FCC & ISED CANADA CERTIFICATION TEST REPORT

for the

FREDERICK ENERGY PRODUCTS, LLC
FMM-T

FCC ID: QUI-FMM-T
IC ID: 11625A-FMMT

WLL REPORT# 18219-01 REV 0

Prepared for:

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Testing Certificate AT-1448

FCC & ISED Canada Certification Test Report

for the

Frederick Energy Products, LLC

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August 14, 2023

WLL Report# 18219-01 Rev 0

Prepared by:

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Reviewed by:

Steven D. Koster
President

Abstract

This report has been prepared on behalf of Frederick Energy Products, LLC to support the attached Application for Equipment Authorization. The test report and application are submitted for an Intentional Radiator under Part 15.231 of the FCC Rules and Regulations current at the time of testing and Innovation, Science and Economic Development (ISED) Canada Spectrum Management and Telecommunications Policy RSS-210, Issue 10 (6/2019). This Certification Test Report documents the test configuration and test results for the Frederick Energy Products, LLC FMM-T. The information provided on this report is only applicable to device herein documented, as the EUT.

Radiated testing was performed in the Free-space Anechoic Chamber Test-site (FACT) 3m chamber of Washington Laboratories, Ltd., located at 4840 Winchester Boulevard, Suite #5. Frederick, MD 21703. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD.

Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Certificate AT-1448 as an independent FCC test laboratory (ISED Canada number 3035A).

The Frederick Energy Products, LLC, FMM-T complies with the requirements for an Intentional Radiator under FCC Part 15.231 and RSS-210 Issue 10 (6/2019).

Revision History	Description of Change	Date
Rev 0	Initial Release	August 14, 2023

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1 Introduction

1.1 Compliance Statement

The Frederick Energy Products, LLC, FMM-T complies with the requirements for an Intentional Radiator under FCC Part 15.231 and RSS-210 Issue 10 (6/2019).

1.2 Test Scope

Tests for radiated emissions were performed. All measurements were performed in accordance with ANSI C63.10. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:	Frederick Energy Products, LLC
Purchase Order Number:	FEP10660
Quotation Number:	74055A

1.4 Test and Support Personnel

Washington Laboratories, LTD	Ryan Mascaro
Customer Representative	Will Murrey

1.5 Test Dates

The Frederick Energy Products, FMM-T (Periodic Transmitter) was tested during the following dates:

7/17/2023 to 7/20/2023

2 Equipment Under Test

2.1 EUT Identification & Description

Table 1: Device Summary

Manufacturer:	Frederick Energy Products, LLC	
FCC ID:	QUI-FMM-T	
ISED ID:	11625A-FMMT	
HVIN:	FMM-T	
Rule Parts:	FCC: §15.231	ISED: RSS-210
FCC Emission Designator:	143K3F1DXN (recommended, or TCB to correct)	
IC Emission Designator:	181K9F1DXN (recommended, or TCB to correct)	
Fixed Transmit Frequency:	917.258 MHz	
Occupied Bandwidth:	20dB	143.3 kHz
	99%	181.89 kHz
Keying:	Automatic	
Modulation or Protocol:	FM, FSK	
Type of Information:	Proximity, Telemetry	
Number of Channels:	1	
3m Radiated Field Strength:	Peak: 101.22 dBuV/m	Average: 80.62 dBuV/m
3m EIRP (from FS):	Peak: 6.06 dBm	Average: -14.54 dBm
Worst-Case Spurious Emission:	815.345 MHz, 37.478 dBuV/m at 3m (see Table 10)	
Power Density for Canada:	0.01 W/m^2 (calculated)	
Antenna Type:	Linx, ANT-916-WRT (Internal to EUT Housing)	
Maximum Antenna Gain:	+4.4 dBi	
Test Software/Firmware:	FEPL Proprietary Test Mode	
Power Source & Voltage:	Battery Powered Only via 2 x 3.6VDC Lithium Batteries	

The Frederick Energy Products, LLC, FMM-T is a proximity monitoring device, used for collision avoidance. The FMM-T has the ability to detect a 73 kHz H-Field, from a Generator device (MFG). The FMM-T only transmits when in the proximity of a Generator. Upon initial power-up, the FMM-T enters a sleep-mode, and remains idle until triggered by the 73 kHz MFG. Once triggered, the 917.258 MHz transmitter employs a timing scheme of 9.3%. See Section 4.8 of this report for DCCF details.

The FMM-T is only powered by two (2) 3.6VDC batteries, which are not rechargeable.

2.2 Testing Algorithm

The FMM-T was tested in a powered-on, steady state, with the transmitter enabled as appropriate. A DCCF of -20.6, as denoted in the table below, shall be employed when averaging the Peak field strength of the transmitter emissions. Overall, the worst-case emissions are provided throughout this report. Table 2 provides a summary of the transmit mode, and the duty cycle information.

Table 2: TX Mode Summary with DCCF

Proximity to Generator	Transmit Mode	Duty Cycle	DCCF
≥ 3-meters *	Sleep/Idle	N/A	N/A
≤ 3-meters *	Danger/Triggered	9.3 %	20.6 dB

** note: these distances were solely used for testing purposes. Actual zone/mode distance may vary, as defined by the manufacturer's theory of operation, or user's manual.*

2.3 Test Configuration

The FMM-T was tested in a stand-alone configuration. As necessary, the EUT was positioned in proximity to a 73 kHz generator (MFG) as a means to trigger the 917.258 MHz radio. The MFG was not introduced onto the test site. The MFG did not influence the testing results.

Table 3: System Configuration List

Name / Description	HVIN	Part Number	Serial Number	Revision
FMM-T	FMM-T	N/A	FMMT0007	N/A

Table 4: Support Equipment

Item	Model/Part Number	Serial Number
73 kHz Generator	MFG	N/A

Table 5: Cable Configuration

Port Identification	Connector Type	Cable Length	Shielded (Y/N)	Termination Point
N/A	N/A	N/A	N/A	N/A

2.4 Test Location

All measurements herein were performed at Washington Laboratories, Ltd. test center in Frederick, MD. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. The ISED Canada number for Washington Laboratories, Ltd. is 3035A. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Testing Certificate AT-1448 as an independent FCC test laboratory.

Figure 1: Test Configuration (Example Only)

2.5 Measurements

2.5.1 References

ANSI C63.2 (Jan-2016) Specifications for Electromagnetic Noise and Field Strength Instrumentation

ANSI C63.4 (Jan 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 (Jun 2013) American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

2.5.2 Radiated Data Reduction and Reporting

To convert the raw spectrum analyzer radiated data into a form that can be compared with the FCC limits, it is necessary to account for various calibration factors that are supplied with the antennas and other measurement accessories. These factors are included into the antenna factor (AF) column of the table and in the cable factor (CF) column of the table. The AF (in dB/m) and the CF (in dB) is algebraically added to the raw Spectrum Analyzer Voltage in dBµV to obtain the Radiated Electric Field in dBµV/m. This logarithm amplitude is converted to a linear amplitude, then compared to the FCC limit.

