Certification Test Report

FCC ID: 2ATKJ-LTSN
IC: 24840-LTSN

FCC Rule Part: 15.249
ISED Canada Radio Standards Specification: RSS-210

Report Number: AT72146891-2C1

Manufacturer: GE Infrastructure Sensing, LLC
Model: LUMEN-TERRAIN-Sensor-1-0-0-0-F-0-2

Test Begin Date: May 13, 2019
Test End Date: May 16, 2019

Report Issue Date: July 31, 2019

FOR THE SCOPE OF ACCREDITATION UNDER Certificate Number: 2955.09

This report must not be used by the client to claim product certification, approval, or endorsement by A2LA, NIST, or any agency of the Federal Government.

Prepared By:

Jeremy Pickens
Senior Wireless Engineer
TÜV SÜD America Inc.

Reviewed by:

Ryan McGann
Senior Engineer
TÜV SÜD America Inc.

This report contains 17 pages

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1 GENERAL

1.1 Purpose

The purpose of this report is to demonstrate compliance with Part 15 Subpart C of the FCC's Code of Federal Regulations and Innovation, Science and Economic Development Canada's Radio Standards Specification RSS-210 for certification.

1.2 Product description

The LUMEN-TERRAIN system consists of a communications (base) station along with ten sensor monitoring nodes supporting a typical 300 ft. by 300 ft. well site. The base station includes a weather station to measure wind speed and direction. Power is provided to the base station and sensor nodes via solar panels and battery backup. Communications between the sensor nodes and base station is via sub 1 GHz (ISM) wireless radio.

Technical Information:

Detail	Description
Frequency Range	902.2 – 927.8 MHz
Number of Channels	129
Modulation Format	FSK
Operating Voltage	12Vdc Battery
Antenna Type / Gain	External Dipole / 2dBi (Pulse Larsen, P/N: W5017)

Manufacturer Information:
GE Infrastructure Sensing, LLC
1100 Technology Park Dr.
Billerica, MA 01821, USA

Test Sample Serial Number(s): Not labeled

Test Sample Condition: The test sample was provided in working order with no visible defects.

1.3 Test Methodology and Considerations

All modes of operation, including all available data rates, were evaluated. The data presented in this report represents the worst case where applicable.

For Radiated Emissions, the EUT was programmed to generate a continuously modulated signal. The EUT was evaluated in a fixed orientation as intended during normal installation. See test setup photos for more information.

The EUT is a battery powered device with no provisions for connection to the public utilities, therefore power line conducted emissions was not performed. To facilitate testing, and external DC power supply was used.

Software power setting during test: -5dBm

2 TEST FACILITIES

2.1 Location

The radiated and conducted emissions test sites are located at the following addresses:

TÜV SÜD America, Inc.
5945 Cabot Pkwy, Suite 100
Alpharetta, GA 30005
Phone: (678) 341-5900

2.2 Laboratory Accreditations/Recognitions/Certifications

TÜV SÜD America, Inc. is accredited to ISO/IEC 17025 by the American Association for Laboratory Accreditation/A2LA accreditation program and has been issued certificate number 2955.09 in recognition of this accreditation.

Unless otherwise specified, all tests methods described within this report are covered under the ISO/IEC 17025 scopes of accreditation.

The Semi-Anechoic Chamber Test Sites and Conducted Emissions Sites have been fully described, submitted to, and accepted by the FCC, ISED Canada and the Japanese Voluntary Control Council for Interference by information technology equipment.

FCC Registration Number:	967699
ISED Canada Lab Code:	23932
VCCI Member Number:	1831
• VCCI Registration Number	A-0295

2.3 Radiated Emissions Test Site Description

2.3.1 Semi-Anechoic Chamber Test Site – Chamber A

The Semi-Anechoic Chamber Test Site consists of a 20' x 30' x 18' shielded enclosure. The chamber is lined with Toyo Ferrite Grid Absorber, model number FFG-1000. The ferrite tile grid is 101 x 101 x 19mm thick and weighs approximately 550 grams. These tiles are mounted on steel panels and installed directly on the inner walls of the chamber.

The turntable is 5' in diameter and is located 5'6" from the back wall of the chamber. The chamber is grounded via 1 - 8' copper ground rod, installed at the center of the back wall, it is bound to the ground plane using 3/4" stainless steel braided cable.

The turntable is all steel, flush mounted EMCO Model 1060 installed in an all steel frame. The table is remotely operated from inside the control room located 25' from the range. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane during operation.

Behind the turntable is a 3' x 6' x 4' deep shielded pit used for support equipment if necessary. The pit is equipped with 1 - 4" PVC chase from the turntable to the pit that allows for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit.

The chamber rear wall is covered with a mixture of Siepel pyramidal absorber. The side walls of the chamber are partially covered with Siepel pyramidal absorber.

