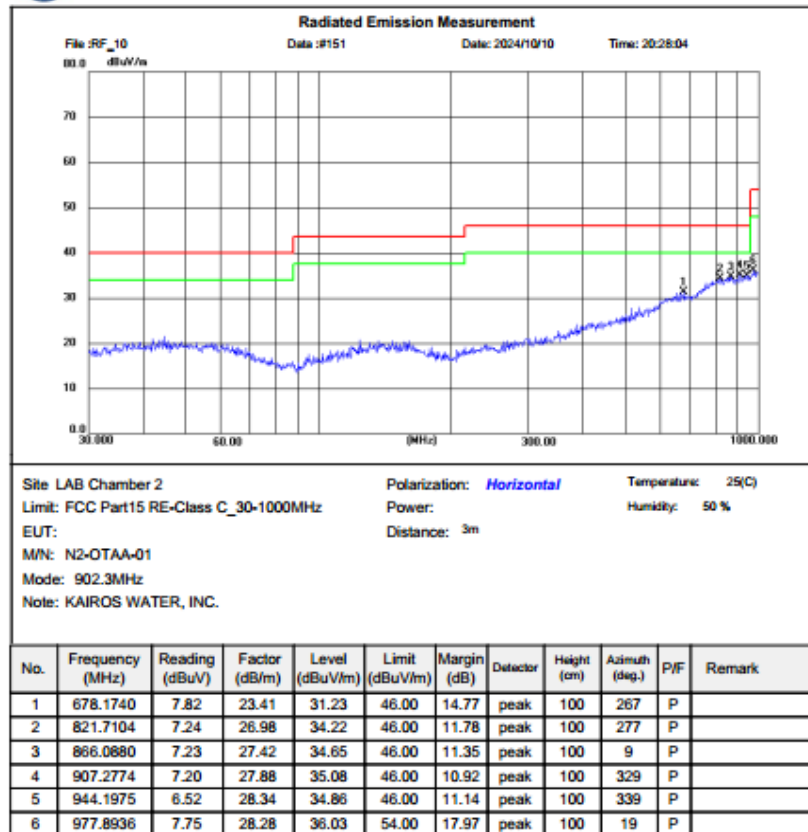
1. For below 1GHz testing recorded worst at high channel.
2. Radiated emission test from 9 KHz to 10th harmonic of fundamental was verified, Found the emission level are attenuated 20dB below the limits from 9 kHz to 30MHz, so it does not recorded in report.

## For 30MHz-1GHz

## Horizontal



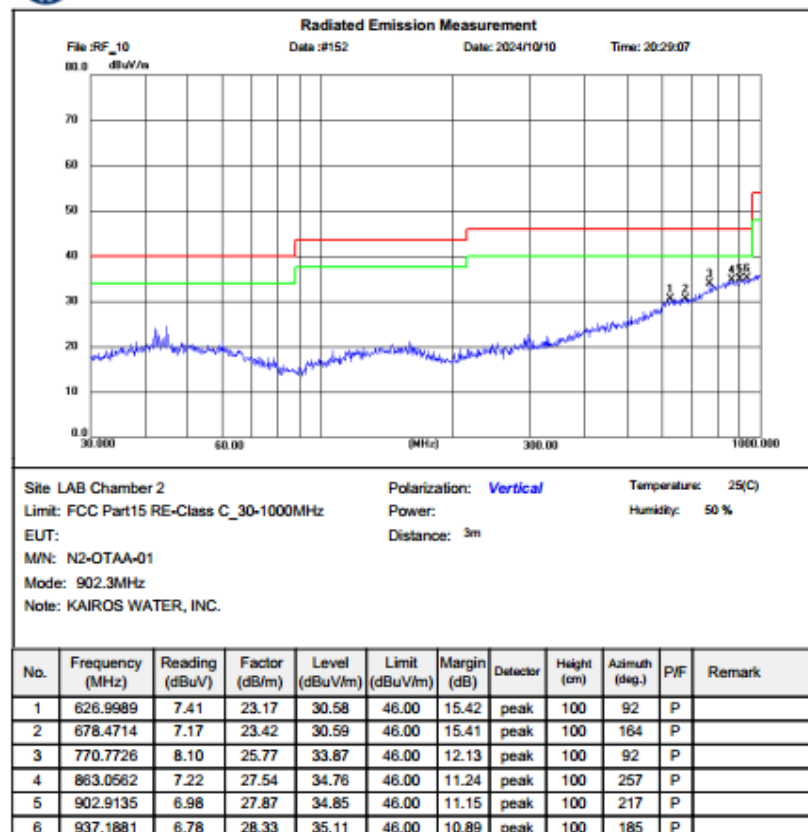
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## Vertical



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### Lora-FHSS (above 1GHz)

No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Azimuth (deg.)	P/F	Remark
1	1803.250	61.46	-20.05	41.41	74.00	32.59	peak	150	234	P	
2	2706.375	67.65	-15.49	52.16	74.00	21.84	peak	150	309	P	
3	6427.250	49.31	-4.52	44.79	74.00	29.21	peak	150	266	P	
4	10702.750	47.38	0.24	47.62	74.00	26.38	peak	150	54	P	
5	13558.750	47.07	3.95	51.02	74.00	22.98	peak	150	97	P	
6	16640.000	45.99	6.36	52.35	74.00	21.65	peak	150	213	P	

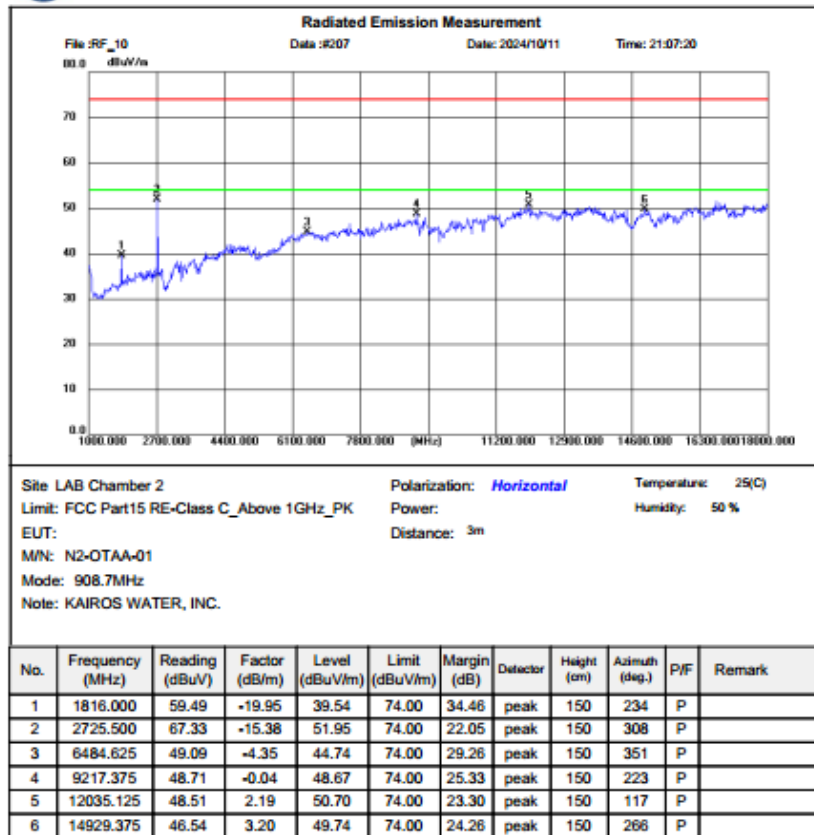
No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Azimuth (deg.)	P/F	Remark
1	2706.375	63.38	+15.49	47.89	74.00	26.11	peak	150	21	P	
2	6701.375	49.46	-4.17	45.29	74.00	28.71	peak	150	211	P	
3	9393.750	47.99	0.20	48.19	74.00	25.81	peak	150	106	P	
4	11873.625	49.19	1.81	51.00	74.00	23.00	peak	150	0	P	
5	13539.625	46.93	3.95	50.88	74.00	23.12	peak	150	116	P	
6	16712.250	45.01	6.49	51.50	74.00	22.50	peak	150	84	P	

