FCC & ISED Canada Limited Modular Approval Test Report

for the

Frederick Energy Products, LLC
RF Module

FCC ID: QUI-RF
IC ID: 11625A-RF

WLL REPORT# 16854-01 REV 2

Prepared for:

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Testing Certificate AT-1448

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September 15, 2021

WLL Report# 16854-01 Rev 2

Prepared by:

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Reviewed by:

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Abstract

This report has been prepared on behalf of Frederick Energy Products, LLC to support the attached Application for a Limited Single-Modular Transmitter Approval. The test report and application are submitted for an Intentional Radiator, Modular Transmitter, under Part §15.231 of the FCC Rules and Regulations (current at the time of testing) and under Innovation, Science and Economic Development (ISED) Canada Spectrum Management and Telecommunications Policy, RSS-210 Issue 10. This Limited Single-Modular Transmitter Approval Test Report documents the test configuration and test results for the Frederick Energy Products, LLC RF Module (HNE200321). The information provided in this report is only applicable to device herein documented as the EUT.

Radiated testing was performed on an Open Area Test Site (OATS) of Washington Laboratories, Ltd, which is located at 4840 Winchester Boulevard, 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 RF Module complies with the requirements for a Limited Single-Modular Transmitter Approval, under FCC Part §15.231 and RSS-210, Issue 10 (6/2019).

Revision History	Description of Change	Date
Rev 0	Initial Release	September 15, 2021
Rev 1	ACB Comments, Dated: 10/4/2021	October 5, 2021
Rev 2	ACB Comments, Dated: 12/22/2021	December 22, 2021

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1 Introduction

1.1 Compliance Statement

The Frederick Energy Products, LLC RF Module complies with the requirements for a Limited Single-Modular Transmitter Approval, 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:	9119
Quotation Number:	72358A

1.4 Test and Support Personnel

Washington Laboratories, LTD	Ryan Mascaro
Customer Representative	Andrew Nichols

1.5 Test Dates

2/23/2021 to 2/25/2021 & 5/19/2021 to 6/22/2021

2 Equipment Under Test

2.1 EUT Identification & Description

Table 1: Device Summary

Manufacturer:	Frederick Energy Products, LLC
FCC ID:	QUI-RF
ISED ID:	11625A-RF
EUT Name/Model:	RF Module
ISED HVIN:	HN-RF
FCC Rule Parts:	§15.231
ISED Rule Parts:	RSS-210, Issue 10
FCC Emission Designator:	161KF1D
IC Emission Designator:	144KF1D
Fixed Transceiver Frequency:	916.48 MHz
20 dB Occupied Bandwidth:	160.50 kHz
99% Occupied Bandwidth:	143.76 kHz
Keying:	Automatic
Modulation/Protocol:	FM, FSK
Firmware/Software:	Normal Operation (no special settings)
Type of Information:	Proximity, Telemetry
Number of Channels:	1
Power Output Level	Fixed, < 30 dBm
Antenna Type:	Monopole (-0.1 dBi)
Antenna Model:	LINX, ANT-916-WRT-RPS
Interface Cables:	N/A
Power Source & Voltage:	12 VDC

The Frederick Energy Products, LLC RF Module is a 916.48 MHz radio module transceiver that resides within a Generator host device. The RF Module provides the wireless transmit and receive capabilities for the 916.48 MHz RF link for the Generator-type product line.

2.2 Test Configuration

The RF Module was provided to the test laboratory as an integrated module, installed in a host Generator.

