



Certification Test Report

FCC ID: P2SL900M

IC: 4171BL900M

FCC Rule Part: 15.247

ISED Canada Radio Standards Specification: RSS-247

Report Number: AT72126503-3C1

Manufacturer: Neptune Technology Group

Model: L900M

Test Begin Date: March 22, 2017

Test End Date: April 6, 2017

Report Issue Date: October 18, 2017



FOR THE SCOPE OF ACCREDITATION UNDER Certificate Number: AT-2021

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

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This report contains 21 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-247 Certification for modular approval.

1.2 Product Description

The L900M is a transceiver designed to wirelessly provide RF telemetry readings for a water meter operating within the 902-928MHz ISM band. The L900M is battery powered (3.6V), and spends the majority of its time in a low power consumption mode (asleep). The on-board microprocessor utilizes an internal clock to briefly "wake up" the L900M for periodic wireless communication of telemetry information from the water meter.

The L900M provides for several communication modes, to accommodate different installation site requirements. Available communication modes are as follows:

- Neptune Proprietary Standard
 - o Mode #1 – SURF (OOK modulation)
 - o Mode #2 – Enhanced fixed network uplink (GFSK modulation)
 - o Mode #3 – Enhanced mobile network uplink/downlink (GFSK, Data Log Retrieval)
- LoRaWAN, open protocol based on proprietary modulation scheme from Semtech

This test report documents the compliance of the LoRaWAN radio operating in hybrid mode.

Technical Information:

Detail	Description
Frequency Range	902.3 – 914.9 MHz
Number of Channels	64
Modulation Format	CSS (Chirp Spread Spectrum)
Data Rates	980, 1760, 3125, 5470 bits/s
Number of Inputs/Outputs	1T1R
Operating Voltage	3.6 Vdc
Antenna Type / Gain	Neptune Technology Group Patch Antenna 1 dBi

Manufacturer Information:

Neptune Technology Group Inc.
1600 Alabama Highway 226
Tallahassee, AL 36078

Test Sample Serial Number: 700002602

Test Sample Condition: The test samples were provided in good working order with no visible defects.

1.3 Test Methodology and Considerations

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

For radiated emissions, the EUT was evaluated in three orthogonal orientations. The worst-case orientation was X-orientation. See test setup photos for more information.

The EUT is a battery powered device with no provision for connection to the public utility mains, therefore AC power line conducted emissions is not applicable.

For RF Conducted Emissions, the EUT was evaluated in a temporary test jig to facilitate connection to the test equipment. The insertion loss of the test jig was characterized for RF conducted emissions testing.

Power setting during test: +4

2 TEST FACILITIES

2.1 Location

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

TÜV SÜD America, Inc.
5015 B.U. Bowman Drive
Buford, GA 30518
Phone: (770) 831-8048
Fax: (770) 831-8598

2.2 Laboratory Accreditations/Recognitions/Certifications

TÜV SÜD America, Inc. is accredited to ISO/IEC 17025 by the ANSI-ASQ National Accreditation Board/ANAB accreditation program, and has been issued certificate number AT-2021 in recognition of this accreditation. Unless otherwise specified, all tests methods described within this report are covered under the ISO/IEC 17025 scope of accreditation.

The Semi-Anechoic Chamber Test Site, Open Area Test Site (OATS) and Conducted Emissions Site 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: 391271

ISED Canada Lab Code: IC 4175A

VCCI Member Number: 1831

- VCCI OATS Registration Number R-1526
- VCCI Conducted Emissions Site Registration Number: C-1608

2.3 Radiated Emissions Test Site Description

2.3.1 Semi-Anechoic Chamber Test Site

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 150cm in diameter and is located 160cm 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 table 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 chases from the turntable to the pit that allow 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.