CH32

Horizontal



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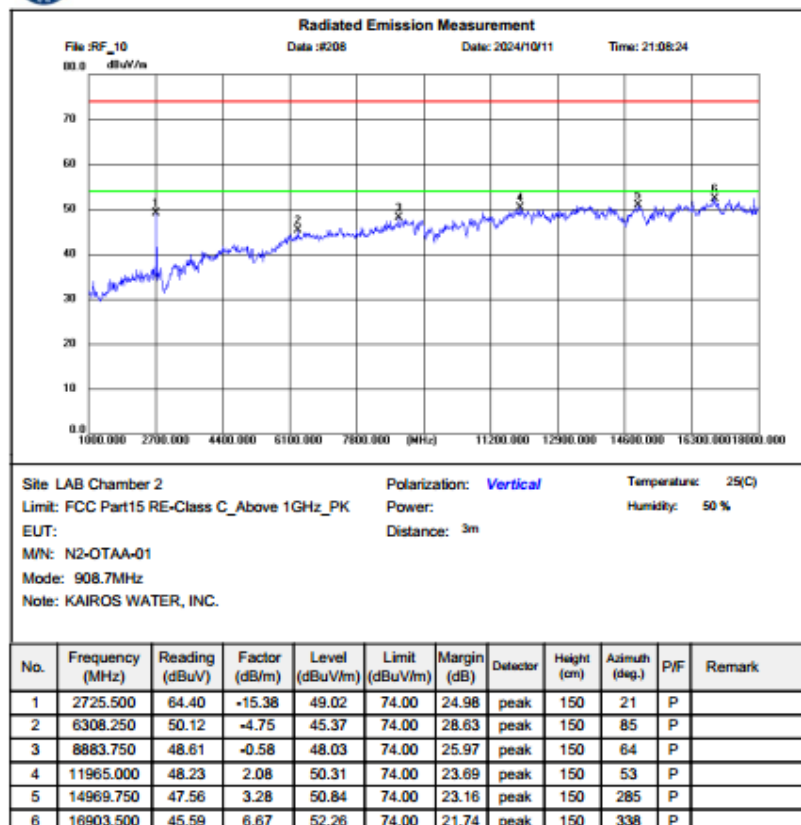


CH32

Vertical



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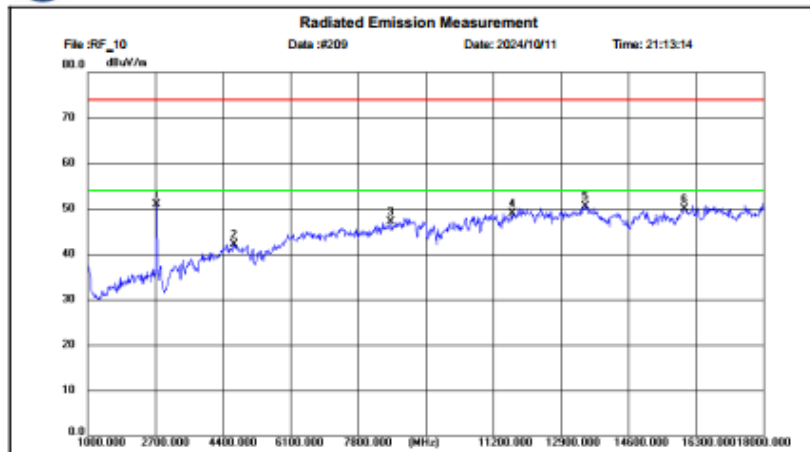


CH63

Horizontal



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Site: LAB Chamber 2

Polarization: **Horizontal**

Temperature: 25(C)

Limit: FCC Part15 RE-Class C\_Above 1GHz\_PK

Power:

Humidity: 50 %

EUT:

Distance: 3m

M/N: N2-OTAA-01

Mode: 914.9MHz

Note: KAIROS WATER, INC.

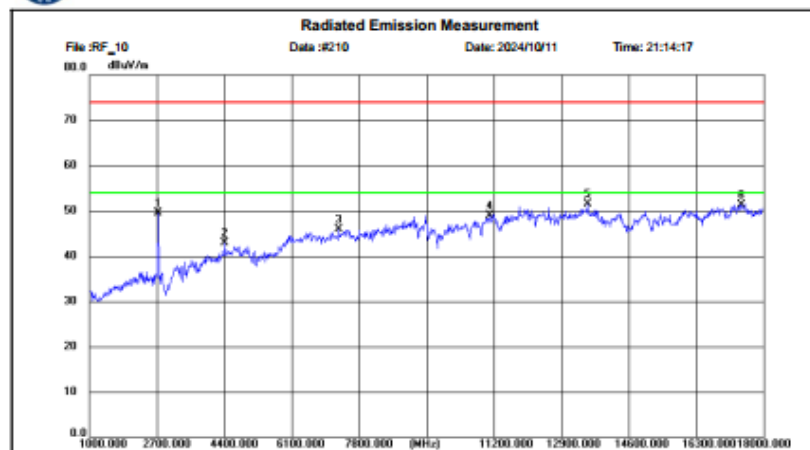
No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Asimuth (deg.)	P/F	Remark
1	2744.625	66.14	+15.27	50.87	74.00	23.13	peak	150	307	P	
2	4695.375	50.36	+8.17	42.19	74.00	31.81	peak	150	339	P	
3	8635.125	48.46	+1.43	47.03	74.00	26.97	peak	150	318	P	
4	11693.000	47.56	1.37	48.93	74.00	25.07	peak	150	33	P	
5	13514.125	46.52	3.93	50.45	74.00	23.55	peak	150	360	P	
6	16013.125	45.03	4.79	49.82	74.00	24.18	peak	150	360	P	

CH63

Vertical



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Site: LAB Chamber 2

Polarization: **Vertical**

Temperature: 25(C)

Limit: FCC Part15 RE-Class C\_Above 1GHz\_PK

Power:

Humidity: 50 %

EUT:

Distance: 3m

M/N: N2-OTAA-01

Mode: 914.9MHz


Note: KAIROS WATER, INC.