Table 2: System Configuration List

EUT Name	FCC ID	HMN	Serial Number	Revision
RF Module	QUI-RF	DDAC-PDS-C-2	N/A	N/A

Table 3: Support Equipment

Item	FCC ID	Model
Generator	QUI-DDAC-PDS-GEN2	DDAC-PDS-C-2
PAD	N/A	N/A
Power Supply	N/A	N/A

Table 4: Cable Configuration

Port Identification	Connector Type	Cable Length	Shielded (Y/N)	Termination Point
Power Input	2-wire	1m	N	Power Mains – EUT

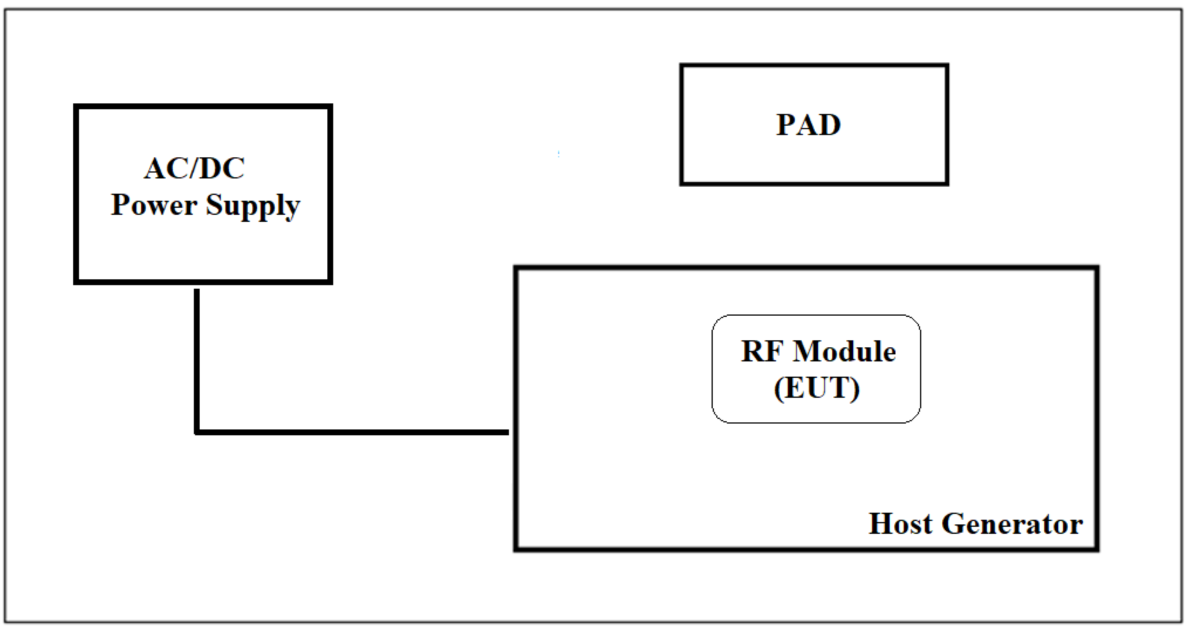
2.3 Testing Algorithm

The RF Module was tested in a powered-on, active transceiver state. Worst case emissions are provided throughout this report.

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 OATS 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



2.6 Measurements

2.6.1 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

2.6.2 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)

2.7 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 5 below.

Table 5: 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 6: Transmitter Testing, Summary

