FCC & ISED Canada Certification Test Report

for the

Frederick Energy Products, LLC
Magnetic Field SXL Generator

FCC ID: QUI-DDAC-PDS-SXLC
ISED ID: 11625A-DDACPDSSXLC

WLL REPORT# 16938-02 REV 3

Prepared for:

Frederick Energy Products, LLC
1769 Jeff Road
Huntsville, Alabama 35806

Prepared By:

Washington Laboratories, Ltd.
4840 Winchester Boulevard
Frederick, Maryland 21703

Testing Certificate AT-1448

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May 19, 2021

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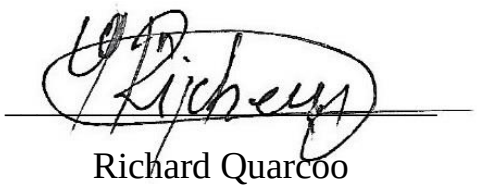
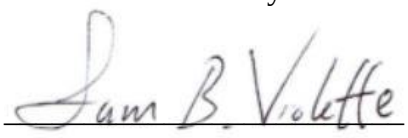


Richard Quarcoo
Compliance Engineer

Reviewed by:



Samuel Violette
Vice President of Operations

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, Magnetic Field SXL Generator 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	May 19, 2021
Rev 1	ACB Comments # ATCB026997	July 9, 2021
Rev 2	ACB Comments # ATCB026997 v2	July 15, 2021
Rev 3	ACB Comments Dated July 21, 2021	August 10, 2021

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1 Introduction

1.1 Compliance Statement

The Frederick Energy Products LLC MAGNETIC FIELD SXL GENERATOR 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

Quotation Number: 72461

1.4 Test Dates

Testing was performed on the following date(s): 12/23/2020 to 2/6/2021 & 7/7/2021 to 8/10/2021.

1.5 Test and Support Personnel

Washington Laboratories, LTD	Richard Quarcoo
Customer Representative	Andrew Nicholas

2 Equipment Under Test

2.1 EUT Identification & Description

The Frederick Energy Products, LLC SXL Generator 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.

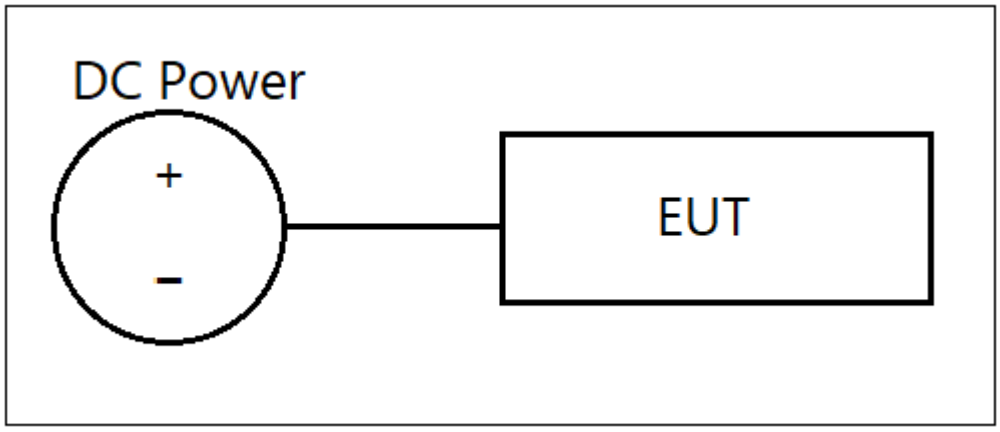
Table 1: Device Summary

Manufacturer:	Frederick Energy Products, LLC
FCC ID:	QUI-DDAC-PDS-SXLC
ISED ID:	11625A-DDACPDSSXLC
EUT Model:	Magnetic Field SXL Generator
FCC Rule Parts:	15.209
ISED Rule Parts:	RSS-210
20 dB OBW:	25.341 kHz
99% OBW:	21.464 kHz
FCC Emission Designator:	25K3N0NXN
IC Emission Designator:	21K5N0NXN
Modulation:	Pulsed CW, No Data
Number of Channels:	1
Highest RF Emission:	73 kHz, 22490.5uV/m @ 10m
Power Output Level	Fixed
Antenna Type:	Wire Loop Antenna
Interface Cables:	N/A
Software/Firmware:	FEPL Proprietary Test Mode, REV A
Power Source & Voltage:	24 VDC

2.2 Test Configuration

The Frederick Energy Products LLC Magnetic Field Generator was operated from a laboratory supplied DC power supply.