Example:

Spectrum Analyzer Voltage:	VdBµV (SA)
Antenna Correction Factor:	AFdB/m
Cable Correction Factor:	CFdB
Pre-Amplifier Gain (if applicable):	GdB
Electric Field:	EdBµV/m = V dBµV (SA) + AFdB/m + CFdB - GdB
To convert to linear units of measure:	Inv Log (EdBµV/m/20)

2.6 Measurement Uncertainty

All results reported herein relate only to the equipment tested. The basis for uncertainty calculation uses ANSI/NCSL Z540-2-1997 (R2002) with a type B evaluation of the standard uncertainty. Elements contributing to the standard uncertainty are combined using the method described in Equation 1 to arrive at the total standard uncertainty. The standard uncertainty is multiplied by the coverage factor to determine the expanded uncertainty which is generally accepted for use in commercial, industrial, and regulatory applications and when health and safety are concerned (see Equation 2). A coverage factor was selected to yield a 95% confidence in the uncertainty estimation

Equation 1: Standard Uncertainty

$$u_c = \pm\sqrt{\frac{a^2}{{div_a}^2} + \frac{b^2}{{div_b}^2} + \frac{c^2}{{div_c}^2} + \ldots\ldots}$$

Where

uc	= standard uncertainty
a, b, c,..	= individual uncertainty elements
Diva, b, c	= the individual uncertainty element divisor based on the probability distribution
Divisor	= 1.732 for rectangular distribution
Divisor	= 2 for normal distribution
Divisor	= 1.414 for trapezoid distribution

Equation 2: Expanded Uncertainty

$$U = ku_c$$

where:

U = expanded uncertainty
k = coverage factor
k ≤ 2 for 95% coverage (ANSI/NCSL Z540-2 Annex G)
uc = standard uncertainty

The measurement uncertainty complies with the maximum allowed uncertainty from CISPR 16-4-2. Measurement uncertainty is not used to adjust the measurements to determine compliance. The expanded uncertainty values for the various scopes in the WLL accreditation are provided in Table 6 below.

Table 6: Expanded Uncertainty List

Scope	Standard(s)	Expanded Uncertainty
Conducted Emissions	CISPR11, CISPR22, CISPR32, CISPR14, FCC Part 15	± 2.63 dB
Radiated Emissions	CISPR11, CISPR22, CISPR32, CISPR14, FCC Part 15	± 4.55 dB

3 Test Sequence and Results Summary

Table 7: Transmitter Testing to 15.231 – Summary

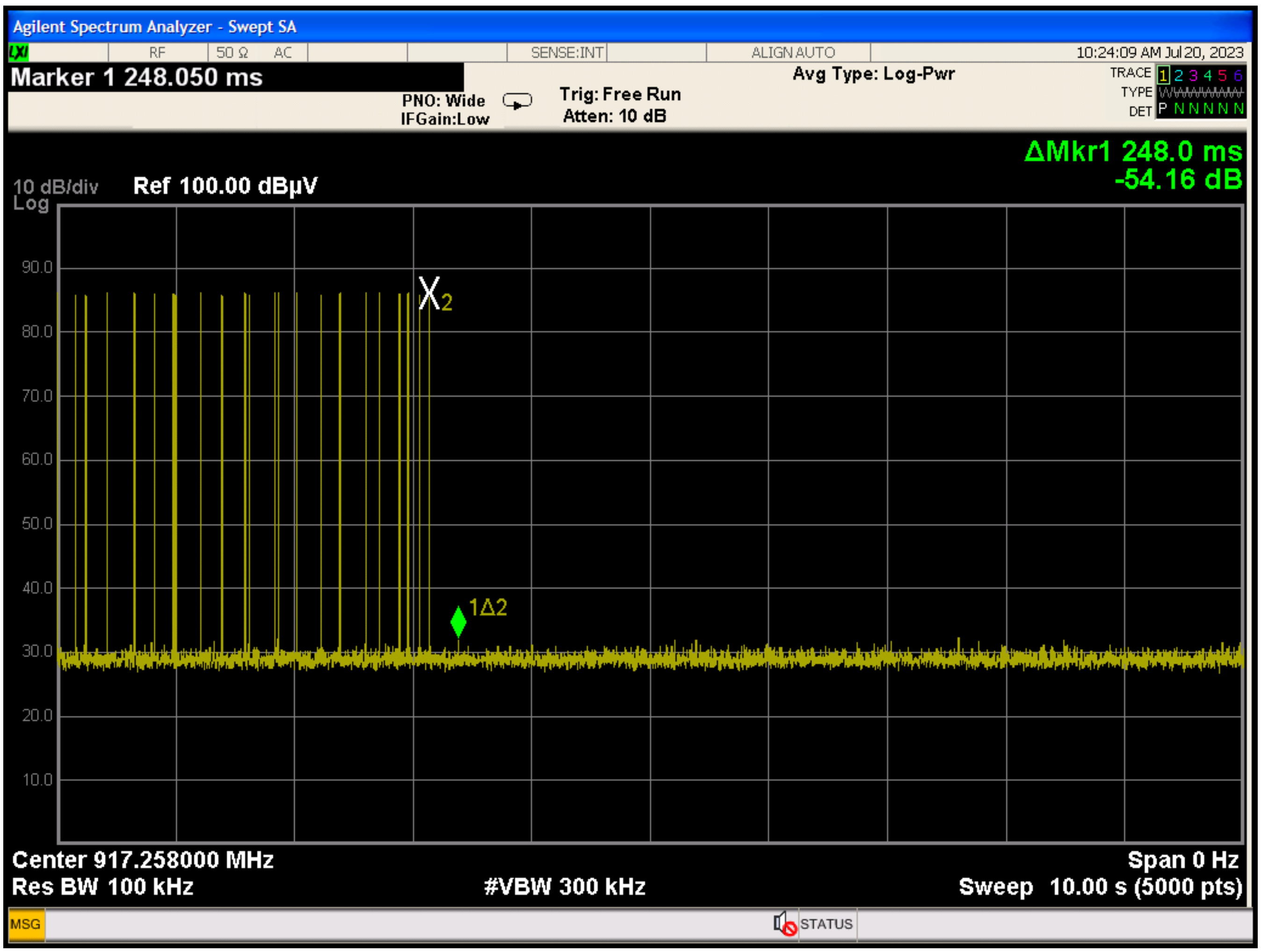
FCC Rule Part	ISED Rule Part	Description	Result
15.231(a)(1)	RSS-210	Transmit Cessation from Release	Pass
15.231(a)(2)	RSS-210	Transmit Cessation from Activation	Pass
15.231(a)(3)	RSS-210	Transmission Polling	Pass
15.231(a)(4)	RSS-210	Pendency of Alarm Conditions	Adopted
15.231(c)	RSS-210	Occupied Bandwidth	Pass
15.231(b)	RSS-210	Field Strength, Fundamental	Pass
15.207(a)	RSS-GEN	AC Power Line Emissions	N/A
15.35(c)	RSS-GEN	100ms Duty Cycle	Completed

4 Test Results

4.1 Transmission Cessation from Time of Release – FCC Part §15.231(a)(1)

A periodic intentional radiator shall cease transmission within a five second period from release of automatic or manual keying of operation. Testing was done to verify that the FMM-T stopped transmitting within the required time period. A 10-second sweep was made, during which time, the transmitter was triggered from Danger Mode into Health Mode. By moving the EUT away from the Generator, the transmitter was triggered into a mode that periodically deactivates transmission. Figure 2 provides the indicated period from un-keying the device until cessation of transmission. The EUT complies with the requirements of this section, as the cessation time is << 5-seconds.

Figure 2: Deactivation of Transmitter



4.2 Transmission Cessation from Time of Activation – FCC Part §15.231(a)(2)

Under this provision, a periodic transmitter, that is activated automatically, shall cease transmission within 5 seconds after activation.

Given the safety of life of this device, and how the proximity detection is incorporated into the transmitter operation, it is important to note that the transmitter remains enabled for the duration of the alarm condition, specifically for safety of life application. However, when the alarm condition is cleared, the EUT reverts back to an idle mode. When this occurs, the transmitter is disabled as shown above.