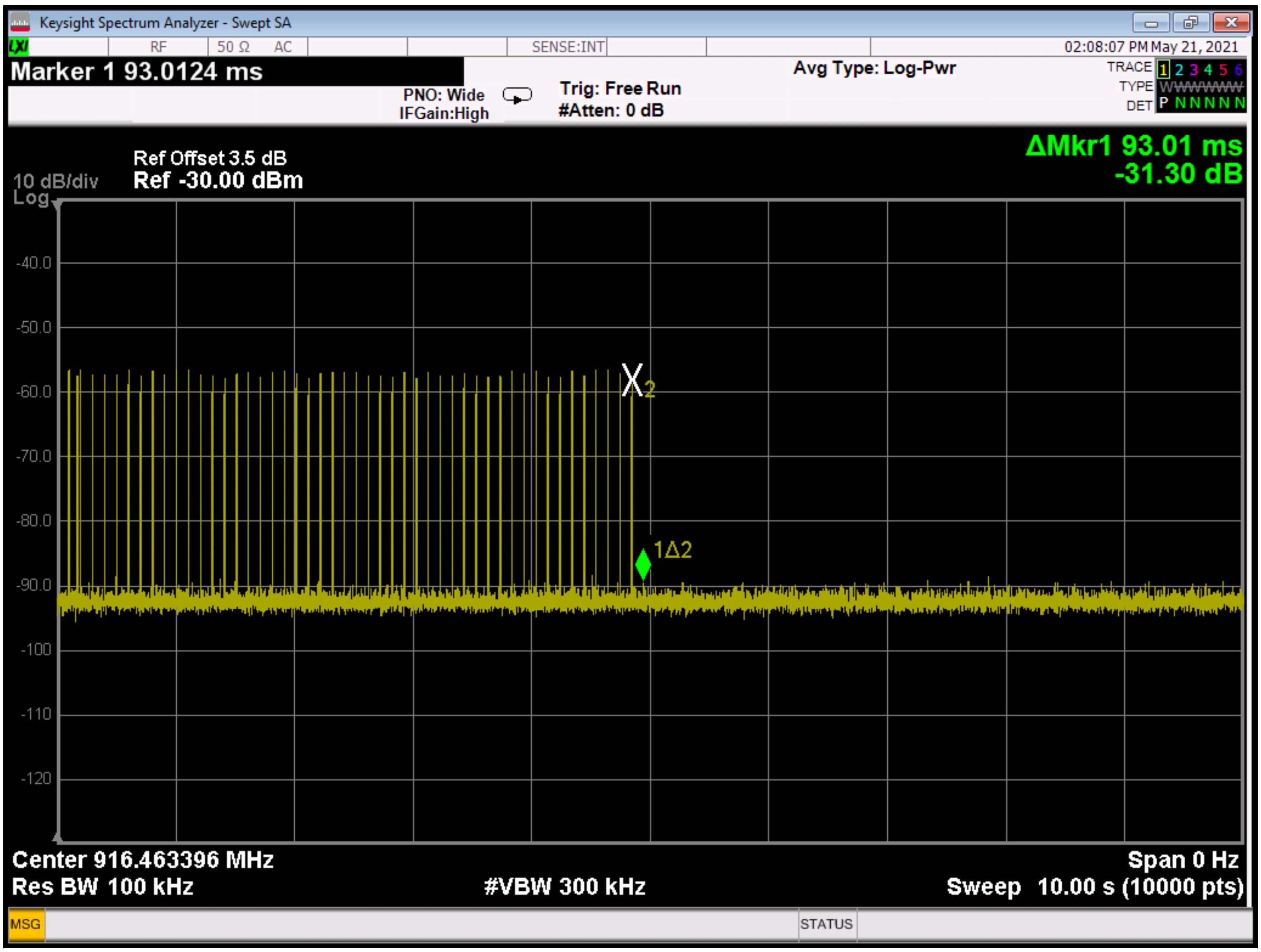
FCC Rule Part	ISED Rule Part	Description	Result
15.231(a)(1)	RSS-GEN/RSS-10, Issue 10	Transmit Cessation from Release	Pass
15.231(a)(2)	RSS-GEN/RSS-10, Issue 10	Transmit Cessation from Activation	Pass
15.231(a)(3)	RSS-GEN/RSS-10, Issue 10	Transmission Polling	N/A
15.231(a)(4)	RSS-GEN/RSS-10, Issue 10	Pendency of Alarm Conditions	Adopted
15.231(c)	RSS-GEN/RSS-10, Issue 10	Occupied Bandwidth	Pass
15.231(b)	RSS-GEN/RSS-10, Issue 10	Field Strength, Fundamental	Pass
15.207(a)	RSS-GEN/RSS-10, Issue 10	AC Power Line Emissions	N/A
15.35(c)	RSS-GEN/RSS-10, Issue 10	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 RF Module stopped transmitting within the required time period. A 10-second sweep was made, during which the transmitter was triggered to deactivate and the time to transmission end was measured. Figure 2 shows the indicated time period from un-keying the device until cessation of transmission. The EUT complies with the requirements of this section, as the cessation time is 93.01 ms.

