ENGINEERING TEST REPORT

QGateway
Model: GTW-RF-3311
FCC ID: 2AS43-GW200

Applicant:

Qualitrol Corporation
1385 Fairport Rd
Fairport, NY 14450
USA

In Accordance With

Federal Communications Commission (FCC)
Part 15, Subpart C, Section 15.247
Digital Modulation Systems (DTS) Operating in 902 – 928 MHz Band

UltraTech's File No.: 22QUALC008_FCC15C247

This Test report is Issued under the Authority of Tri M. Luu Vice President of Engineering UltraTech Group of Labs Date: July 12, 2022	
Report Prepared by: Dan Huynh Issued Date: July 12, 2022	Tested by: Nimisha Desai Test Dates: June 10, 13 &14, 2022

- *The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.*
- *This report must not be used by the client to claim product endorsement by any agency of the US Government.*
- *This test report shall not be reproduced, except in full, without a written approval from UltraTech*

TABLE OF CONTENTS

EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	FCC Part 15, Subpart C, Section 15.247
Title:	Code of Federal Regulations (CFR), Title 47 – Telecommunication, Part 15 – Radio Frequency Devices
Purpose of Test:	Equipment Certification for Digital Modulation Systems (DTS) Operating Under §15.247
Test Procedures:	▪ ANSI C63.4 ▪ ANSI C63.10 ▪ FCC KDB Publication No. 558074 D01 15.247 Meas Guidance v05r02
Environmental Classification:	[x] Commercial, industrial or business environment [ ] Residential environment

1.2. RELATED SUBMITTAL(S)/GRANT(S)

None.

1.3. NORMATIVE REFERENCES

Publication	Year	Title
47 CFR Parts 0-19	2021	Code of Federal Regulations (CFR), Title 47 – Telecommunication
ANSI C63.4	2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 KHz to 40 GHz
ANSI C63.10	2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
FCC, KDB Publication No. 558074 D01 15.247 Meas Guidance v05r02	2019	GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

Applicant	
Name:	Qualitrol Corporation
Address:	1385 Fairport Rd Fairport, NY 14450 USA

Manufacturer	
Name:	Qualitrol Corporation
Address:	1385 Fairport Rd Fairport, NY 14450 USA

2.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information (with the exception of the Date of Receipt) has been supplied by the applicant.

Brand Name:	Qualitrol Corporation
Product Name:	QGateway
Model Name or Number:	GTW-RF-3311
Serial Number:	Test Sample
Type of Equipment:	Digital Transmission System (DTS)
Input Power Supply Type:	Internal, solar rechargeable, 3 x D cells
Primary User Functions of EUT:	LoRa to cellular conversion

2.3. EUT'S TECHNICAL SPECIFICATIONS

Transmitter	
Equipment Type:	Mobile Base station (fixed use)
Intended Operating Environment:	Commercial, industrial or business environment
Power Supply Requirement:	Internal, solar rechargeable, 3 x D cells
RF Output Power Rating:	17.33 dBm maximum conducted power
Operating Frequency Range:	915 MHz
RF Output Impedance:	50 Ω
Duty Cycle:	Continuous
Modulation Type:	LoRa
Antenna Connector Types:	RP-SMA

2.4. ASSOCIATED ANTENNA DESCRIPTIONS

Manufacturer	Antenna Type	Model or P/N	Maximum Gain (dBi)
Nearson	½ wave whip, right angle	S161AH-915R	2.5

2.5. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	Antenna Port	1	RP-SMA	Direct connection

2.6. ANCILLARY EQUIPMENT

The EUT was tested while connected to the following representative configuration of ancillary equipment necessary to exercise the ports during tests:

None.

EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

3.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21 to 23 ^{o}C
Humidity:	45 to 58%
Pressure:	102 kPa
Power Input Source:	3 x D cells

3.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TESTS

Operating Modes:	The transmitter was operated in a continuous transmission mode with the carrier modulated as specified in the Test Data.
Special Test Software:	N/A
Special Hardware Used:	N/A
Transmitter Test Antenna:	The EUT is tested with the antenna fitted in a manner typical of normal intended use as non-integral antenna equipment as described with the test results.

