FCC/Industry Canada Certification Test Report

for the

Frederick Energy Products LLC
Hit-Not Magnetic Field Generator (DDAC-PDS-C-2)

FCC ID: QUI-DDAC-PDS-GEN2
ISED ID: 11625A-DDACPDSGEN2

WLL REPORT# 16955-02 REV 7

Prepared for:

Frederick Energy Products, LLC
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Prepared By:

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4840 Winchester Boulevard
Frederick, Maryland 21703

Testing Certificate AT-1448

FCC & ISED Canada Certification Test Report

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April 22, 2021

WLL Report # 16955-02 Rev 7

Prepared by:

Richard Quarcoo
Compliance Engineer

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 a Transmitter under Part 15.209 (10/2014) of the FCC Rules and Regulations and Industry Canada RSS-Gen issue 5 (3/2019). This Certification Test Report documents the test configuration and test results for the Frederick Energy Products LLC Magnetic Field Generator.

Testing was performed on an Open Area Test Site (OATS) of Washington Laboratories, Ltd, 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. The ISED Canada number is 3035A for Washington Laboratories, Ltd. Washington Laboratories, Ltd. has been accepted by the FCC, ISED and approved by ANAB under Certificate AT-1448 as an independent FCC test laboratory.

The Frederick Energy Products LLC Hit-Not Magnetic Field Generator (DDAC-PDS-C-2) complies with the limits for a Transmitter device under FCC Part 15.209 and RSS-GEN issue 5.

Revision History	Description of Change	Date
Rev 0	Initial Release	April 22, 2021
Rev 1	Correct FCC and ISED Numbers	May 26, 2021
Rev 2	ACB Comments (ATCB026996)	June 4, 2021
Rev 3	ACB Comments v2 (ATCB026996)	July 12, 2021
Rev 4	Update Transmitter References per ACB	July 16, 2021
Rev 5	ACB Comments v3 (ATCB026996)	July 23, 2021
Rev 6	ACB Comments dated July 28, 2021	August 16, 2021
Rev 7	Update Requirements of 15.31(f)(2)	August 25, 2021

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1 Introduction

1.1 Compliance Statement

The Frederick Energy Products LLC Hit-Not Magnetic Field Generator (DDAC-PDS-C-2) complies with the limits for an Intentional Radiator device under Part 15.209 of the FCC Rules and Regulations and Industry Canada RSS-GEN Issue 5.

1.2 Test Scope

Tests for radiated emissions were performed. All measurements were performed according to the 2014 version of ANSI C63.4. The measurement equipment conforms to ANSI C63.4 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:
Frederick Energy Products LLC
1769 Jeff Drive,
Huntsville, AL, 35806

1.4 Test Dates

Testing was performed during the following dates: 2/3/2021 to 7/30/2021.

1.5 Test and Support Personnel

Washington Laboratories, LTD	Richard Quarcoo
Customer Representative	Andrew Nichols

2 Equipment Under Test

2.1 EUT Identification & Description

The Frederick Energy Products, LLC Hit-Not Magnetic Field Generator (DDAC-PDS-C-2) is used to activate a PAD when a PAD is within a certain range of the generator. The PAD generates a continuous tone when it is within about 50’ of the generator and generates a beeping tome at about 67’ of the generator. So, there are two zones for the PAD. A warning zone and a danger zone. The generator is supplied power by the vehicle. The generator can operate with power as low as 12V, but the field is reduced in that case. Optimally the generator requires 24VDC for optimal field generation. The EUT uses a pre-approved BLE module: FCC ID: T9JRN4020; IC ID: 6514A-RN4020.

Table 1: Device Summary

Manufacturer:	Frederick Energy Products, LLC
FCC ID:	QUI-DDAC-PDS-GEN2
ISED ID:	11625A-DDACPDSGEN2
EUT Name:	Hit-Not Magnetic Field Generator
EUT Model:	DDAC-PDS-C-2
FCC Rule Parts:	§15.209
ISED Rule Parts:	RSS-210
FCC Emission Designator:	17K5N0N
IC Emission Designator:	19K5N0N
Modulation:	CW: Pulsed
Number of Channels:	1
Power Output Level	Fixed
Antenna Type:	Wire Loop Antenna
Interface Cables:	N/A
Software/Firmware Test Settings:	Test Mode/Normal (no special settings or details)
Power Source & Voltage:	36 VDC

2.2 Test Configuration

The Frederick Energy Products LLC Magnetic Field Generator, Equipment Under Test (EUT), was operated from a supplied AC/DC power supply.