A diagram of the Semi-Anechoic Chamber Test Site is shown in Figure 2.3-1 below:

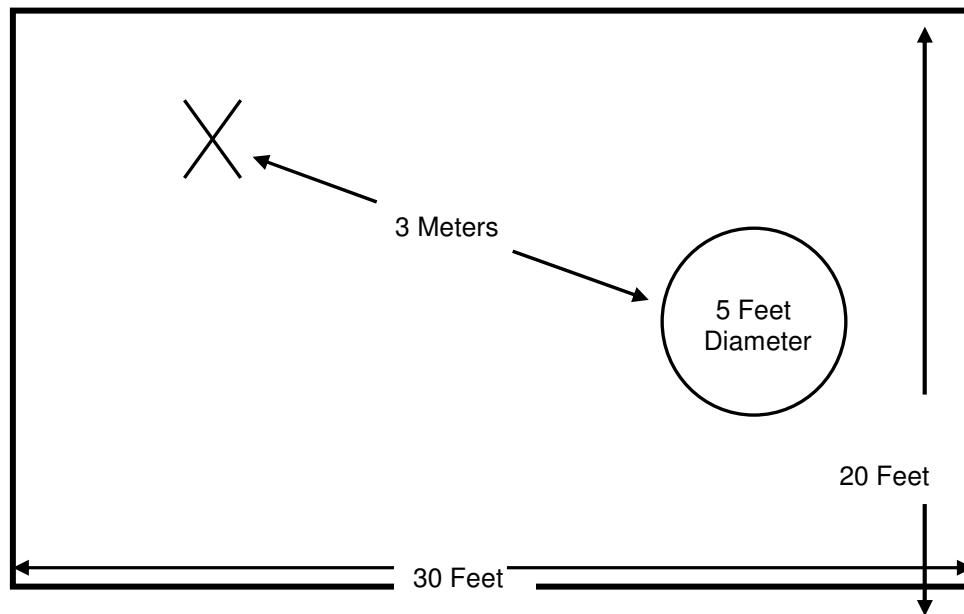


Figure 2.3-1: Semi-Anechoic Chamber Test Site

2.3.2 Open Area Tests Site (OATS)

The open area test site consists of a 40' x 66' concrete pad covered with a perforated electro-plated galvanized sheet metal. The perforations in the sheet metal are 1/8" holes that are staggered every 3/16". The individual sheets are placed to overlap each other by 1/4" and are riveted together to provide a continuous seam. Rivets are spaced every 3" in a 3 x 20 meter perimeter around the antenna mast and EUT area. Rivets in the remaining area are spaced as necessary to properly secure the ground plane and maintain the electrical continuity.

The entire ground plane extends 12' beyond the turntable edge and 16' beyond the antenna mast when set to a 10 meter measurement distance. The ground plane is grounded via 4 - 8' copper ground rods, each installed at a corner of the ground plane and bound to the ground plane using 3/4" stainless steel braided cable.

The turntable is an all aluminum 10' flush mounted table installed in an all aluminum frame. The table is remotely operated from inside the control room located 40' 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.

Adjacent to the turntable is a 7' x 7' square and 4' deep concrete pit used for support equipment if necessary. The pit is equipped with 5 - 4" PVC chases from the pit to the control room that allow 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 pit is covered with 2 sheets of 1/4" diamond style re-enforced steel sheets. The sheets are painted to match the perforated steel ground plane; however the underside edges have been masked off to maintain the electrical continuity of the ground plane. All reflecting objects are located outside of the ellipse defined in ANSI C63.10.

A diagram of the Open Area Test Site is shown in Figure 2.3-2 below:

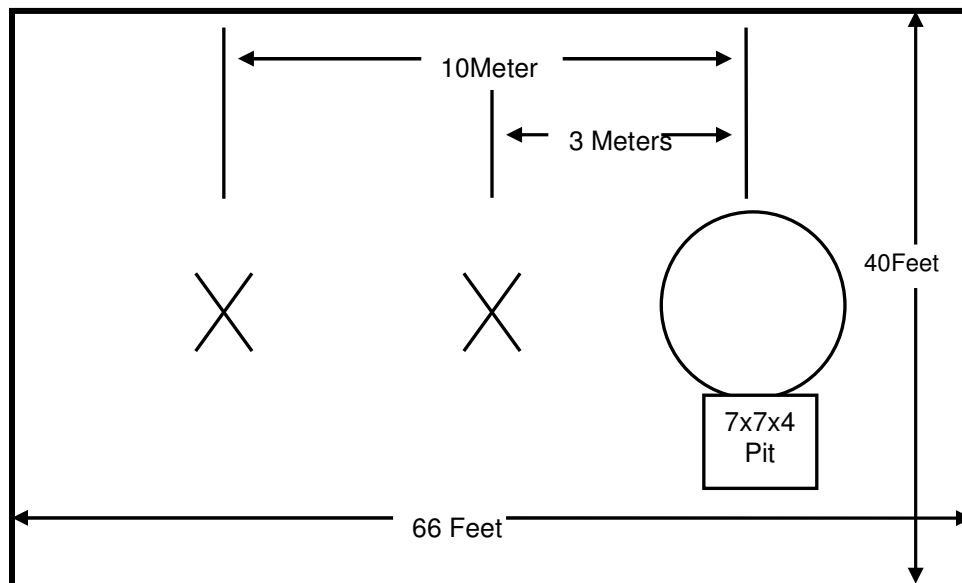


Figure 2.3-2: Open Area Test Site

2.4 Conducted Emissions Test Site Description

The AC mains conducted EMI site is located in the main EMC lab. It consists of an 8' x 8' solid aluminum horizontal ground reference plane (GRP) bonded every 3" to an 8' X 8' vertical ground plane.

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

A diagram of the room is shown below in figure 2.4-1:

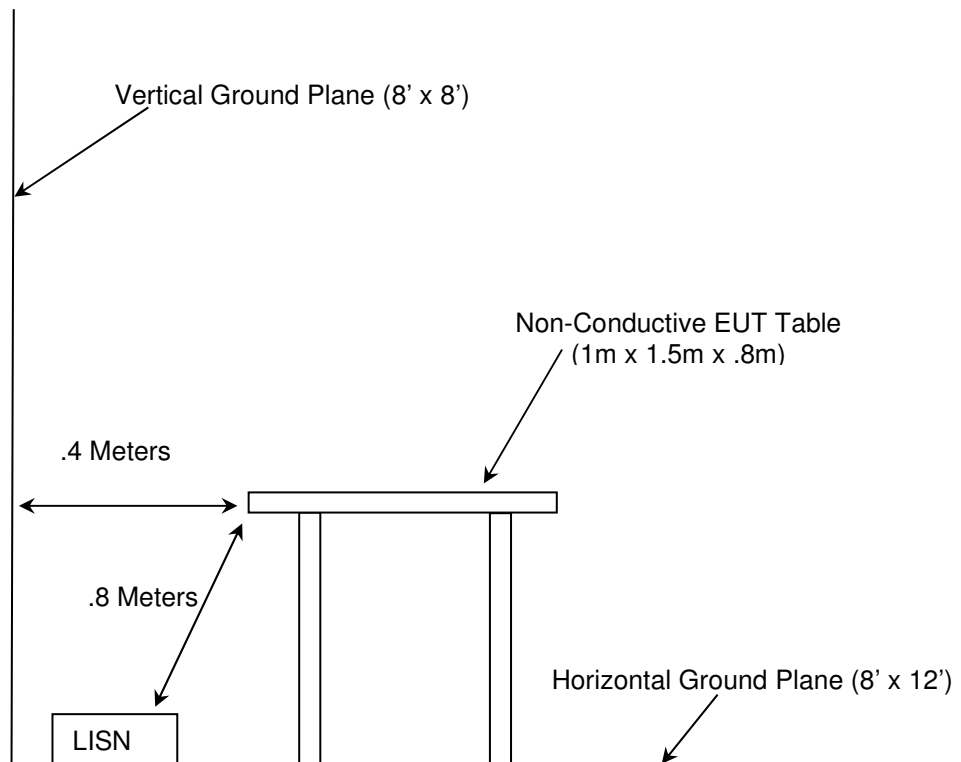


Figure 2.4-1: AC Mains Conducted EMI Site

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, 2017
- ❖ US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators, 2017
- ❖ FCC KDB 558074 D01 DTS Meas Guidance v04 - Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247, April 5, 2017
- ❖ ISED Canada Radio Standards Specification: RSS-247 – Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices, Issue 2, Feb 2017.
- ❖ ISED Canada Radio Standards Specification: RSS-GEN – General Requirements for Compliance of Radio Apparatus, Issue 4, Nov 2014.