Transmitter Test Signals	
Frequency Band(s):	915 MHz
Frequency(ies) Tested:	915 MHz
RF Power Output: (measured maximum peak conducted output power)	17.33 dBm
Normal Test Modulation:	LoRa
Modulating Signal Source:	Internal

EXHIBIT 4. SUMMARY OF TEST RESULTS

4.1. LOCATION OF TESTS

All of the measurements described in this report were performed at Ultratech Group of Labs located in the city of Oakville, Province of Ontario, Canada.

- AC Power Line Conducted Emissions were performed in UltraTech's shielded room, 24'(L) by 16'(W) by 8'(H).

- Radiated Emissions were performed at the Ultratech's 3-10 TDK Semi-Anechoic Chamber situated in the Town of Oakville, province of Ontario. This test site been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Sec. 2.948 of the FCC Rules. The descriptions and site measurement data of the Oakville 3-10 TDK Semi-Anechoic Chamber has been filed with ANAB File No.: AT-1945.

4.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Compliance (Yes/No)
15.203	Antenna requirements	Yes[1]
15.207(a)	AC Power Line Conducted Emissions	N/A[2]
15.247(a)(2)	6 dB Bandwidth	Yes
15.247(b)(3)	Peak Conducted Output Power	Yes
15.247(d)	Band-Edge and RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	--
15.247(d), 15.209 & 15.205	Band-Edge and Transmitter Spurious Radiated Emissions	Yes
15.247(e)	Power Spectral Density	Yes
15.247(i), 1.1307, 1.1310, 2.1091	RF Exposure	Yes

[1] The EUT complies with the requirement; it employs a unique (non-standard) antenna connector or integral antenna.

[2] The EUT is used exclusively in electrical power utilities and is exempted pursuant to section 15.103(b).

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None.

EXHIBIT 5. TEST DATA

5.1. OCCUPIED BANDWIDTH [§ 15.247(a)(2)]

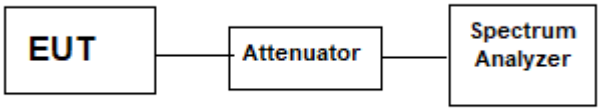
5.1.1. Limit(s)

The minimum 6 dB bandwidth shall be at least 500 kHz.

5.1.2. Method of Measurements

FCC KDB 558074 D01 15.247 Meas Guidance V05r02, Section 8.2, ANSI C63.10, 11.8.2 Option 2