Figure 1: EUT Power/Test Configuration

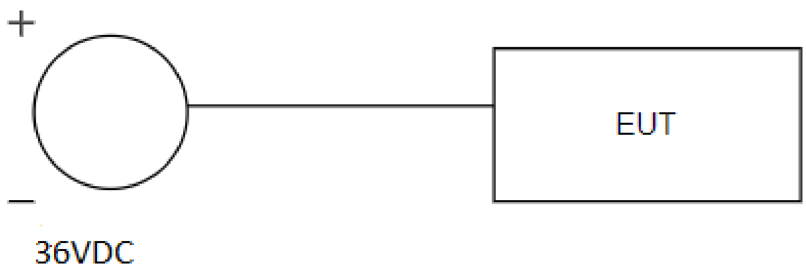


Table 2: Equipment Configuration

Name / Description	Manufacturer	Model	Serial Number	Revision
Hit-Not Magnetic Field Generator (DDAC-PDS-C-2)	Frederick Energy Products, LLC	DDAC-PDS-C	Not Listed	Not Listed

2.3 Support Equipment

Table 3: Support Equipment

Item	Model/Part Number	Serial Number
DC Power Supply	N/A	N/A

2.4 Equipment Configuration

In accordance with RSS-GEN Annex A, the FEPL Test Mode Software/Firmware that was used during test, has no identifiable settings or details.

2.5 Interface Cables

Table 4: Interface Cables

Port Identification	Connector Type	Cable Length	Shielded (Y/N)	Termination Point
DC Power	F70-2	<3m	N	Pos/Neg

2.6 EUT Modifications

No modifications were performed in order to meet the test requirements.

2.7 Testing Algorithm

Hit-Not Magnetic Field Generator (DDAC-PDS-C-2) creates a magnetic field and a PAD or another generator responds to it.

2.8 Test Location

Testing was performed on an Open Area Test Site (OATS) of Washington Laboratories, Ltd, 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. The ISED Canada number is 3035A for Washington Laboratories, Ltd. Washington Laboratories, Ltd. has been accepted by the FCC, ISED and approved by ANAB under Certificate AT-1448 as an independent FCC test laboratory.

2.9 Measurements

2.9.1 References

ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation

ANSI C63.4 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

2.10 Measurement Uncertainty

All results reported herein relate only to the equipment tested. The basis for uncertainty calculation uses ANSI/NCSL Z540-2-1997 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 u_c = standard uncertainty

a, b, c,.. = individual uncertainty elements

$Div_{a,\ b,\ c}$ = 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

$k \leq 2$ for 95% coverage (ANSI/NCSL Z540-2 Annex G)

u_c = 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, CISPR14, FCC Part 15	±2.63 dB
Radiated Emissions	CISPR11, CISPR22, CISPR14, FCC Part 15	±4.55 dB

3 Test Equipment

Table 6 shows a list of the test equipment used for measurements along with the calibration information.

