FCC Part 15 & ISED Canada Certification Test Report

for the

Frederick Energy Products, LLC

HN-LZM

FCC ID: QUI-HN-LZM
ISED ID: 11625A-HNLZM

WLL REPORT# 18878-01 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

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January 6, 2025

WLL Report# 18878-01 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. 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 HN-LZM.

Radiated testing above 30 MHz was performed in the Free-space Anechoic Chamber Test-site (FACT) 3m 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. 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 HN-LZM complies with the limits for a 73kHz transmitter device under FCC Part 15.209 and ISED Canada RSS-GEN.

Revision History	Description of Change	Release Date
Rev 0	Initial Release	January 6, 2025
Rev 1	ACB Comments; dated: 2/26/2025	February 27, 2025

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1 Introduction

1.1 Compliance Statement

The Frederick Energy Products, LLC HN-LZM 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: 74656 & 74970

1.4 Testing Dates

Testing was performed on the following date(s):

10/16/2024 to 11/14/2024

1.5 Test and Support Personnel

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

2 Equipment Under Test

2.1 EUT Identification & Description

The LZM only transmits at 73kHz and has no receiving ability. The LZM emits a 73 kHz pulsed magnetic field via a long wire loop to create essentially a long, narrow rectangular magnetic field. The length of the field is fixed and is determined by the length of the wire loop. Wire loops can be used to produce magnetic fields up to 200 feet long. The width of the magnetic field is adjustable using a potentiometer inside the main housing. This field adjustment produces the desired mode. The wire loop is typically installed approximately 4 feet above the floor, either on a wall or behind a rack face. Power to the LZM is 12-24VDC power from an external power adapter connected to a 110-120 VAC source.

Table 1: EUT Device Summary

<table>
<tr><th>ITEM</th><th colspan="2">DESCRIPTION</th></tr>
<tr><td>Manufacturer:</td><td colspan="2">Frederick Energy Products, LLC</td></tr>
<tr><td>FCC ID:</td><td colspan="2">QUI-HN-LZM</td></tr>
<tr><td>IC ID:</td><td colspan="2">11625A-HNLZM</td></tr>
<tr><td>Model:</td><td colspan="2">HN-LZM</td></tr>
<tr><td>HVIN:</td><td colspan="2">HN-LZM</td></tr>
<tr><td>Power Source & Voltage:</td><td colspan="2">120VAC, 60Hz</td></tr>
<tr><td>FCC Rule Parts:</td><td colspan="2">15.209</td></tr>
<tr><td>IC Rule Part:</td><td colspan="2">RSS-GEN</td></tr>
<tr><td>TX Frequency:</td><td colspan="2">73.0 kHz</td></tr>
<tr><td>TX Antenna Type:</td><td colspan="2">wire loop (35’ to 200’)</td></tr>
<tr><td rowspan="2">Maximum Field Strength (10-meters):</td><td>5.51 uV/m (Peak)</td><td>0.63 uV/m (AVG)</td></tr>
<tr><td>0.15 uA/m (Peak)</td><td>0.0017 uA/m (AVG)</td></tr>
<tr><td>20dB Occupied Bandwidth:</td><td colspan="2">3.4 kHz</td></tr>
<tr><td>99% Occupied Bandwidth:</td><td colspan="2">16.4 kHz</td></tr>
<tr><td>FCC Emission Designator</td><td colspan="2">3K40P0N</td></tr>
<tr><td>IC Emission Designator</td><td colspan="2">16K4P0N</td></tr>
<tr><td>Number of Channels:</td><td colspan="2">1</td></tr>
<tr><td>Keying:</td><td colspan="2">Automatic</td></tr>
<tr><td>Type of Information:</td><td colspan="2">Proximity</td></tr>
<tr><td>EUT Software Version:</td><td colspan="2">not declared by applicant</td></tr>
<tr><td>EUT Firmware Version:</td><td colspan="2">not declared by applicant</td></tr>
<tr><td>Interface Cables:</td><td colspan="2">AC/DC mains input</td></tr>
<tr><td>Worst-Case Spurious Emissions:</td><td colspan="2">6.26 MHz, 4.3 uV/m Peak</td></tr>
</table>