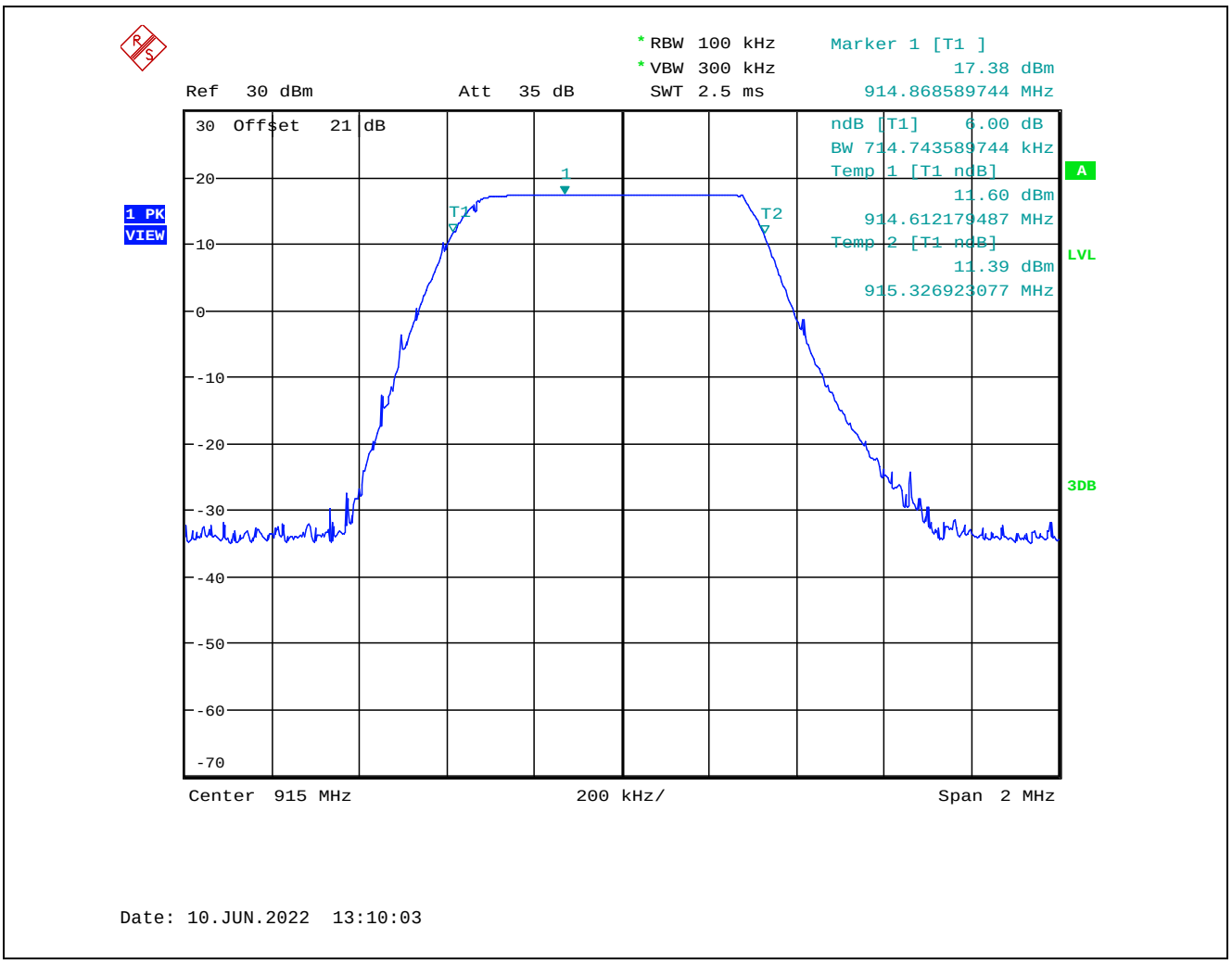
5.1.3. Test Arrangement



5.1.4. Test Data

Modulation	Frequency (MHz)	6dB BW (kHz)	Min. Limit (kHz)
LoRa	915	714.744	500

Plot 5.1.4.1. 6 dB Bandwidth, LoRa Modulation, 915 MHz



5.2. PEAK CONDUCTED OUTPUT POWER - DTS [§ 15.247(b)(3)]

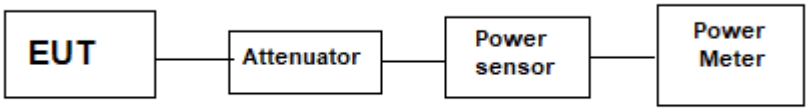
5.2.1. Limit(s)

§ 15.247(b)(3): For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the *maximum conducted output power* is the highest total transmit power occurring in any mode.

5.2.2. Method of Measurements

KDB 558074 D01 15.247 Meas Guidance V05r02, Section 8.3.2.3 Measurement using Power meter Method Subclause 11.9.2.3 of ANSI C63.10.

5.2.3. Test Arrangement



5.2.4. Test Data

Modulation	Frequency (MHz)	Maximum Conducted (average) Output Power (dBm)	Maximum Antenna Gain (dBi)	EIRP (dBm)	Peak Power Limit (dBm)	EIRP Limit (dBm)
LoRa	915	17.33	2.5	19.83	30	36

5.3. TRANSMITTER SPURIOUS RADIATED EMISSIONS AT 3 METERS [§§ 15.247(d), 15.209 & 15.205]

5.3.1. Limit(s)

§ 15.247 (d): 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 Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

Section 15.205(a) - Restricted Bands of Operation

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
[1] 0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2655–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	[2]
13.36–13.41.			