Figure 1: Test Configuration



2.3 Equipment Configuration

The EUT was set up as outlined in Figure 1. The EUT was comprised of the following equipment. (All Modules, PCBs, etc. listed were considered as part of the EUT, as tested.)

Table 2: Equipment Configuration

Name / Description	Manufacturer	Model	Serial Number	Revision
SXL Generator	FEPL	N/A	N/A	N/A

2.4 Support Equipment

The following support equipment was used during testing:

Table 3: Support Equipment

Item	Model/Part Number	Serial Number
DC Power Supply	EVENTEK	KPS3010D

Table 4: Interface Cables

Port Identification	Connector Type	Cable Length	Shielded (Y/N)	Termination Point
Power Input (24VDC)	Multi-Pin	>3m	N	Power Supply

2.5 EUT Modifications

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

2.6 Testing Algorithm

The EUT was tested with all transmitters enabled. Worst case emissions are reported.

2.7 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.

2.8 Measurements

2.8.1 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

2.9 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

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

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 ≤ 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 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 Results

3.1 Radiated Spurious Emissions: (FCC Part §15.209, RSS-Gen Table 6)

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

Table 6: Radiated Emissions Limits

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (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

3.1.1 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 examined in three orthogonal planes and the orthogonal that demonstrated the highest emission was reported. All Fundamental and Harmonics were tested for peak emissions and compared to the Average limits as this is a pulsed CW signal. The EUT complies with both the peak and average limits.

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 scanned up to the 10th harmonic.

During all testing all EUT transmitters, including the BT radio, were set to enabled (TX On).

Radiated measurements were taken at 10 meters.

Notes for the table below:

- Distance correction factor is defined as: 60*LOG(300/10) = 88.6 dB (incorporated into the corrected levels)

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

- (reference: ANSI C63.10, 7.7.2).

Table 7: Radiated Emissions Test Data – Fundamental

Frequency (kHz)	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	82.90	11.0	0.0	5.3	1.841	330	50.3	-45.0	Peak
73.0	X	82.90	11.0	24.7	-19.4	0.107	33	30.3	-49.7	Peak *
73.0	Y	106.10	11.0	0.0	28.5	26.607	330	50.3	-21.8	Peak
73.0	Y	106.10	11.0	24.7	3.8	1.549	33	30.3	-26.5	Peak *
73.0	Z	86.60	11.0	0.0	9.0	2.818	330	50.3	-41.3	Peak
73.0	Z	86.60	11.0	24.7	-15.7	0.164	33	30.3	-46.0	Peak *
note: * indicates this data is the corrected field strength, compared to the average limit										