Figure 2: Deactivation of Transmitter (TX Cessation)



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 transmitter is disabled. When this occurs, the transmitter is disabled as shown in Figure 2.

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 scheme of any kind.

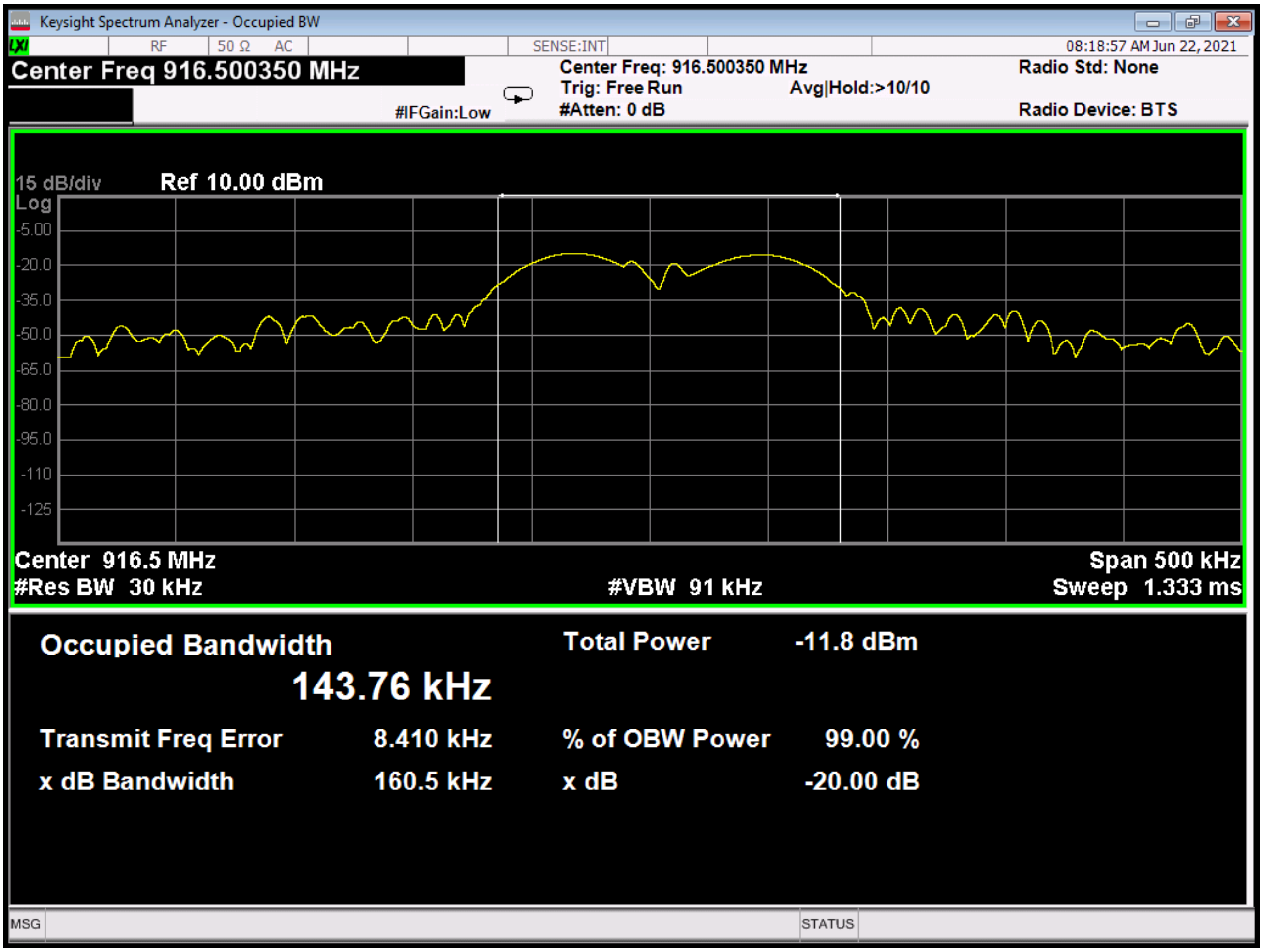
4.4 Occupied Bandwidth – FCC Part §15.231(c)

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. The EUT complies with the requirements of this section.