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

AssetID	Manufacturer	Model #	Equipment Type	Serial #	Last Calibration Date	Calibration Due Date
30	Spectrum Technologies	DRH-0118	Antennas	970102	4/30/2015	4/30/2017
30	Spectrum Technologies	DRH-0118	Antennas	970102	5/9/2017	5/9/2019
40	EMCO	3104	Antennas	3211	6/8/2016	6/8/2018
73	Agilent	8447D	Amplifiers	2727A05624	7/21/2016	7/21/2017
167	ACS	Chamber EMI Cable Set	Cable Set	167	9/30/2016	9/30/2017
267	Agilent	N1911A	Meters	MY45100129	8/24/2015	8/24/2017
268	Agilent	N1921A	Sensors	MY45240184	8/13/2015	8/13/2017
329	A.H.Systems	SAS-571	Antennas	721	7/22/2015	7/22/2017
331	Microwave Circuits	H1G513G1	Filters	31417	5/13/2016	5/13/2017
331	Microwave Circuits	H1G513G1	Filters	31417	5/13/2017	5/13/2018
338	Hewlett Packard	8449B	Amplifiers	3008A01111	8/21/2015	8/21/2017
340	Aeroflex/Weinschel	AS-20	Attenuators	7136	7/12/2016	7/12/2017
412	Electro Metrics	LPA-25	Antennas	1241	8/8/2016	8/8/2018
422	Florida RF	SMS-200AW-72.0-SMR	Cables	805	10/27/2016	10/27/2017
616	Florida RF Cables	SMRE-200W-12.0-SMRE	Cables	N/A	9/2/2016	9/2/2017
622	Rohde & Schwarz	FSV40	Analyzers	101338	7/15/2016	7/15/2018
676	Florida RF Labs	SMS-290AW-480.0-SMS	Cables	MFR2Y194	11/4/2016	11/4/2017
RE135	Rohde & Schwarz	FSP30	Spectrum Analyzers	835618/031	10/31/2016	10/31/2017

NCR = No Calibration Required

NOTE: All test equipment was used only during active calibration cycles.

5 SUPPORT EQUIPMENT

Table 5-1: Support Equipment – Radiated Emissions

Item	Equipment Type	Manufacturer	Model/Part Number	Serial Number
1	Battery	Tadiran	TL-4930	N/A

Table 5-2: Cable Description – Radiated Emissions

Cable	Cable Type	Length	Shield	Termination
A	RF Cable	61 cm	Yes	EUT to Antenna
B	DC Power Cable	14 cm	No	EUT to Battery

6 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

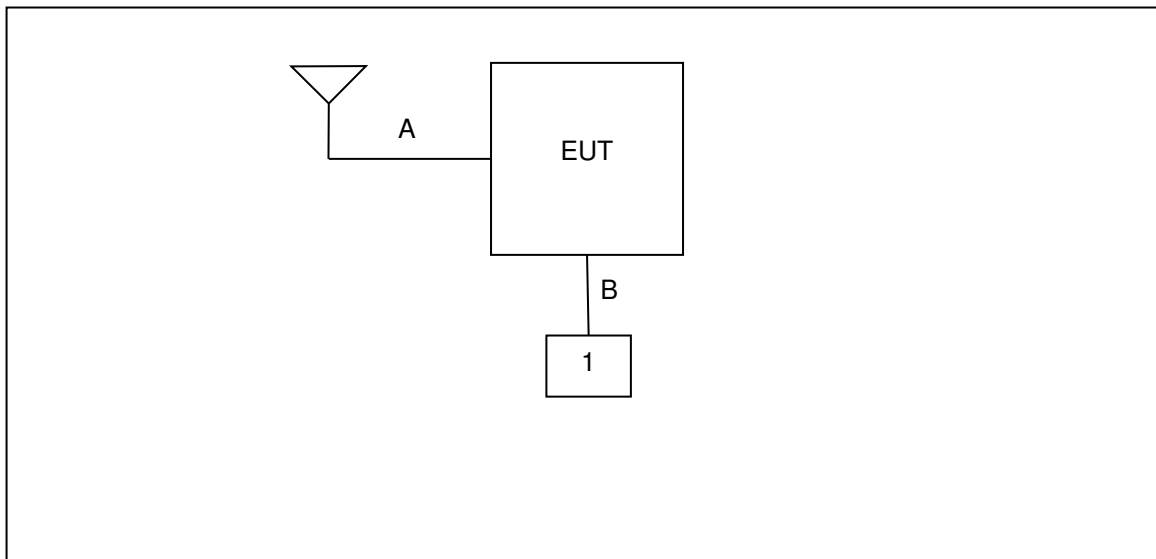


Figure 6-1: Test Setup Block Diagram

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 15.203

The external patch antenna interfaces with the EUT via a coax cable and special sealed connector. The gain of the antenna is 1 dBi. Professional installation is required.