Table 6: Test Equipment List

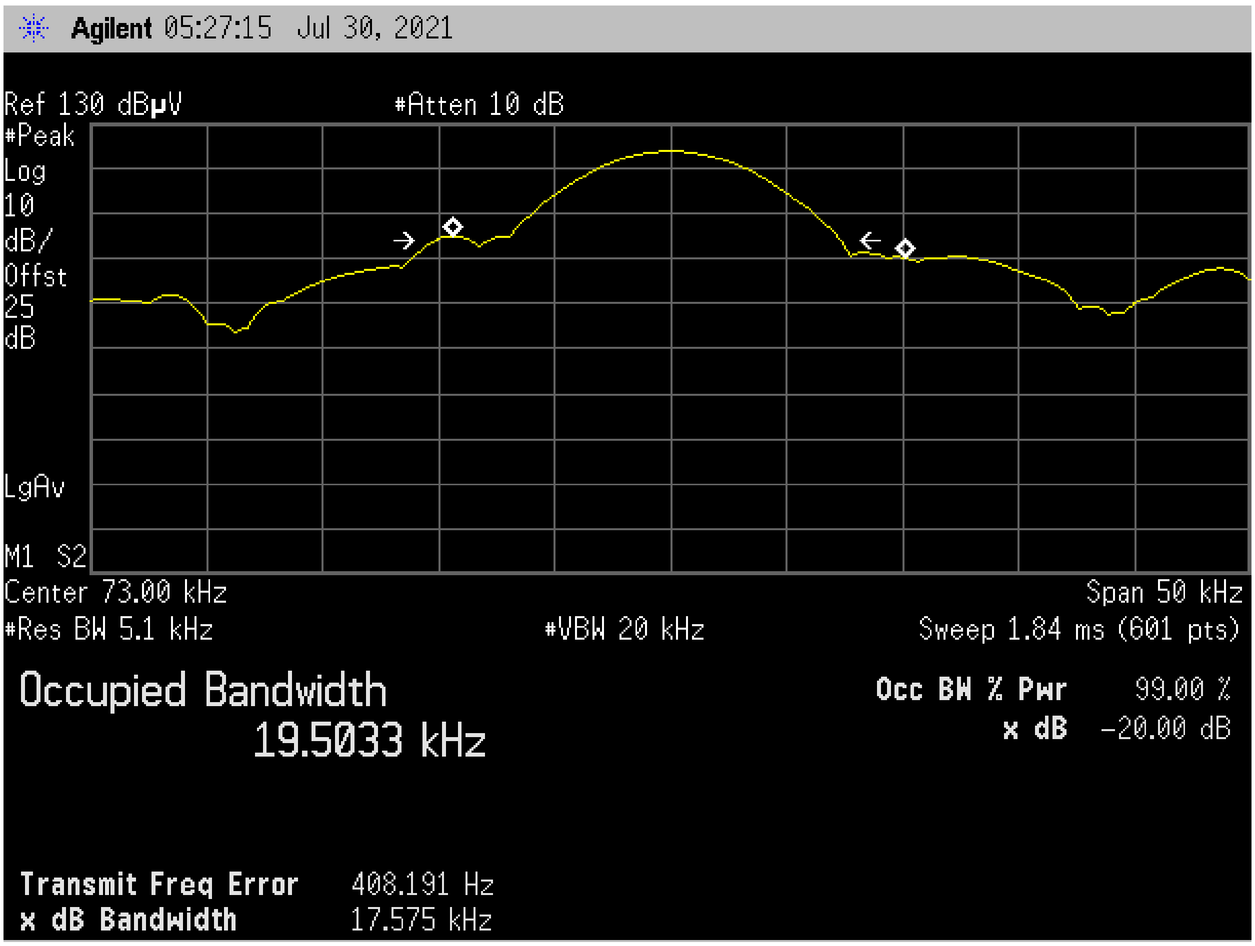
Test Name:	**Radiated Emissions**	Test Date:	**See Section 1.4**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00031	EMCO 6502	ANTENNA ACTIVE LOOP	9/17/2022
00823	AGILENT N9010A	EXA SPECTRUM ANALYZER	5/27/2022
00558	HP 8447D	AMPLIFIER	6/3/2022
00942	MXA-N9020A	SPEC. ANALYZER	10/30/2021
00559	HP	PREAMP	6/3/2022
00627	AGILENT	PREAMP	8/31/2021
00093	KIKISUI	POWER SUPPLY	CNR
00425	ARA DRG-118/A	HORN ANTENNA	8/18/2022
00382	SUNOL SCIENCES CORPORATION	JB1 ANTENNA	5/12/2023

4 Test Results

4.1 Occupied Bandwidth: (FCC Part §2.1049, RSS –Gen)

The transmit signal is a 73 kHz CW. The OBW measurement is provided in the test data figure below.