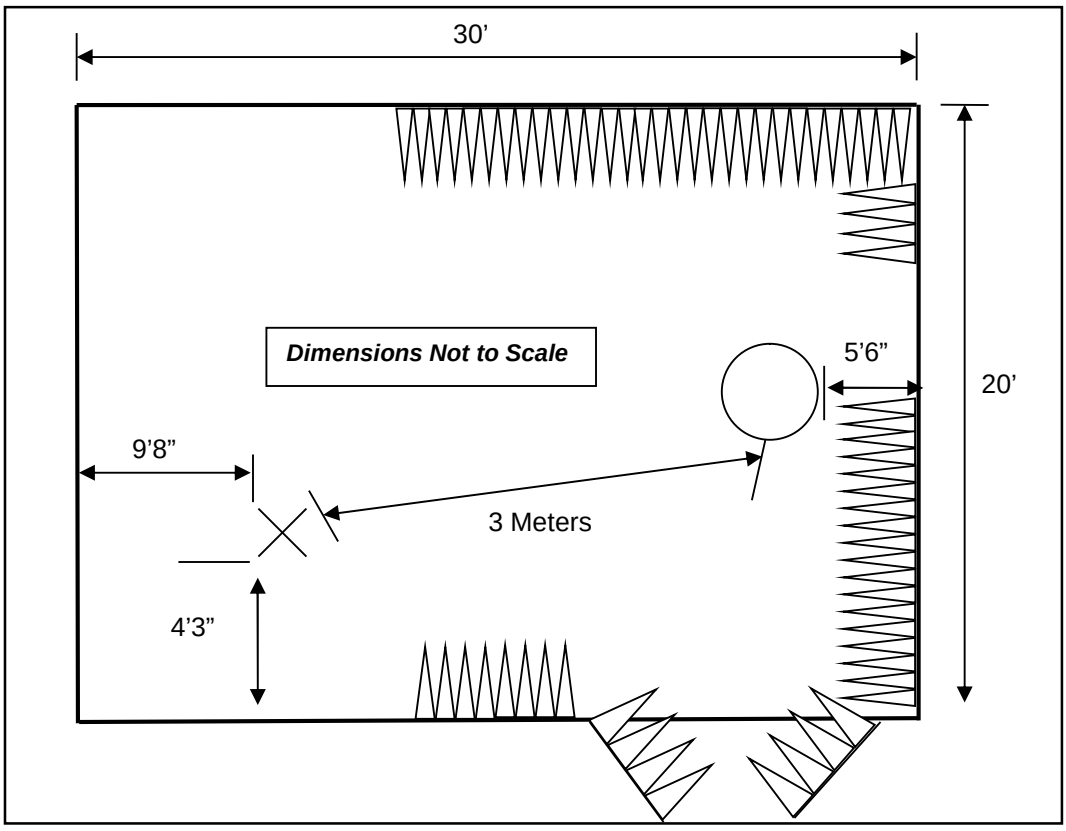

Figure 2.3.1-1: Semi-Anechoic Chamber Test Site – Chamber A

2.3.2 Semi-Anechoic Chamber Test Site – Chamber B

The Semi-Anechoic Chamber Test Site consists of a 20'W x 30'L x 20'H shielded enclosure. The chamber is lined with ETS-Lindgren Ferrite Absorber, model number FT-1500. The ferrite tile 600 mm x 600 mm (2.62 in x 23.62 in) panels and are mounted directly on the inner walls of the chamber shield.

The specular regions of the chamber are lined with additional ETS-Lindgren PS-600 hybrid absorber to extend its frequency range up to 18GHz and beyond.

The turntable is a 2m ETS-Lindgren Model 2170 and installed off the center axis is located 5'6" from the back wall of the chamber. The chamber is grounded via 1 - 8' copper ground rod, installed at the center of the back wall, it is bound to the shield using #8 solid copper wire.

The antenna mast is an EMCO 1060 and is remotely controlled from the control room for both antenna height and polarization.