Under the exception of §15.231(a)(4), the EUT complies with the requirements of this rule part.

4.3 Transmission Polling – FCC Part §15.231(a)(3)

Under this provision, polling transmissions, or supervision transmissions, including data, to determine system integrity of transmitters used in security or safety applications are allowed. However, the total duration of transmissions shall not exceed more than two seconds per hour for each transmitter. There is no limit on the number of individual transmissions, provided the total transmission time does not exceed two seconds per hour.

The EUT does not have a polling mode.

Upon initial power-up, the FMM-T enters a sleep-mode, and remains idle until triggered by a MFG.

The EUT complies with the requirements of this rule part.

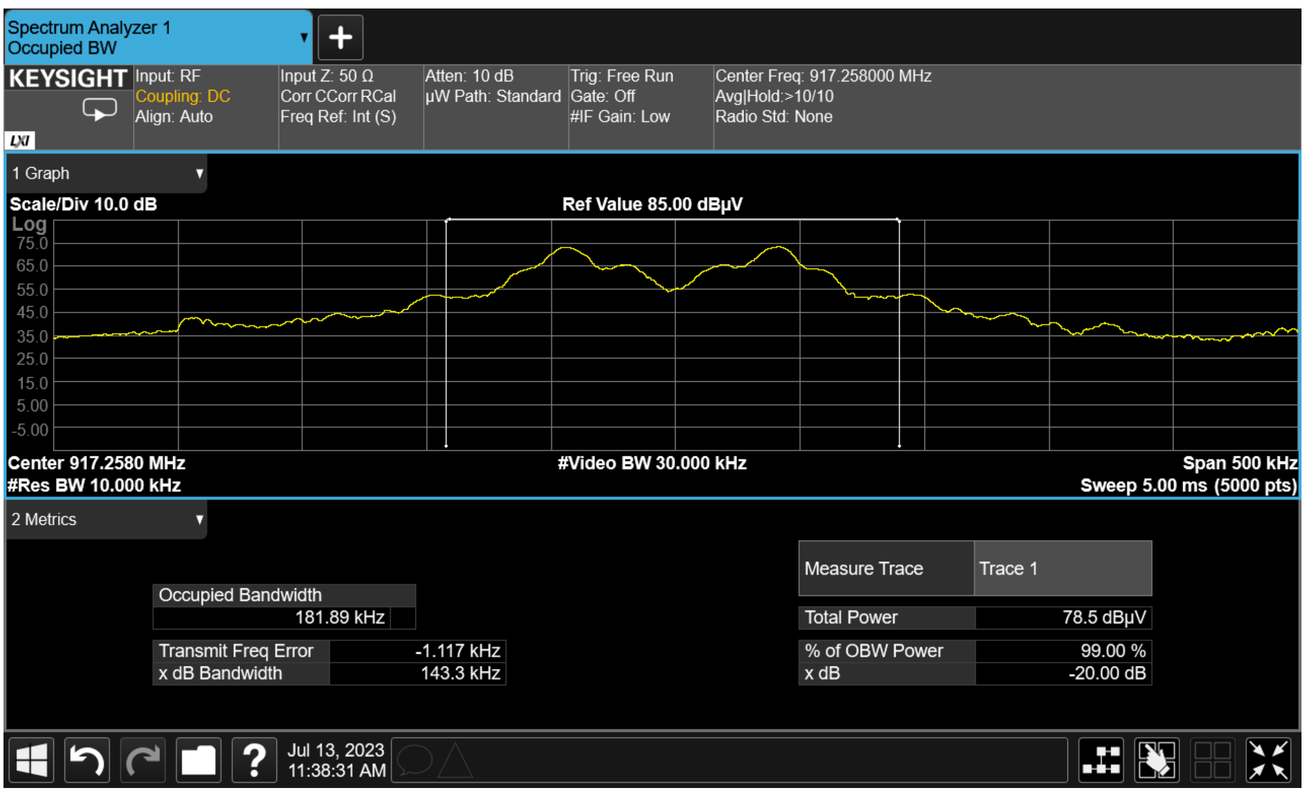
4.4 Occupied Bandwidth – FCC Part §15.231(c)

The bandwidth of the emission shall be no wider than 0.25% of the center frequency for devices operating above 70 MHz and below 900 MHz. For devices operating above 900 MHz, the emission shall be no wider than 0.5% of the center frequency. The OBW is determined at the points 20 dB down from the peak of the transmitter carrier. As 917.258 * 0.005 = 4.586, the EUT complies with the requirements of this section.

Table 8: Occupied Bandwidth Results (Worst-Case)

TX Frequency	Bandwidth	Limit	Results
917.258 MHz	143.3 kHz	4.586 MHz	Pass

Figure 3: 20dB Occupied Bandwidth



4.5 Radiated Emissions, Fundamental Transmitter – FCC Part §15.231(b)

The field strength of emissions from intentional radiators operated under this section shall not exceed the following limits, as measured at a distance of 3m:

Fundamental Frequency (MHz)	Field Strength of Fundamental (μV/m)
40.66 – 40.70	2250
70 – 130	1250
130 – 174	1250 to 3750
174 – 260	3750
260 – 470	3750 to 12500
Above 470	12500

The above limits are based on the average value of the measured emissions. The provisions in §15.35(c) for averaging pulsed emissions, and for limiting peak emissions, shall apply. The calculated DCCF of 20.6 dB shall be applied to the Peak Field Strength in order to obtain the Average Field Strength and compared to limits in the table above.

The requirements for this test call for the EUT to be placed on a 1m X 1.5m non-conductive motorized turntable for radiated testing at 3-meters. The height of the table shall be 80cm for testing below 1000 MHz, and 1.5m for testing above 1000 MHz, both in accordance with ANSI C63.10. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. A log periodic broadband antenna was mounted on an antenna mast to determine the height of maximum emissions. The height of the antenna was varied between 1 and 4 meters. The output of the antenna was connected to the input of the spectrum analyzer and the 917.258 MHz radio emissions were measured. the horizontal and vertical field components were measured, to determine the worst-case levels. The detector function was set to peak mode, for measurements of the fundamental. The measurement bandwidth of the spectrum analyzer system was set to at least 120 kHz, with all post-detector filtering no less than 10 times the measurement bandwidth.

The EUT complies with the requirements of this section.

The EUT was evaluated at three orthogonal axes (X, Y, Z) to determine the orientation that yielded the highest radiated field strength. The worst-case emissions are reported below.

The final test data appears on the next page.

Table 9: Fundamental Field Strength, Test Results (3-meters)