[1] Until February 1, 1999, this restricted band shall be 0.490–0.510 MHz.
[2] Above 38.6

Section 15.209(a) - Field Strength Limits within Restricted Frequency Bands

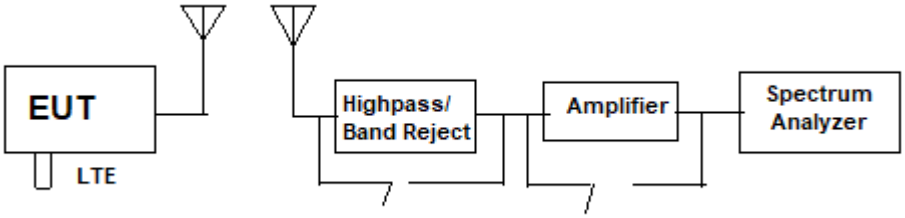
Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 - 0.490	2,400 / F (kHz)	300
0.490 - 1.705	24,000 / F (kHz)	30
1.705 - 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3

5.3.2. Method of Measurements

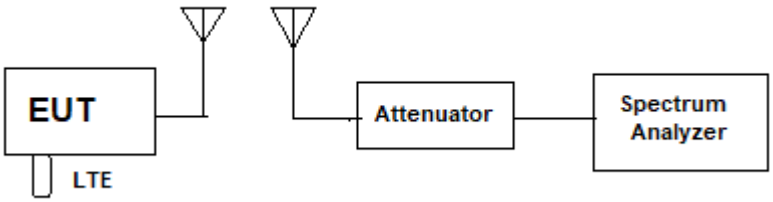
KDB 558074 D01 DTS Meas Guidance v05r02 Sections 8.5, 8.6 and 8.7 or
ANSI C63.10.subclauses 11.11, 11.12 and 6.10.6.2.

5.3.3. Test Arrangement

Transmitter Radiated Emissions



Band-Edge Radiated Emissions



5.3.4. Test Data

Remark(s):
- All spurious emissions that are in excess of 20 dB below the specified limit shall be recorded.
- The following test data represent the worst-case derived from exploratory tests.

