FCC Part 15 & ISED Canada Certification Test Report

for the

Frederick Energy Products, LLC

DDAC-SPOT-Z

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

WLL REPORT# 18886-01 REV 2

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 Certification Test Report

for the

Frederick Energy Products, LLC

DDAC-SPOT-Z

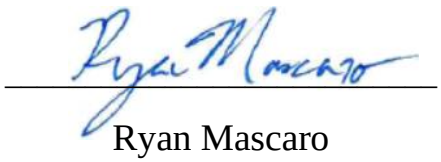
FCC ID: QUI-SPOT-Z

ISED ID: 11625A-SPOT-Z

October 30, 2024

WLL Report# 18886-01 Rev 2

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. 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, LLC DDAC-SPOT-Z.

Testing above 30 MHz was performed on the Open Area Test Site (OATS) 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. The ISED Canada number for Washington Laboratories, Ltd. is 3035A. Washington Laboratories, Ltd. has been accepted by the FCC and ISED Canada as an independent test laboratory; approved by ANAB under Certificate AT-1448.

The Frederick Energy Products, LLC DDAC-SPOT-Z complies with the limits 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	October 30, 2024
Rev 1	TCB Comments; dated 12/20/2024	December 23, 2024
Rev 2	Minor Corrections, Typos	January 7, 2025

Table of Contents

List of Tables

List of Figures

1 Introduction

1.1 Compliance Statement

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

1.2 Test Scope

Tests for radiated emissions and AC powerline emissions were performed. All measurements were performed according with ANSI C63.4 & ANSI C63.10. 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

Quotation Number: 74867

1.4 Testing Dates

Testing was performed on the following date(s):

10/8/2024 to 10/14/2024

1.5 Test and Support Personnel

Washington Laboratories, LTD	Ryan Mascaro
Customer Representative	Andrew Nicholas and Will Murrey

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.

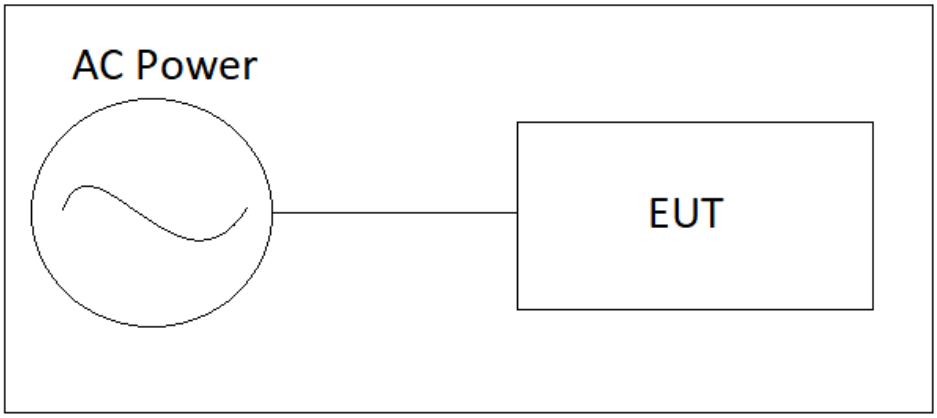
Table 1: EUT Device Summary

ITEM	DESCRIPTION
Manufacturer:	Frederick Energy Products, LLC
FCC ID:	QUI-SPOT-Z
IC ID:	11625-SPOT-Z
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:	0.79 uV/m (Peak)
20dB Occupied Bandwidth:	3.898 kHz
99% Occupied Bandwidth:	5.713 kHz
FCC Emission Designator	3K91P0N
IC Emission Designator	5K71P0N
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:	*not declared by applicant*
Interface Cables:	AC/DC mains input
Worst-Case Spurious Emissions:	215.44MHz, 42.04dBuV/m, QP

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 wort-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 EUT Modifications

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

2.6 Test Location

Radiated testing above 30MHz 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.