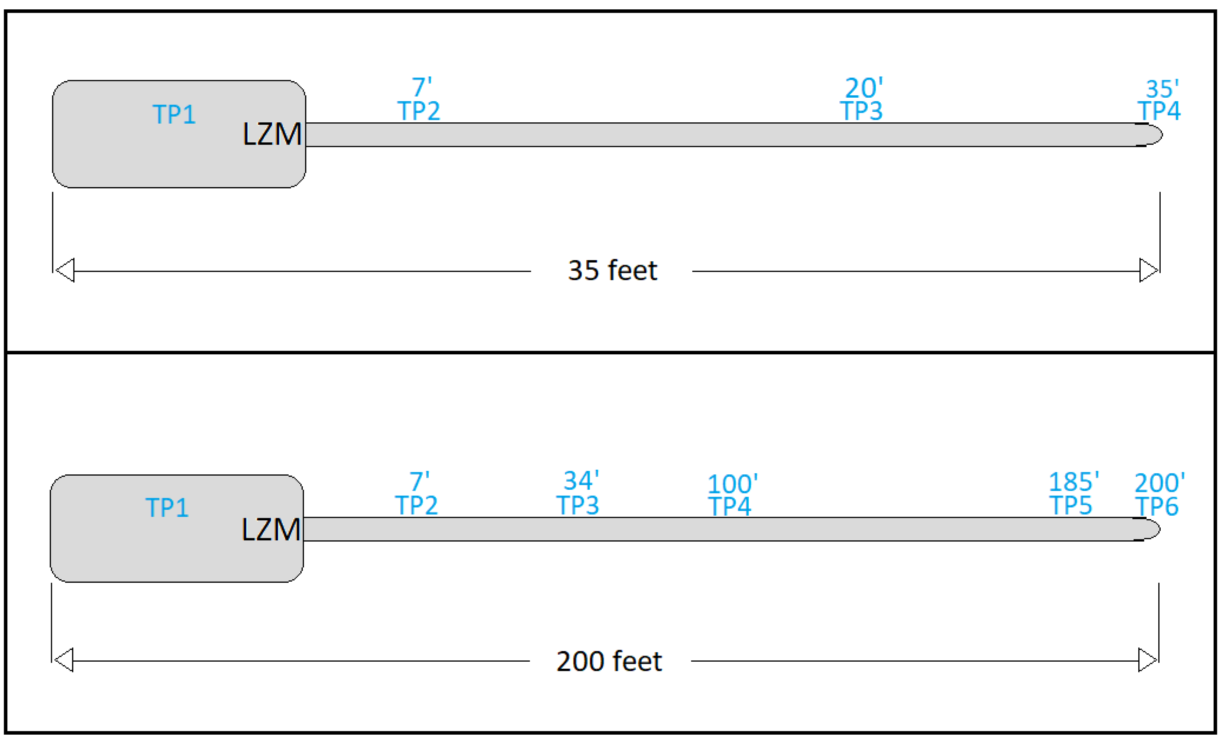
2.2 Test Configuration and Algorithm

The EUT was tested in a stand-alone configuration, with the input voltage supplied from the EUT's AC/DC power adapter. The EUT operates continuously when power is applied. The EUT was evaluated in three total operational modes, Silencer (ZP), Silencer (Jammer), and Rack Alert modes, (for power, bandwidth, and timing). The rack alert mode 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 housing (x, y, z). The wire loop antenna of the EUT was placed on 80cm non-conducive tables and positioned in the use-case orientation. The EUT was investigated and tested with both the 35' and 200' wire loops, and the length of the wire antenna was investigated to determine the point that produced the highest radiated field strength. Overall, the wire antenna produces a relatively smooth and even magnetic field, varying by less than ±2dB when investigated at multiple points along the entire length of the loop.

Please note that while all test points produce very similar levels, test point 2 (TP2) was consistently the worst-case point, regardless of wire length. All of the test data provided throughout this report was taken at TP2 with the LZM in the rack alert mode, positioned on the test site to produce the wort-case emissions. Only the worst-case emission levels are reported. Figure 1 provides a summary of the test points.

Figure 1: EUT Investigation and Testing Points



** drawing not to scale*

2.3 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
HN-LZM, 35-ft Loop	Frederick Energy	HN-LZM	--	--
HN-LZM, 200-ft Loop	Frederick Energy	HN-LZM		
HN-LZM, Matched Inductor	Frederick Energy	*engineering sample*	--	--

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

2.4 EUT Modifications

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

2.5 Test Location

Radiated testing above 30 MHz was performed in the Free-space Anechoic Chamber Test-site (FACT) 3m 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. 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.

2.5.1 Environmental Conditions During Emissions Testing

Ambient Temperature:	~17 °C
Relative Humidity:	51%

2.6 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

2.7 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 1to 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 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, 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: 10/16/2024 to 11/8/2024	
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
00865	STORM 874-0101-036	LOW LOSS, COAXIAL CABLE	6/25/2025
00731	NARDA 4779-3	2W, 3DB ATTENUATOR	6/20/2025
00849	AH SYSTEMS, SAC-18G-16	HF COAXIAL CABLE	1/8/2025