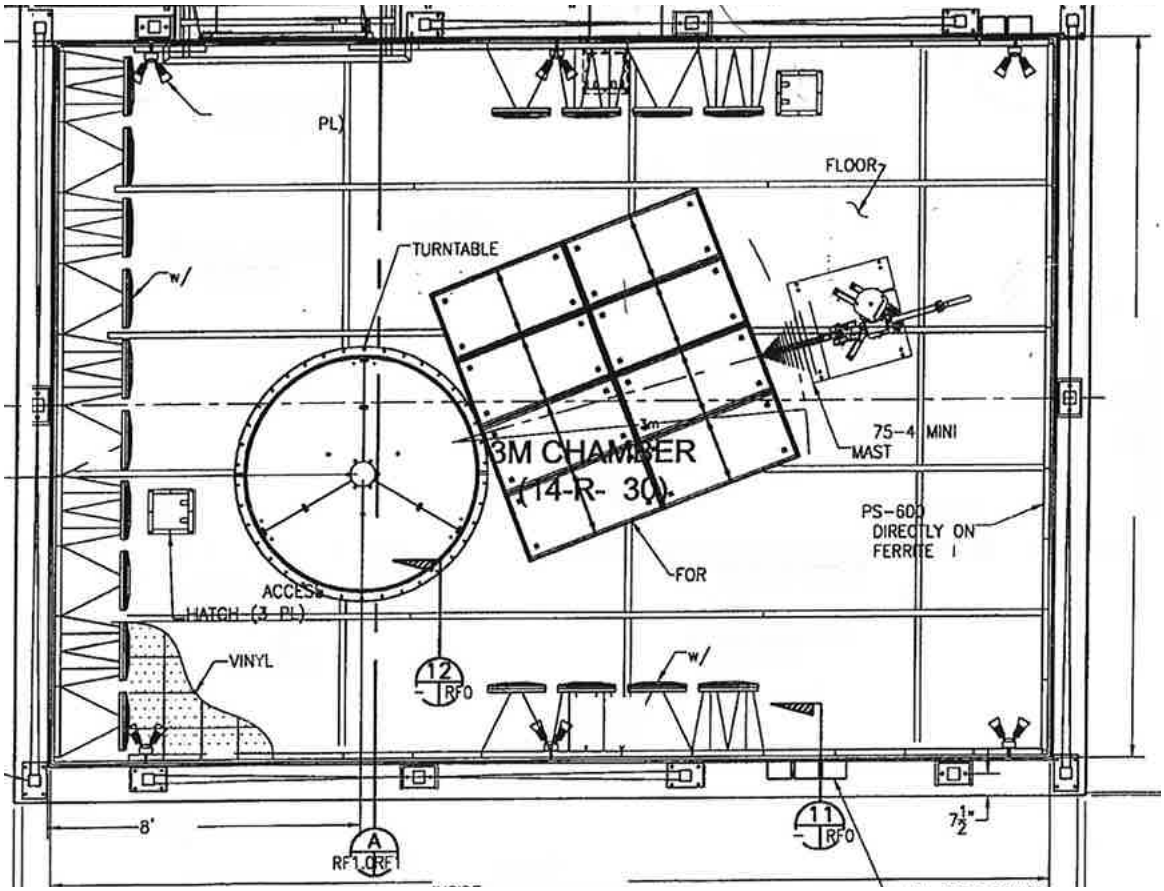

Figure 2.3.2-1: Semi-Anechoic Chamber Test Site – Chamber B

2.4 Conducted Emissions Test Site Description

2.4.1 Conducted Emissions Test Site

The AC mains conducted EMI site is located in the main EMC lab. It consists of a 12' x 10' horizontal coupling plane (HCP) as well as a 12'x8' vertical coupling plane (VCP). The HCP is constructed of 4' x 10' sheets of particle board sandwiched by galvanized steel sheets. These panels are bonded using 11AWG 1/8" x 2" by 10' galvanized sheet steel secured to the panels via by screws. The VCP is constructed of three 4'x8' sheets of 11AWG solid aluminum.

The HCP and VCP are electrically bonded together using 1"x1" angled aluminum secured with screws.

The site is of sufficient size to test table top and floor standing equipment in accordance with ANSI C63.10.