5.3.4.1. Spurious Radiated Emission

Fundamental Frequency: 915 MHz

Test Frequency Range: 30 MHz – 10 GHz

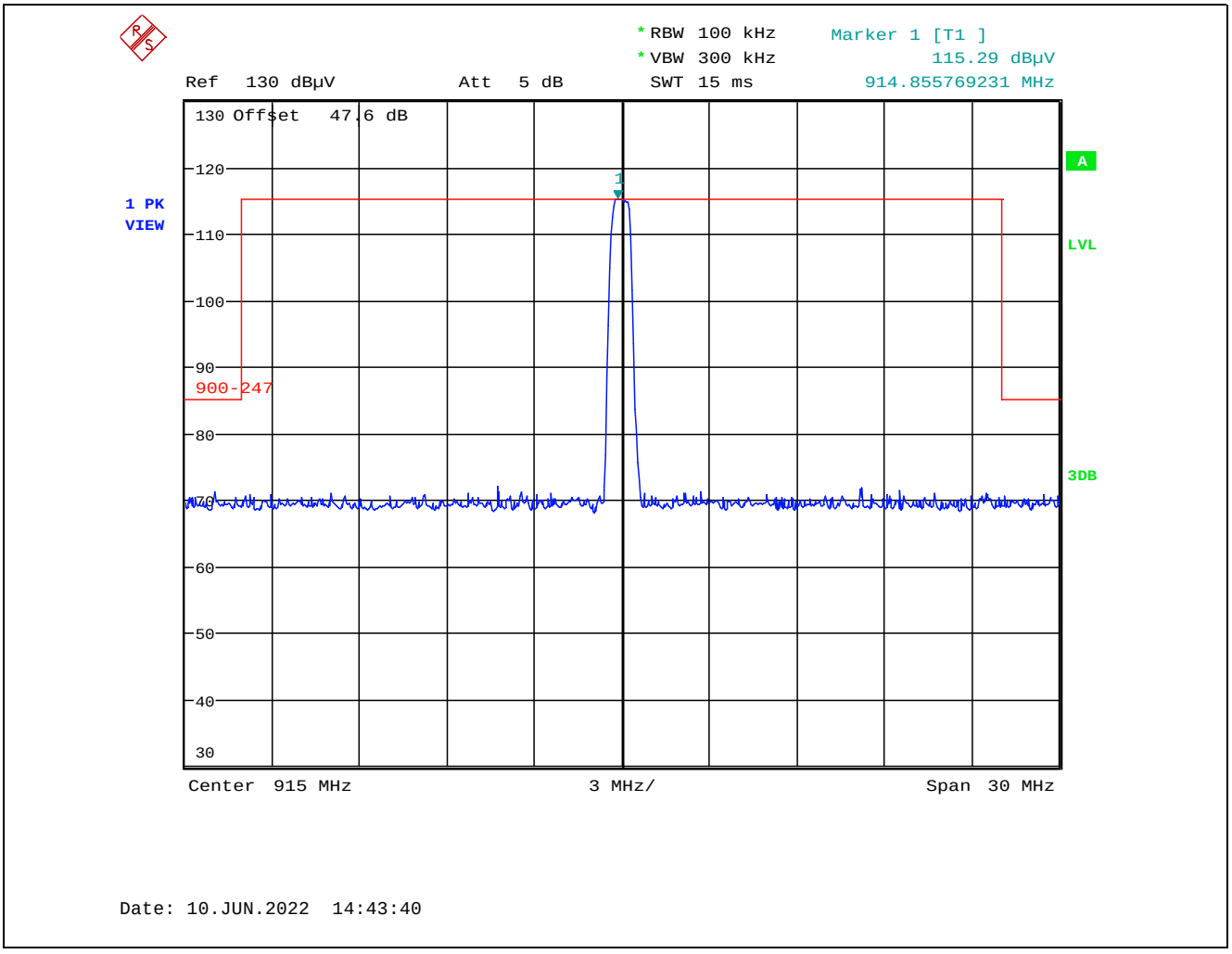
Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
915.0	115.29	--	V	--	--	--	--
915.0	116.31	--	H	--	--	--	--
2745.0	58.18	53.09	V	54.0	86.3	-0.9	Pass*
2745.0	58.26	52.93	H	54.0	86.3	-1.1	Pass*
3660.0	59.55	51.97	V	54.0	86.3	-2.0	Pass*
3660.0	57.42	50.14	H	54.0	86.3	-3.9	Pass*
4575.0	60.67	50.67	V	54.0	86.3	-3.3	Pass*
4575.0	57.92	48.86	H	54.0	86.3	-5.1	Pass*
7320.0	55.45	43.60	V	54.0	86.3	-10.4	Pass*
7320.0	53.37	41.58	H	54.0	86.3	-12.4	Pass*
8235.0	47.40	34.30	V	54.0	86.3	-19.7	Pass*
8235.0	47.33	34.73	H	54.0	86.3	-19.3	Pass*
9150.0	48.83	36.55	V	54.0	86.3	-17.5	Pass*
9150.0	49.24	35.57	H	54.0	86.3	-18.4	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