No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Asimuth (deg.)	P/F	Remark
1	2744.625	64.77	+15.27	49.50	74.00	24.50	peak	150	22	P	
2	4429.750	51.56	+8.70	42.86	74.00	31.14	peak	150	75	P	
3	7300.625	48.89	+3.05	45.84	74.00	28.16	peak	150	233	P	
4	11104.375	48.07	0.77	48.84	74.00	25.16	peak	150	148	P	
5	13563.000	47.47	3.95	51.42	74.00	22.58	peak	150	1	P	
6	17451.750	42.37	8.96	51.33	74.00	22.67	peak	150	348	P	

## REMARKS:

1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB/m)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB) - Pre-amplifier Factor
3. Margin value = Limit value - Emission level.
4. RBW 1MHz VBW 3MHz Peak detector is for PK value; RBW 1MHz VBW 10Hz Peak detector is for AV value.
5. Other emissions are attenuated 20dB below the limits from 9kHz to 30MHz, so it does not recorded in report.
6. 18GHz-26GHz not recorded for no spurious point have a margin of less than 6 dB with respect to the limits.

CH00
Vertical

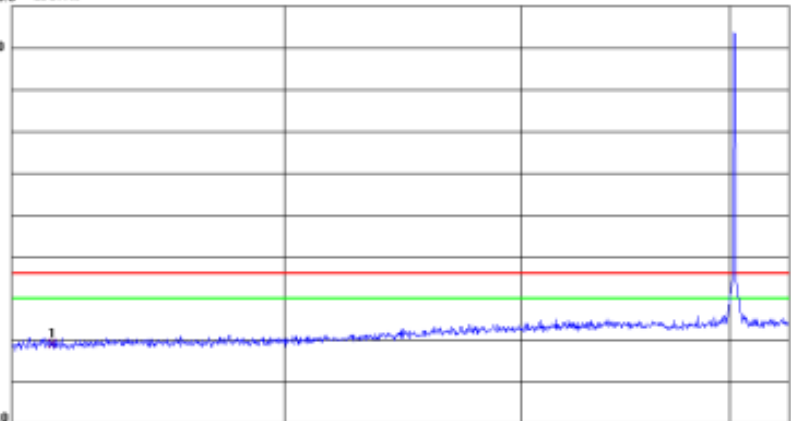


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### Radiated Emission Measurement

File :RF\_10      Data :#416      Date: 2024/10/15      Time: 21:05:11

110.0    dBuV/m



(MHz)

930.000

Site: LAB Chamber 2

Limit: FCC Part15 RE-Class C\_30-1000MHz

EUT:

M/N: N2-OTAA-01

Mode: 902.3MHz

Note: KAIROS WATER, INC.

Polarization: Vertical

Power:

Distance: 3m

Temperature: 25(C)

Humidity: 50 %

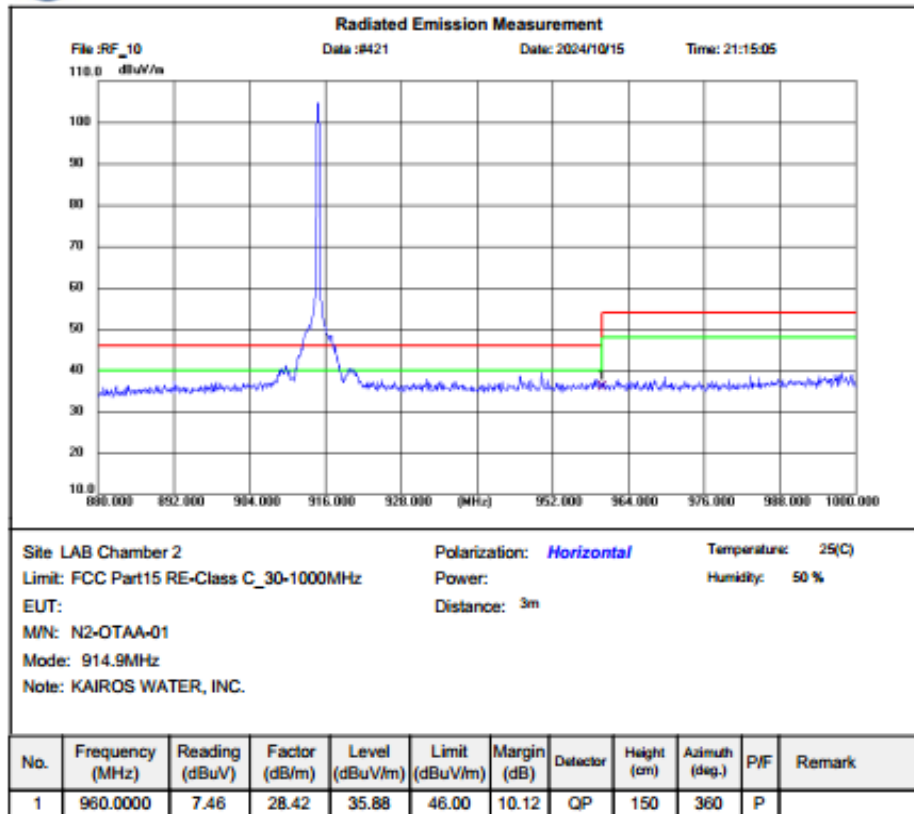
No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Azimuth (deg.)	P/F	Remark
1	614.0000	5.65	22.87	28.52	46.00	17.48	QP	150	0	P	

CH63

Horizontal



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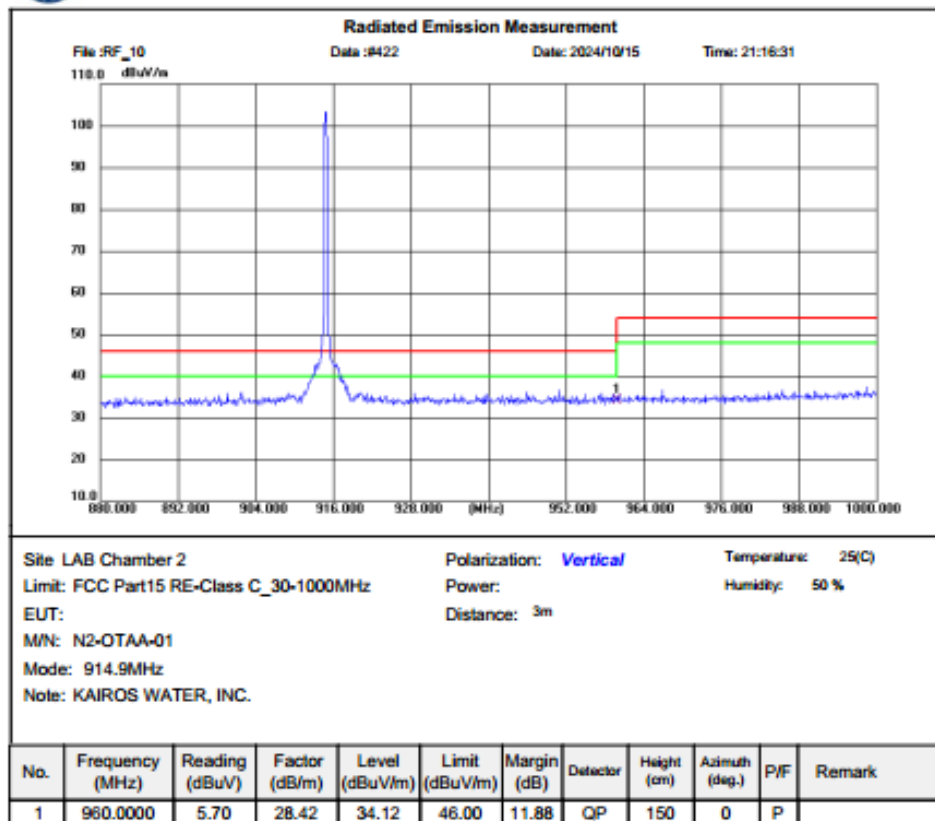


