



**FCC Part 15 & ISED Canada
Class 2 Permissive Change (C2PC) Test Report**

for the

**Frederick Energy Products, LLC
DDAC-SPOT-Z**

**FCC ID: QUI-SPOT-Z
ISED ID: 11625-SPOTZ**

WLL REPORT# 19803-01 REV 1

Prepared for:

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

Prepared By:

**Washington Laboratories, Ltd.
4840 Winchester Boulevard, Suite 5.
Frederick, Maryland 21703**



Testing Certificate AT-1448

FCC Part 15 & ISED Canada
Class 2 Permissive Change (C2PC) Test Report

for the
Frederick Energy Products, LLC
DDAC-SPOT-Z

FCC ID: QUI-SPOT-Z
ISED ID: 11625A-SPOTZ

August 25, 2026
WLL Report# 19803-01 Rev 1

Prepared by:



Ryan Mascaro
RF Test 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 under a Class 2 Permissive Change (C2PC). The test report and application are submitted for a 73kHz transmitter device under Part 15.209 of the FCC Rules and Regulations and ISED Canada RSS-Gen, Issue 5 (4/2018). This certification test report documents the test configuration and test results for the Frederick Energy Products, DDAC-SPOT-Z. The results obtained relate only to the items tested. The test article was the EUT.

The reason for the C2PC is due to the increased radiated power of the transmitter fundamental. No other changes were made to the device.

All testing was performed at Washington Laboratories. Radiated testing above 30MHz was performed in the Free-space Anechoic Chamber Test-site (FACT) 3-meter 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 has been accepted and designated by the FCC under Test Firm Number US3001. Washington Laboratories is approved by the ANSI National Accreditation Board (ANAB), as an independent test laboratory under ISO/IEC 17025:2017. Please refer to Certificate Number AT-1448. The ISED Canada number for Washington Laboratories is 3035A. Washington Laboratories, Ltd. has also been accepted as a Notified Body (NB) and Conformity Assessment Body (CAB) under the United States/European Union Mutual Recognition Agreement.

Compliance Statement:

The Frederick Energy Products, LLC DDAC-SPOT-Z complies with the requirements for a 73kHz transmitter device under FCC Part 15.209 and ISED Canada RSS-GEN.

Revision History	Description of Change	Issue Date
Rev 0	Initial Release	August 25, 2026
Rev 1	ACB comments, powerline spectral plots	September 8, 2026

Table of Contents

Abstract	ii
1 Introduction	6
1.1 Compliance Statement	6
1.2 Test Scope	6
1.3 Contract Information	6
1.4 Testing Dates	6
1.5 Test and Support Personnel	6
1.6 Test Deviations to the Standard or Test Plan	6
2 Equipment Under Test	7
2.1 EUT Identification & Description	7
2.2 Test Configuration	8
2.3 Testing Algorithm	8
2.4 Equipment Configuration	8
2.5 Customer Supplied Data or EUT Information	9
2.6 EUT Modifications	9
2.7 Test Location	10
2.8 References	10
2.9 Environmental Conditions During the Testing Date(s)	10
2.10 Measurement Uncertainty	10
3 Test Equipment	12
4 Test Results	13
4.1 Occupied Bandwidth (Part §2.1049; RSS-Gen, 6.7)	13
4.2 Radiated Emissions (FCC Part §15.209)	14
4.3 Radiated Emissions (ISED-Canada, RSS-Gen)	18
4.4 Transmitter Duty Cycle (DCCF)	23
4.5 AC Powerline Conducted Emissions	25

List of Tables

Table 1: EUT Device Summary.....	7
Table 2: Equipment Configuration	9
Table 3: Support Equipment	9
Table 4: Interface Cables	9
Table 5: Expanded Uncertainty List	11
Table 6: Test Equipment List.....	12
Table 7: Radiated Emissions Limits, FCC.....	14
Table 8: Fundamental Transmitter Test Data, FCC.....	16
Table 9: Radiated Emissions Test Data < 30MHz, FCC	17
Table 10: Radiated Emissions Limits, ISED Canada	18
Table 11: Fundamental Transmitter Test Data, ISED Canada	19
Table 12: Radiated Emissions Test Data < 30MHz, ISED Canada.....	20
Table 13: Radiated Emissions Limits, 30MHz to 1GHz	21
Table 14: Radiated Emissions Test Data > 30MHz.....	22
Table 15: AC Powerline Conducted Emissions Test Data, Line/Phase.....	26
Table 16: AC Powerline Conducted Emissions Test Data, Neutral	27

List of Figures

Figure 1: EUT Testing Configuration.....	8
Figure 2: Occupied Bandwidth Test Results, Worst-Case.....	13
Figure 3: Uncorrected Radiated Field Strength, 73kHz Fundamental.....	16
Figure 4: TX On Time per 100ms.....	24
Figure 4: AC Powerline Conducted Emissions Test Data	28

1 Introduction

1.1 Compliance Statement

The Frederick Energy Products, LLC DDAC-SPOT-Z complies with the requirements for a 73kHz transmitter device under FCC Part 15.209 and ISSED Canada RSS-GEN.