Table 8: Radiated Emissions Test Data – Harmonics

Frequency (kHz)	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	X	59.70	10.5	0.0	-18.4	0.120	160	44.3	-62.7	Peak
146.0	X	59.70	10.5	24.7	-43.1	0.007	16	24.3	-67.4	Peak *
146.0	Y	65.20	10.5	0.0	-12.9	0.226	160	44.3	-57.2	Peak
146.0	Y	65.20	10.5	24.7	-37.6	0.013	16	24.3	-61.9	Peak *
146.0	Z	66.70	10.5	0.0	-11.4	0.269	160	44.3	-55.7	Peak
146.0	Z	66.70	10.5	24.7	-36.1	0.016	16	24.3	-60.4	Peak *
219.0	X	59.60	10.5	0.0	10.1	3.199	110	40.8	-30.7	Peak
219.0	X	59.60	10.5	24.7	-14.6	0.186	11	20.8	-35.4	Peak *
219.0	Y	56.00	10.5	0.0	6.5	2.113	110	40.8	-34.3	Peak
219.0	Y	56.00	10.5	24.7	-18.2	0.123	11	20.8	-39.0	Peak *
219.0	Z	55.40	10.5	0.0	5.9	1.972	110	40.8	-34.9	Peak
219.0	Z	55.40	10.5	24.7	-18.8	0.115	11	20.8	-39.6	Peak *
292.0	X	55.00	10.5	0.0	5.5	1.884	80	38.3	-32.8	Peak
292.0	X	55.00	10.5	24.7	-19.2	0.110	8	18.3	-37.5	Peak *
292.0	Y	53.80	10.5	0.0	4.3	1.641	80	38.3	-34.0	Peak
292.0	Y	53.80	10.5	24.7	-20.4	0.095	8	18.3	-38.7	Peak *
292.0	Z	50.60	10.5	0.0	1.1	1.135	80	38.3	-37.2	Peak
292.0	Z	50.60	10.5	24.7	-23.6	0.066	8	18.3	-41.9	Peak *
365.0	X	54.40	10.5	0.0	4.9	1.758	70	36.9	-32.0	Peak
365.0	X	54.40	10.5	24.7	-19.8	0.102	7	16.4	-36.2	Peak *
365.0	Y	48.00	10.5	0.0	-1.5	0.841	70	36.9	-38.4	Peak
365.0	Y	48.00	10.5	24.7	-26.2	0.049	7	16.4	-42.6	Peak *
365.0	Z	56.00	10.5	0.0	6.5	2.113	70	36.9	-30.4	Peak
365.0	Z	56.00	10.5	24.7	-18.2	0.123	7	16.4	-34.6	Peak *
438.0	X	56.50	10.5	0.0	7.0	2.239	50	34.8	-27.8	Peak
438.0	X	56.50	10.5	24.7	-17.7	0.130	5	14.8	-32.5	Peak *
438.0	Y	47.90	10.5	0.0	-1.6	0.832	50	34.8	-36.4	Peak
438.0	Y	47.90	10.5	24.7	-26.3	0.048	5	14.8	-41.1	Peak *
438.0	Z	52.50	10.5	0.0	3.0	1.413	50	34.8	-31.8	Peak
438.0	Z	52.50	10.5	24.7	-21.7	0.082	5	14.8	-36.5	Peak *
note: * indicates this data is the corrected field strength, compared to the average limit										

3.1.2 Test Data for ISED Canada

The EUT complies with the requirements of RSS 210 (RSS-GEN limits) as shown in the data tables.

For measurement data shown in this section, the EUT was evaluated to the 10th harmonic of the fundamental. All transmitters were set to an enabled mode throughout the testing.

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

The highest amplitude, of the EUT fundamental, measured 106.1 dBuV at 10m.

RSS-Gen Notes for the table below:

- Distance correction factor is defined as: 60*LOG(300/10) = 88.6 dB
- E-to H-field conversion is 0*LOG(120pi) = 20 *LOG(377) = 51.5 dBΩ
- (reference: ANSI C63.10, 7.7.2).

Table 9: 73kHz Test Data for ISED Canada

Frequency (kHz)	EUT Polarity	SA Level (dBuV)	Antenna Factor (dB)	Distance Corr.	H-Field Corr.	DCCF (dB)	Corr. Level (dBuA/m)	Limit (uA/m)	Limit (dBuA/m)	Margin (dB)	Detector
73.0	X	82.90	11.0	88.6	51.5	0.0	-46.2	0.87	-1.2	-45.0	Peak
73.0	X	82.90	11.0	88.6	51.5	24.7	-70.9	0.087	-21.2	-49.7	Peak *
73.0	Y	106.10	11.0	88.6	51.5	0.0	-23.0	0.87	-1.2	-21.8	Peak
73.0	Y	106.10	11.0	88.6	51.5	24.7	-47.7	0.087	-21.2	-26.5	Peak *
73.0	Z	86.60	11.0	88.6	51.5	0.0	-42.5	0.87	-1.2	-41.3	Peak
73.0	Z	86.60	11.0	88.6	51.5	24.7	-67.2	0.087	-21.2	-46.0	Peak *
note: * indicates this data is the corrected field strength, compared to the average limit											