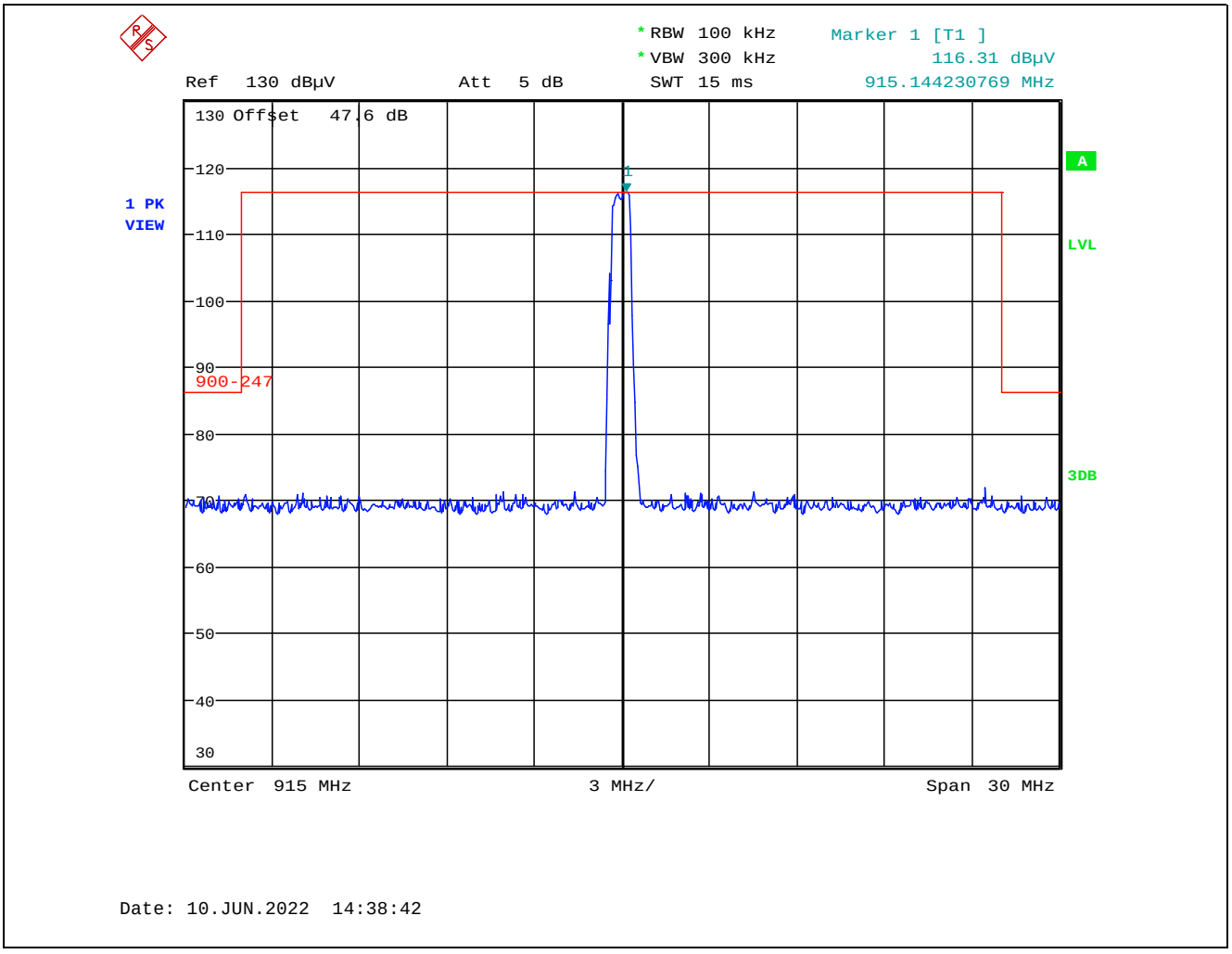
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

5.3.4.2. Band-Edge RF Radiated Emission

Plot 5.3.4.2.1. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, Peak, 915 MHz



Plot 5.3.4.2.2. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, Peak, 915 MHz



5.4. POWER SPECTRAL DENSITY [§ 15.247(e)]

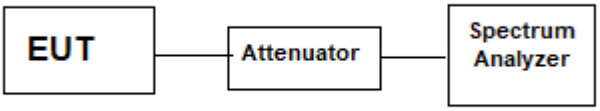
5.4.1. Limit(s)

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

5.4.2. Method of Measurements

FCC KDB 558074 D01 15.247 Meas Guidance V05r02, Section 8.4 , ANSI C63.10, 11.10.3 AVGPSD-1