1.2 Test Scope

Tests for radiated emissions and AC powerline emissions were performed. All measurements were performed in accordance with ANSI C63.4-2014+C63.4a-2017 and with ANSI C63.10-2020+Cor.1-2023+C63.10a-2024 “ANSI Procedures for Compliance Testing of Unlicensed Wireless Devices”. 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
1769 Jeff Drive,
Huntsville, AL, 35806
Quotation Number: 76119

1.4 Testing Dates

Testing was performed on the following date(s):
8/11/2026 to 8/18/2026

1.5 Test and Support Personnel

Washington Laboratories, LTD	Ryan Mascaro
Customer Representative	Ishmael Chigumira
Date the EUT arrived at the Lab:	7/29/2026

1.6 Test Deviations to the Standard or Test Plan

There were no deviations to the requirements established in the specification.

2 Equipment Under Test

2.1 EUT Identification & Description

The EUT has an internal 73 kHz transmitter and an inductor that creates a pulsed magnetic field. The magnetic field serves as a silent zone for pedestrians standing within its zone. In some cases, an EMI background within the area is strong enough to interfere with the operator's PAD detecting/interpreting the Spot-Z magnetic field. For this case, an internal switch on the printed circuit can be activated to cause the Spot-Z to emit a more robust silencing field to counteract the EMI interference. Overall, the EUT is a 73kHz magnetic field generator, for small areas, to act as a silent zone for PADs worn by pedestrians near forklift travel that are protected by guard rails.

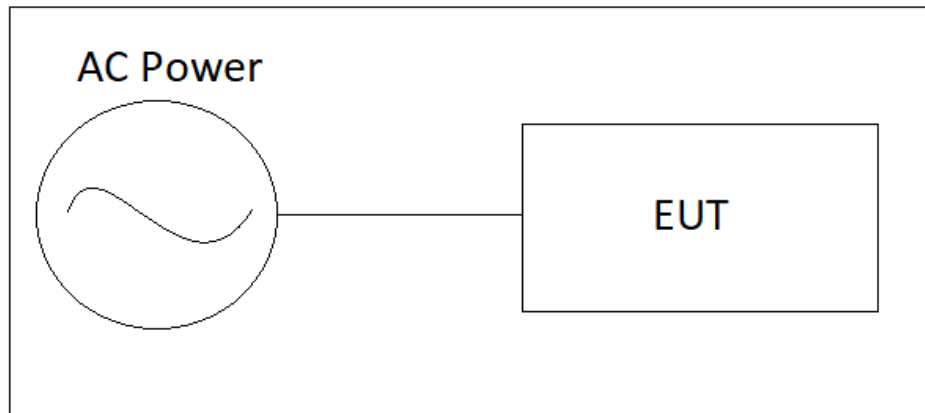
Table 1: EUT Device Summary

ITEM	DESCRIPTION
Manufacturer:	Frederick Energy Products, LLC
FCC ID:	QUI-SPOT-Z
IC ID:	11625-SPOTZ
Model:	DDAC-SPOT-Z
Power Source & Voltage:	120VAC, 60Hz
FCC Rule Parts:	15.209
IC Rule Part:	RSS-GEN
TX Frequency:	73.0 kHz
TX Antenna Type:	copper wound ferrite
Maximum Field Strength:	41.952 uV/m (Peak)
20dB Occupied Bandwidth:	3.281 kHz
99% Occupied Bandwidth:	5.938 kHz
FCC Emission Designator	3K31P0N
IC Emission Designator	5K91P0N
Number of Channels:	1
Modulation:	Pulsed-CW
Keying:	Automatic
Type of Information:	Proximity
EUT Software Version:	Silencer (ZP) ((aka: Zap Ping, Full Power))
EUT Firmware Version:	<i>not declared by applicant</i>
Interface Cables:	AC/DC mains input
Worst-Case Spurious Emissions:	219kHz @ 0.0061 uA/m

2.2 Test Configuration

The EUT was tested in a stand-alone configuration, with the main input voltage supplied from the EUT's AC/DC power supply.

Figure 1: EUT Testing Configuration



2.3 Testing Algorithm

The EUT operates continuously when power is applied. The EUT was evaluated in four total operation modes. The production mode (ZP, Full Power) is the worst-case mode. This mode was maintained during the final testing. The EUT was investigated for worst-case radiated emissions by varying the orthogonal axis of the EUT (x, y, z). For testing of frequencies below 30MHz, the active loop antenna was rotated about its vertical and horizontal axis in accordance with ANSI C63.10-2020, clause 6.4.6 and 6.11.2. The EUT was positioned on the testing site to produce the worst-case emissions. For the final compliance measurements, the EUT was tested in the Zap Ping (ZP), Full Power mode. Only the worst-case emission levels are reported.