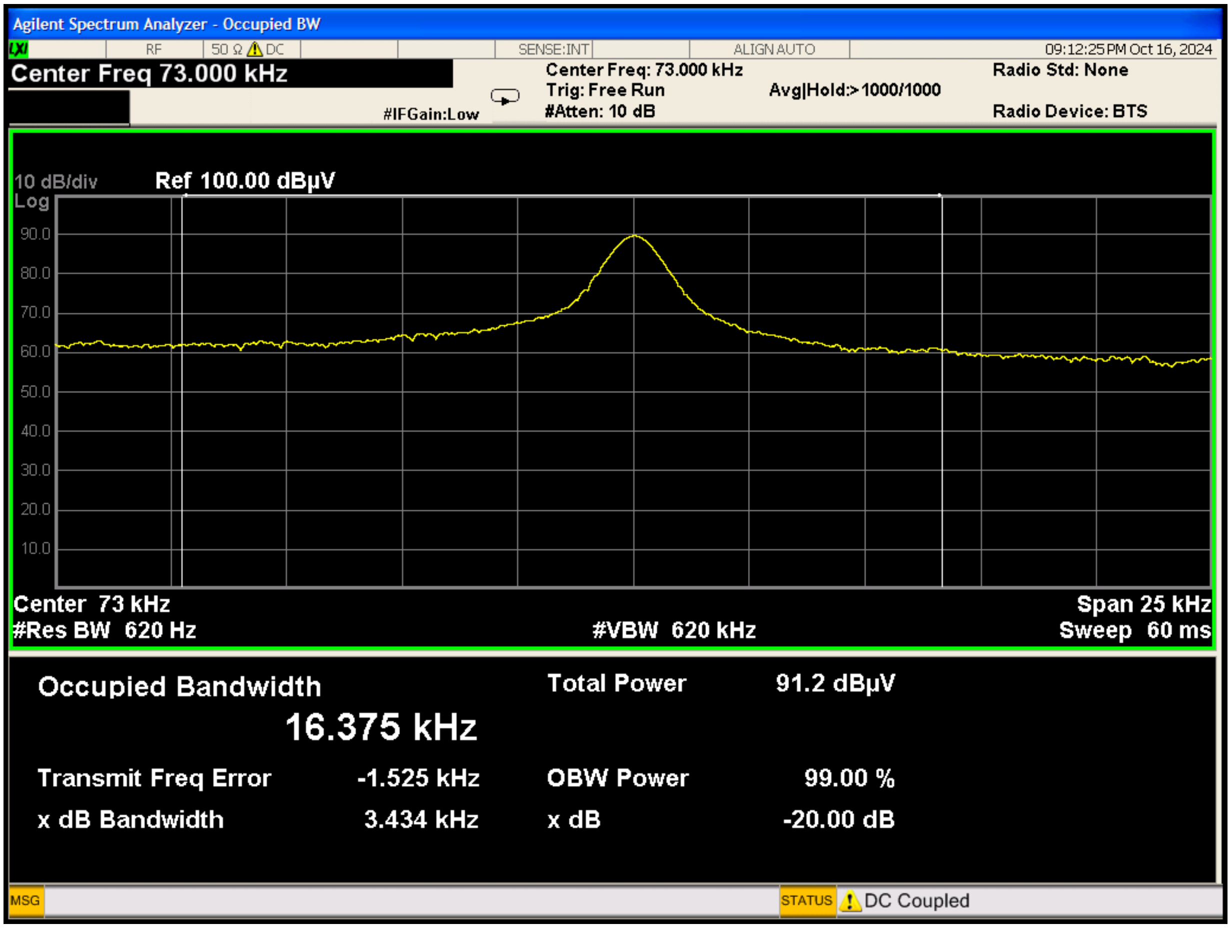
Test Name:	**AC Power Emissions**	Test Date: 11/14/2024	
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00823	AGILENT, N9010A	EXA SPECTRUM ANALYZER	6/21/2026
00330	WLL CE SITE CABLE	BNC COAXIAL CABLE	6/25/2025
00125	SOLAR 8028-50-TS-24-BNC	LISN	4/18/2025
00126	SOLAR 8028-50-TS-24-BNC	LISN	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



20dB OBW = 3.4 kHz

99% OBW = 16.4 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:

Frequency (MHz)	**Field Strength (μV/m)**	**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 testing and evaluation procedures outlined in Section 2.2 of this report were employed. For all radiated testing, the EUT was placed on an 80 cm high non-conductive table. Additionally, for testing between 9 kHz and 30 MHz, an active loop receiver antenna was mounted at a fixed-height of 1-meter. The 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.

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. 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 30MHz to 1 GHz were measured, which covers the 10th harmonic of the fundamental. Cables were varied in position to produce maximum emissions.

For all testing: 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 the above table.

Only the worst-case emissions are reported.

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

4.2.2 Distance Correction for 10-meter Test Site

FCC Rule Part §15.31(f)(2) allows for the use of the square of an inverse linear distance extrapolation factor (i.e., 40 dB/decade). In this case, the practices outlined in ANSI C63.10-2020 clause 6.4.4.2, Equation 4 shall be employed. The measurement standard allows for the use of 40 dB/decade without considering the multi-measurement, single radial investigation approach. Therefore, a roll-off factor of 40LOG(300/10) shall be used to correct the transmitter field strength.