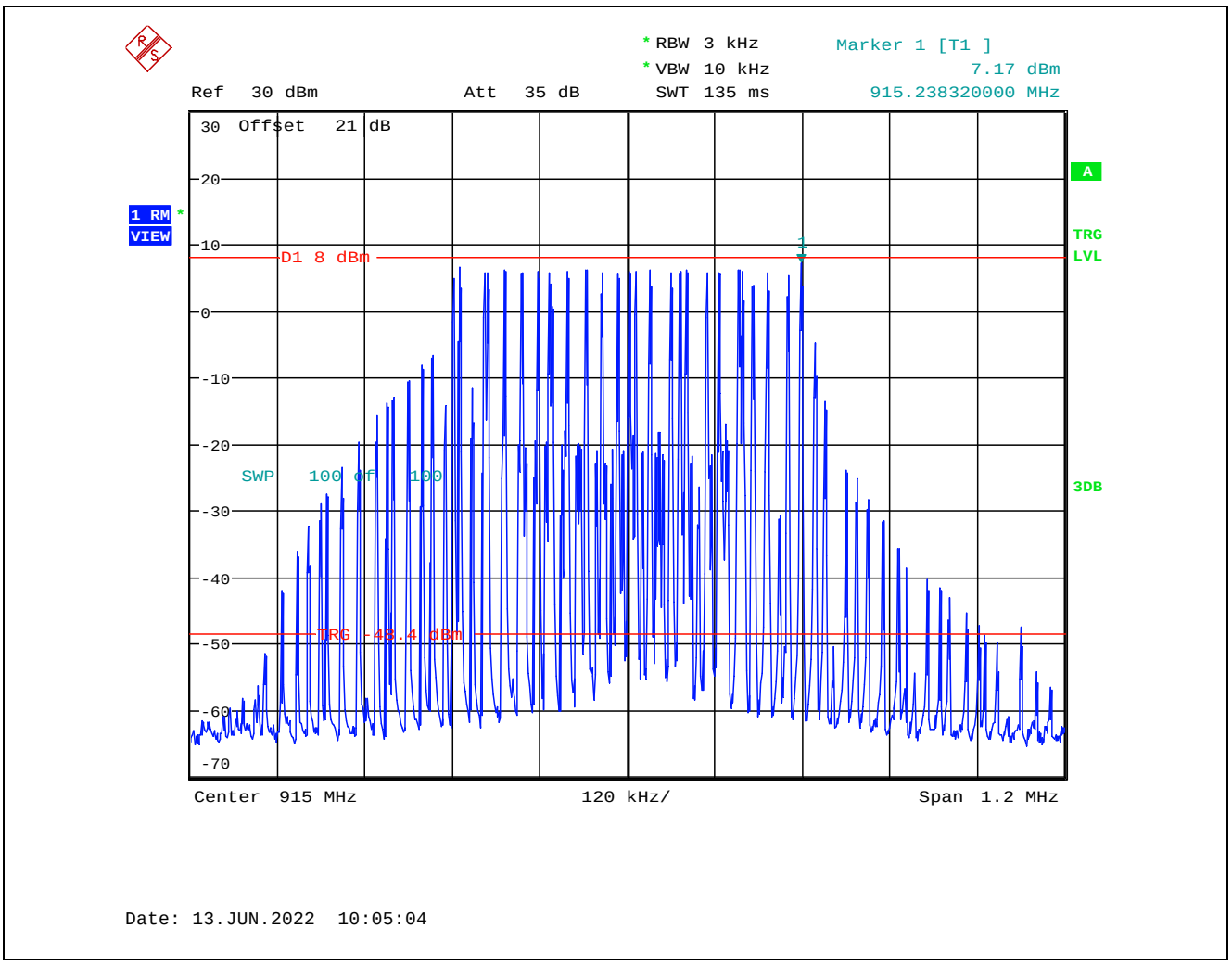
5.4.3. Test Arrangement



5.4.4. Test Data

Modulation	Frequency (MHz)	PSD (dBm)	Max. Limit (dBm)	Margin (dBm)
LoRa	915	7.17	8	-0.83

Plot 5.4.4.1. Power Spectral Density, LoRa Modulation, 915 MHz
Sweep points: 5000, Sweep count: 100 traces



5.5. RF EXPOSURE REQUIRMENTS [§§ 15.247(i), 1.1310 & 2.1091]

5.5.1. Limits

§ **1.1310:** The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b).

Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3-3.0	614	1.63	*(100)	6
3.0-30	1842/f	4.89/f	*($900/f^2$)	6
30-300	61.4	0.163	1.0	6
300-1500			f/300	6
1500-100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*($180/f^2$)	30
30-300	27.5	0.073	0.2	30
300-1500			f/1500	30
1500-100,000			1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density

Note 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

Note 2: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

5.5.2. Method of Measurements

Calculation Method of Power Density/RF Safety Distance:

$$S = \frac{PG}{4\pi \cdot r^2} = \frac{EIRP}{4\pi \cdot r^2}$$

Where, P: power input to the antenna in mW
EIRP: Equivalent (effective) isotropic radiated power.
S: power density mW/cm^2
G: numeric gain of antenna relative to isotropic radiator
r: distance to centre of radiation in cm

5.5.3. RF Evaluation

Pursuant to FCC KDB 447498 D01 General RF Exposure Guidance v06, Section 7.2:

Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0, according to calculated/estimated, numerically modeled, or measured field strengths or power density.