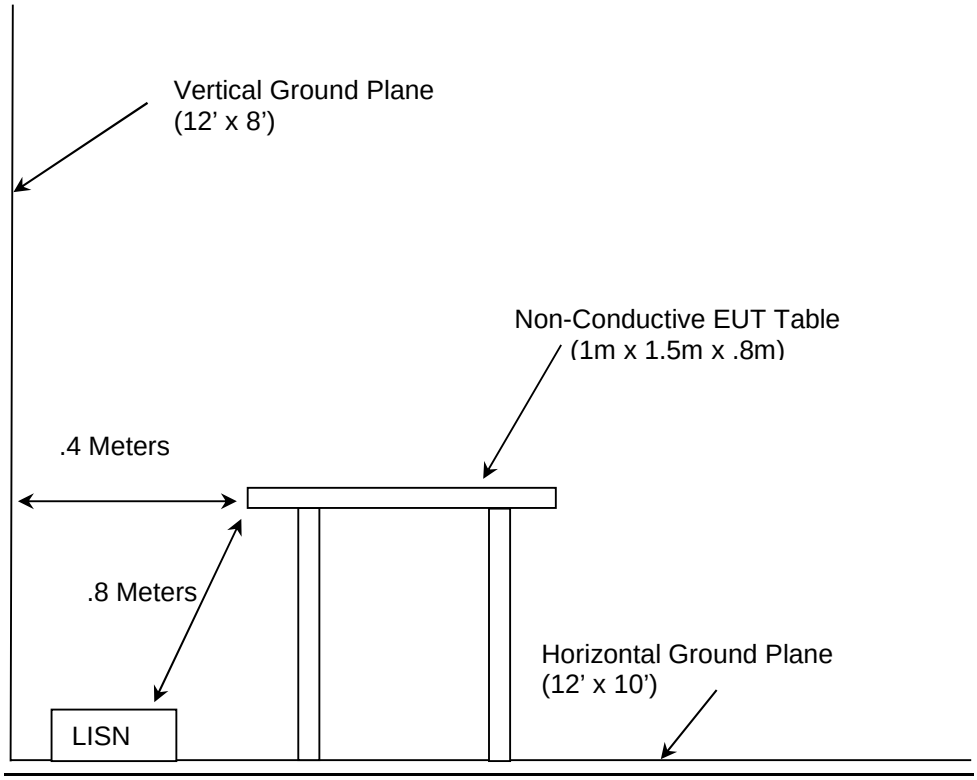

Figure 2.4.1-1: AC Mains Conducted EMI Site

3 APPLICABLE STANDARD REFERENCES

The following standards were used:

- ANSI C63.10-2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- US Code of Federal Regulations (CFR): Title 47, Part 2, Subpart J: Equipment Authorization Procedures, 2019
- US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators, 2019
- Innovation, Science and Economic Development Canada Radio Standards Specification: RSS-210 – Low-power License-exempt Radiocommunication Devices (All Frequency Bands): Category I Equipment, Issue 9, August 2016, (Amendment November 2017)
- Innovation, Science and Economic Development Canada Radio Standards Specification: RSS-GEN – General Requirements for Compliance of Radio Apparatus, Issue 5, April 2018, Amendment (March 2019)

4 LIST OF TEST EQUIPMENT

The calibration interval of test equipment is annually or the manufacturer's recommendations. Where the calibration interval deviates from the annual cycle based on the instrument manufacturer's recommendations, it shall be stated below.

Table 4-1: Test Equipment

Asset ID	Manufacturer	Model	Equipment Type	Serial Number	Last Calibration Date	Calibration Due Date
22	Hewlett Packard	8449B	High Frequency Pre-Amp	3008A00526	07/11/2018	07/11/2020
213	TEC	PA 102	Amplifier	44927	07/19/2018	07/19/2019
329	A.H.Systems	SAS-571	Horn Antenna	721	08/03/2017	08/03/2019
628	EMCO	6502	Active Loop Antenna 10kHz-30MHz	9407-2877	02/11/2019	11/02/2021
819	Rohde & Schwarz	ESR26	EMI Test Receiver	101345	11/06/2018	11/06/2019
836	ETS Lindgren	SAC Cable Set	SAC Cable Set includes 620, 837, 838	N/A	05/01/2019	5/1/2020
853	Teseq	CBL 6112D; 6804.17.A	Bilog Antenna; Attenuator	51616; 20181110A	10/15/2018	10/15/2019

5 SUPPORT EQUIPMENT

Table 5-1: Support Equipment

Item #	Type Device	Manufacturer	Model/Part #	Serial #
1	DC Power Supply	TekPower	TP300ST	483280