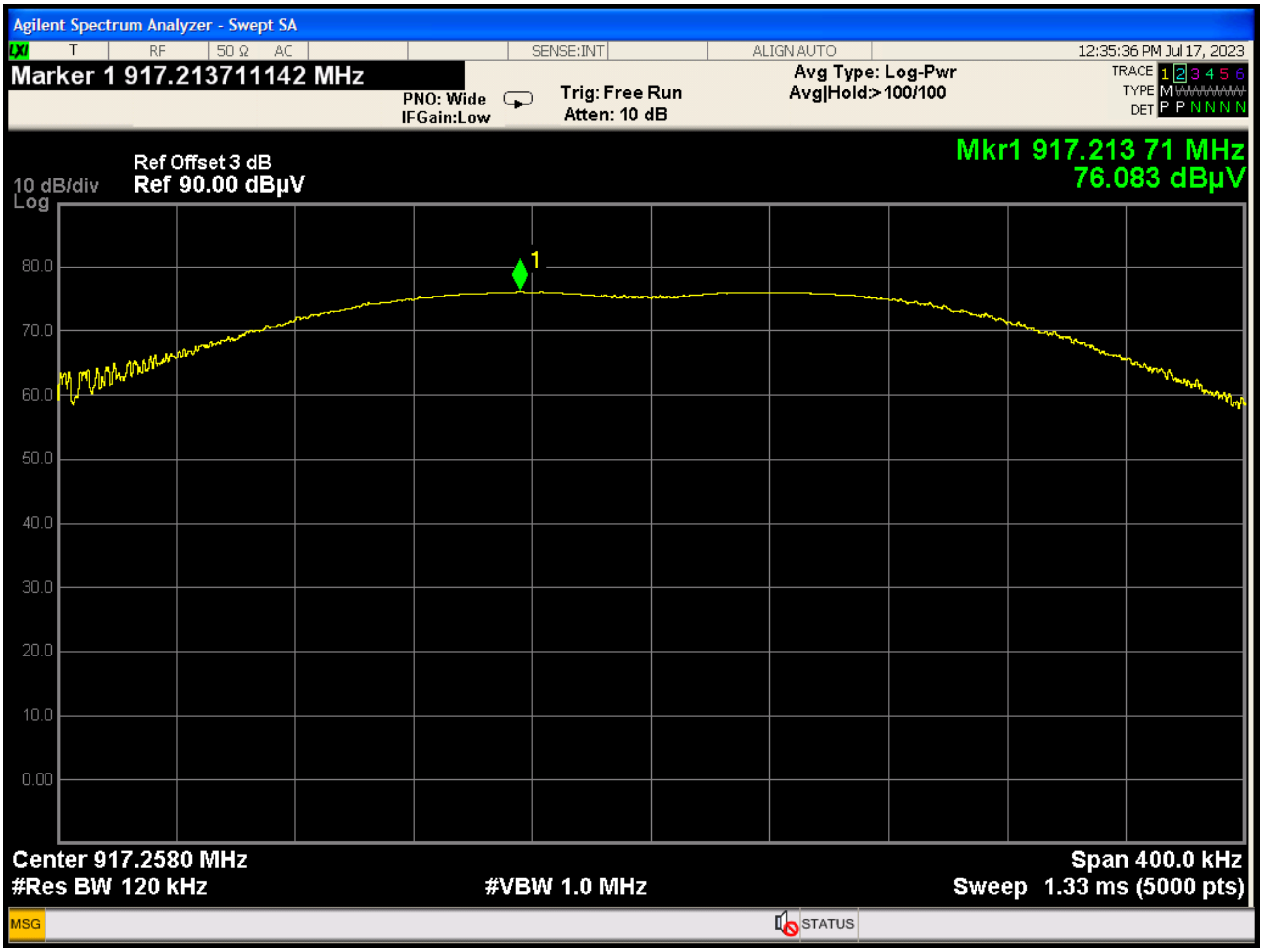
Frequency (MHz)	**Antenna Polarity**	**EUT Axis**	**SA Level (dBuV)**	**Corr. Factors (dB)**	**DCCF (dB)**	**Corr. Level (dBuV/m)**	**Limit (dBuV/m)**	**Margin (dB)**	**Emission Type**
917.258	V	Z	75.98	25.14	0.00	101.12	101.94	-0.82	Peak
		Z	75.98	25.14	-20.60	80.52	81.94	-1.42	AVG
917.258	H	Y	76.08	25.14	0.00	101.22	101.94	-0.72	Peak
		Y	76.08	25.14	-20.60	80.62	81.94	-1.32	AVG

Limit Conversion:

20LOG(12,500 uV/m) = 81.94 dBuV/m (AVG)

81.94 dBuV/m + 20 = 101.94 dBuV/m (Peak)

Figure 4: Worst-Case Fundamental, 3-meter Field Strength



* for Table 9, the device was set to transmit at full power in the Danger Mode. All three orthogonal planes were investigated. The data provided in this section is final, and represents the highest possible fundamental field strength from the transmitter. Figure 4 provides the worst-case data point and supports Table 9. The Peak level of 76.083 dBuV is uncorrected and taken at a measurement distance of 3-meters.

4.6 Radiated Spurious Emissions – FCC Part §15.231(b)

The field strength of spurious emissions, related to the transmitter, shall not exceed the following limits, as measured at a distance of 3m:

Fundamental Frequency (MHz)	Field Strength of Spurious Emissions (µV/M)
40.66 – 40.70	225
70 – 130	125
130 – 174	125 to 375
174 – 260	375
260 – 470	375 to 1250
Above 470	1250

The limits for the field strength of the spurious emissions, in the above table, are based on the fundamental frequency of the intentional radiator. Spurious emissions shall be attenuated to the average (or, alternatively, CISPR quasi-peak) limits shown in this table, or to the general limits shown in §15.209, whichever limit permits a higher field strength. In accordance with the provisions outlined in §15.205(b), compliance with the limits in the above table may be based on the use of measurement instrumentation with a CISPR quasi-peak detector, for spurious measurements made below 1000 MHz.

Because the device transmitter is pulsed, the harmonic spurious emissions (if detected) shall be measured using only a Peak Detector, and then corrected using a DCCF, in order to calculate the Average Field Strength and compare to the limits in the table above. The uncorrected Peak Field Strength shall not be more than 20 dB over the Average limit.

The requirements for this test call for the EUT to be placed on a 1m X 1.5m non-conductive motorized turntable for radiated testing at a 3m open air test site. The height of the table shall be 80cm for testing below 1000 MHz, and 1.5m for testing above 1000 MHz, both in accordance with ANSI C63.10. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. Bi-conical and log-periodic broadband antennas were mounted on an antenna mast to determine the height of maximum emissions. The height of the antenna was varied between 1 and 4 meters.

The output of the antenna was connected to the input of the spectrum analyzer and the emissions in the frequency range of 30 MHz to 12 GHz were measured, which covers the tenth harmonic of the fundamental. Both the horizontal and vertical field components were measured. The detector function was set to quasi-peak for measurements below 1 GHz. The measurement bandwidth of the spectrum analyzer system was set to at least 120 kHz, with all post-detector filtering no less than 10 times the measurement bandwidth.

The EUT complies with the requirements of this section.

The EUT was evaluated at three orthogonal axes (X, Y, Z) to determine the orientation that yielded the highest radiated field strength. The worst-case position was maintained during the test. The worst-case emissions are reported below.