2.7 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

ANSI C63.10 (9/2020) American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

2.8 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 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: 10/8/2024 to 10/11/2024	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00942	AGILENT, N9010A	MXA SPECTRUM ANALYZER	12/19/2024
00644	SUNOL SCIENCES CORP.	BICONALOG ANTENNA	11/7/2024
00977	JUNKOSHA, MWX322	ARMORED COAX. CABLE	12/26/2024
00806	MINI-CIRCUITS	SMA COAXIAL CABLE	12/26/2024
00031	EMCO 6502	ANTENNA ACTIVE LOOP	6/17/2027
00065	HP, 8447D	RF PRE-AMPLIFIER	8/23/2025
00731	NARDA 4779-3	2W, 3DB ATTENUATOR	6/20/2025
00849	AH SYSTEMS, SAC-18G-16	HF COAXIAL CABLE	1/8/2025

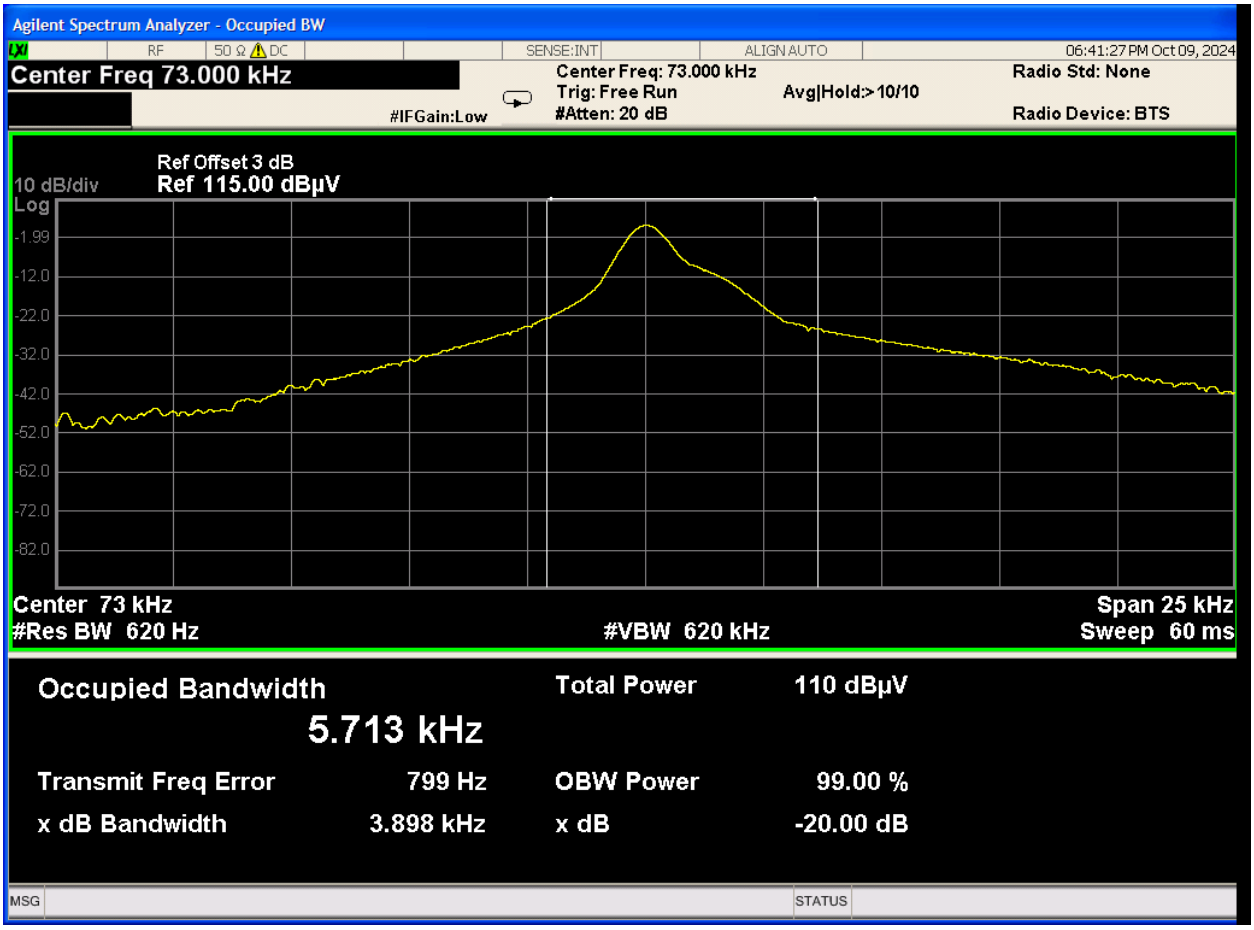
Test Name:	**AC Power Emissions**	Test Date: 10/14/2024	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00823	AGILENT, N9010A	EXA SPECTRUM ANALYZER	6/21/2026
00865	STORM 874-0101-036	LOW LOSS, HF COAXIAL CABLE	6/25/2025
00330	WLL CE SITE CABLE	BNC COAXIAL CABLE	6/25/2025
00125	SOLAR 8028-50-TS-24-BNC	LISN	4/18/2025
00126	SOLAR 8028-50-TS-24-BNC	LISN	4/18/2025