Table 5-2: Cable Description

Cable #	Cable Type	Length	Shield	Termination
A	DC Power	2 m	None	EUT - 1

6 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

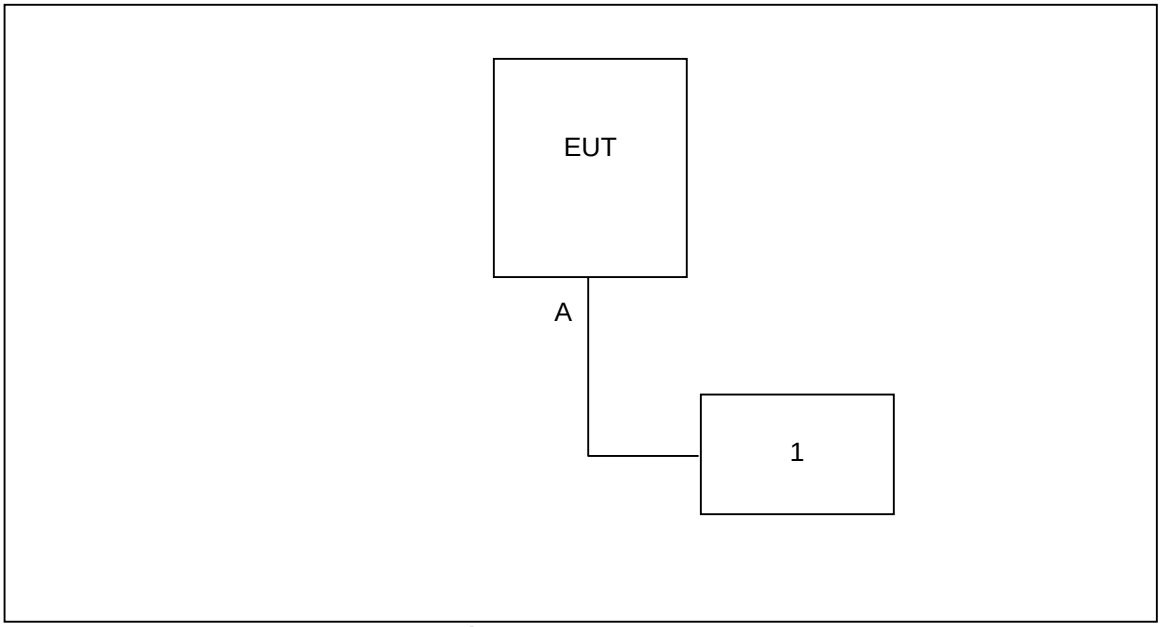

Figure 6-1: EUT Test Setup

7 SUMMARY OF TESTS

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

7.1 Antenna Requirement – FCC: Part 15.203

The antenna is an external detachable dipole antenna that utilizes a standard SMA connector; however, the system is professionally installed and not intended to be modified by the end-user, therefore satisfying Part 15.203.

7.2 Power Line Conducted Emissions – FCC: Part 15.207; ISED Canada: RSS-GEN 8.8

7.2.1 Measurement Procedure

The EUT is a battery powered device with no provisions for connection to the public utilities, therefore power line conducted emissions was not performed.

7.3 Occupied Bandwidth – FCC: Part 15.215(c); ISED Canada: RSS-GEN 6.7

7.3.1 Test Methodology

The occupied bandwidth measurement function of the spectrum analyzer was used to measure the 99% bandwidth. The span of the analyzer was set to capture all products of the modulation process, including the emission sidebands. The resolution bandwidth was set to 1% to 5% of the occupied bandwidth. The video bandwidth was set to 3 times the resolution bandwidth. A peak detector was used.

7.3.2 Test Results

Performed by: Jeremy Pickens

Table 7.3.2-1: 99% Bandwidth

Frequency [MHz]	99% Bandwidth [kHz]
902.2	96.95
915.0	93.95
927.8	94.95

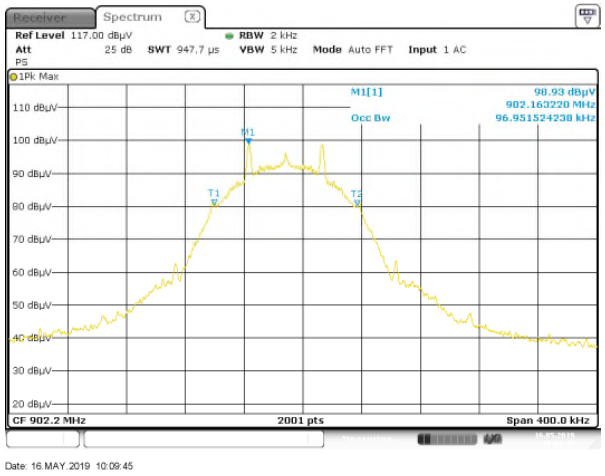

Figure 7.3.2-1: 99% Bandwidth – Low Channel

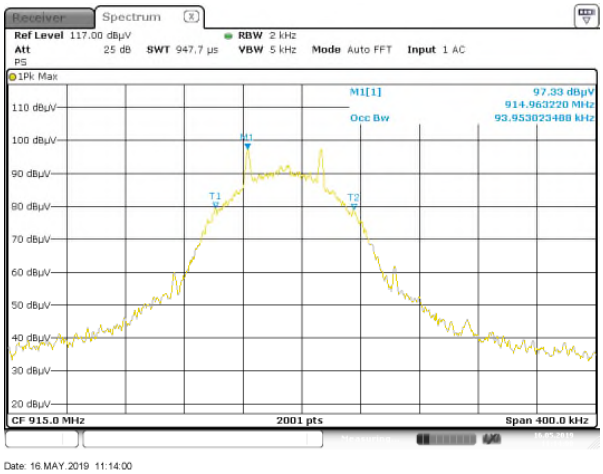

Figure 7.3.2-2: 99% Bandwidth – Mid Channel

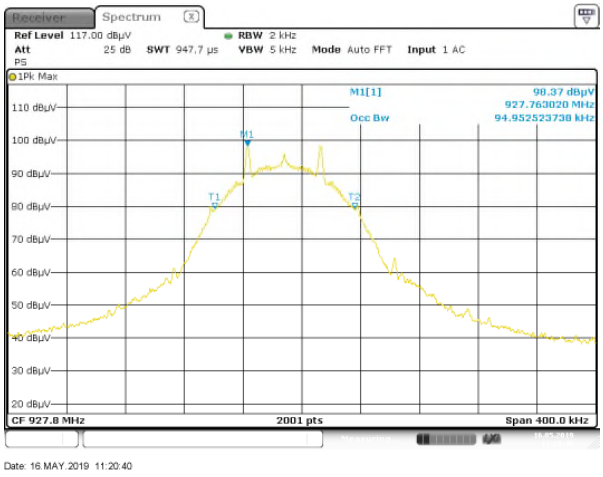

Figure 7.3.2-3: 99% Bandwidth – High Channel

7.4 Radiated Emissions – FCC: Part 15.249(a)(d)(e); ISED Canada: RSS-210 B.10(a)(b)

7.4.1 Measurement Procedure

Radiated emissions tests were made over the frequency range of 9 kHz to 10 GHz, 10 times the highest fundamental frequency.