4.2.2(a) Final Correction Defined

The wavelength (λ) for 73kHz = 4100m.

The near-field-far-field intersection is defined by $\lambda/2\pi$ = 652.8 meters

Because the test distance is < 652m, the 40 dB/decade extrapolation is authorized.

where,

λ = wavelength in meters

c = speed of light in meters/second

f = frequency in Hz

finally,

The 10m distance correction factor (DF_{dB}) = 40LOG(300/10) = 59.0 dB

4.2.3 Test Data

Table 7: 10-meter Fundamental Transmitter Test Data, FCC

Frequency (kHz)	RX Antenna Polarity	SA Level (dBuV)	CF (dB/m)	DCCF (dB)	Distance Corr. Factor (dB)	Corr. F/S (uV/m)	Limit (uV/m)	Margin (dB)	Emission Type
73.0	X	60.41	13.42	0.0	59.0	5.51	330	-35.54	Peak
73.0	X	60.41	13.42	-18.8	59.0	0.63	33	-34.31	AVG *

73kHz Transmitter Calculations Expanded (10-meter Test Site):

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

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

= 60.41 + 13.42 + -18.8 – 59.0 = -3.97 dBuV/m = 0.63 uV/m AVG (worst-case)

Limit = 2400 ÷ 73 = 32.87 = 33 uV/m for 73kHz

Figure 3: Peak Uncorrected Radiated Field Strength, 73kHz Fundamental

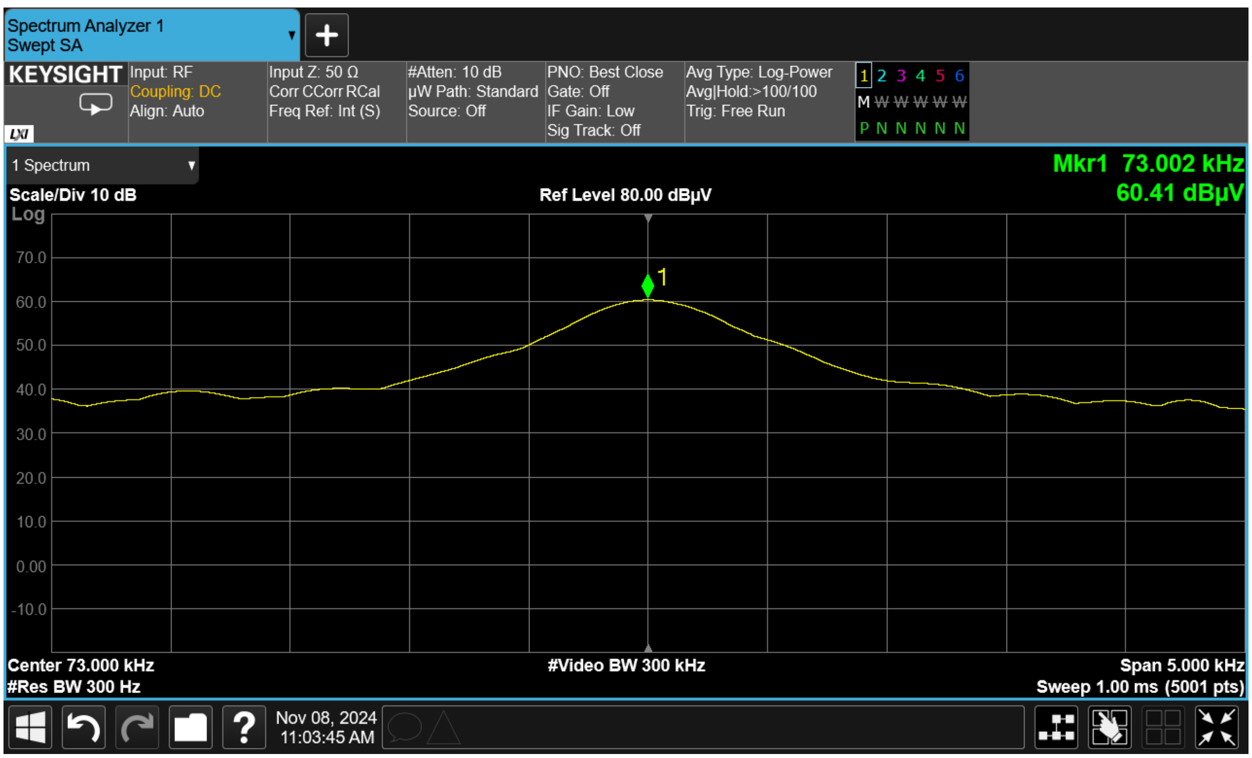


Table 8: Radiated Spurious Emissions Test Data < 30MHz, FCC

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
.146	42.90	13.22	0.0	59.0	0.718	164	-47.2	Peak
.146	42.90	13.22	-18.8	59.0	0.082	16	-46.0	AVG *
.365	45.67	13.31	0.0	59.0	0.998	66	-36.4	Peak
.365	45.67	13.31	-18.8	59.0	0.115	7	-35.2	AVG *
.438	39.40	13.45	0.0	59.0	0.493	55	-40.9	Peak
.438	39.40	13.45	-18.8	59.0	0.06	5.5	-39.7	AVG *
6.26	17.80	13.90	0.0	19.0	4.315	300	-36.8	Peak
6.26	17.80	13.90	-18.8	19.0	0.495	30	-35.6	AVG *
9.43	16.60	14.00	0.0	19.0	3.802	300	-37.9	Peak
9.43	16.60	14.00	-18.8	19.0	0.437	30	-36.7	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 9.43MHz is written at 30m; therefore, 40LOG30/10 = 19.08 dB
5. dBuV/m = 20LOG(uV/m)
6. testing performed at 10-meters

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 9: Radiated Emissions Limits, ISED Canada

Frequency (MHz)	Field Strength (µA/m)	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)**	**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 and 4.2.2 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.

Only the worst-case emissions are reported.

Table 10: Fundamental Transmitter Test Data, ISED Canada

Frequency (kHz)	SA Level (dBuV)	CF (dB/m)	DCCF (dB)	Distance Factor (dB)	H-Field Corr. Factor (dB)	Corr. Level (uA/m)	Limit (uA/m)	Margin (dB)	Emission Type
73.0	60.41	13.42	0.0	59.0	51.5	.015	0.87	-35.27	Peak
73.0	60.41	13.42	-18.8	59.0	51.5	.0017	0.087	-34.18	AVG *

Calculations Expanded:

dBµA = dBµV – 51.5 dB

dBµA/m = $\text{SA Level}_{dBuV} + CF_{dB/m} + DCCF_{dB} - DF_{dB} - HCF_{dB}$