Figure 2: Transmitter OBW



4.2 Radiated Spurious Emissions: (FCC Part §15.209, RSS-Gen)

Transmitters operating under §15.209 & Industry Canada RSS-GEN must comply with the radiated emissions listed in the following table:

Table 7: Radiated Emissions Limits

Frequency	Field Strength	Measurement Distance
(MHz)	(microvolts/meter)	(meters)
0.009 - 0.490	2400/F(kHz)	300
0.490 - 1.705	24000/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

4.2.1 Test Procedure

The EUT was placed on motorized turntable for radiated testing on an open field test site. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable

For frequencies between 10 kHz and 30 MHz, a loop antenna was mounted of a tripod at height of 1 m. The Loop antenna was rotated about its vertical and horizontal axis to determine the highest emissions.

For frequencies above 30MHz the receiving 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. Both the horizontal and vertical field components were measured.

The EUT was scanned from 10kHz to 3GHz (in order to include the 10th harmonic of the fundamental and the receiver data).

The EUT was examined in three orthogonals, and the orthogonal that demonstrated the highest emission was reported.

Transmitter fundamental and Harmonics were tested for peak emissions and compared to the Average limits, as this is a pulsed CW signal.

Resolution bandwidths used for frequencies measured between:

- 9 kHz – 150kHz, RBW = 200Hz
- 150kHz – 30MHz, RBW = 9kHz
- 30MHz – 1GHz, RBW = 120kHz

And, for frequencies measured above 1GHz:

- RBW = 1MHz

The EUT was examined in three orthogonal, and the orthogonal that demonstrated the highest emission was reported below.

Below 30 MHz radiated measurements were taken at 10 meters.

The 300m distance is interpolated to 10m, as explained on Page 19.

Test results reflect worst case emissions in regard to EUT orientation to the measurement loop antenna.

The limits in CFR 47, Part 15 Subpart C, para. 15.209(a) are the same as RSS-GEN. The measurements in this section were made in terms of Electric FS, that were then then converted to a Magnetic FS, for comparison to the limit expressed as an H-Field.

The EUT was evaluated, to the 10th harmonic of the fundamental. All modules and transmitters were set to a transmit enabled mode throughout the testing.

The RSS-Gen field strength limit for the 73 kHz transmitter is .087 uA/m at 300m.

E-Field to H-field conversion is 0LOG(120pi) = 20LOG(377) = 51.5 dBΩ

In accordance with FCC Rule Part 15.31(f)(2):

For measurements of frequencies below 30 MHz, the measurement distance is permitted to be less than specified in the applicable limitation tables, with the field strength levels corrected using an extrapolated calculation to the specified measurement distance. This extrapolated distance-calculation is defined by making measurements at two separate distances, on the same radial, to determine the proper extrapolation factor.

As such, the field strength of the MAC transmit signal was evaluated at 10m and at 3m.

The measured field strength results were as follows:

10m: 78.3 dBµV (Raw, Peak)

3m: 108.0 dBµV (Raw, Peak)

108 – 78.3 = 29.7

29.7 shall be rounded to 30 dB, which is the fall-off factor for these two distances.

Extrapolation Defined:

xLOG(10/3) = 30 dB

x = 30 ÷ (LOG10/3)) = 57.4

The implementation of a 57.4 dB/decade factor, for the ratio of the two evaluation distances, produces the sum of 30 dB.

That is: 57.4LOG(10/3) = 30.01

Extrapolation Applied for Compliance:

The limit for the 73 kHz transmitter is defined at a distance of 300m.

The final radiated emissions testing was performed at 10m.

As specified for a 10m fall-off: 57.4LOG(300/10) = 84.78

85 dB shall be used to correct the field strength, prior to the final limit comparisons.

Table 8: TX Fundamental, Radiated Emissions Test Data for FCC

Frequency (kHz)	Antenna Polarity	EUT Polarity	SA Level (dBuV)	Antenna Factor (dB)	DCCF (dB)	Corr. Level (dBuV/m)	Corr. F/S (uV/m)	Limit (uV/m)	Limit (dBuV/m)	Margin (dB)	Detector
73.0	X	X	76.90	11.0	0.0	2.9	1.4	330	50.3	-47.4	Peak
73.0	X	X	76.90	11.0	21.0	-18.1	0.12	33	30.3	-48.4	Peak *
73.0	Y	X	76.30	11.0	0.0	2.3	1.3	330	50.3	-48.0	Peak
73.0	Y	X	76.30	11.0	21.0	-18.7	0.12	33	30.3	-49.0	Peak *
73.0	Z	X	78.90	11.0	0.0	4.9	1.8	330	50.3	-45.4	Peak
73.0	Z	X	78.90	11.0	21.0	-16.1	0.16	33	30.3	-46.4	Peak *
note: ***** indicates this data is the corrected field strength, compared to the average limit											