CH63

Vertical



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## REMARKS:

1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB/m)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB) - Pre-amplifier Factor
3. Margin value = Limit value - Emission level.
4. RBW 1MHz VBW 3MHz Peak detector is for PK value; RBW 1MHz VBW 10Hz Peak detector is for AV value.
5. For fundamental frequency, RBW 3MHz VBW 3MHz Peak detector is for PK Value; RMS detector is for AV value.
6. Other emissions are attenuated 20dB below the limits from 9kHz to 30MHz, so it does not recorded in report.

### 3.3. Maximum Peak Output Power

#### Limit

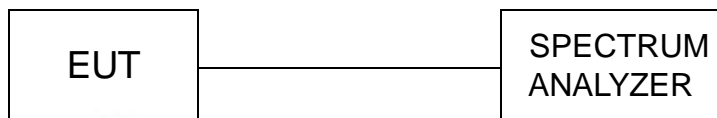
For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

#### Test Procedure

Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the Spectrum Analyzer.

- a) Set the RBW=200KHz..
- b) Set VBW=200KHz.
- c) Set span $\geq$ [3 $\times$ RBW].
- d) Sweep time = auto couple.
- e) Detector=peak.
- f) Trace mode=max hold.
- g) Allow trace to fully stabilize.
- h) Use peak marker function to determine the peak amplitude level.

#### Test Configuration



#### Test Results

Raw data reference to Section 2 from CTL2407153031-WF\_LoRa\_Appendix.

### 3.4. 20dB Bandwidth

#### Limit

The following table provides a shorthand summary of the FHSS power limits and other basic requirements, per Sections 15.247(a), 15.247(b)(1), and 15.247(b)(2).

902-928 MHz	$P_{\text{max-pk}} \leq 1 \text{ W}$ $N_{\text{ch}} \geq 50$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $BW_{20\text{dB}} \leq 250 \text{ kHz}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 20 \text{ s}$	$P_{\text{max-pk}} \leq 0.25 \text{ W}$ $25 \leq N_{\text{ch}} < 50$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $250 \text{ kHz} < BW_{20\text{dB}} \leq 500 \text{ kHz}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 10 \text{ s}$
2400-2483.5 MHz	$P_{\text{max-pk}} \leq 1 \text{ W}$ $N_{\text{ch}} \geq 75$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $\text{max. } BW_{20\text{dB}} \text{ not specified}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 0.4 \cdot N_{\text{ch}}$	$P_{\text{max-pk}} \leq 0.125 \text{ W}$ $N_{\text{ch}} \geq 15$ $\Delta f \geq [ \text{MAX} \{ 25 \text{ kHz}, 0.67 \cdot BW_{20\text{dB}} \} \text{ OR } \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \} ]$ $\text{max. } BW_{20\text{dB}} \text{ not specified}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 0.4 \cdot N_{\text{ch}}$
5725-5850 MHz	$P_{\text{max-pk}} \leq 1 \text{ W}$ $N_{\text{ch}} \geq 75$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $BW_{20\text{dB}} \leq 1 \text{ MHz}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 30 \text{ s}$	

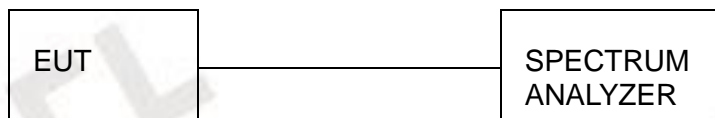
$t_{\text{ch}}$  = average time of occupancy;  $T$  = period;  $N_{\text{ch}}$  = # hopping frequencies;  
 BW = bandwidth;  $\Delta f$  = hopping channel carrier frequency separation

#### Test Procedure

The transmitter output was connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 30 KHz RBW and 91 KHz VBW.

The 20dB bandwidth is defined as the total spectrum the power of which is higher than peak power minus 20dB.

#### Test Configuration



#### Test Results

Raw data reference to Section 1 from CTL2407153031-WF\_LoRa\_Appendix.

### 3.5. Frequency Separation

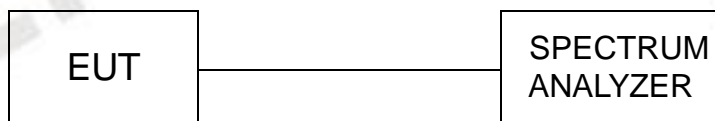
#### LIMIT

According to 15.247(a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by minimum of 25KHz or the  $2/3 \times 20\text{dB}$  bandwidth of the hopping channel, whichever is greater.

#### TEST PROCEDURE

The transmitter output was connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 300 KHz RBW and 300 KHz VBW.

#### TEST CONFIGURATION



#### TEST RESULTS

Raw data reference to Section 3 from CTL2407153031-WF\_LoRa\_Appendix.



### 3.6. Number of hopping frequency

#### Limit

FCC §15.247 (a)(1)(i)

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

#### Test Procedure

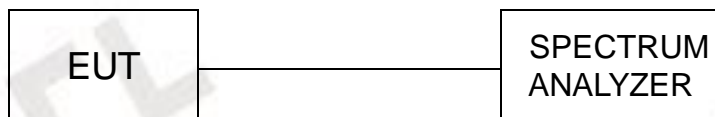
According to ANSI C63.10-2013 Section 7.8.3

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

- a) Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
- b) RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- c) VBW  $\geq$  RBW.
- d) Sweep: Auto.
- e) Detector function: Peak.
- f) Trace: Max hold.
- g) Allow the trace to stabilize

It might prove necessary to break the span up into subranges to show clearly all of the hopping frequencies. Compliance of an EUT with the appropriate regulatory limit shall be determined for the number of hopping channels. A plot of the data shall be included in the test report.

#### Test Configuration



#### Test Results

Raw data reference to Section 4 from CTL2407153031-WF\_LoRa\_Appendix.

### 3.7. Time of Occupancy (Dwell Time)

#### Limit

FCC §15.247 (a)(1)(i)

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the averagetime of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

#### Test Procedure

The transmitter output was connected to the spectrum analyzer through an attenuator. Set center frequency of spectrum analyzer=operating frequency with 910 KHz RBW and 910 KHz VBW, Span 0Hz.

#### Test Configuration



#### Test Results

Raw data reference to Section 5 from CTL2407153031-WF\_LoRa\_Appendix.

### 3.8. Out-of-band Emissions

#### Limit

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required.