Table 7: Occupied Bandwidth Results

TX Frequency	20 dB Bandwidth	Limit	Results
916 MHz	160.50 kHz	4.583 MHz	Pass

Figure 3: 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 29.9 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 an 80 cm high 1 X 1.5 meters non-conductive motorized turntable for radiated testing at a 3m open area test site (OATS). 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 916 MHz radio emissions were measured. The peripherals were placed on the table in accordance with ANSI C63.4. Cables were varied in position to produce maximum emissions. Both 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.

Table 8: Fundamental Field Strength, Test Results

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	DCCF (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Detector
916.48	V	180.0	2.4	91.8	0.7	0.0	42177.7	125000.0	-9.4	Peak
916.48	V	180.0	2.4	91.8	0.7	29.9	1349.2	12500.0	-19.3	Peak *
916.48	H	135.0	2.4	91.8	0.7	0.0	42177.7	125000.0	-9.4	Peak
916.48	H	135.0	2.4	91.8	0.7	29.9	1349.2	12500.0	-19.3	Peak *

** note: this data indicates the corrected field strength, applied to the average limit.*

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 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 of FCC Part 15 and ICES-003 call for the EUT to be placed on an 80 cm high 1 X 1.5 meters non-conductive motorized turntable for radiated testing at a 3m open field test site. 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. The peripherals were placed on the table in accordance with ANSI C63.4. Cables were varied in position to produce maximum emissions. 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).

The worst-case emissions are reported below.

Table 9: Spurious Emissions Test Data – 30 MHz to 1000 MHz

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Detector
31.00	V	180.0	2.7	0.0	-4.6	0.6	100.0	-44.6	QP
46.78	V	180.0	2.4	45.7	-15.7	31.3	100.0	-10.1	QP
55.24	V	135.0	2.4	39.3	-17.8	11.8	100.0	-18.6	QP
126.51	V	180.0	2.4	29.5	-10.9	8.5	150.0	-24.9	QP
215.83	V	135.0	2.4	34.5	-13.7	10.9	150.0	-22.8	QP
237.82	V	135.0	2.4	28.1	-13.0	5.7	200.0	-30.9	QP
429.00	V	180.0	2.4	33.8	-7.2	21.4	200.0	-19.4	QP
46.78	H	135.0	2.4	34.4	-15.7	8.6	100.0	-21.4	QP
55.24	H	180.0	2.4	36.2	-17.8	8.3	100.0	-21.6	QP
126.51	H	180.0	2.4	40.8	-10.9	31.4	150.0	-13.6	QP
215.83	H	180.0	2.4	43.4	-13.7	30.5	150.0	-13.8	QP
237.82	H	135.0	2.4	38.4	-13.0	18.5	200.0	-20.7	QP
429.00	H	180.0	2.4	31.9	-7.2	17.1	200.0	-21.3	QP