7.2 20dB / 99% Bandwidth – FCC: Section 15.247(a)(1); ISED Canada: RSS-247 5.1(a)

7.2.1 Measurement Procedure

The RF output port of the EUT was directly connected to the input of the spectrum analyzer using suitable attenuation. The span of the spectrum analyzer display was set between two times and five times the occupied bandwidth (OBW) of the emission. The RBW of the spectrum analyzer was set to approximately 1 % to 5 % of the OBW. The trace was set to max hold with a peak detector active. The ndB down measurement functions of the analyzer were utilized to determine the 20 dB bandwidth of the emission.

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 from 1% to 5% of the occupied bandwidth and the video bandwidth set to at least 3 times the resolution bandwidth. A peak detector was used.

7.2.2 Measurement Results

Performed by: Ryan McGann

Table 7.2.2-1: 20dB / 99% Bandwidth

Frequency [MHz]	20dB Bandwidth [kHz]	99% Bandwidth [kHz]
902.3	138.589	125.904
908.7	139.168	125.904
914.9	138.558	125.904

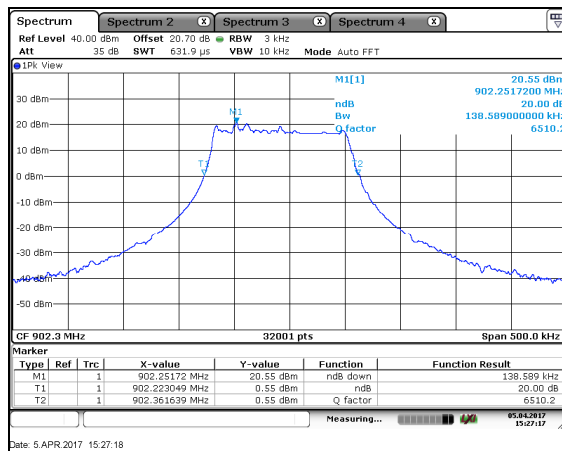


Figure 7.2.2-1: 20dB Bandwidth – LCH

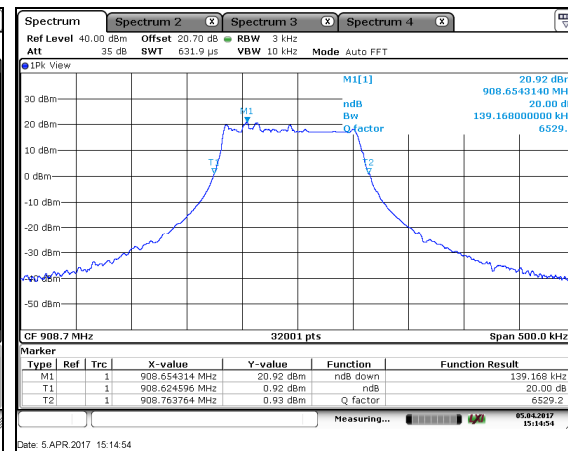


Figure 7.2.2-2: 20dB Bandwidth – MCH

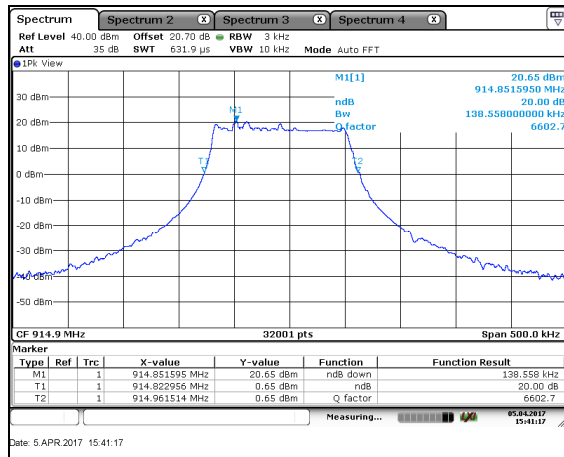


Figure 7.2.2-3: 20dB Bandwidth – HCH

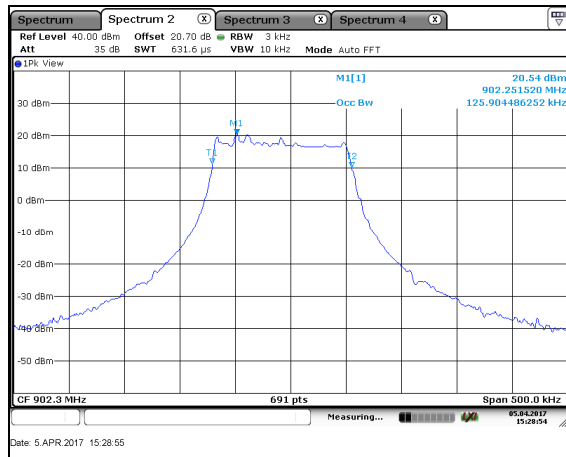


Figure 7.2.2-4: 99% Occupied Bandwidth – LCH