The 85 dB, distance correction, as defined on Page 16 is inclusive of the Corrected Level in dBuV/m. *Example:* 78.90 + 11 – 85 = 4.9 dBuV/m

Table 9: TX Fundamental, Radiated Emissions Test Data for ISED Canada

Frequency (kHz)	Antenna Polarity	SA Level (dBuV)	Antenna Factor (dB)	Distance Corr. (dB)	H-Field Corr.	DCCF (dB)	Corr. Level (dBuA/m)	Limit (uA/m)	Limit (dBuA/m)	Margin (dB)	Detector
73.0	X	76.90	11.0	85.0	51.5	0.0	-48.6	0.87	-1.2	-47.4	Peak
73.0	X	76.90	11.0	85.0	51.5	21.0	-69.6	0.087	-21.2	-48.4	Peak *
73.0	Y	76.30	11.0	85.0	51.5	0.0	-49.2	0.87	-1.2	-48.0	Peak
73.0	Y	76.30	11.0	85.0	51.5	21.0	-70.2	0.087	-21.2	-49.0	Peak *
73.0	Z	78.90	11.0	85.0	51.5	0.0	-46.6	0.87	-1.2	-45.4	Peak
73.0	Z	78.90	11.0	85.0	51.5	21.0	-67.6	0.087	-21.2	-46.4	Peak *
note: ***** indicates this data is the corrected field strength, compared to the average limit											

Table 10: Harmonics, Radiated Emissions Test Data

Frequency (kHz)	Antenna Polarity	EUT Polarity	SA Level (dBuV)	Antenna Factor (dB)	DCCF (dB)	Corr. Level (dBuV/m)	Corr. F/S (uV/m)	Limit (uV/m)	Limit (dBuV/m)	Margin (dB)	Detector
146.0	146	X	70.50	10.5	0.0	-7.6	0.4168	160	44.3	-51.9	Peak
146.0	146	X	70.50	10.5	21.0	-28.6	0.0371	16	24.3	-52.9	Peak *
146.0	146	Y	67.40	10.5	0.0	-10.7	0.2917	160	44.3	-55.0	Peak
146.0	146	Y	67.40	10.5	21.0	-31.7	0.0260	16	24.3	-56.0	Peak *
146.0	146	Z	71.40	10.5	0.0	-6.7	0.4623	160	44.3	-51.0	Peak
146.0	146	Z	71.40	10.5	21.0	-27.7	0.0412	16	24.3	-52.0	Peak *
219.0	146	X	69.20	10.5	0.0	0.0	1.0000	110	40.8	-40.8	Peak
219.0	146	X	69.20	10.5	21.0	-21.0	0.0891	11	20.8	-41.8	Peak *
219.0	146	Y	55.70	10.5	0.0	0.0	1.0000	110	40.8	-40.8	Peak
219.0	146	Y	55.70	10.5	21.0	-21.0	0.0891	11	20.8	-41.8	Peak *
219.0	146	Z	68.50	10.5	0.0	0.0	1.0000	110	40.8	-40.8	Peak
219.0	146	Z	68.50	10.5	21.0	-21.0	0.0891	11	20.8	-41.8	Peak *
292.0	146	X	62.90	10.5	0.0	0.0	1.0000	80	38.3	-38.3	Peak
292.0	146	X	62.90	10.5	21.0	-21.0	0.0891	8	18.3	-39.3	Peak *
292.0	146	Y	51.70	10.5	0.0	0.0	1.0000	80	38.3	-38.3	Peak
292.0	146	Y	51.70	10.5	21.0	-21.0	0.0891	8	18.3	-39.3	Peak *
292.0	146	Z	58.80	10.5	0.0	0.0	1.0000	80	38.3	-38.3	Peak
292.0	146	Z	58.80	10.5	21.0	-21.0	0.0891	8	18.3	-39.3	Peak *
365.0	146	X	60.30	10.5	0.0	0.0	1.0000	70	36.9	-36.9	Peak
365.0	146	X	60.30	10.5	21.0	-21.0	0.0891	7	16.4	-37.4	Peak *
365.0	146	Y	46.80	10.5	0.0	0.0	1.0000	70	36.9	-36.9	Peak
365.0	146	Y	46.80	10.5	21.0	-21.0	0.0891	7	16.4	-37.4	Peak *
365.0	146	Z	49.90	10.5	0.0	0.0	1.0000	70	36.9	-36.9	Peak
365.0	146	Z	49.90	10.5	21.0	-21.0	0.0891	7	16.4	-37.4	Peak *
438.0	146	X	60.40	10.5	0.0	0.0	1.0000	50	34.8	-34.8	Peak
438.0	146	X	60.40	10.5	21.0	-21.0	0.0891	5	14.8	-35.8	Peak *
438.0	146	Y	46.70	10.5	0.0	0.0	1.0000	50	34.8	-34.8	Peak
438.0	146	Y	46.70	10.5	21.0	-21.0	0.0891	5	14.8	-35.8	Peak *
438.0	146	Z	50.60	10.5	0.0	0.0	1.0000	50	34.8	-34.8	Peak
438.0	146	Z	50.60	10.5	21.0	-21.0	0.0891	5	14.8	-35.8	Peak *