= 60.41 + 13.42 + -18.8 – 59 – 51.5 = -55.39 dBµA/m = .0017 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

Testing was performed at 10-meters.

Table 11: 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
.146	42.9	-45.78	0.0	51.5	0.0019	0.436	-47.2	Peak
.146	42.9	-45.78	-18.8	51.5	0.0002	0.044	-46.8	AVG *
.365	45.67	-45.69	0.0	51.5	0.0027	0.092	-30.6	Peak
.365	45.67	-45.69	-18.8	51.5	0.0003	0.009	-29.5	AVG *
.438	39.4	-45.55	0.0	51.5	0.0013	0.145	-40.9	Peak
.438	39.4	-45.55	-18.8	51.5	0.0002	0.015	-37.5	AVG *
6.26	17.8	-5.1	0.0	51.5	0.0115	0.800	-36.8	Peak
6.26	17.8	-5.1	-18.8	51.5	0.0013	0.080	-35.8	AVG *
9.43	16.6	-5.0	0.0	51.5	0.0101	0.800	-38.0	Peak
9.43	16.6	-5.0	-18.8	51.5	0.0012	0.080	-36.5	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 9.43 MHz is written at 30m; therefore, 40LOG30/10 = 19.08 dB
5. Corr. Factors: 14.0 – 19.0 = -5.0 dB/m *(example for 9.43MHz)*
6. testing performed at 10-meters

4.3.2 General Unwanted Radiated Emissions (Part §15; RSS-Gen, ICES-003)

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

Table 12: Radiated Emissions Limits, 30MHz to 1GHz

Frequency (MHz)	**Field Strength (μV/m)**	**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 this section 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; this covers the 10th harmonic of the fundamental. 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 Test Results Summary

The EUT complies with the radiated emissions requirements of this section.

4.3.5 Radiated Data Reduction and Reporting

To convert the raw spectrum analyzer radiated data into a form that can be compared with the FCC limits, it is necessary to account for various calibration factors that are supplied with the antennas and other measurement accessories. These factors are included into the antenna factor (AF) column of the table and in the cable factor (CF) column of the table. The AF (in dB/m) and the CF (in dB) is algebraically added to the raw Spectrum Analyzer Voltage in dBµV to obtain the Radiated Electric Field in dBµV/m. This logarithm amplitude is converted to a linear amplitude, then compared to the FCC limit.

Example:

Spectrum Analyzer Voltage: VdBµV
Antenna Correction Factor: AFdB/m
Cable Correction Factor: CFdB
Pre-Amplifier Gain (if applicable): GdB
Electric Field: EdBµV/m = V dBµV + AFdB/m + CFdB - GdB
To convert to linear units of measure: EdBµV/m/20 Inv log

4.3.6 Test Data

For testing in the frequency range of 30MHz to 1GHz, it was not practical to configure the very long EUT wire loop antenna within the boundaries of the 80 cm test table. Please note that the EUT would never be installed with the wire loop bundled within the confines of 1 X 1.5-meters.