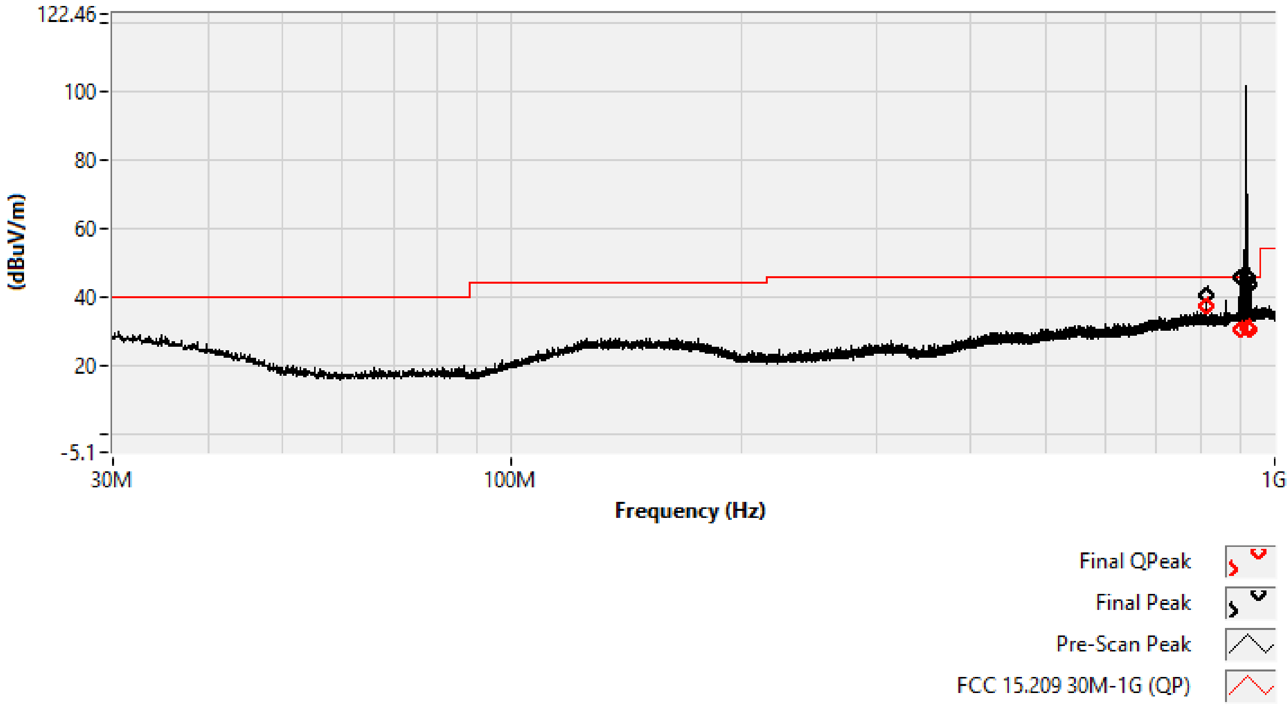
In the frequency range of 1 GHz to 6 GHz, all Peak emissions meet the Average limit.

In the frequency range of 6 GHz to 12 GHz, all measurements were made at the noise floor of the measurement system.

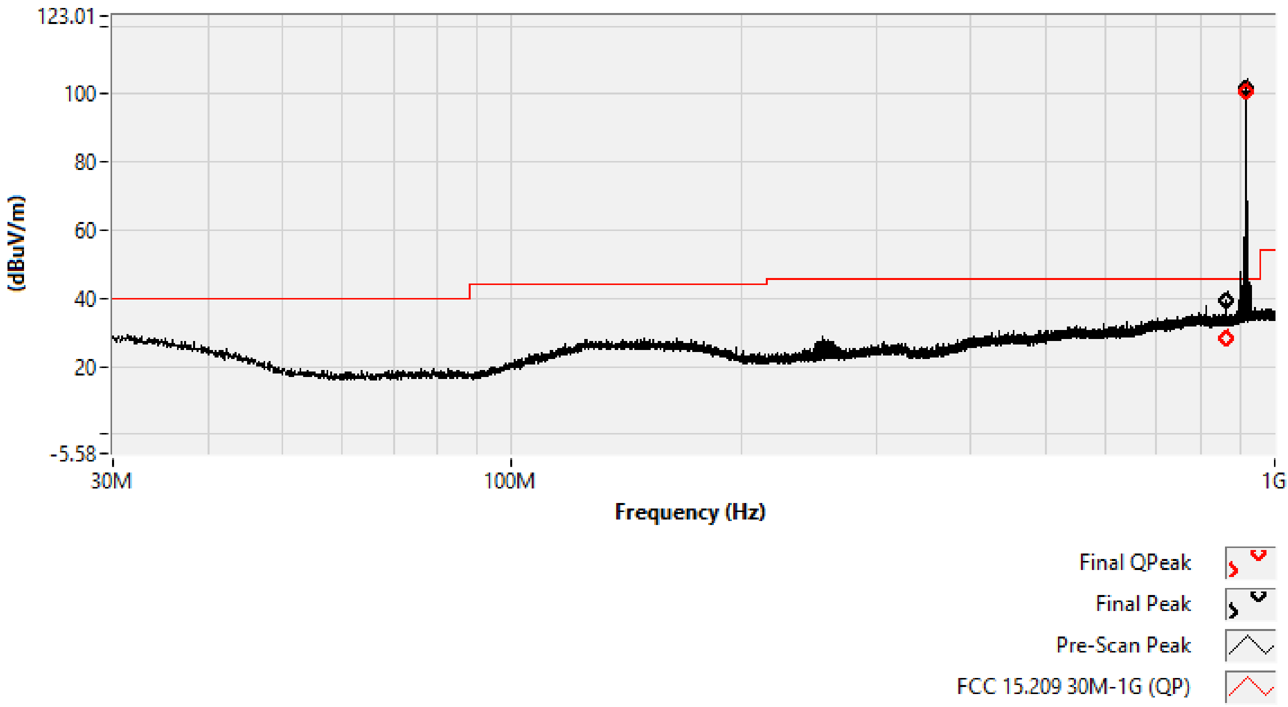
Table 10: 3m Radiated Emissions Test Data

Frequency (MHz)	Detector	Corr. Meas. (dBuV/m)	Limit (dBuV/m)	Delta (dB)	Turn Table (deg)	Antenna (cm)
815.345	Peak	40.356	--	--	0	Vert, 110
	QP	37.478	46	-8.522	0	Vert, 110
863.212	Peak	39.361	--	--	0	Horiz, 145
	QP	28.431	46	-17.569	0	Horiz, 145
901.411	Peak	45.881	--	--	0	Vert, 110
	QP	30.832	46	-15.168	0	Vert, 110
917.258	Peak	**101.221**	101.94	-0.719	0	Horiz, 145
	QP	--	--	--	--	--
922.012	Peak	45.955	--	--	0	Vert, 110
	QP	31.352	46	-14.648	0	Vert, 110
929.160	Peak	43.500	--	--	0	Vert, 110
	QP	30.500	46	-15.500	0	Vert, 110
7483.00	Peak	56.674	74	-17.326	0	Vert, 120
	Avg	39.314	54	-14.686	0	Vert, 110
8802.00	Peak	56.140	74	-17.860	0	Horiz, 120
	Avg	39.600	54	-14.400	0	Horiz, 110
9980.00	Avg	41.511	74	-12.489	0	Vert, 110
10302.00	Peak	59.027	54	-14.973	0	Horiz, 120
	Avg	44.161	74	-9.839	0	Horiz, 110