note: ***** indicates this data is the corrected field strength, compared to the average limit

4.3 Transmitter Duty Cycle and DCCF

Figure 3: TX On-Time, per 100ms

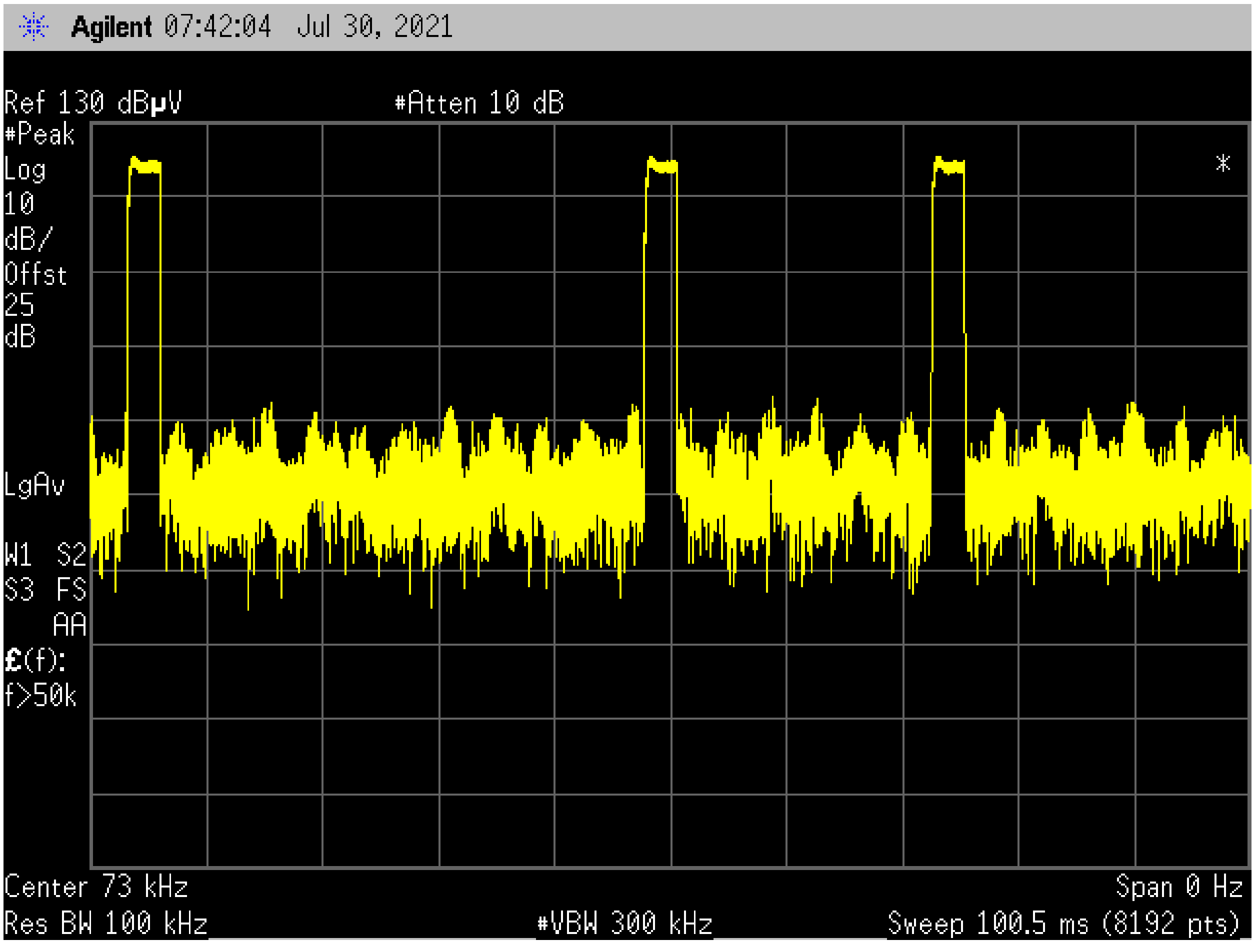
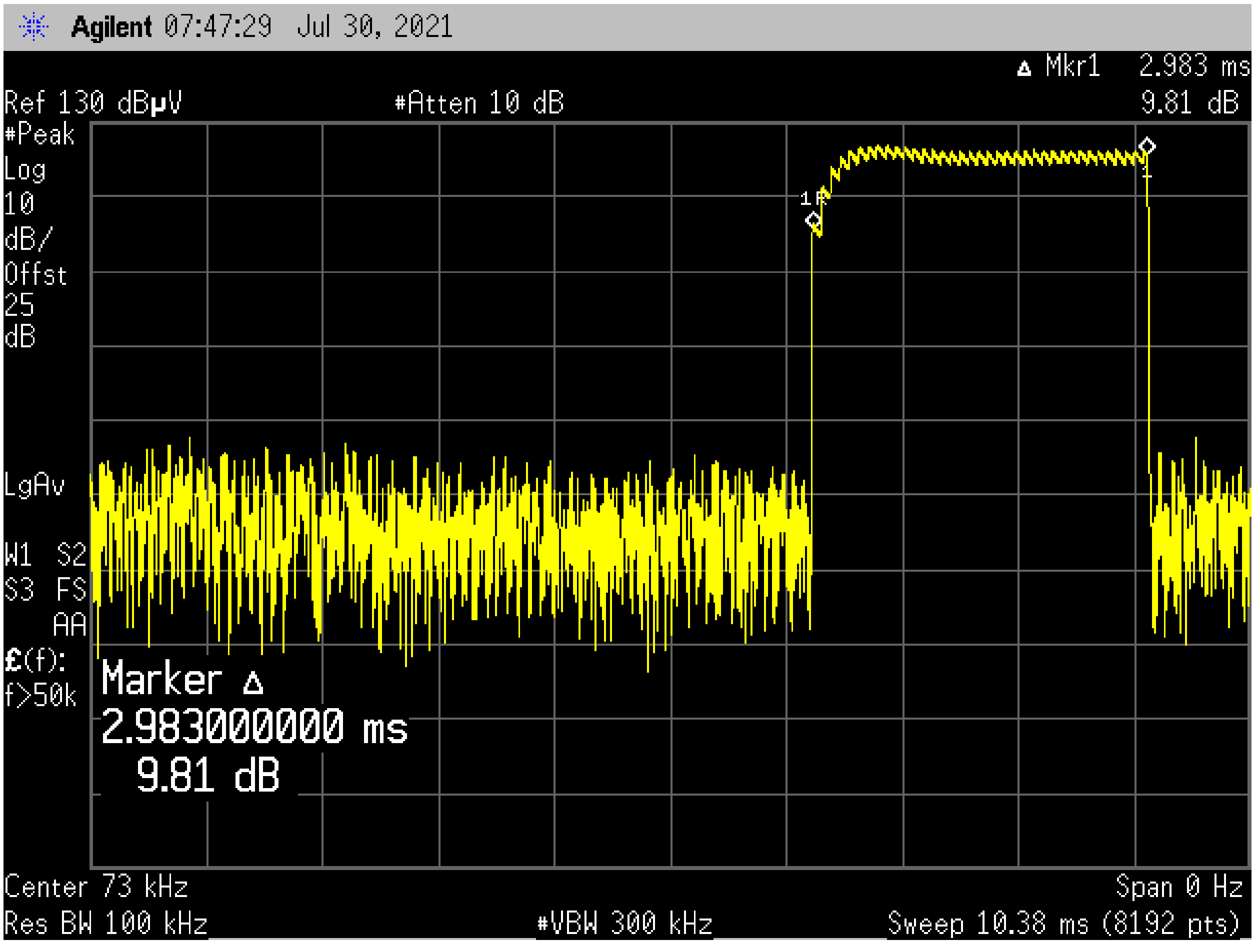