2.4 Equipment Configuration

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

EUT	Manufacturer	Model	Serial Number	Revision
SPOT-Z	Frederick Energy	DDAC-SPOT-Z	--	--

Table 3: Support Equipment

Item	Model/Part Number	Serial Number
--	--	--

Table 4: Interface Cables

Port Identification	Connector Type	Cable Length	Shielded (Y/N)	Termination Point
DC Input	Jack	< 3-meters	N	AC Mains

2.5 Customer Supplied Data or EUT Information

Please note that the customer has provided the information on the EUT contents and configuration of the EUT system during testing. The test laboratory is not responsible for verifying the accuracy of this information.

2.6 EUT Modifications

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

2.7 Test Location

All testing was performed at Washington Laboratories. Radiated testing above 30MHz was performed in the Free-space Anechoic Chamber Test-site (FACT) 3-meter 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 has been accepted and designated by the FCC under Test Firm Number US3001. Washington Laboratories is approved by the ANSI National Accreditation Board (ANAB), as an independent test laboratory under ISO/IEC 17025:2017. Please refer to Certificate Number AT-1448. The ISED Canada number for Washington Laboratories is 3035A.

2.8 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 C63.10-2020+Cor. 1-2023+C63.10a-2024 + Errata to C63.10a-2024: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

CISPR 32:2015 Electromagnetic compatibility of multimedia equipment – Emission Requirements

2.9 Environmental Conditions During the Testing Date(s)

Ambient Temperature:	Between 15.2°C and 23.5 °C
Relative Humidity:	Between 39% and 55%

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

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

where,

u_c = standard uncertainty

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

$Div_{a, b, c}$ = the individual uncertainty element divisor based on 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 in Table 5 below.

Table 5: Expanded Uncertainty List

Scope	Standard(s)	Expanded Uncertainty
Conducted Emissions	CISPR11, CISPR32, CISPR14, FCC Part 15	± 2.63 dB
Radiated Emissions	CISPR11, CISPR32, 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 Dates: 8/14/2026 to 8/18/2026	
Asset #	Manufacturer/Model	Description	Cal. Due
00031	EMCO 6502	ANTENNA ACTIVE LOOP	6/17/2027
00934	HP/AGILENT 8648D	SIGNAL GENERATOR	4/13/2027
00823	AGILENT N9010A	EXA SPECTRUM ANALYZER	5/29/2028
00993	KEYSIGHT N9020B	MXA SIGNAL ANALYZER	12/23/2027
00644	SUNOL SCIENCES CORP. JB1	BICONALOG ANTENNA	7/1/2028
00865	STORM 874-0101-036	LOW LOSS SMA CABLE	5/26/2027
00849	CABLE ASSOCIATES	LOW LOSS SMA CABLE	4/14/2027
00559	HP 8447D	AMPLIFIER	5/6/2027

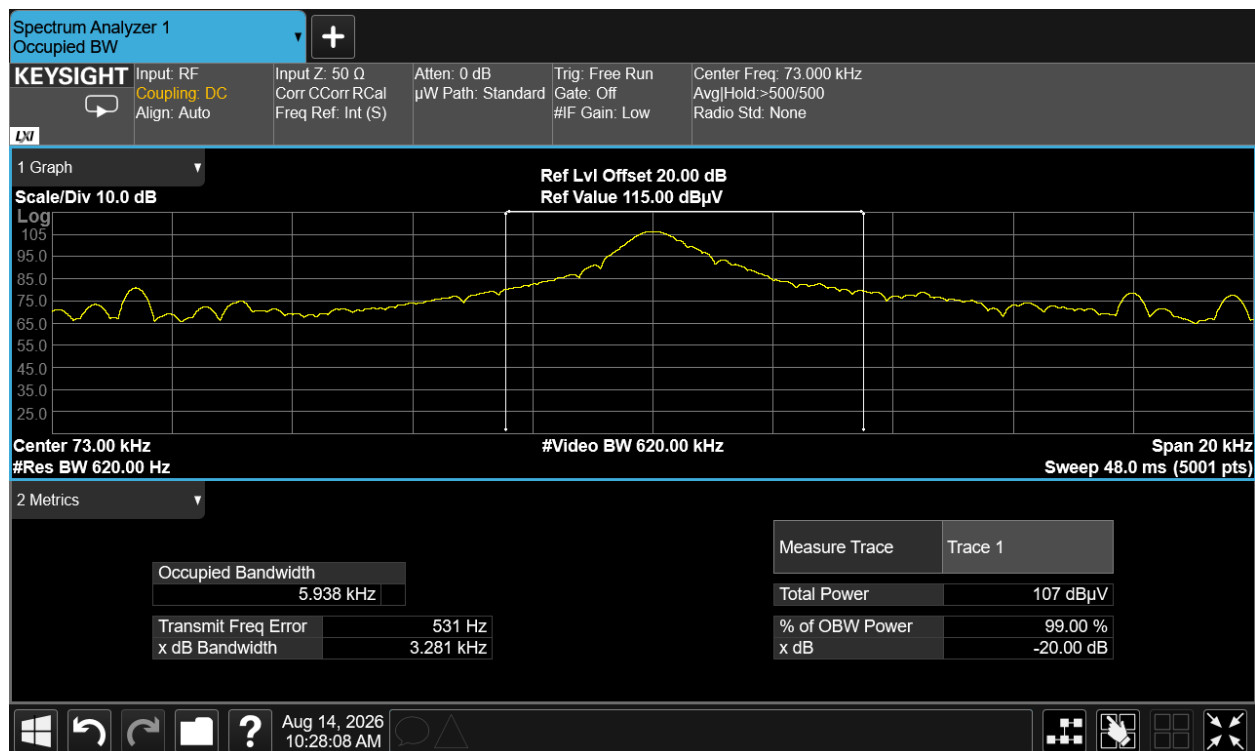
Test Name:	AC Powerline Emissions	Test Date: 8/17/2026	
Asset #	Manufacturer/Model	Description	Cal. Due
00993	KEYSIGHT, N9020B	MXA SPECTRUM ANALYZER	12/23/2027
00125	SOLAR 8028-50-TS-24-BNC	LISN	4/24/2027
00126	SOLAR 8028-50-TS-24-BNC	LISN	4/24/2027
00895	HP 11947A	TRANSIENT LIMITER	12/23/2027
00799	FLUKE 87V	DMM RMS	2/25/2027
00330	WLL CE SITE CABLE	BNC COAXIAL CABLE	4/14/2027
00934	HP/AGILENT 8648D	SIGNAL GENERATOR	4/13/2027