4 Test Results

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

The occupied bandwidth measurement was performed in accordance with ANSI C63.10 (2020), 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



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, a loop antenna was mounted at a fixed-height of 1-meter and rotated about its vertical and horizontal axis in accordance with ANSI C63.10-2020, 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.

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:

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

In accordance with FCC 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 EUT transmit signal was evaluated at 10m and at 3m. The measured field strength values are as follows:

10-meters: 74.10 dBµV (Peak, un-corrected)

3-meters: 104.64 dBµV (Peak, un-corrected)

104.64 – 74.10 = 30.54

30.54 shall be rounded to 31 dB, which is the fall-off factor for these two evaluation distances.

Distance Correction Factor Explained

The use of 60 dB/decade for factoring the ratio of the two distances produces the equivalent sum of 31dB as follows:

60LOG(10/3) = 31.3 (shall be rounded to 31 dB).

therefore,

60LOG(300/10) shall be used to calculate the distance correction from 300-meters to 10-meters.

60LOG(300/10) = 88.6

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	75.5	11.1	0.0	88.6	0.79	330	-52.4	Peak
73.0	X	X	75.5	11.1	-18.0	88.6	0.100	33	-50.4	AVG *

Calculations Expanded:

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

dBuV/m $= \text{SA Level}_{\text{dBuV}} + \text{CF}_{\text{dB/m}} + \text{DCCF}_{\text{dB}} - \text{DF}_{\text{dB}}$

$= 75.5 + 11.1 + -18.0 - 88.6 = -20$ dBuV/m = 0.10 uV/m (AVG)