Figure 4: Sub-Pulse – On-Time



The sweep time in Figure 3 was set to 100ms, in order to observe the pulsed transmitter. In this case, the full pulse train is greater than the measurement period. As such, the cycle time (Tcycle) shall be declared as 100 ms.

As shown in Figure 4, any given individual transmitter sub-pulse, measures 2.98 ms. As such, the worst case on-time ($t$on) is 3 x 2.98 = 8.94 ms.

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

$t$on ÷ Tcycle = Δ

8.94 ÷ 100 = 0.0894

Δ = 8.9 %

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(0.089) = –21.012

δ = 21.0 dB

Where δ is the final DCCF.

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

4.4 Receiver Radiated Emissions (RSS-GEN)

4.4.1 Requirements

Test Arrangement: Table top

Compliance Standard: RSS-Gen

RSS-Gen Compliance Limits for Receivers	
Frequency	**Limits**
30-88 MHz	100 µV/m
88-216 MHz	150 µV/m
216-960 MHz	200 µV/m
>960MHz	500 µV/m

4.4.2 Test Procedure

The requirements of RSS-GEN call for the EUT to be placed on an 80 cm high 1 X 1.5 meters non-conductive motorized turntable for radiated testing on a 3-meter 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 3 GHz were measured. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured.

The output from the antenna was connected, via a preamplifier, to the input of the spectrum analyzer. The detector function was set to quasi-peak, peak, or average as appropriate. 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.

All measurements above 1 GHz were made at a distance of 3m with a Resolution Bandwidth of 1 MHz and a Video bandwidth of 10Hz. Average readings were taken in a linear mode with zero-span.

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) are 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 linear amplitude, and then compared to the Industry Canada limit.

Example:

Spectrum Analyzer Voltage:	VdBμV	
Antenna Correction Factor:	AFdB/m	
Cable Correction Factor:	CFdB	
Electric Field:	EdBV/m =	V dBμV + AfdB/m + CFdB

Table 11: Receiver Radiated Emissions Test Data > 30MHz

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)
46.78	V	180	2.4	45.7	-15.7	31.3	100	-10.1
55.24	V	135	2.4	39.3	-17.8	11.8	100	-18.6
126.51	V	180	2.4	29.5	-10.9	8.5	150	-24.9
215.83	V	135	2.4	34.5	-13.7	10.9	150	-22.8
237.82	V	135	2.4	28.1	-13	5.7	200	-30.9
429.00	V	180	2.4	33.8	-7.2	21.4	200	-19.4
46.78	H	135	2.4	34.4	-15.7	8.6	100	-21.4
55.24	H	180	2.4	36.2	-17.8	8.3	100	-21.6
126.51	H	180	2.4	40.8	-10.9	31.4	150	-13.6
215.83	H	180	2.4	43.4	-13.7	30.5	150	-13.8
237.82	H	135	2.4	38.4	-13	18.5	200	-20.7
429.00	H	180	2.4	31.9	-7.2	17.1	200	-21.3

Note:

1. See WLL test report 16955-01 for the 916.48 MHz Transmitter.