Measurements below 30 MHz were performed with a 3-meter separation distance between the EUT and measurement antenna. The EUT was rotated 360° to maximize each emission. The magnetic loop receiving antenna was positioned with its lowest point 1 meter above the ground. The loop antenna was aligned along the site axis, orthogonal to the site axis, and ground-parallel to the site axis.

For expedited pre-scans, the spectrum analyzer's resolution and video bandwidths were set to 1 kHz and 3 kHz respectively for frequencies below 150 kHz and 9 kHz and 30 kHz respectively for frequencies above 150 kHz and below 30 MHz. In the case where final measurements were required, the spectrum analyzer's resolution and video bandwidths were set to 200 Hz and 1000 Hz respectively for frequencies below 150 kHz.

For measurements above 30 MHz, the EUT was rotated through 360° and the receive antenna height was varied from 1 meter to 4 meters so that the maximum radiated emissions level would be detected. For frequencies below 1000 MHz, measurements were made using a resolution bandwidth (RBW) of 120 kHz and a video bandwidth (VBW) of 300 kHz. For frequencies above 1000 MHz, measurements were made with RBW of 1 MHz and a VBW of 3 MHz.

The peak and average emissions were compared to the limits according to Part 15.249(a). The final measurements were then corrected by antenna correction factors and cable loss for comparison to the limits. Further, compliance with the provisions of Part 15.205 was demonstrated using the measurement instrumentation specified in that section where applicable.

7.4.2 Test Results

Performed by: Jeremy Pickens

Radiated spurious emissions are reported in Table 7.4.2-1. Emissions not reported were below the noise floor of the measurement system. Peak data below 30MHz was more than 20dB below the applicable limits.

Table 7.4.2-1: Radiated Emissions

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	Qpk/Avg	(H/V)	(dB)	pk	Qpk/Avg	pk	Qpk/Avg	pk	Qpk/Avg
Fundamental Emission - Low Channel										
902.2	81.70	81.40	H	1.97	---------	83.37	--------	94.0	--------	10.6
902.2	92.2	91.9	V	1.97	---------	93.87	--------	94.0	--------	0.1
Fundamental Emission - Mid Channel										
915	81.90	81.60	H	1.95	---------	83.55	--------	94.0	---------	10.4
915	91.60	91.30	V	1.95	---------	93.25	--------	94.0	---------	0.7
Fundamental Emission - High Channel										
927.8	81.2	80.9	H	1.77	---------	82.67	--------	94.0	--------	11.3
927.8	90.9	90.6	V	1.77	---------	92.37	--------	94.0	--------	1.6
Spurious Emissions - Low Channel										
451.1	46.1	45.5	V	-2.88	---------	42.62	--------	46.0	---------	3.4
1804.4	48.00	42.90	V	-2.45	45.55	40.45	74.0	54.0	28.5	13.6
2706.6	45.00	34.40	H	1.72	46.72	36.12	74.0	54.0	27.3	17.9
2706.6	46.70	35.90	V	1.72	48.42	37.62	74.0	54.0	25.6	16.4
Spurious Emissions - Mid Channel										
457.5	46.4	45.5	V	-2.72	---------	42.78	--------	46.0	---------	3.2
1830	47.10	41.70	V	-2.22	44.88	39.48	74.0	54.0	29.1	14.5
Spurious Emissions - High Channel										
463.9	46.8	46.1	V	-2.55	---------	43.55	--------	46.0	---------	2.5
1855.6	46.5	40.4	V	-1.99	44.51	38.41	74.0	54.0	29.5	15.6

Note: Measurements at 902MHz (Low Channel) and 928 (High Channel) were in the equipment noise floor.

7.4.3 Sample Calculation:

$R_C = R_U + CF_T$

Where:

CF_T = Total Correction Factor (AF+CA+AG)
R_U = Uncorrected Reading
R_C = Corrected Level
AF = Antenna Factor
CA = Cable Attenuation
AG = Amplifier Gain

Example Calculation: Fundamental Frequency
Corrected Level: 91.9 + 1.97 = 93.87dBuV
Margin: 94.0dBuV – 93.87dBuV = 0.1dB

8 ESTIMATION OF MEASUREMENT UNCERTAINTY

The expanded laboratory measurement uncertainty figures (U_{Lab}) provided below correspond to an expansion factor (coverage factor) k = 1.96 which provide confidence levels of 95%.