Table 10: Spurious Emissions Test Data – 1 GHz to 12 GHz

Frequency (MHz)	Polarity H/V	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	DCCF (dB)	Corr. Level (uV/m)	Limit (uV/m)	Margin (dB)	Emission Type
1833.00	V	180.0	1.2	56.1	-10.8	0.0	183.7	12500	-36.7	Peak
1833.00	V	180.0	1.2	56.1	-10.8	29.9	5.9	1250	-46.6	AVG*
2749.50	V	135.0	1.2	45.0	-8.8	0.0	64.3	5000	-39.2	Peak
2749.50	V	180.0	1.2	45.0	-8.8	29.9	2.1	500	-25.9	AVG *
3666.00	V	135.0	1.2	43.2	-8.0	0.0	57.7	12500	-46.7	Peak
3666.00	V	135.0	1.2	43.2	-8.0	29.9	1.8	1250	-56.6	AVG*
4582.50	V	180.0	1.2	42.7	-8.9	0.0	49.0	5000	-41.8	Peak
4582.50	V	180.0	1.2	42.7	-8.9	29.9	1.6	500	-33.2	AVG *
5499.00	V	180.0	1.2	41.9	-7.2	0.0	54.6	12500	-47.2	Peak
5499.00	V	180.0	1.2	41.9	-7.2	29.9	1.7	1250	-57.1	AVG*
6415.50	V	180.0	1.2	39.2	-6.9	0.0	41.3	12500	-49.6	Peak
6415.50	V	180.0	1.2	39.2	-6.9	29.9	1.3	1250	-59.5	AVG *
1833.00	H	180.0	1.1	52.7	-10.8	0.0	124.2	12500	-40.1	Peak
1833.00	H	180.0	1.1	52.7	-10.8	29.9	4.0	1250	-50.0	AVG*
2749.50	H	135.0	1.1	44.6	-8.8	0.0	61.4	5000	-39.6	Peak
2749.50	H	135.0	1.1	44.6	-8.8	29.9	2.0	500	-26.8	AVG *
3666.00	H	180.0	1.1	43.3	-8.0	0.0	58.4	12500	-46.6	Peak
3666.00	H	180.0	1.1	43.3	-8.0	29.9	1.9	1250	-56.5	AVG*
4582.50	H	180.0	1.2	43.3	-8.9	0.0	52.6	5000	-41.2	Peak
4582.50	H	180.0	1.2	43.3	-8.9	29.9	1.7	500	-31.2	AVG *
5499.00	H	180.0	1.2	40.0	-7.2	0.0	43.8	12500	-49.1	Peak
5499.00	H	180.0	1.2	40.0	-7.2	29.9	1.4	1250	-59.0	AVG*
6415.50	H	180.0	1.2	41.0	-6.9	0.0	50.8	12500	-47.8	Peak
6415.50	H	180.0	1.2	41.0	-6.9	29.9	1.6	1250	-57.7	AVG *

** note: this data indicates the corrected field strength, applied to the average limit.*

4.7 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.