3.1.3 Receiver Radiated Emissions (RSS-GEN)

3.1.4 Requirements

Test Arrangement: Table Top

Compliance Standard: RSS-Gen sect 6.1

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

3.1.5 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 1GHz were made at a distance of 3m with a Resolution Bandwidth of 1MHz and a Video bandwidth of 10Hz. Average readings were taken in a linear mode with zero-span.

3.1.6 Test Data

The EUT complies with the requirements of RSS 210 (RSS-GEN limits) as shown in Table 10.

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

Example:

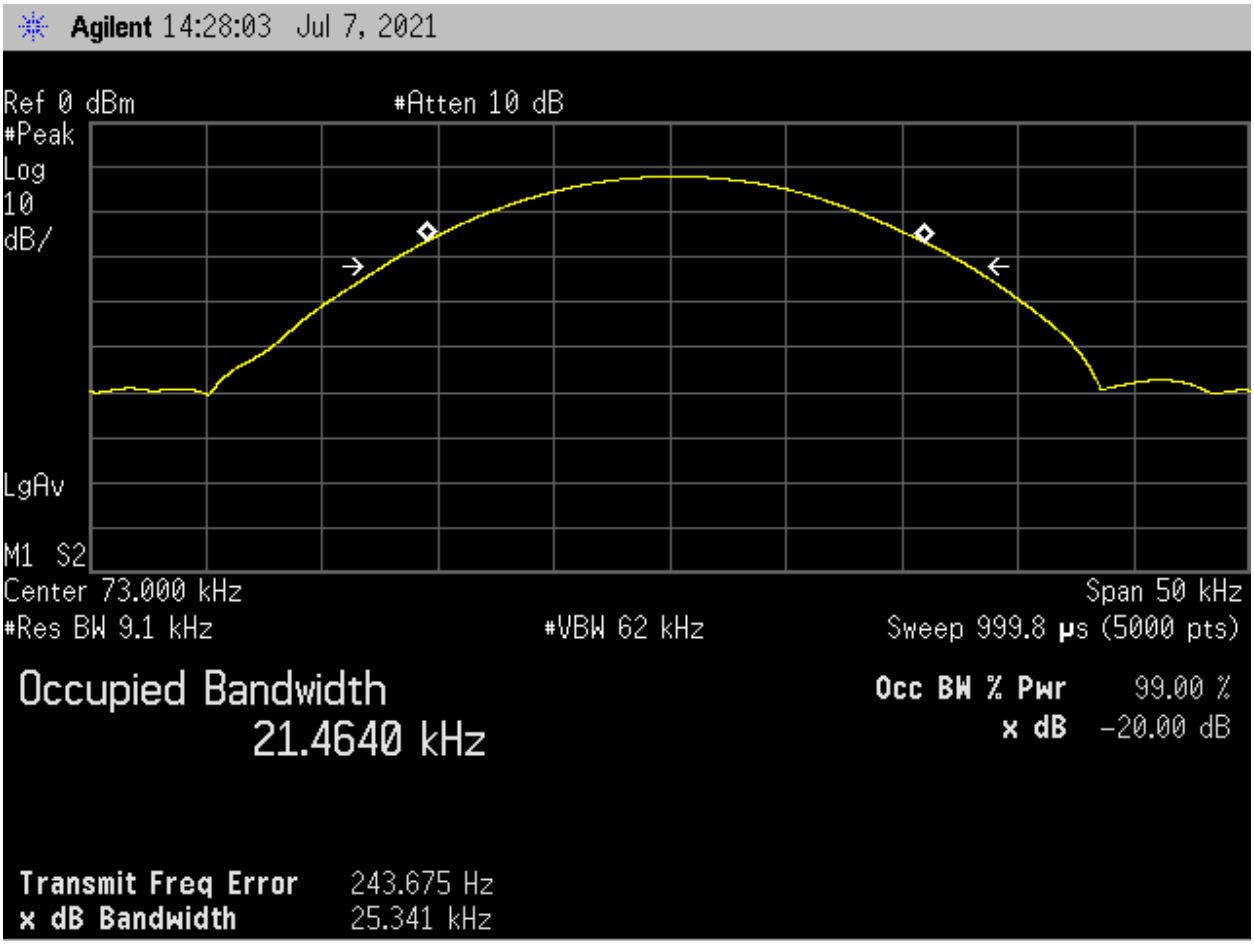
Spectrum Analyzer Voltage:	VdBµV	
Antenna Correction Factor:	AFdB/m	
Cable Correction Factor:	CFdB	
Electric Field:	EdBV/m =	V dBµV + AfdB/m + CFdB