#### Test Procedure

Connect the transmitter output to spectrum analyzer using a low loss RF cable, and set the spectrum analyzer to RBW=100 kHz, VBW= 300 kHz, peak detector, and max hold. Measurements utilizing these settings are made of the in-band reference level, band edge and out-of-band emissions.

#### Test Configuration



#### Test Results

Raw data reference to Section 6 from CTL2407153031-WF\_LoRa\_Appendix.

### 3.9. Antenna Requirement

#### Standard Applicable

For intentional device, according to FCC 47 CFR Section 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.

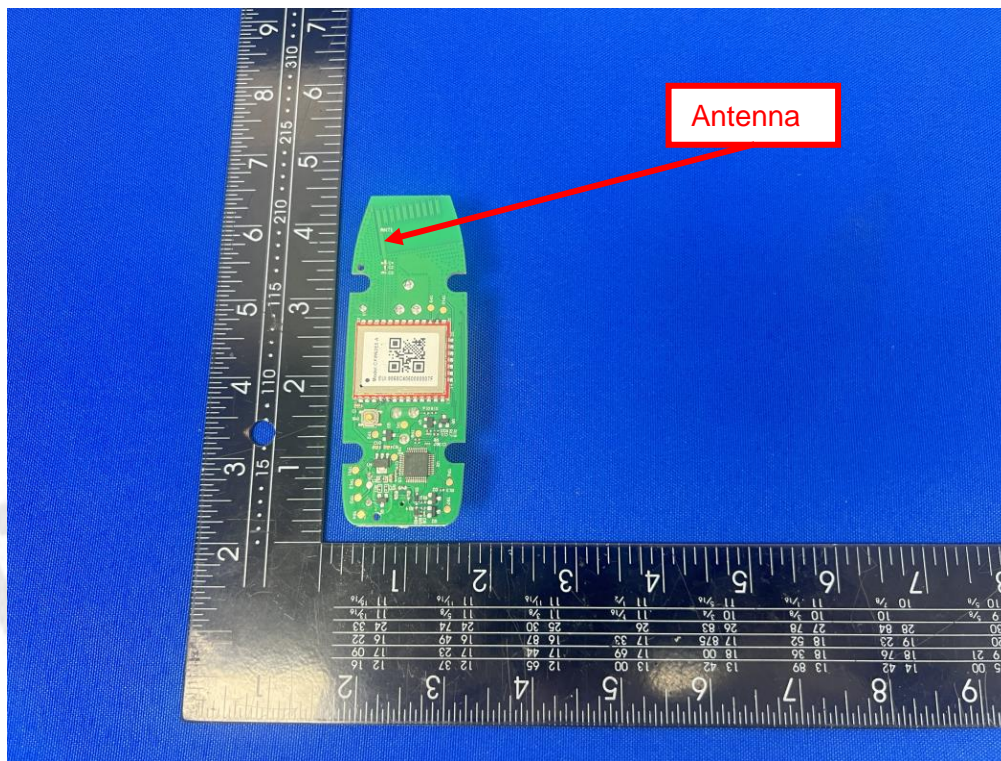
And according to FCC 47 CFR Section 15.247 (b), if transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

#### **Refer to statement below for compliance**

The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited. Further, this requirement does not apply to intentional radiators that must be professionally installed.