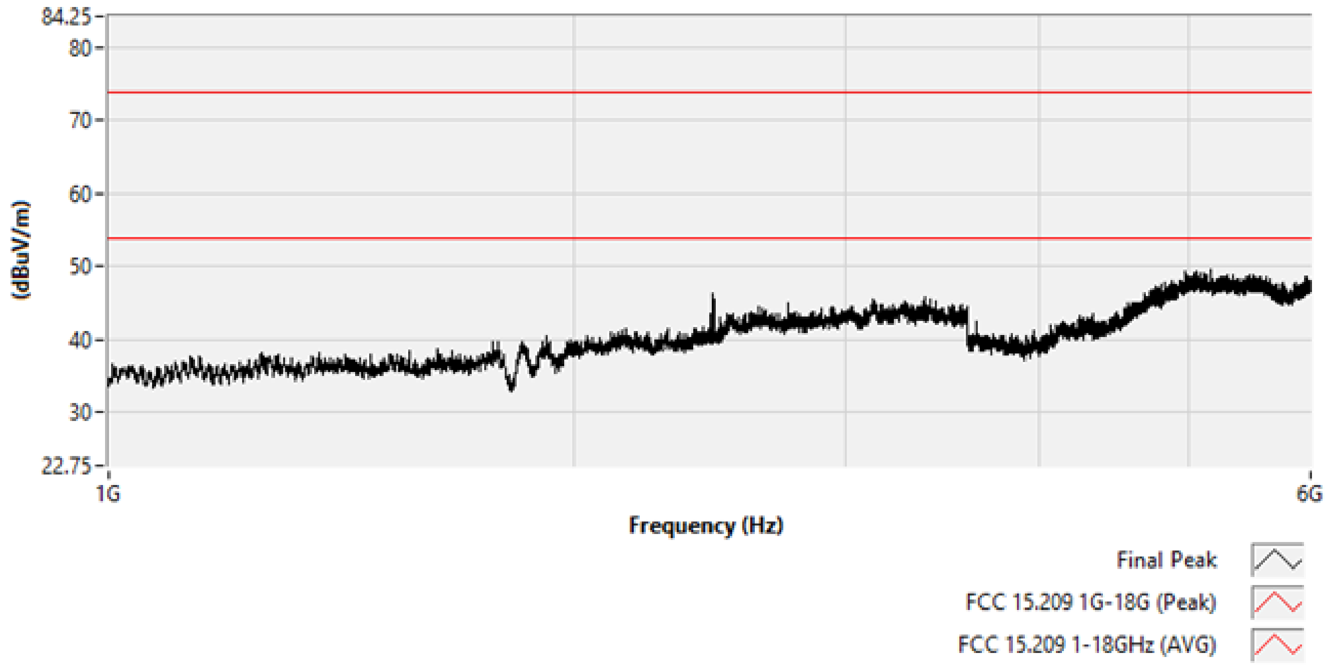
Pre-scan and Final Data (Vertical)



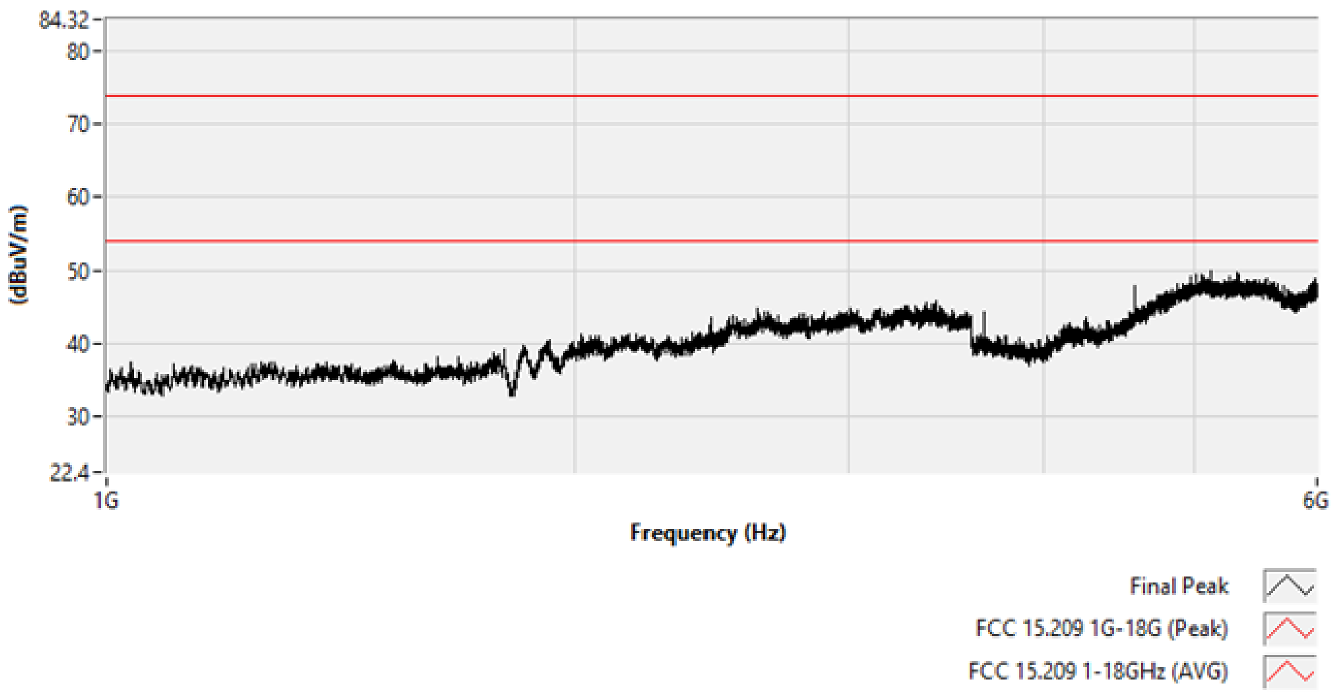
Pre-scan and Final Data (Horizontal)



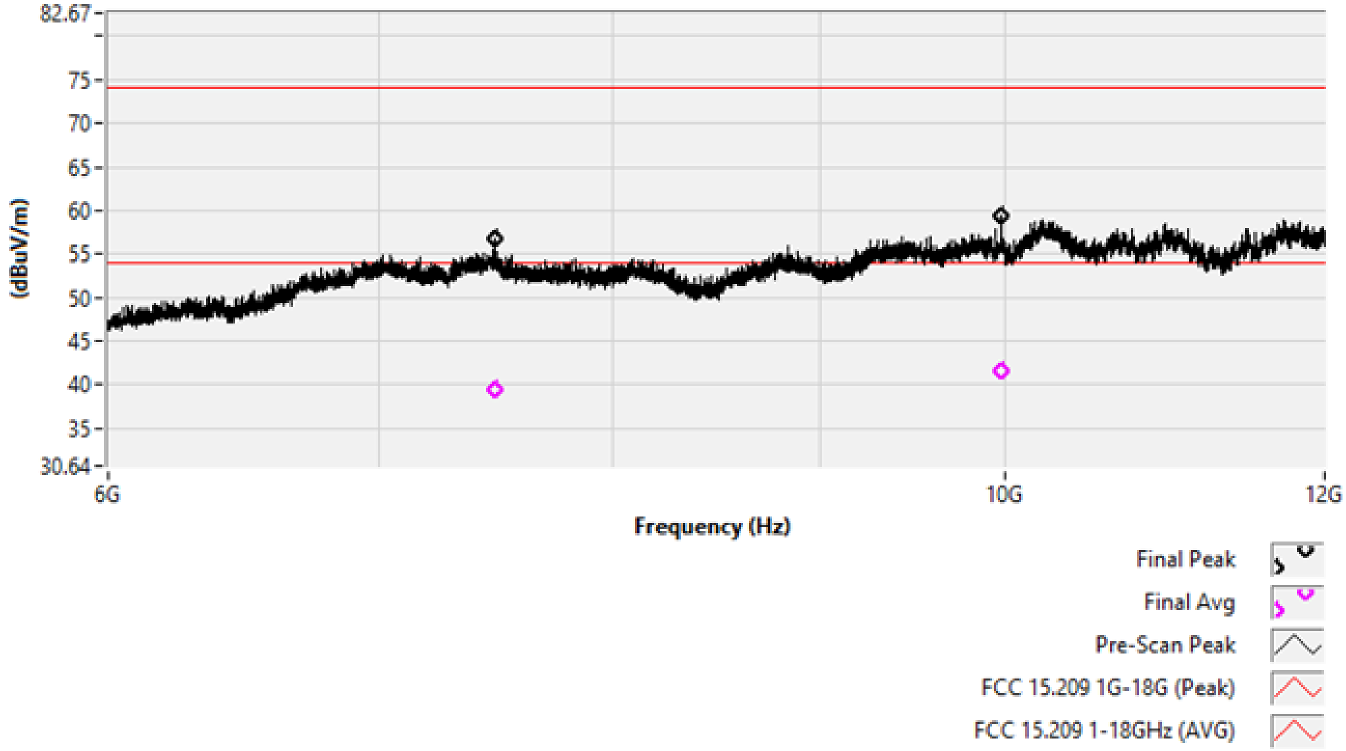
Pre-scan and Final Data (Vertical)