4 Test Results

4.1 Occupied Bandwidth (Part §2.1049; RSS-Gen, 6.7)

The occupied bandwidth measurement was performed in accordance with ANSI C63.1 clause 6.9.2. The EUT was positioned 3-meters from an active loop antenna. The EUT was positioned on the test site to produce the worst-case emissions. The trace was provided sufficient time to stabilize. The final test result is provided below.

Figure 2: Occupied Bandwidth Test Results, Worst-Case



99% OBW = 5.938 kHz

20dB OBW = 3.281 kHz

4.2 Radiated Emissions (FCC Part §15.209)

Transmitters operating under §15.209 must comply with the radiated emission limitations listed in the following table:

Table 7: Radiated Emissions Limits, FCC

Frequency (MHz)	Field Strength (μV/m)	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

4.2.1 Test Procedure

The EUT was investigated in three orthogonal axes (x, y, z). The worst-case positioning was maintained during the final measurements.

For frequencies between 9 kHz and 30 MHz, the EUT was tested at 10-meters and a loop antenna was mounted at a fixed-height of 1-meter and rotated about its vertical and horizontal axis in accordance with ANSI C63.10 clause 6.4.6 and 6.11.2. For frequencies above 30MHz the receiving antenna was mounted on a mast and the height of the antenna was varied between 1 and 4 meters to determine the maximum emissions. Both the horizontal and vertical field components were measured and the EUT was tested at 3-meters.

For all radiated testing, the EUT was placed on an 80 cm high 1 X 1.5 meters non-conductive motorized turntable. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. The output of the antenna was connected to the input of the spectrum analyzer and the emissions in the frequency range of 9 kHz to 1 GHz were measured, which covers the 10th harmonic of the fundamental. Cables were varied in position to produce maximum emissions.

Test Procedure Continued

Because the 73kHz transmit signal is pulsed, the fundamental and harmonics were tested for Peak emissions. The average field strength is mathematically averaged using DCCF, then compared to the Average limits defined in Table 7.

The following measurement bandwidths were employed:

- 9 kHz to 150 kHz = 300 Hz
- 150 kHz to 30 MHz = 10 kHz
- 30 MHz to 1 GHz = 120 kHz

The following test distances were employed:

- 9kHz to 30MHz = 10-meters
- 30MHz to 1GHz = 3-meters

Distance Correction Factor Explained

The use of 40 dB/decade for factoring the ratio of the two distances was employed.

An investigation of the transmit signal, on a single radial, (to determine the roll-off) was not performed.

$$40\text{LOG}(300/10) = 59.1 \text{ dB}$$

In this case, 59.1 dB shall be subtracted from the raw value, and the 300-meter limitation shall be employed.