Figure 4: Transmitter Pulse, per 100ms

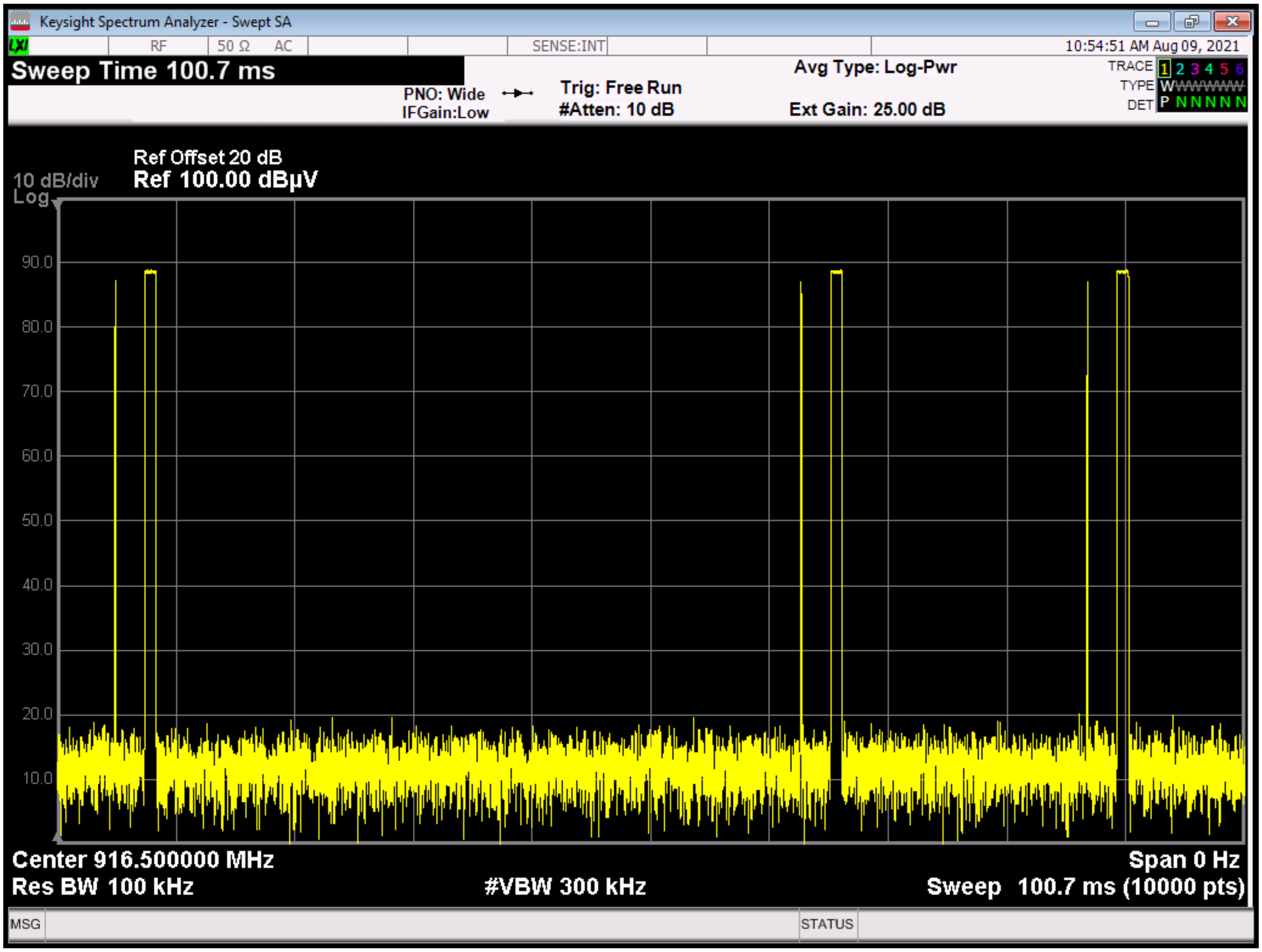
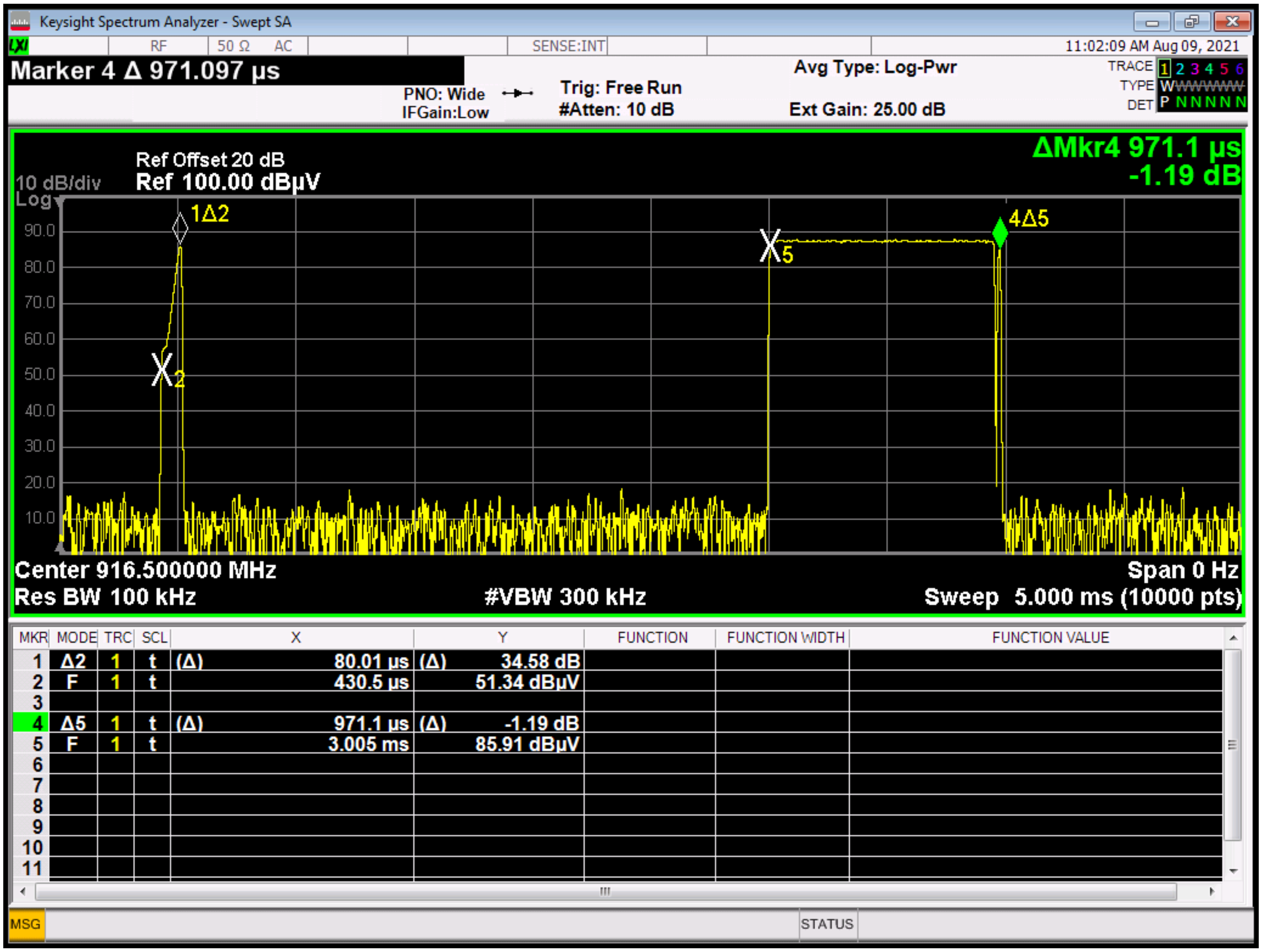