Figure 3: Uncorrected Radiated Field Strength, 73kHz Fundamental

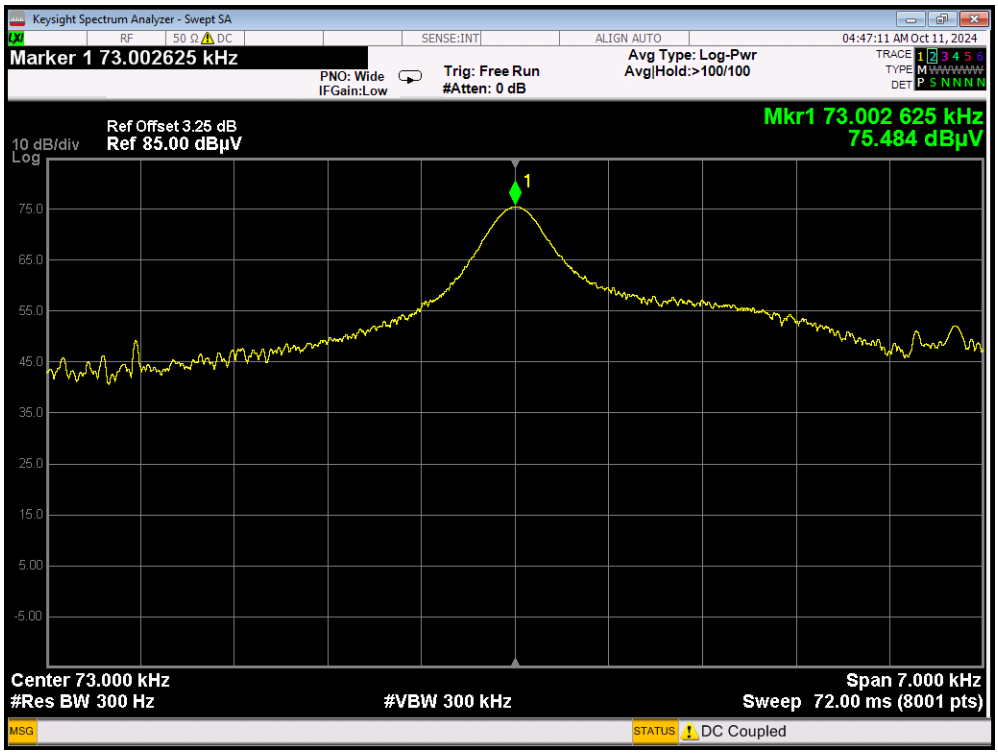


Table 9: Radiated Emissions Test Data < 30MHz, FCC

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	49.26	18.05	0.00	88.63	0.0859	1333.3	-83.82	Peak
0.018	49.26	18.05	-18.00	88.63	0.0108	133.3	-81.82	AVG *
0.116	47.21	14.35	0.00	88.63	0.0443	206.9	-73.38	Peak
0.116	47.21	14.35	-18.00	88.63	0.0056	20.69	-71.38	AVG *
0.146	61.88	14.35	0.00	88.63	0.2399	164.4	-56.72	Peak
0.146	61.88	14.35	-18.00	88.63	0.0302	16.4	-54.72	AVG *
0.219	52.20	14.25	0.00	88.63	0.0778	109.6	-62.97	Peak
0.219	52.20	14.25	-18.00	88.63	0.0098	10.96	-60.97	AVG *
0.438	41.33	14.15	0.00	88.63	0.0220	54.8	-67.92	Peak
0.438	41.33	14.15	-18.00	88.63	0.0028	5.48	-65.92	AVG *

Please note the following:

1. * indicates the average value is mathematically obtained using DCCF
2. the EUT was investigated for emissions in the range of 9kHz to 1GHz.
3. only emissions detected from the EUT are reported, unless noted as ambient
4. dBuV/m = 20LOG(uV/m)
5. regardless of DCCF, all peak emissions meet the average limits.

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 (µA/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 (µV/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	75.50	11.1	0.0	88.6	51.5	0.0021	0.87	-52.4	Peak
73.0	75.50	11.1	18.0	88.6	51.5	0.00027	0.087	-50.4	AVG *

Calculations Expanded:

dBµA = dBµV – 51.5

dBµA/m = $SA\ Level_{dBuV} + CF_{dB/m} + DCCF_{dB} – DF_{dB} – HCF$

= 75.5 + 11.1 + -18.0 – 88.6 – 51.5 = -71.5 dBµA/m = 0.00027 µA/m

µA/m = $10^{(dBuA/m \div 20)}$

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

The 300-meter average limit for 73kHz is 6.37 ÷ 73 = 0.087 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	49.26	-70.55	0.00	51.5	0.000229	0.354	-63.77	Peak
0.018	49.26	-70.55	-18.00	51.5	0.000029	0.354	-81.77	AVG *
0.116	47.21	-74.25	0.00	51.5	0.000118	0.055	-53.36	Peak
0.116	47.21	-74.25	-18.00	51.5	0.000015	0.055	-71.36	AVG *
0.146	61.88	-74.28	0.00	51.5	0.000638	0.044	-36.70	Peak
0.146	61.88	-74.28	-18.00	51.5	0.000080	0.044	-54.70	AVG *
0.219	52.20	-74.38	0.00	51.5	0.000207	0.029	-42.96	Peak
0.219	52.20	-74.38	-18.00	51.5	0.000026	0.029	-60.96	AVG *
0.438	41.33	-74.48	0.00	51.5	0.000059	0.015	-48.06	Peak
0.438	41.33	-74.48	-18.00	51.5	0.000007	0.015	-66.06	AVG *

Please note the following:

1. * indicates the average value is mathematically obtained using DCCF
2. the EUT was investigated for emissions in the range of 9kHz to 1GHz.
3. only emissions detected from the EUT are reported, unless noted as ambient
4. the limit for 511kHz is written at 30m; therefore, 60LOG30/10 = 28.63
5. Corr. Factors: 14.35 – 88.6 = -74.25 dB/m *(example for 116kHz)*
6. regardless of DCCF, all peak emissions meet the average limits.