#### Antenna Connected Construction

The maximum gain of antenna was 2.47dBi





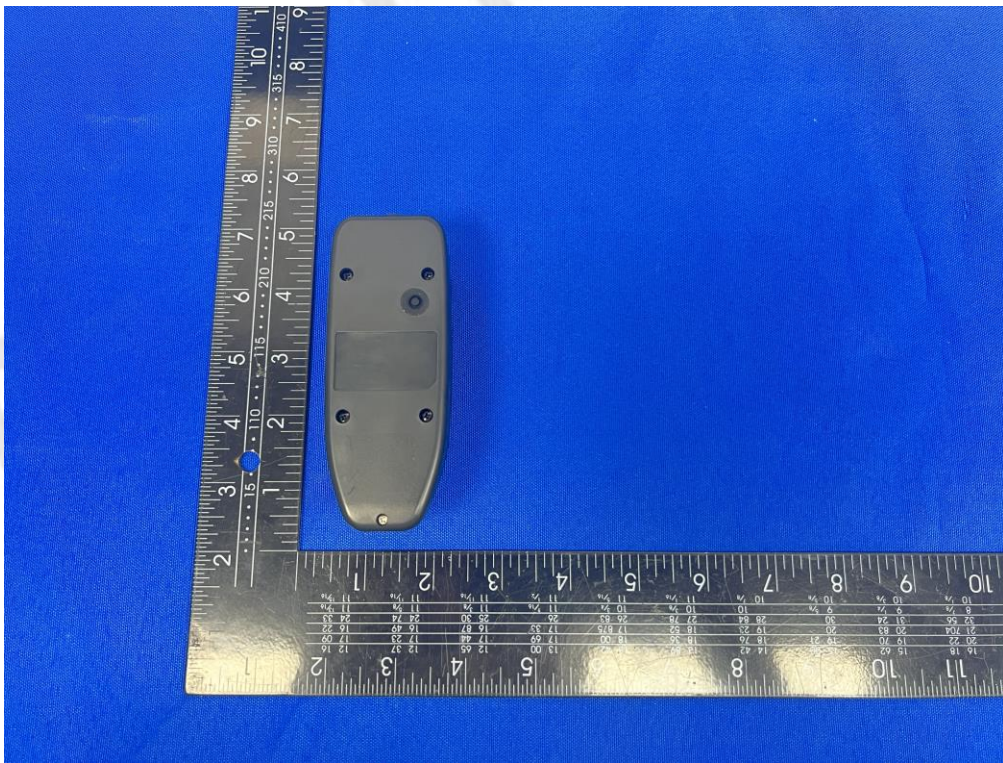
#### 4. Test Setup Photos of the EUT



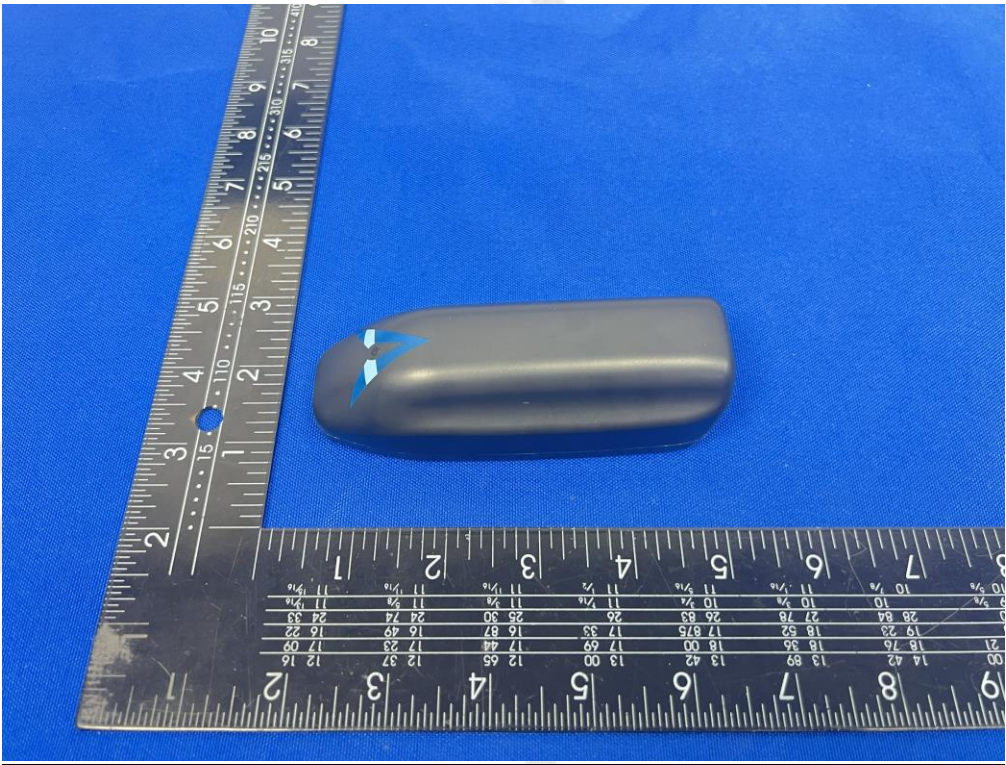
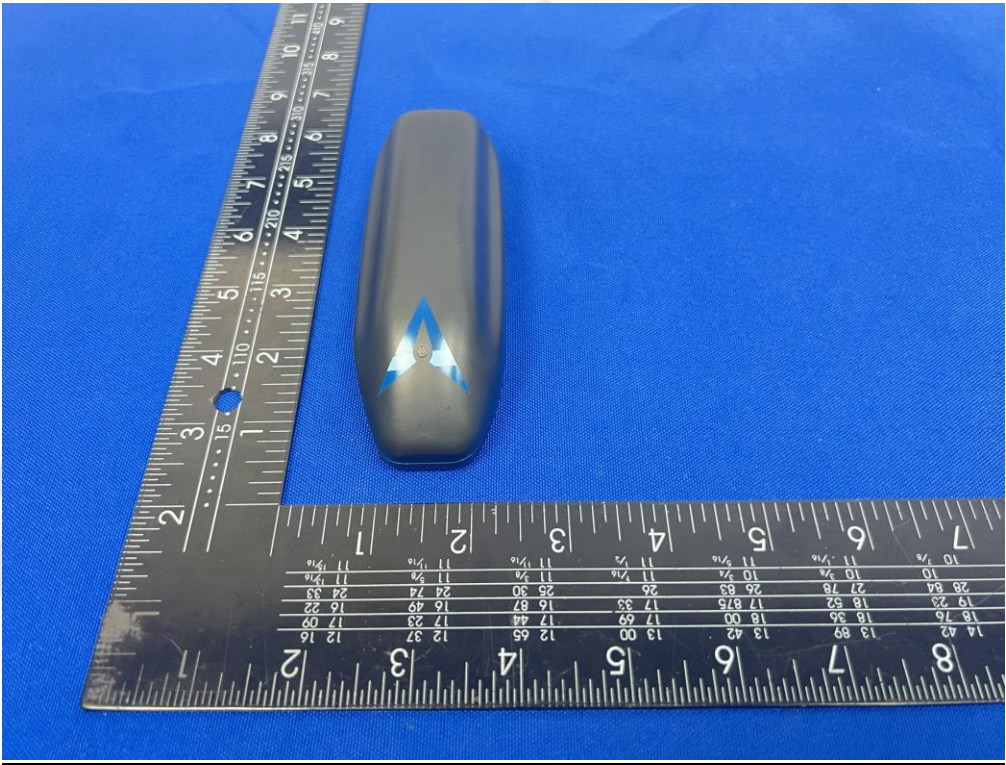


## 5. Photos of the EUT

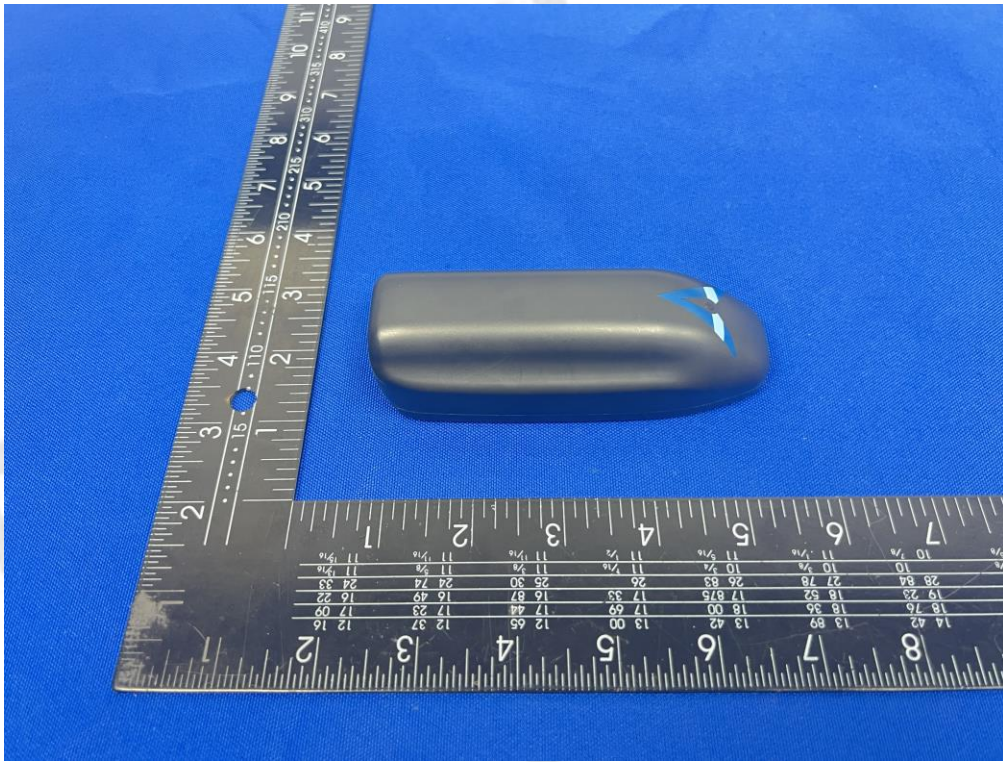
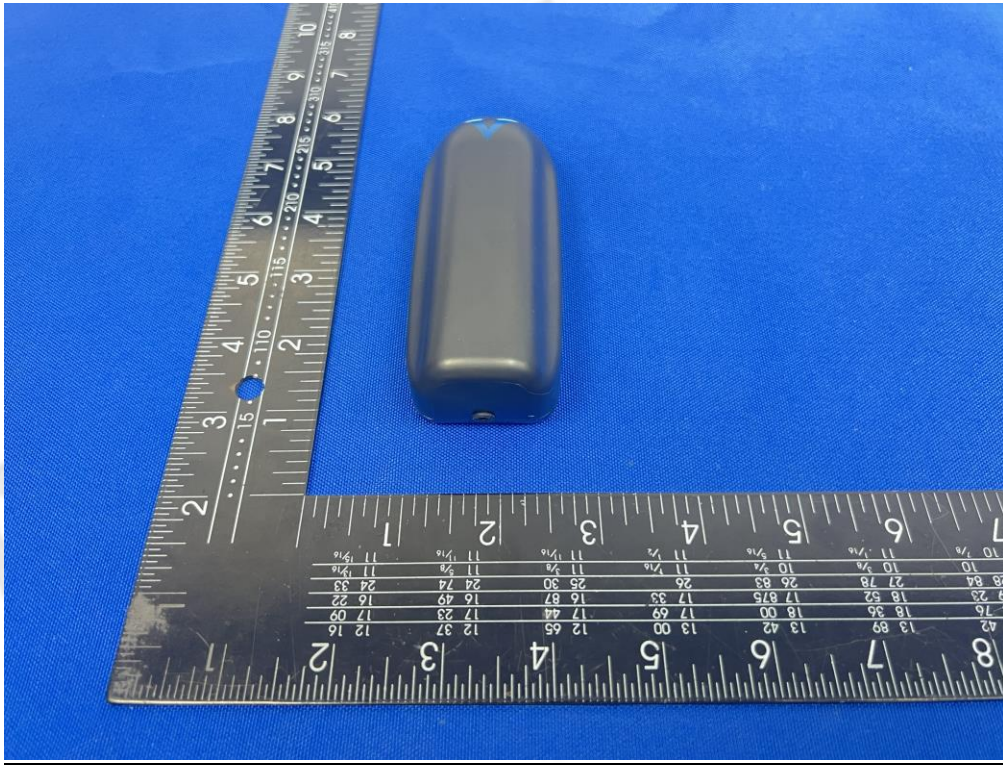
### External Photos of EUT