Figure 5: Transmitter Sub-Pulse, On-Time



The transmitter 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 declared as 100 ms.

As depicted in Figure 4, the worst-case transmitter on-time (in any 100ms) is made of six sub-pulses. These series of pulses are not representative of a repeatable pulse train. In some cases, this measurement only yielded one set of pulses, with no distinguishable pattern.

The sweep time in Figure 5 was set to 5 ms, to make an accurate measurement of the individual sub-pulses. The longer pulse measures 971.1 us, and the shorter pulse measures 80 us.

As such, the worst case on-time ($t$on) is: 3(971.1) + 3(80) = 3.153 ms.

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

$t$on ÷ Tcycle = Δ

3.153 ÷ 100 = .0315

Δ = 3.2%

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(0.032) = –29.897

δ = 29.9 dB

Where δ is the final DCCF.

(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:	**Benchtop RF Emissions**	Test Date: See Section 1.5 of this Report	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00823	AGILENT, N9010A	SPECTRUM ANALYZER	5/27/2022
00885	UTIFLEX, UFA2108	HF COAXIAL	5/10/2022

Test Name:	**Radiated Emissions**	Test Date: See Section 1.5 of this Report	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00823	AGILENT, N9010A	SPECTRUM ANALYZER	5/27/2022
00644	SUNOL SCIENCES CORP.	JB1 LOGPERIOD ANT.	11/9/2022
00425	ARA, DRG-118/A	HORN ANTENNA	8/18/2022
00955	JUNKOSHA USA	HF COAXIAL	5/10/2022
00885	UTIFLEX MICRO COAX	HF COAXIAL	5/10/2022
00280	ITC, 21C-3A1	WAVEGUIDE FILTER	1/18/2022
00885	UTIFLEX, UFA2108	HF COAXIAL	5/10/2022
00721	WEINSCHEL, DS109	ATTENUATOR	CNR