Table 8-1: Estimation of Measurement Uncertainty

Parameter	U_{lab}
Occupied Channel Bandwidth	± 0.009 %
RF Conducted Output Power	± 0.349 dB
Power Spectral Density	± 0.372 dB
Antenna Port Conducted Emissions	± 1.264 dB
Radiated Emissions ≤ 1 GHz	± 5.814 dB
Radiated Emissions > 1 GHz	± 4.318 dB
Temperature	± 0.860 °C
Radio Frequency	± 2.832 x 10^{-8}
AC Power Line Conducted Emissions	± 3.360 dB

9 CONCLUSION

In the opinion of TÜV SÜD America Inc. the LUMEN-TERRAIN Sensor Node manufactured by GE Infrastructure Sensing, LLC met the requirements of FCC Part 15 subpart C and Innovation, Science and Economic Development Canada's Radio Standards Specification RSS-210 for the tests documented herein.

Appendix A: Plots

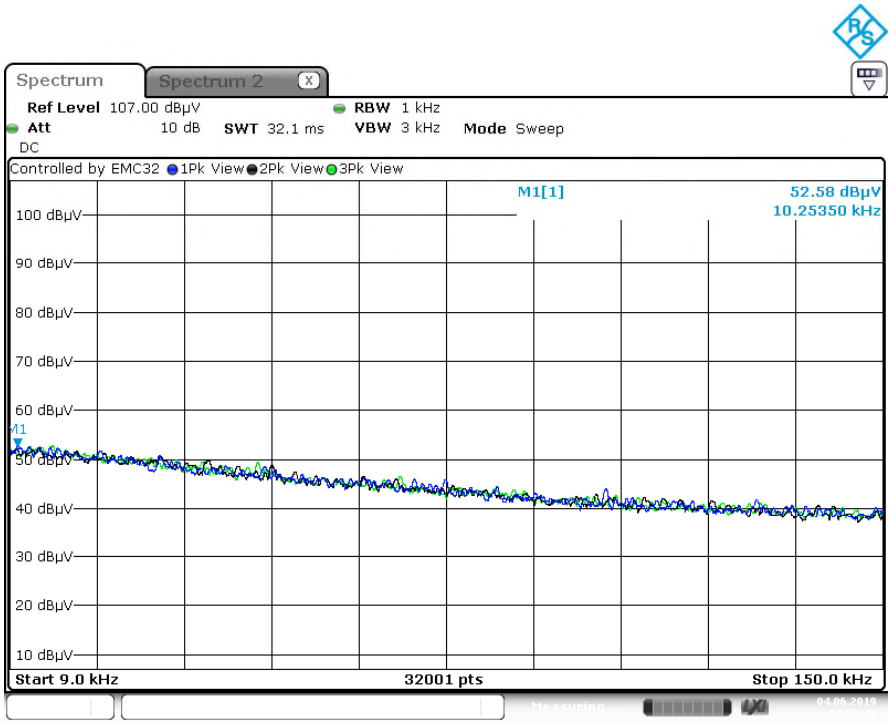

Figure A-1: 9kHz-150kHz

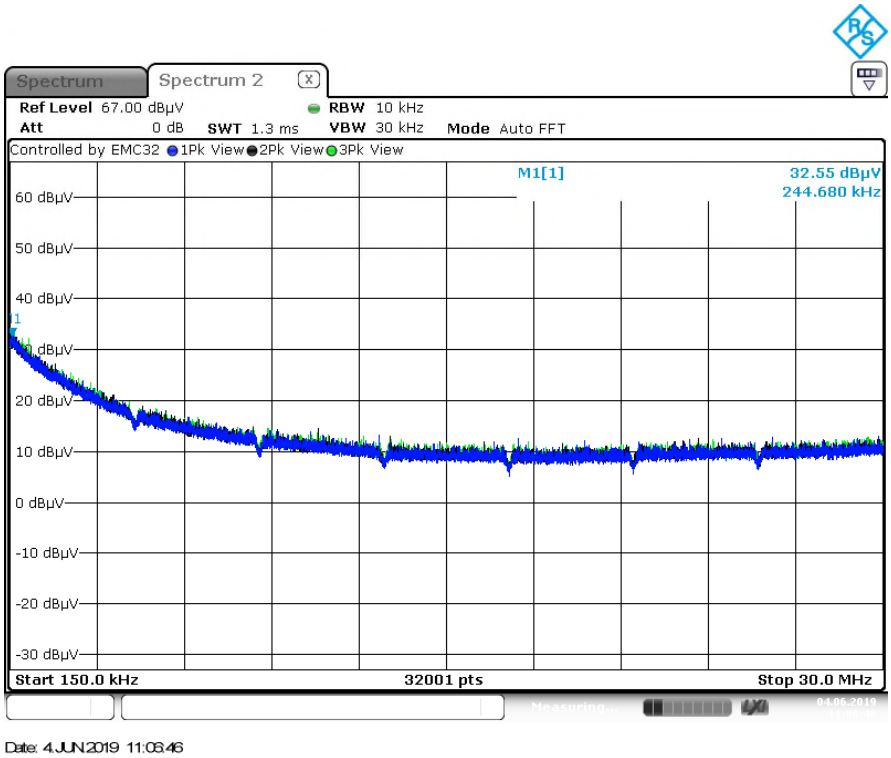

Figure A-2: 150kHz-30MHz

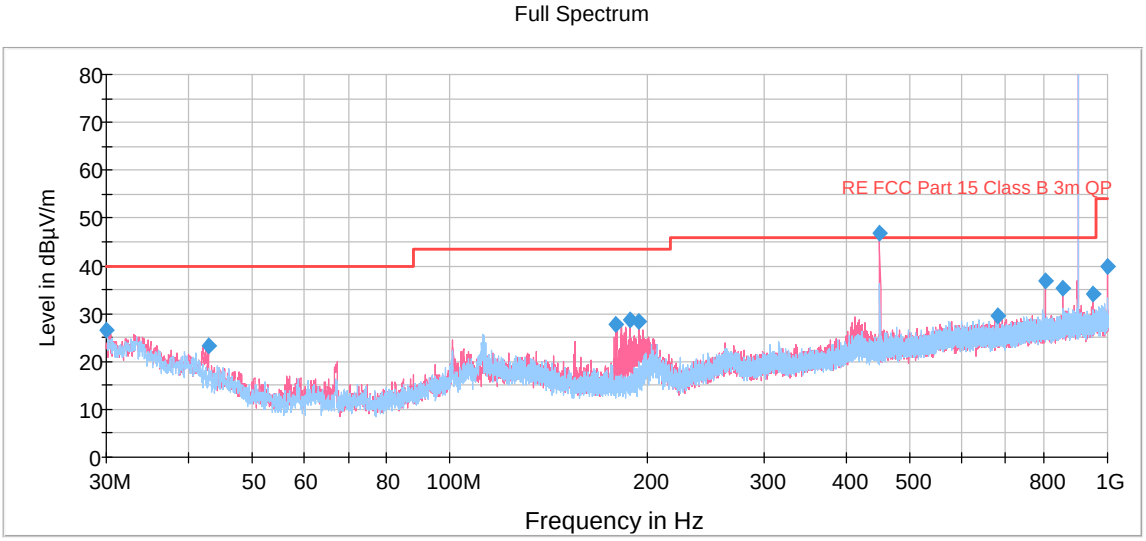

Figure A-3: 30MHz-1GHz

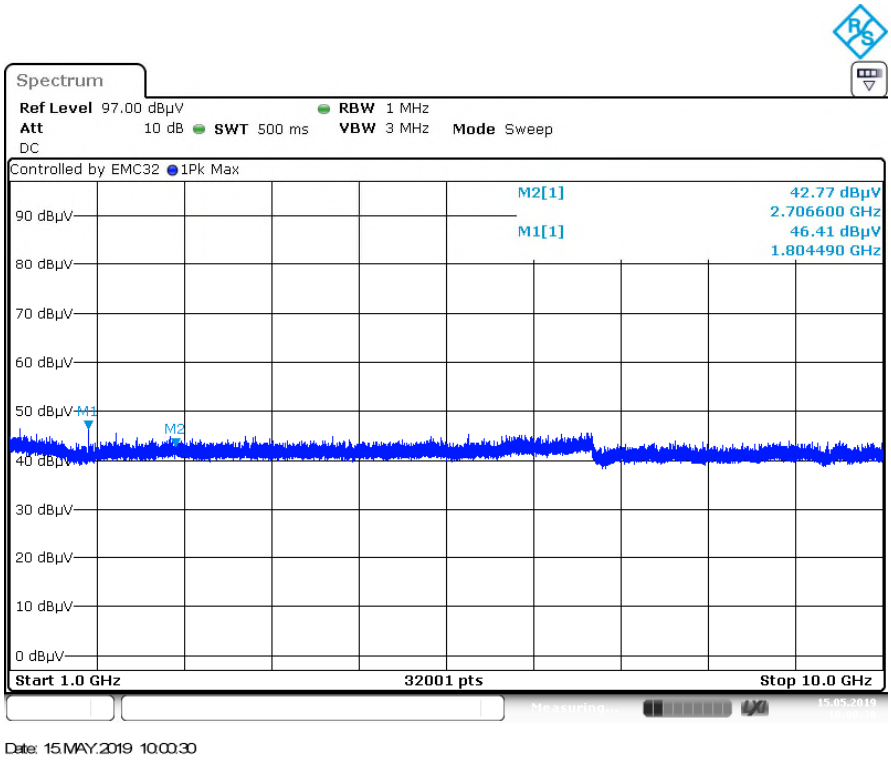

Figure A-4: 1GHz-10GHz

END REPORT