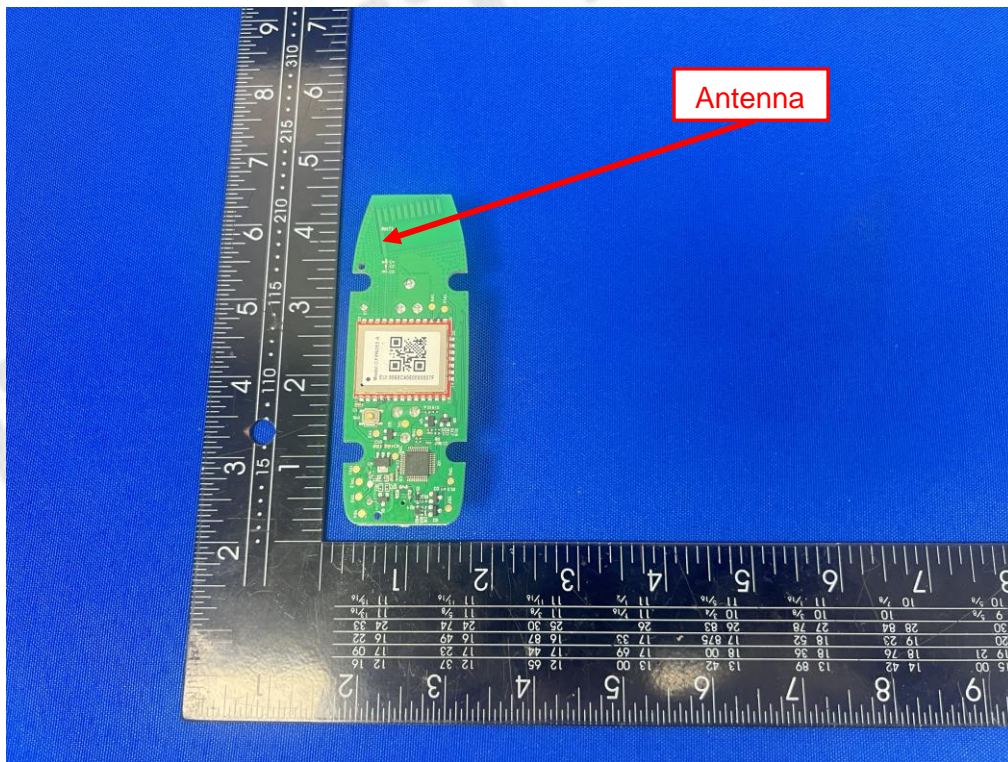




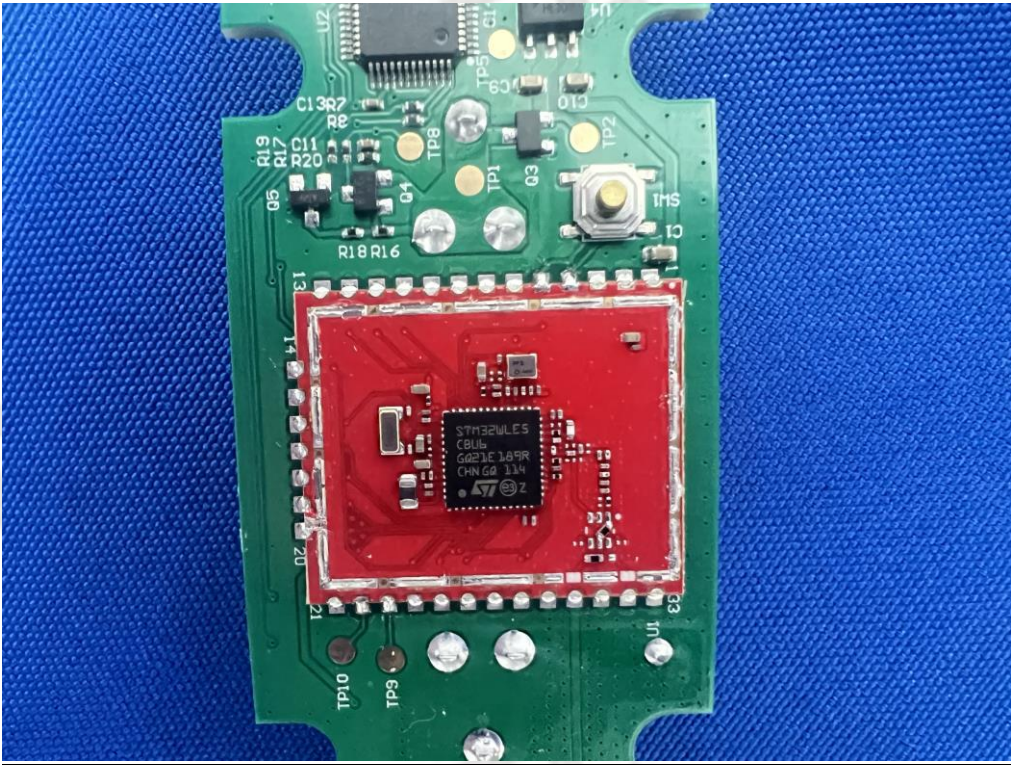
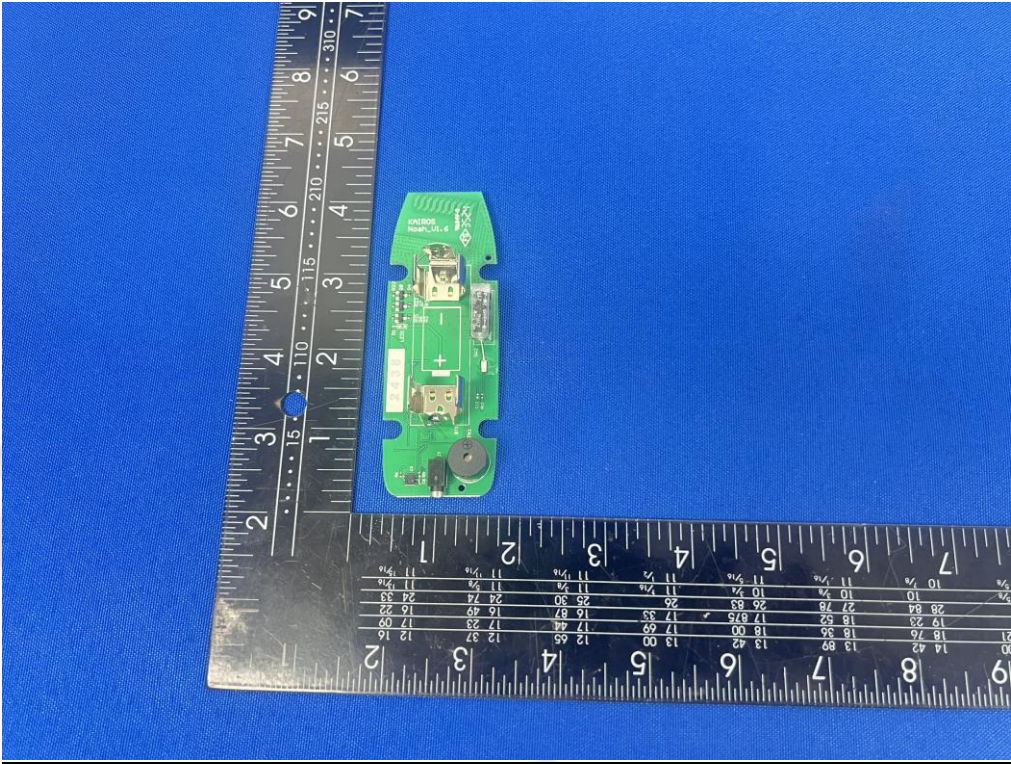