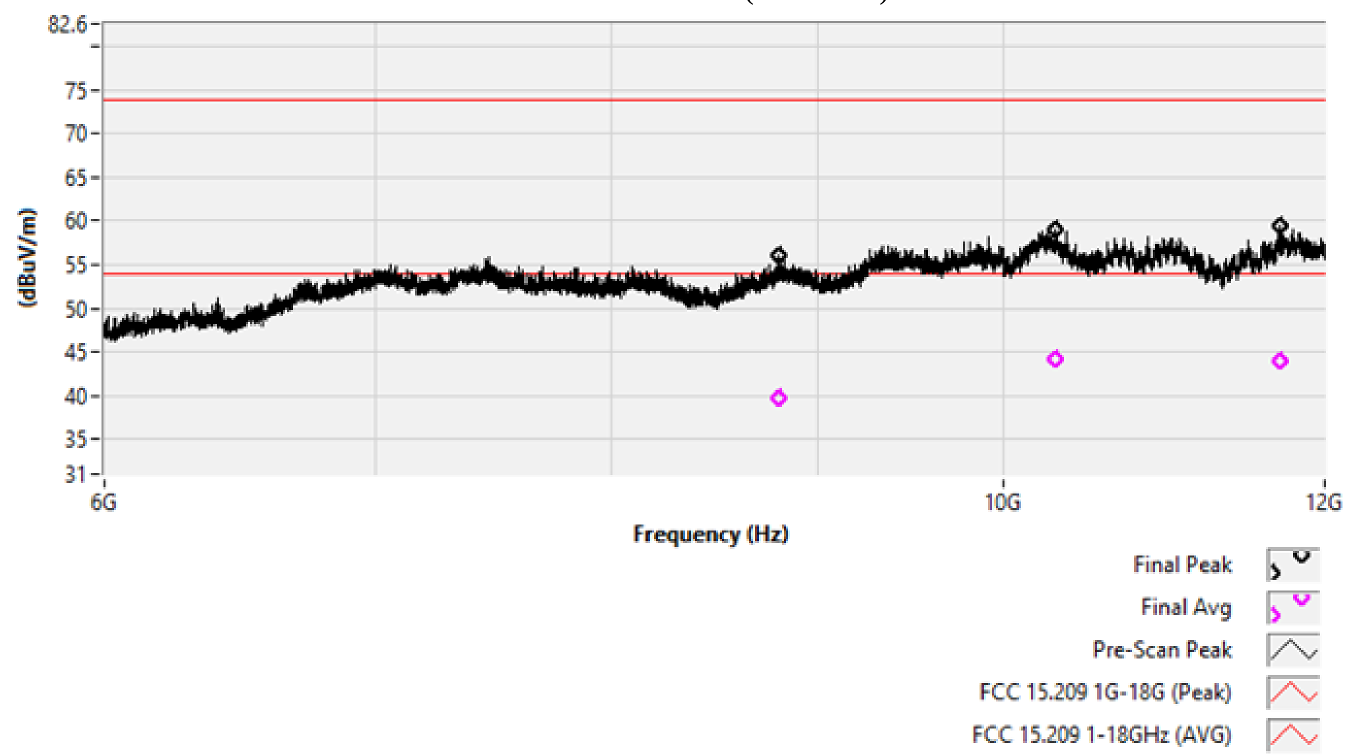
Pre-scan and Final Data (Horizontal)



Pre-scan and Final Data (Vertical)



Pre-scan and Final Data (Horizontal)



4.7 AC Power Conducted Emissions, Voltage

Compliance Standard: FCC Part 15, Class B

FCC Compliance Limits				
Frequency Range	Class A Device		Class B Device	
	Quasi-peak	Average	Quasi-peak	Average
0.15 – 0.5 MHz	79 dBµV	66 dBµV	66 to 56 dBµV	56 to 46 dBµV
0.5 – 5 MHz	79 dBµV	66 dBµV	56 dBµV	46 dBµV
0.5 – 30 MHz	73 dBµV	60 dBµV	60 dBµV	50 dBµV

Please note that the EUT is battery powered.

The batteries are not rechargeable, and the EUT is not provided with a battery charger.

No portion of the EUT, directly or indirectly, couples to an AC Public Mains Network.

The EUT is not subject to this test.

4.8 Transmitter, Duty Cycle Correction Factor (DCCF)

When the average-mode field strength of a pulsed transmitter is measured, a DCCF shall be applied to the Peak value, and compared to the applicable Average limits. Under the provisions of §15.35(c), the duty cycle measurement shall be made in reference to a 100 ms period.