Table 10: Receiver Radiated Emissions Test Data > 30 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 Type
60.00	V	180.0	1.3	54.4	-17.5	69.4	100.0	-3.2	QP
71.35	V	180.0	1.3	48.5	-16.7	38.8	100.0	-8.2	QP
86.23	V	135.0	1.3	46.5	-17.3	28.8	100.0	-10.8	QP
129.23	V	135.0	1.3	44.2	-11.0	46.1	150.0	-10.3	QP
143.36	V	135.0	1.3	47.3	-12.0	58.1	150.0	-8.2	QP
300.00	V	135.0	1.3	36.9	-10.6	20.6	200.0	-19.8	QP
916.50	**V**	**0.0**	**1.8**	**37.3**	**2.4**	**96.4**	**12500.0**	**-42.3**	***See Note**
48.93	H	180.0	1.0	55.8	-16.8	89.0	100.0	-1.0	QP
58.53	H	180.0	1.0	55.5	-17.7	77.4	100.0	-2.2	QP
77.31	H	180.0	1.0	55.3	-17.0	82.6	100.0	-1.7	QP
129.23	H	180.0	1.0	44.1	-11.0	45.3	150.0	-10.4	QP
143.36	H	180.0	1.0	46.3	-12.0	51.8	150.0	-9.2	QP
300.00	H	180.0	1.0	38.7	-10.6	25.4	200.0	-17.9	QP
916.50	**H**	**0.0**	**1.8**	**49.4**	**2.4**	**388.2**	**12500.0**	**-30.2**	***See Note**

* See WLL test report 16938-01 for the 916.5 MHz test data.

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



3.3 Transmitter Duty Cycle and DCCF

The TX pulse train was observed over a 100ms sweep. In this case, the total pulse train is greater than the measurement period. As such, the cycle time (T_{cycle}) shall be declared as 100 ms.

The total transmitter on-time (in any given 100ms) is made of two sub-pulses, as depicted in Figure 2.

The sweep time of Figure 3 was reduced to 10ms, in order to make an accurate measurement of an individual pulse. Either of the sub-pulses measure 2.91ms.

As such, the worst case on-time (t_{on}) is: 2 x 2.91 = 5.82 ms.

The duty cycle can be calculated from the following formula:

$t_{on} \div T_{cycle} = \Delta$

$5.82 \div 100 = 0.0582$

$\Delta = 5.8\%$

Where Δ is the final duty cycle.