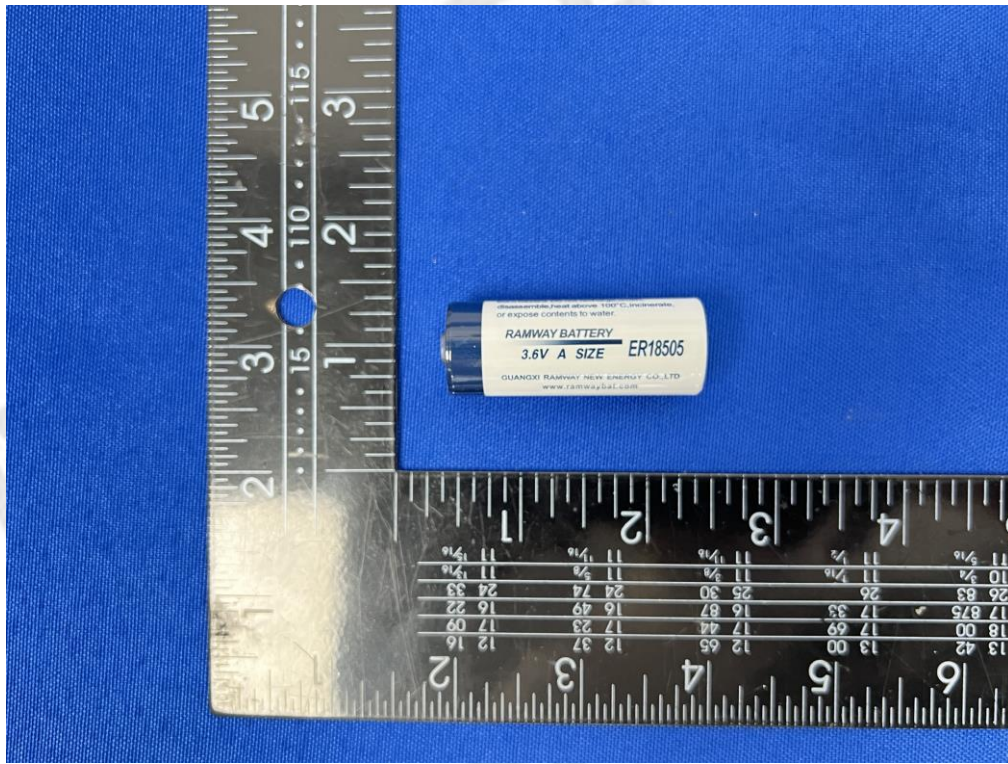
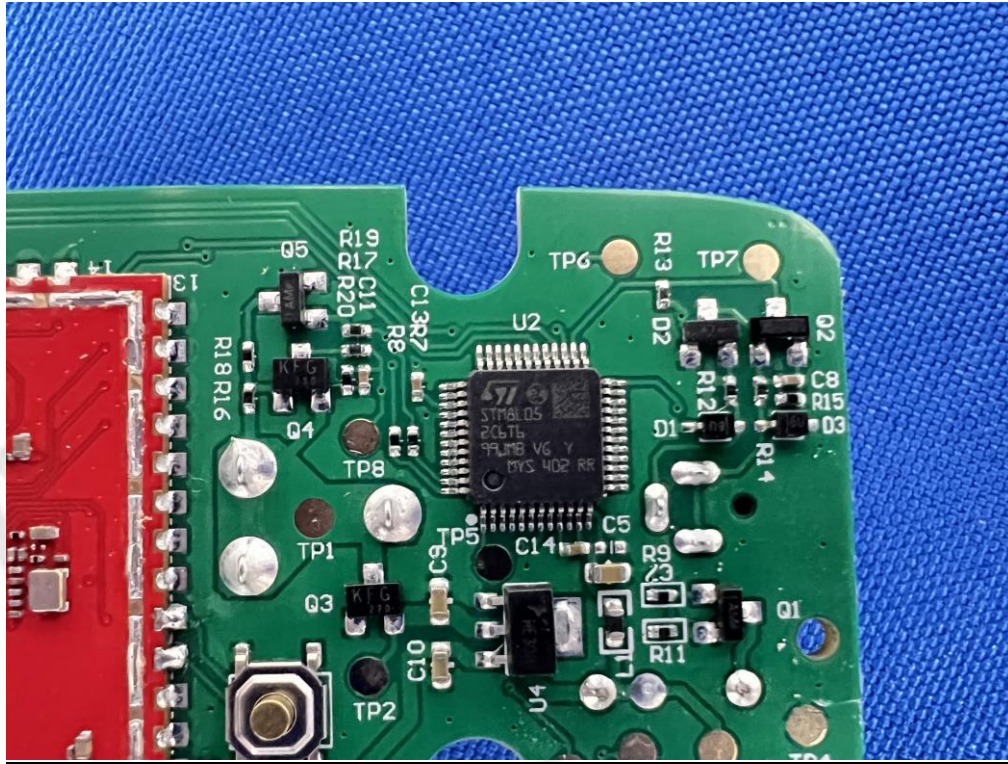


Internal Photos of EUT









\*\*\*\*\* End of Report \*\*\*\*\*