4.8.1 Transmit Mode (Triggered by MFG)

Figure 5: Transmitter Pulse On-Time, Plot 1 – Danger Mode

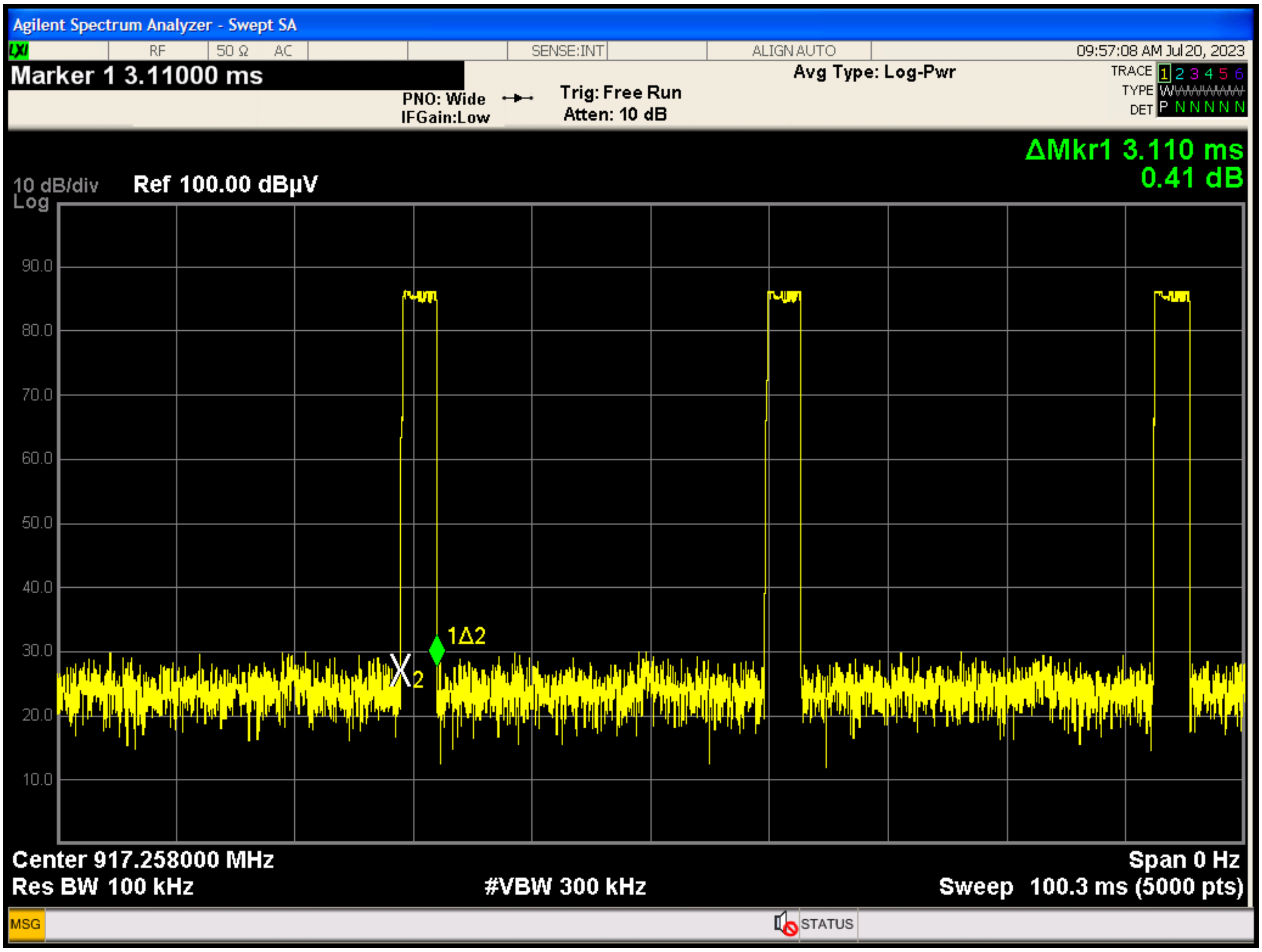
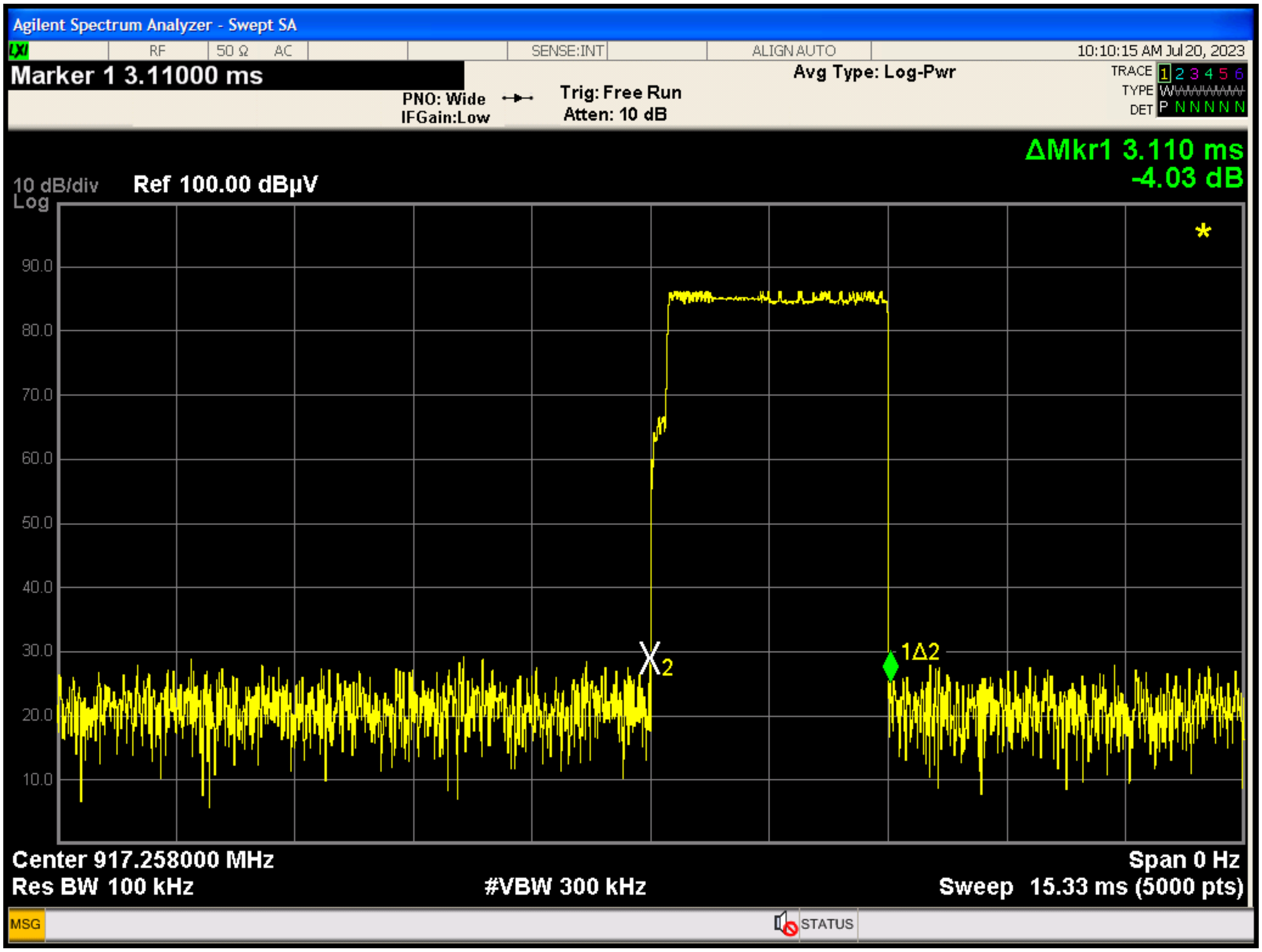


Figure 6: Transmitter Pulse On-Time, Plot 2 – Danger Mode



The Danger Mode pulse train was observed over a 100 ms sweep. In this case, the total pulse train is greater than the measurement period. As such, the cycle time (Tcycle) shall be 100 ms.

The total transmitter on-time is made of three sub-pulses, that measure 3.110 ms each.

As such, the on-time ($t$on) is: 3(3.11) = 9.33 ms (worst-case).

<u>The duty cycle can be calculated from the following formula:</u>

$t$on ÷ Tcycle = Δ

9.33 ÷ 100 = 0.093

Δ = 9.3%

Where Δ is the final duty cycle.

<u>The duty cycle correction factor can be calculated from the following formula:</u>

20LOG(Δ) = δ

20LOG(0.093) = –20.6

δ = 20.6 dB (worst-case)

Where δ is the final DCCF for the Danger Mode.

(Reference ANSI C63.10-2013, Section 7.5)

5 Test Equipment

Table 11 shows a list of the test equipment used for measurements along with the calibration information.

Table 11: Test Equipment List

Test Name:	**Radiated Emissions**	Test Date: 7/17/2023 – 7/20/2023	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00644	SUNOL SCIENCES CORP. JB1	BICONALOG ANTENNA	11/7/2024
00626	ARA DRG-118/A	ANTENNA HORN	6/19/2024
00977	JUNKOSHA MWX322-06000	ARMORED COAXIAL CABLE	12/28/2023
00806	MINI-CIRCUITS CBL-6FT	SMA COAXIAL CABLE	12/28/2023
00834	ULTIFLEX UFA 2108-0-360	SMA COAXIAL CABLE 90CM	12/28/2023
00823	AGILENT N9010A	EXA SPECTRUM ANALYZER	6/7/2024
00065	HP 8447D	RF PRE-AMPLIFIER	5/9/2024
00066	BZ-01002650-401545-282525	HF PRE-AMPLIFIER 1-26.5GHZ	5/24/2024
00742	PENN ENGINEERING WR284	2.2-4.15GHZ BANDPASS FILTER	6/27/2025
00280	ITC 21C-3A1	WAVEGUIDE FILTER	6/27/2025
00281	ITC 21A-3A1	WAVEGUIDE FILTER 4.51-10.0GHZ	6/27/2025
00282	ITC 21X-3A1	WAVEGUIDE FILTER 6.8-15GHZ	6/27/2025