Fundamental Calculations Expanded:

$$\text{uV/m} = 10^{(\text{dBuV/m} \div 20)}$$

$$\begin{aligned} \text{dBuV/m} &= \text{SA Level}_{\text{dBuV}} + \text{CF}_{\text{dB/m}} + \text{DCCF}_{\text{dB}} - \text{DF}_{\text{dB}} \\ &= 80.44 + 11.1 + -18.0 - 59.1 = 14.5 \text{ dBuV/m} = 5.282 \text{ uV/m (AVG)} \end{aligned}$$

Table 8: Fundamental Transmitter Test Data, FCC

Frequency (kHz)	RX Antenna Polarity	EUT Polarity	SA Level (dBuV)	Antenna Factor (dB/m)	DCCF (dB)	Distance Corr. Factor (dB)	Corr. F/S (uV/m)	Limit (uV/m)	Margin (dB)	Emission Type
73.0	X	X	80.44	11.1	0.0	59.1	41.952	330	-17.9	Peak
73.0	X	X	80.44	11.1	-18.0	59.1	5.282	33	-15.9	AVG *

* indicates mathematically corrected field strength, compared to the average limit

Figure 3: Uncorrected Radiated Field Strength, 73kHz Fundamental

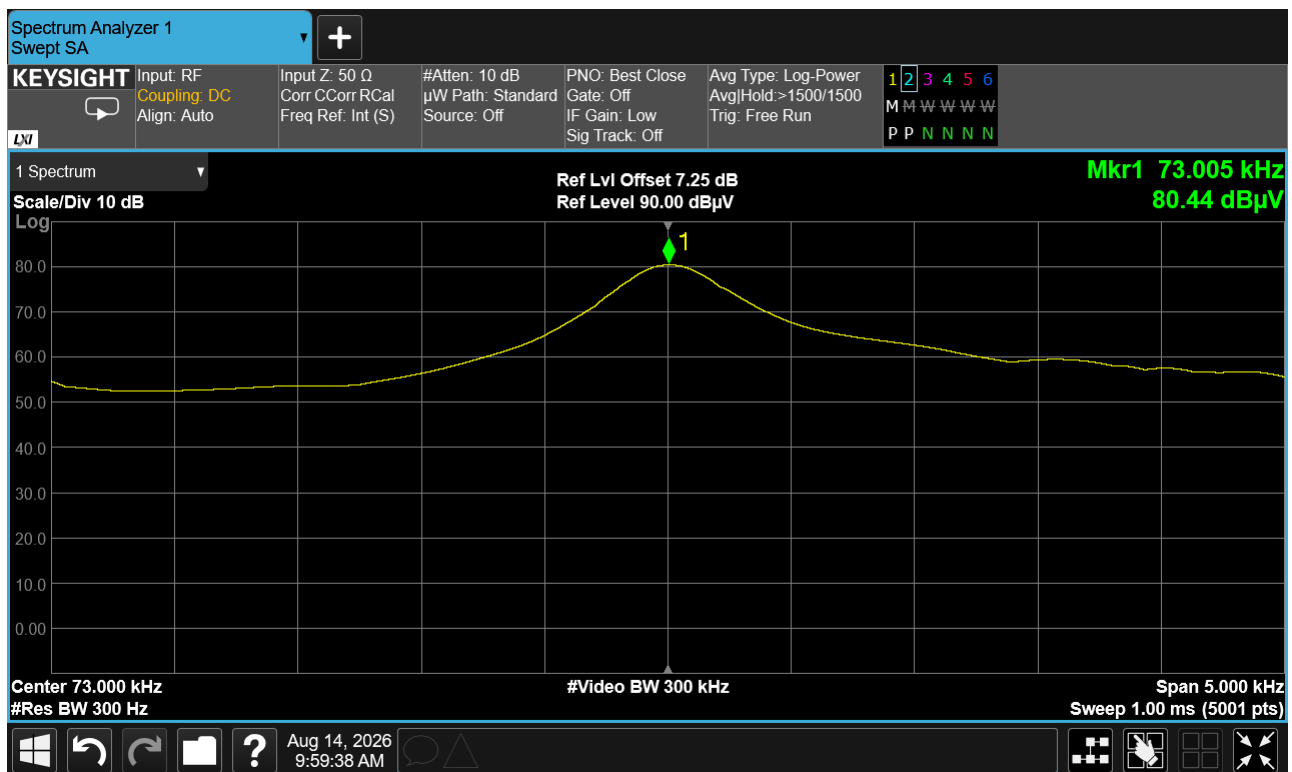


Table 9: Radiated Emissions Test Data < 30MHz, FCC

Frequency (MHz)	SA Level (dBuV)	Corr. Factors (dB/m)	DCCF (dB)	Distance Factor (dB)	Corr. FS (uV/m)	Limit uV/m	Margin (dB)	Emission Type
0.018	50.56	17.10	0.00	59.1	2.6826	1333.3	-53.93	Peak
0.018	50.56	17.10	-18.00	59.1	0.3377	133.3	-51.93	AVG *
0.116	47.90	16.80	0.00	59.1	1.9088	206.9	-40.70	Peak
0.116	47.90	16.80	-18.00	59.1	0.2403	20.69	-38.70	AVG *
0.146	52.22	16.80	0.00	59.1	3.1388	164.4	-34.38	Peak
0.146	52.22	16.80	-18.00	59.1	0.3951	16.4	-32.38	AVG *
0.219	49.65	16.70	0.00	59.1	2.3348	109.6	-33.43	Peak
0.219	49.65	16.70	-18.00	59.1	0.2906	10.96	-31.53	AVG *
0.438	43.77	16.70	0.00	59.1	1.1729	54.8	-33.39	Peak
0.438	43.77	16.70	-18.00	59.1	0.1477	5.48	-31.39	AVG *