The EUT consisted of a LoRa Transmitter and a certified u-blox AG SARA-R410M LTE Cat M1 module (FCC ID: XPY2AGQN4NNN, IC: 8595A-2AGQN4NNN). The table below is a summary of the calculated MPE ratios for co-location at an evaluation distance of 20 cm.

Source	Maximum MPE Ratio
LoRa 915 MHz Transmitter	**0.019**
u-blox AG SARA-R410M LTE Cat M1 module	**0.324**
Sum of the MPE ratios from all sources	**0.343**

The sum of the MPE ratios from all sources is < 1. Thus, in compliant with general population/uncontrolled exposure MPE limit.

For detailed MPE ratio calculation for LoRa Transmitter and certified u-blox AG LTE Cat M1 module, refer to the following tables.

Calculated MPE Ratio for LoRA Transmitter (EUT) with 2.5 dBi Antenna							
Frequency (MHz)	**Maximum Conducted EUT Power (dBm)**	**Maximum Antenna Gain (dBi)**	**Maximum EIRP (mW)**	**Evaluation Distance (cm)**	**Power Density (mW/cm^2)**	**MPE Limit (mW/cm2)**	**MPE Ratio**
915	17.33	2.5	96.161	20	0.019	1.000	**0.019**

Calculated MPE Ratio for u-blox AG SARA-R410M LTE Cat-M1 Module									
LTE Band	**Frequency (MHz)**	**[1]Input Power of the Antenna (dBm)**	**[2]Antenna Gain (dBi)**	**Max. E.I.R.P. (dBm)**	**Max. E.I.R.P. (mW)**	**Evaluation Distance (cm)**	**Calculation (mW/cm^2)**	**Limit (mW/cm^2)**	**MPE Ratio**
B12	699.7	25.0	3.67	28.67	736.21	20	0.146	0.466467	0.314
B2	1909.3	25.0	7.12	32.12	1629.30	20	0.324	1.0	**0.324**

[1] Data derived from u-blox AG SARA-R410M LTE Cat-M1 Module MPE test report is the worst case, Test Report No. N/A (FCC ID: XPY2AGQN4NNN, IC: 8595A-2AGQN4NNN).

[2] Maximum permitted antenna gain.

EXHIBIT 6. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Cal. Due Date
Peak power Analyzer	HP	8991A	3342A00657	Sensor dependant	11 Mar 2024
Power sensor	HP	84814A	3205A00175	0.5-40GHz	11 Mar 2024
Attenuator	Radiall	R411.820.121	-	DC–18 GHz	See Note 1
Spectrum Analyzer	Rohde & Schwarz	FSU26	100398	20Hz–26.5 GHz	20 Sep 2023
EMI Receiver	Rohde & Schwarz	ESU40	100037	20Hz–40 GHz	01 Sep 2022
Biconilog Antenna	EMCO	3142C	00026873	26-2000MHz	16 Dec 2023
Horn Antenna	ETS	3115	5955	1-18GHz	12 Oct 2022
Horn Antenna	ETS	3117	00119425	1-18GHz	20 Jan 2024
Preamp	Com-Power	PAM-118A	551016	500MHz-18GHz	04 Mar 2023
Band Reject Filter	Microtronics	BRC50722	001	Cut off 902-928	See Note 1
High Pass Filter	K & L	11SH-10-1500/T8000	2	Cut off 1.5GHz	See Note 1
Log Periodic Antenna	ETS	3148	00023845	200-2000MHz	14 Apr 2023
Note 1: Internal Verification/Calibration check					

EXHIBIT 7. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of CISPR 16-4-2 @ IEC:2003 and JCGM 100:2008 (GUM 1995) – Guide to the Expression of Uncertainty in Measurement.

Test description		Expanded Uncertainty, K=2 for 95% Confidence Level
Conducted Output Power		+/- 0.62 dB
Occupied bandwidth		+/-0.2Hz
Power spectral Density		+/- 0.63 dB
Radiated Out of Band/Spurious Emissions	30-1000 MHz	+/-4.20dB
	>1 GHz	+/-2.70dB

All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)