Therefore, the EUT wire loop antenna was removed and a matched inductor, supplied by the applicant, was installed in its place. This matched load provides similar inductance to that of the 35’ and 200’ wire loop(s). The use of an inductor coupled to the output of the transmitter assembly is for engineering and testing purposes.

Overall, the EUT meets the Class B radiated emissions requirements for a digital device that couples directly to the AC public mains.

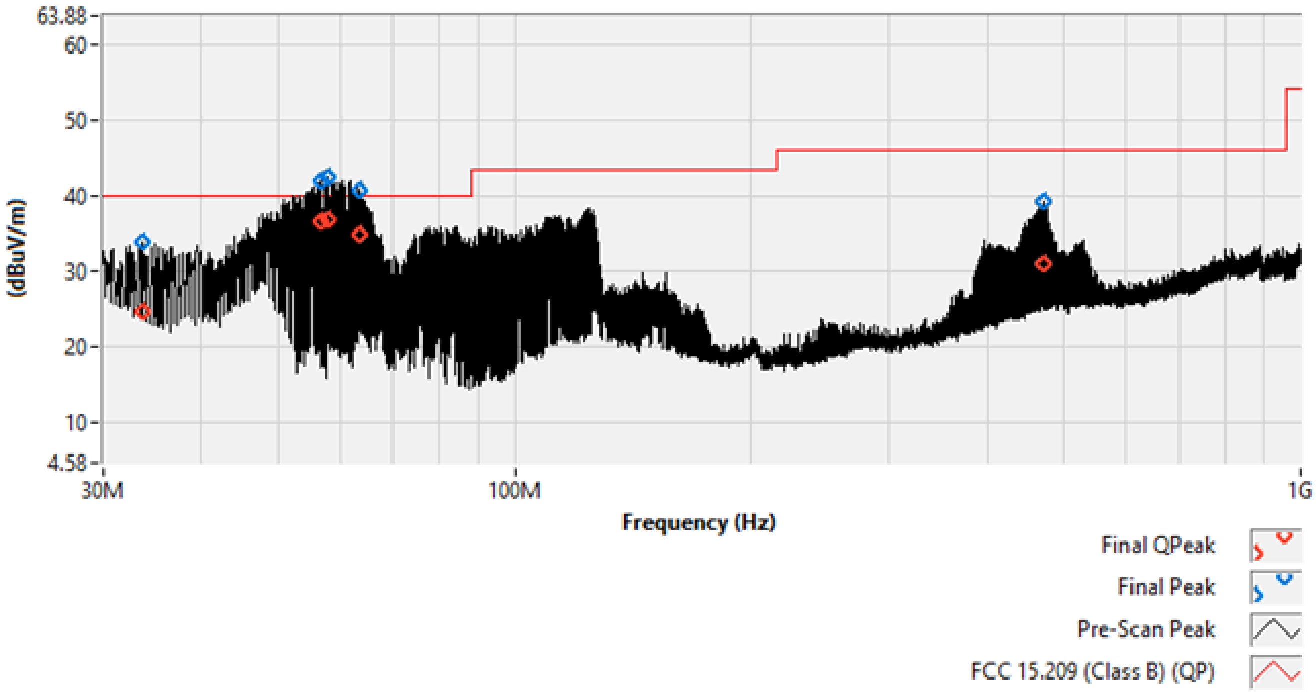
The EUT was investigated and tested with both the 35’ and 200’ matched inductors.

Only the worst-case emissions are reported.