Please note the following:

- * indicates the average value is mathematically obtained using DCCF
- the EUT was investigated for emissions in the range of 9kHz to 1GHz.
- only emissions detected from the EUT are reported, unless noted as ambient
- $\text{dBuV/m} = 20\text{LOG}(\text{uV/m})$

4.3 Radiated Emissions (ISED-Canada, RSS-Gen)

Transmitters operating under the provisions of RSS-Gen must comply with the radiated emission limitations listed in the following table:

Table 10: Radiated Emissions Limits, ISED Canada

Frequency (MHz)	Field Strength (μ A/m)	Measurement Distance (meters)
0.009 - 0.490	6.37/F(kHz)	300
0.490 - 1.705	63.7/F(kHz)	30
1.705 - 30.0	0.08	30
> 30MHz		
Frequency (MHz)	Field Strength (μ V/m)	Measurement Distance (meters)
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

4.3.1 Test Procedure

The procedures outlined in Section 4.2.1 of this report were employed.

For frequencies below 30MHz, the measurements from the previous section, expressed as electric field strength, were converted to magnetic field strength, for comparison to the average limits expressed in RSS-Gen.

Table 11: Fundamental Transmitter Test Data, ISED Canada

Frequency (kHz)	SA Level (dBuV)	Antenna Factor (dB)	DCCF (dB)	Distance Factor (dB)	H-Field Corr. Factor (dB)	Corr. Level (uA/m)	Limit (uA/m)	Margin (dB)	Emission Type
73.0	80.44	11.1	0.0	59.1	51.5	0.111	0.87	-17.89	Peak
73.0	80.44	11.1	18.0	59.1	51.5	0.014	0.087	-15.89	AVG *

Calculations Expanded:

$$\text{dB}\mu\text{A} = \text{dB}\mu\text{V} - 51.5$$

$$\begin{aligned} \text{dB}\mu\text{A/m} &= \text{SA Level}_{\text{dBuV}} + \text{CF}_{\text{dB/m}} + \text{DCCF}_{\text{dB}} - \text{DF}_{\text{dB}} - \text{HCF} \\ &= 80.44 + 11.1 + -18.0 - 59.1 - 51.5 = -37.07 \text{ dB}\mu\text{A/m} = 0.014 \mu\text{A/m} \end{aligned}$$

$$\mu\text{A/m} = 10^{(\text{dB}\mu\text{A/m} \div 20)}$$

$$\text{E-Field to H-field conversion} = 20\text{LOG}(120\pi) = 20\text{LOG}(377\Omega) = 51.5 \text{ dB}\Omega$$

$$\text{The 300-meter average limit for 73kHz is } 6.37 \div 73 = 0.087 \text{ uA/m}$$

Table 12: Radiated Emissions Test Data < 30MHz, ISED Canada

Frequency (MHz)	SA Level (dBuV)	Corr. Factors (dB/m)	DCCF (dB)	H-Field Corr. Factor (dB)	Corr. FS (uA/m)	Limit uA/m	Margin (dB)	Emission Type
0.018	50.56	-42.00	0.00	51.5	0.0071	0.354	-33.92	Peak
0.018	50.56	-42.00	-18.00	51.5	0.0009	0.354	-51.92	AVG *
0.116	47.90	-42.30	0.00	51.5	0.0051	0.055	-20.69	Peak
0.116	47.90	-42.30	-18.00	51.5	0.0006	0.055	-38.69	AVG *
0.146	52.22	-42.30	0.00	51.5	0.0083	0.044	-14.38	Peak
0.146	52.22	-42.30	-18.00	51.5	0.0010	0.044	-32.38	AVG *
0.219	49.65	-42.40	0.00	51.5	0.0061	0.029	-13.52	Peak
0.219	49.65	-42.40	-18.00	51.5	0.0008	0.029	-31.52	AVG *
0.438	43.77	-42.40	0.00	51.5	0.0031	0.015	-13.54	Peak
0.438	43.77	-42.40	-18.00	51.5	0.0004	0.015	-31.54	AVG *

Please note the following:

- * indicates the average value is mathematically obtained using DCCF
- the EUT was investigated for emissions in the range of 9kHz to 1GHz.
- only emissions detected from the EUT are reported, unless noted as ambient
- Corr. Factors: $16.8_{(EAF)} - 59.1_{(DCF)} = -42.40 \text{ dB/m}$ (example for 116kHz)
- $40\text{LOG}(300/10) = 59.1_{\text{dB}}$

4.3.2 General Unwanted Radiated Emissions (Part §15.209; RSS-Gen)

Devices operating under §15.209 and RSS-Gen must comply with the radiated emission limitations listed in the following table:

Table 13: Radiated Emissions Limits, 30MHz to 1GHz

Frequency (MHz)	Field Strength ($\mu\text{V/m}$)	Measurement Distance (meters)
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

4.3.3 Test Procedure

The requirements of FCC Part 15 and 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 antennas were mounted on a 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 1 GHz were measured. 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 or peak, 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.