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 (µV/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 dBµV) to obtain the corrected radiated electric field, which shall be the final corrected logarithm amplitude ((Corr. Meas.)(in µV/m or dBµV/m)). This amplitude is then compared to the limit.

Table 14: 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)	Detector	Comment
35.17	V	90.0	1.6	35.6	-2.9	43.0	100.0	-7.3	QP	EUT
62.79	V	90.0	1.2	37.9	-10.9	22.5	100.0	-13.0	QP	EUT
112.45	V	120.0	1.4	35.3	-4.7	33.9	150.0	-12.9	QP	EUT
215.44	V	90.0	1.1	46.9	-7.4	126.5	150.0	-1.5	QP	EUT
428.43	V	270.0	1.2	33.8	-1.0	43.6	200.0	-13.2	QP	EUT
998.00	V	0.0	1.0	26.5	7.3	49.1	500.0	-20.2	Peak	AMBIENT
35.17	H	180.0	2.6	26.5	-2.9	15.1	100.0	-16.4	QP	EUT
62.79	H	180.0	1.9	33.0	-10.9	12.8	100.0	-17.9	QP	EUT
112.45	H	180.0	1.3	30.9	-4.7	20.4	150.0	-17.3	QP	EUT
215.44	H	180.0	2.5	46.8	-7.4	93.7	150.0	-4.1	QP	EUT
428.43	H	180.0	1.5	28.6	-1.0	24.0	200.0	-18.4	QP	EUT
998.00	H	0.0	1.0	21.3	7.3	27.0	500.0	-25.4	Peak	AMBIENT

Note:

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 from linear units:	dBuV/m = 20LOG(uV/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:

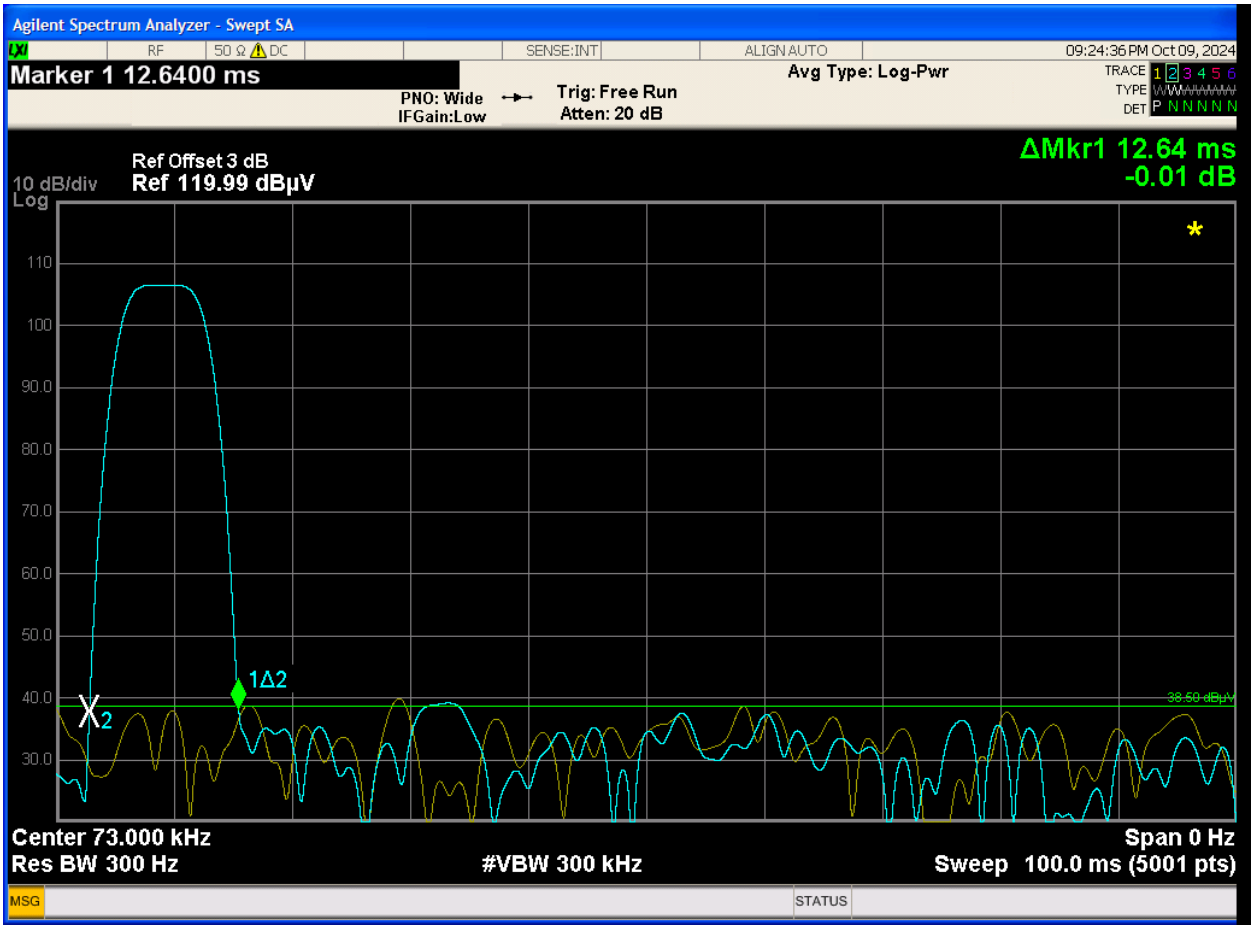
12.6 ÷ 100 = 0.126 = 12.6 %

20LOG(0.126) = –17.993 (rounded to 18.0)

- 18.0 dB is the final DCCF.

(Reference ANSI C63.10-2020, clause 7.5)

Figure 4: TX On Time per 100ms



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 dBµV	56 to 46 dBµV
0.5 – 5 MHz	56 dBµV	46 dBµV
0.5 – 30 MHz	60 dBµV	50 dBµV

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 µH 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: VdBµV(raw)

LISN Correction Factor: LISN dB

Cable Correction Factor: CF dB

Voltage: VdBµV = V dBµV (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

NEUTRAL / L1										
Frequency (MHz)	**Level QP (dBµV)**	**Level AVG (dBµV)**	**Cable Loss (dB)**	**LISN Corr (dB)**	**Level QP Corr (dBµV)**	**Level Avg Corr (dBµV)**	**Limit QP (dBµV)**	**Limit AVG (dBµV)**	**Margin QP (dB)**	**Margin AVG (dB)**
0.154	32.9	13.2	10.04	0.6	43.6	23.9	65.8	55.8	-22.2	-31.9
0.176	27.4	14.2	10.04	0.5	38.0	24.8	64.7	54.7	-26.7	-29.9
0.353	19.1	11.0	10.04	0.3	29.5	21.4	58.9	48.9	-29.4	-27.5
1.101	17.0	9.0	10.04	0.3	27.3	19.3	56.0	46.0	-28.7	-26.7
4.915	24.3	5.0	10.04	0.5	34.8	15.5	56.0	46.0	-21.2	-30.5
PHASE / L2										
Frequency (MHz)	**Level QP (dBµV)**	**Level AVG (dBµV)**	**Cable Loss (dB)**	**LISN Corr (dB)**	**Level QP Corr (dBµV)**	**Level Avg Corr (dBµV)**	**Limit QP (dBµV)**	**Limit AVG (dBµV)**	**Margin QP (dB)**	**Margin AVG (dB)**
0.153	30.2	13.0	10.04	0.5	40.7	23.5	65.8	55.8	-25.1	-32.3
0.169	31.1	13.4	10.04	0.4	41.5	23.8	65.0	55.0	-23.5	-31.2
0.463	18.5	9.0	10.04	0.3	28.8	19.3	56.6	46.6	-27.8	-27.3
0.967	17.6	7.0	10.04	0.3	27.9	17.3	56.0	46.0	-28.1	-28.7
8.876	11.0	1.5	10.04	0.6	21.6	12.1	60.0	50.0	-38.4	-37.9