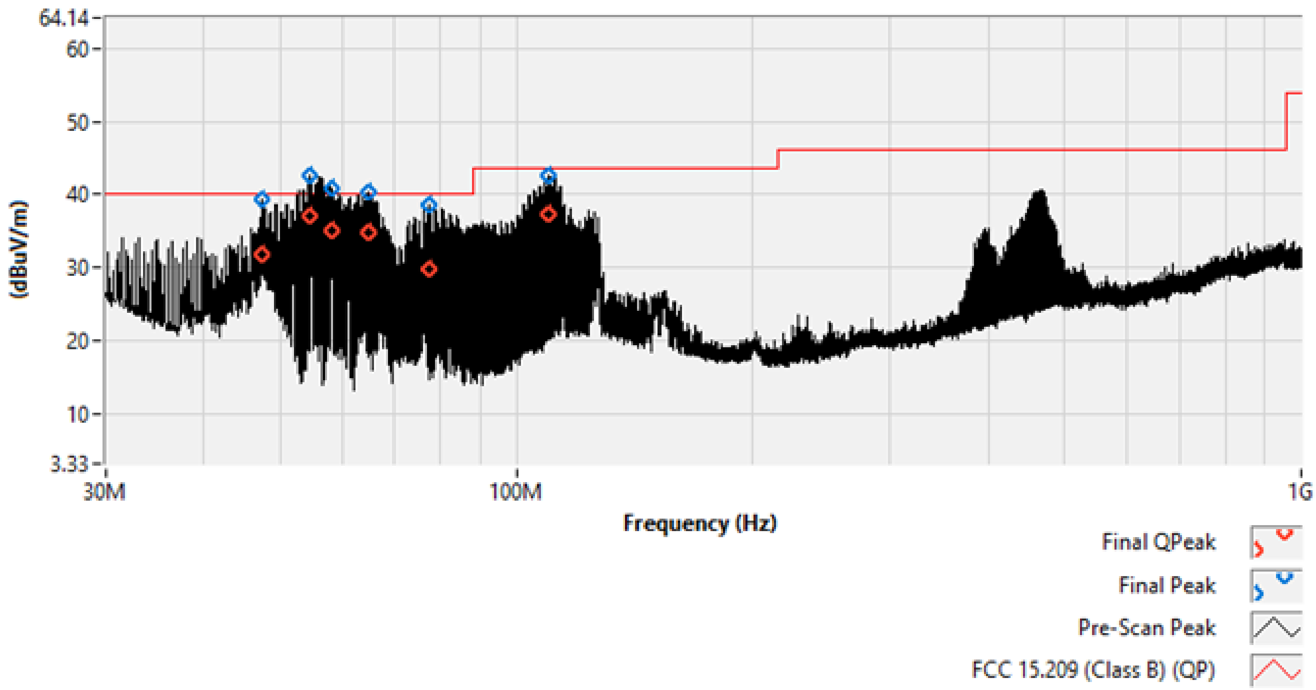
Table 13: Radiated Emissions Test Data > 30MHz. Matched Indcutor (Worst-Case)

Frequency (MHz)	Detector	Corr. Meas (dBuV/m)	Limit (dBuV/m)	Delta (dB)	Turn Table (deg)	Antenna (cm)
47.522	Peak	39.358	--	--	180	Vert, 120
	QP	31.809	40	-8.191	180	Vert, 120
54.542	Peak	42.508	--	--	180	Vert, 120
	QP	37.078	40	-2.922	180	Vert, 120
56.756	Peak	42.026	--	--	200	Vert, 110
	QP	36.495	40	-3.505	200	Vert, 110
58.263	Peak	40.949	--	--	200	Vert, 100
	QP	35.027	40	-4.973	200	Vert, 100
63.355	Peak	40.583	--	--	215	Vert, 120
	QP	34.82	40	-5.18	215	Vert, 120
64.863	Peak	40.33	--	--	215	Vert, 100
	QP	34.879	40	-5.121	215	Vert, 100
77.593	Peak	38.531	--	--	25	Vert, 120
	QP	29.965	40	-10.035	25	Vert, 110
110.168	Peak	42.554	--	--	190	Vert, 100
	QP	37.368	43.5	-6.132	190	Vert, 100

35’ Matched Inductor, Worst-Case Pre-scan and Final Data



200’ Matched Inductor, Worst-Case Pre-scan and Final Data



4.4 Transmitter Duty Cycle (DCCF)

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

Table 14: Transmitter Timing and Duty Factor Summary

EUT Mode	TX On-Time Per 100ms	Duty Cycle	Final DCCF	Switch Notes
Silencer (ZP)	11.22 ms	11.22%	-19.0	SW1 = On SW2 = On
Silencer (Jammer)	~100 ms	> 99 %	--	SW1 = Off SW2 = On
Rack Alert	11.42 ms	11.42%	-18.8	SW1 = On SW2 = Off

Each of these modes was investigated by WLL.
The Rack Alert Mode is the worst-case mode for radiated field strength and DDCF.
The Jammer mode appears to be near 100% duty cycle, regardless of evaluation period.

Final Data:

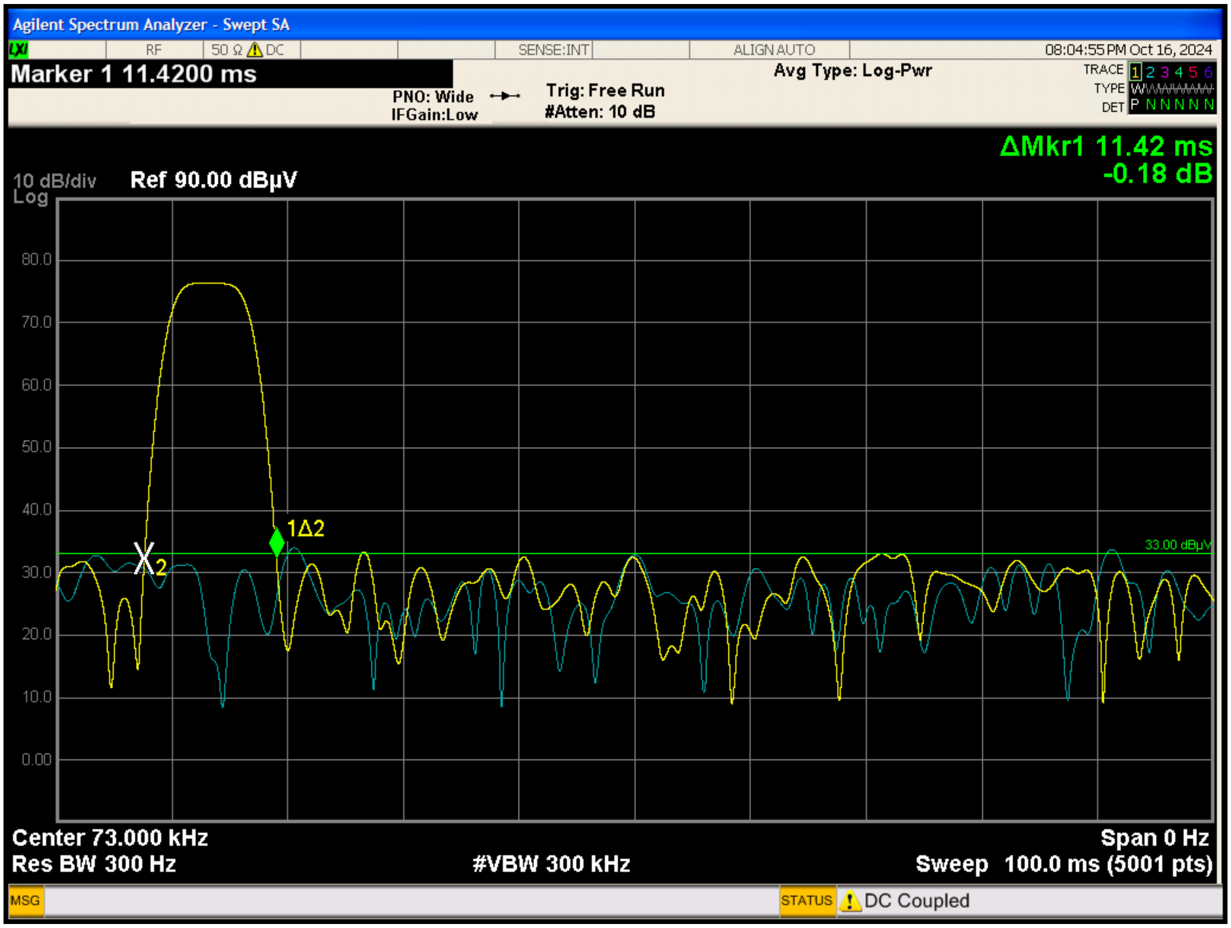
$11.42 \div 100 = 0.1142 = 11.42\ \%$

$20LOG(0.1142) = -18.8$

- 18.8 dB is the final DCCF

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

Figure 4: TX On Time per 100ms (worst-case for DCCF)



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

For testing of the AC powerline, it was not practical to configure the very long EUT wire loop antenna within the boundaries of the 80 cm test table. Please note that the EUT would never be installed with the wire loop bundled within the confines of 1 X 1.5-meters.

Therefore, the EUT wire loop antenna was removed and a matched inductor, supplied by the applicant, was installed in its place. This matched load provides similar inductance to that of the 35' and 200' wire loop(s). The use of an inductor coupled to the output of the transmitter assembly is for engineering and testing purposes.

Overall, the EUT meets the Class B conducted powerline emission requirements for a digital device that couples directly to the AC public mains.

The EUT was investigated and tested with both the 35' and 200' matched inductors.

Only the worst-case emissions are reported.

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)**
0.624	33.6	25.1	10.04	0.3	43.9	35.5	56.0	46.0	-12.1	-7.5
1.387	25.2	11.1	10.04	0.3	35.5	21.4	56.0	46.0	-20.5	-24.6
15.630	16.7	6.5	10.12	0.9	27.8	17.5	60.0	50.0	-32.2	-32.5
18.410	25.4	10.5	10.15	1.0	36.5	21.7	60.0	50.0	-23.5	-28.3
23.123	27.3	11.6	10.23	1.9	39.4	23.6	60.0	50.0	-20.6	-26.4
25.096	28.1	12.2	10.25	2.3	40.7	24.8	60.0	50.0	-19.3	-25.2
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)**
0.630	33.7	25.5	10.04	0.3	44.0	35.8	56.0	46.0	-12.0	-10.2
1.390	25.1	11.1	10.04	0.3	35.4	21.4	56.0	46.0	-20.6	-24.6
15.640	20.0	7.7	10.12	0.7	30.8	18.6	60.0	50.0	-29.2	-31.4
18.410	25.8	10.7	10.15	0.8	36.8	21.6	60.0	50.0	-23.2	-28.4
23.123	27.6	11.8	10.23	1.6	39.4	23.6	60.0	50.0	-20.6	-26.4
25.100	28.2	12.2	10.25	2.0	40.5	24.4	60.0	50.0	-19.5	-25.6