4.3.4 Radiated Data Reduction and Reporting

To convert the raw spectrum analyzer radiated data into a form that can be compared with the limits, it is necessary to account for various calibration factors that are supplied with the antenna(s) and other measurement equipment. These factors include the antenna factor ((AF)(in dB/m)), cable loss factors ((CF)(in dB)), and the pre-amplifier gain [if applicable] ((G)(in dB)). These correction values are algebraically added to the raw Spectrum Analyzer Voltage (in dB μV) to obtain the corrected radiated electric field, which shall be the final corrected logarithm amplitude ((Corr. Meas.)(in $\mu\text{V/m}$ or dB $\mu\text{V/m}$)). This amplitude is then compared to the limit.

Table 14: Radiated Emissions Test Data > 30MHz

Frequency (MHz)	Detector	Corr. Meas (dBuV/m)	Limit (dBuV/m)	Delta (dB)	Turn Table (deg)	Antenna (cm)
38.761	Peak	32.185	--	--	180	Vert, 100
	QP	23.179	40	-16.821	90	Vert, 100
43.177	Peak	39.356	--	--	180	Vert, 100
	QP	30.588	40	-9.412	90	Vert, 100
54.302	Peak	41.815	--	--	180	Vert, 100
	QP	32.428	40	-7.572	90	Vert, 100
55.168	Peak	43.494	--	--	180	Vert, 100
	QP	34.419	40	-5.581	90	Vert, 100
57.386	Peak	45.055	--	--	180	Vert, 100
	QP	36.622	40	-3.378	90	Vert, 100
59.544	Peak	43.599	--	--	180	Vert, 100
	QP	36.493	40	-3.507	90	Vert, 100
66.739	Peak	42.654	--	--	180	Vert, 100
	QP	30.626	40	-9.374	90	Vert, 100
73.153	Peak	39.958	--	--	180	Vert, 100
	QP	31.197	40	-8.803	90	Vert, 100
74.892	Peak	37.723	--	--	180	Vert, 100
	QP	27.855	40	-12.145	90	Vert, 100
142.200	Peak	41.461	--	--	180	Vert, 100
	QP	32.075	43.5	-11.425	90	Vert, 100
200.717	Peak	39.430	--	--	180	Vert, 100
	QP	30.572	43.5	-12.928	90	Vert, 100
343.291	Peak	38.130	--	--	180	Horiz, 100
	QP	25.466	46	-20.534	90	Horiz, 100

Note:

Spectrum Analyzer Voltage:

VdB μ V (SA)

Antenna Correction Factor:

AFdB/m

Cable Correction Factor:

CFdB

Pre-Amplifier Gain (if applicable):

GdB

Electric Field:

EdB μ V/m = V dB μ V (SA) + AFdB/m + CFdB - GdB

To convert from linear units:

dBuV/m = 20LOG(μ V/m)

To convert limit, based on DMeasure:

3m Limit = 10m Limit + 20LOG(10/3)

4.4 Transmitter Duty Cycle (DCCF)

The following table provides a summary of the EUT transmit modes and the respective timing.

EUT Mode	TX On-Time Per 100ms	Duty Cycle	Final DCCF	Switch Notes
Zap Ping (ZP) Full Power	12.6 ms	12.6 %	18.0 dB	SW1 = On SW2 = On
Jammer Full Power	~100 ms	> 99 %	--	SW1 = On SW2 = Off
Jammer Low Power	~100 ms	> 99 %	--	SW1 = Off SW2 = Off
Zap Ping (ZP) Low Power	12.0 ms	12 %	18.4 dB	SW1 = Off SW2 = On

Each of these modes was investigated by WLL.

The difference in transmitter on-time between the two ZP modes is negligible.

The ZP, Full Power mode is the use-case production mode.

The ZP, Full Power mode is also the worst-case mode for radiated field strength.

The Jammer mode appears to be near 100% duty cycle, regardless of evaluation period.

Final Data:

$$12.6 \div 100 = 0.126 = 12.6 \%$$

$$20\text{LOG}(0.126) = -17.993 \text{ (rounded to 18.0)}$$

- 18.0 dB is the final DCCF.