The duty cycle correction factor can be calculated from the following formula:

$20LOG(\Delta) = \delta$

$20LOG(0.058) = -24.731$

$\delta = 24.7$ dB

Where δ is the final DCCF

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

Figure 2: TX On-Time per 100ms

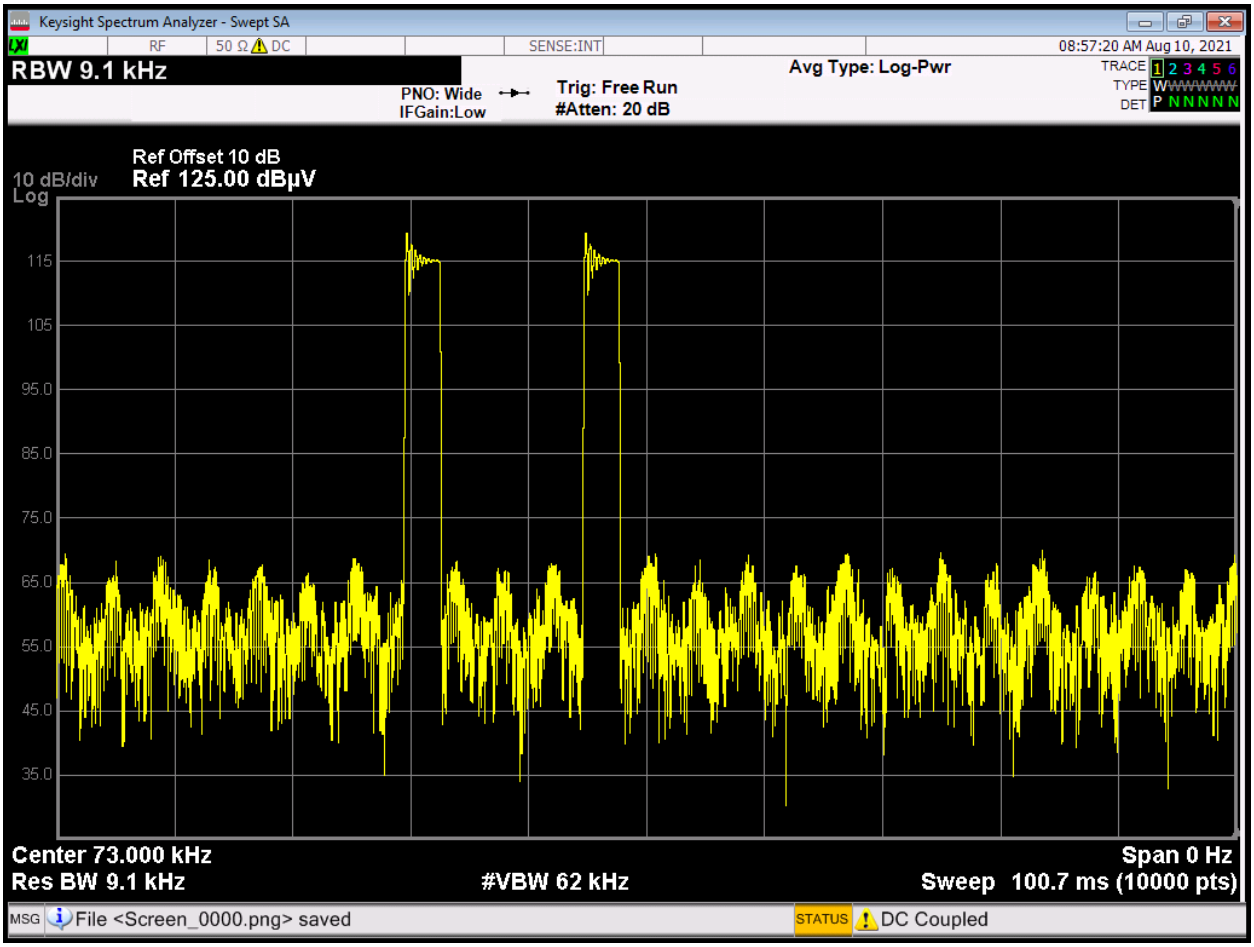
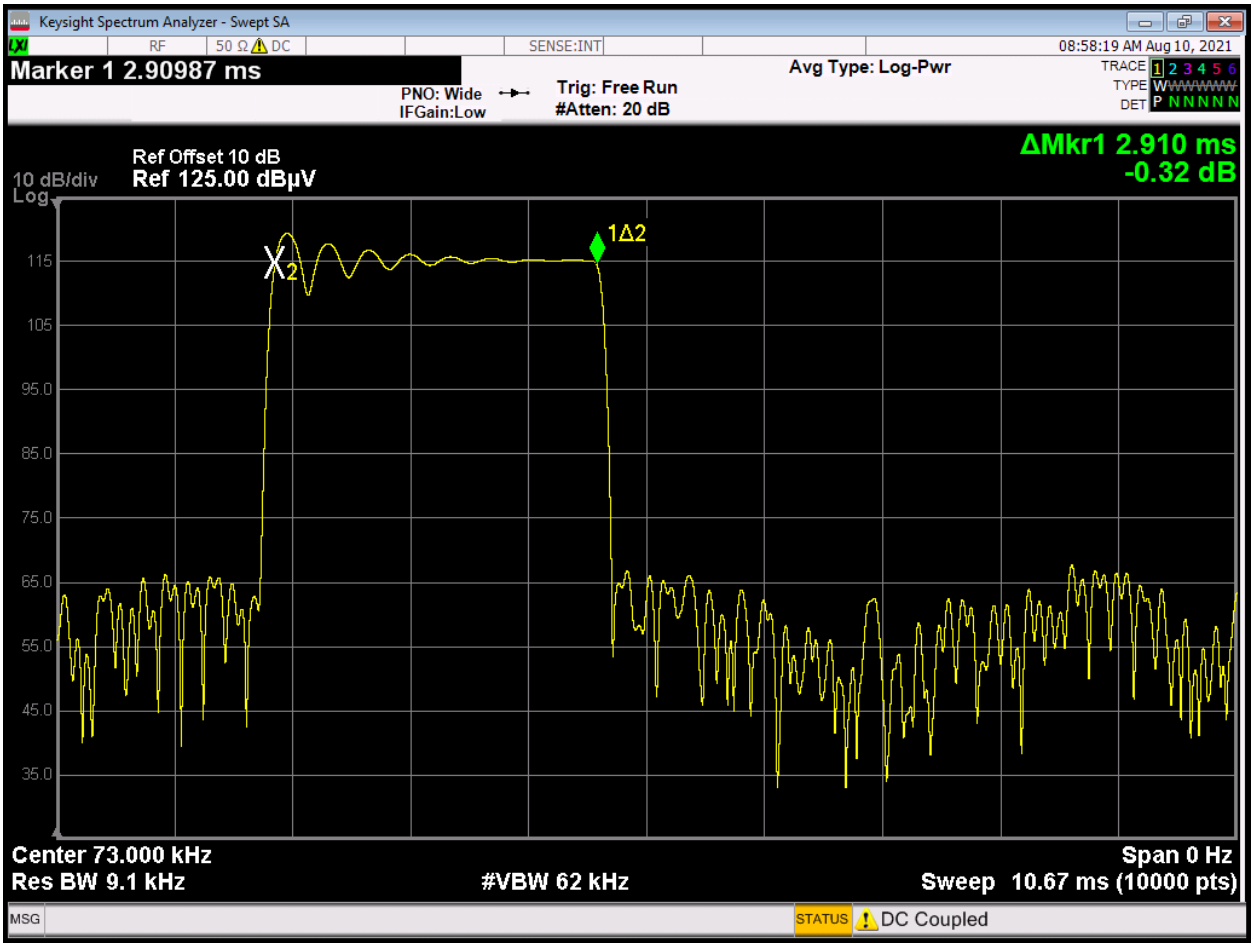


Figure 3: TX Pulse On-Time



4 Test Equipment

The below table 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:	**See Section 1.4**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00382	SUNOL SCIENCES CORP.	ANTENNA BICONLOG	5/12/2023
00031	EMCO 6502	ANTENNA ACTIVE LOOP	9/17/2022
00823	AGILENT N9010A	EXA SPECTRUM ANALYZER	5/27/2022
00559	HP 8447D	AMPLIFIER	6/3/2022