Spectrum Analyzer 1
Swept SA

KEYSIGHT Input: RF
Coupling: DC
Align: Auto

Input Z: 50 Ω
Corr CCorr RCal
Freq Ref: Int (S)

#Atten: 0 dB
 μ W Path: Standard
Source: Off

PNO: Best Close
Gate: Off
IF Gain: Low
Sig Track: Off

Avg Type: Log-Power
Trig: Free Run

1 2 3 4 5 6
W W W W W W
P N N N N N

1 Spectrum

Scale/Div 10 dB
Log

Ref Level 70.00 dB μ V

Δ Mkr1 12.64 ms
-1.43 dB

X2

1 Δ 2

Center 73.000 kHz
#Res BW 300 Hz

#Video BW 1.0 MHz

Span 0 Hz
Sweep 100 ms (2501 pts)

4.5 AC Powerline Conducted Emissions

4.5.1 Requirements

Compliance Standard: FCC Part 15.207(a)

Frequency Range	AC Powerline Emission Limits	
	Quasi-peak	Average
0.15 – 0.5 MHz	66 to 56 dB μ V	56 to 46 dB μ V
0.5 – 5 MHz	56 dB μ V	46 dB μ V
0.5 – 30 MHz	60 dB μ V	50 dB μ V

4.5.2 Test Procedure

The requirements of FCC Part 15 and ICES-003 call for the EUT to be placed on an 80cm-high non-conductive table above a ground plane. Power to the EUT was provided through a Solar Corporation 50 Ω /50 μ H Line Impedance Stabilization Network bonded to a 3 X 2-meter ground plane. The LISN has its AC input supplied from a filtered AC power source. Power was supplied to the peripherals through a second LISN. The peripherals were placed on the table in accordance with ANSI C63.4. Power and data cables were moved about to obtain maximum emissions.

The 50 Ω output of the LISN was connected to the input of the spectrum analyzer and the emissions in the frequency range of 150 kHz to 30 MHz were measured. The detector function was set to quasi-peak, peak, or average as appropriate, and the resolution bandwidth during testing was at least 9 kHz, with all post-detector filtering no less than 10 times the resolution bandwidth. For average measurements, the post-detector filter was set to 10 Hz.

These emissions must meet the limits specified in §15.107 for quasi-peak and average measurements.

4.5.3 Conducted Data Reduction and Reporting

The comparison between the Conducted emissions level and the FCC limit is calculated as shown in the following example:

Spectrum Analyzer Voltage: $V_{dB\mu V}(raw)$

LISN Correction Factor: LISN dB

Cable Correction Factor: CF dB

Voltage: $V_{dB\mu V} = V_{dB\mu V}(raw) + LISN\ dB + CF\ dB$

4.5.4 Test Data

The EUT complies with the Powerline Emissions requirements.

The EUT is AC powered, and directly couples to the public mains network.

The worst-case emission test data is provided below.

Table 15: AC Powerline Conducted Emissions Test Data, Line/Phase

Frequency (Hz)	Detector	Meas (dBuV)	Limit (dBuV)	Delta (dB)
163.499k	Peak	50.336	--	--
	QP	44.142	65.284	-21.142
	Avg	18.301	55.284	-36.983
194.996k	Peak	43.086	--	--
	QP	40.023	63.821	-23.798
	Avg	15.914	53.821	-37.907
253.49k	Peak	41.452	--	--
	QP	28.134	61.642	-33.508
	Avg	13.366	51.642	-38.276
523.462k	Peak	39.388	--	--
	QP	31.587	56	-24.413
	Avg	15.296	46	-30.704
653.949k	Peak	31.129	--	--
	QP	24.168	56	-31.832
	Avg	9.675	46	-36.325
23.197M	Peak	32.661	--	--
	QP	24.484	60	-35.516
	Avg	8.246	50	-41.754

Table 16: AC Powerline Conducted Emissions Test Data, Neutral

Frequency (Hz)	Detector	Meas (dBuV)	Limit (dBuV)	Delta (dB)
172.498k	Peak	43.001	--	--
	QP	40.341	64.839	-24.499
	Avg	17.080	54.839	-37.759
190.496k	Peak	52.439	--	--
	QP	42.19	64.015	-21.825
	Avg	17.043	54.015	-36.972
415.473k	Peak	36.300	--	--
	QP	28.406	57.538	-29.132
	Avg	12.434	47.538	-35.104
541.461k	Peak	38.435	--	--
	QP	30.637	56	-25.363
	Avg	12.297	46	-33.703
1.09M	Peak	28.173	--	--
	QP	18.789	56	-37.211
	Avg	7.209	46	-38.791
1.531M	Peak	27.487	--	--
	QP	20.013	56	-35.987
	Avg	7.070	46	-38.93
22.688M	Peak	30.595	--	--
	QP	24.686	60	-35.314
	Avg	8.073	50	-41.927
23.125M	Peak	32.326	--	--
	QP	24.373	60	-35.627
	Avg	8.294	50	-41.706

Figure 5: AC Powerline Conducted Emissions Test Data