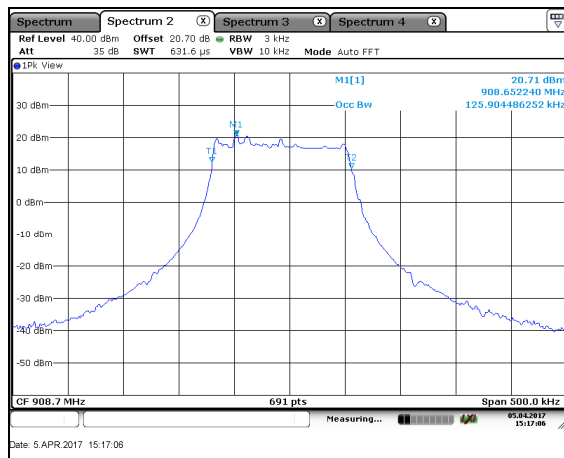


Figure 7.2.2-5: 99% Occupied Bandwidth – MCH

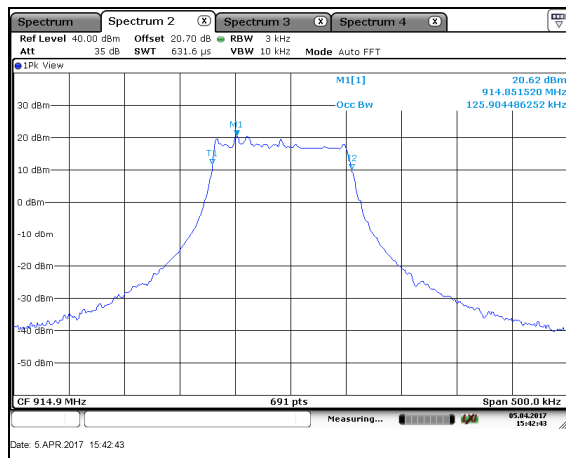


Figure 7.2.2-6: 99% Occupied Bandwidth – HCH

7.3 Fundamental Emission Output Power – FCC: Section 15.247(b)(3); ISED Canada: RSS-247 5.4(d)**7.3.1 Measurement Procedure**

The maximum conducted output power was measured in accordance with FCC KDB 558074 D01 DTS Meas Guidance utilizing the AVGPM procedure. The RF output of the equipment under test was directly connected to the input of the power meter applying suitable attenuation.

7.3.2 Measurement Results

Performed by: Ryan McGann

Table 7.3.2-1: Maximum Average Conducted Output Power

Frequency [MHz]	Level [dBm]
902.3	22.05
908.7	22.22
914.9	22.19

7.4 Channel Usage Requirements

7.4.1 Carrier Frequency Separation – FCC: Section 15.247(a)(1); ISED Canada: RSS-247 5.1(b)

7.4.1.1 Measurement Procedure

The RF output port of the EUT was directly connected to the input of the spectrum analyzer using suitable attenuation. The span of the spectrum analyzer was set wide enough to capture two adjacent peaks. The RBW was set to approximately 30 % of the channel spacing and adjusted as necessary to best identify the center of each channel. The VBW was set > RBW.

7.4.1.2 Measurement Results

Performed by: Ryan McGann

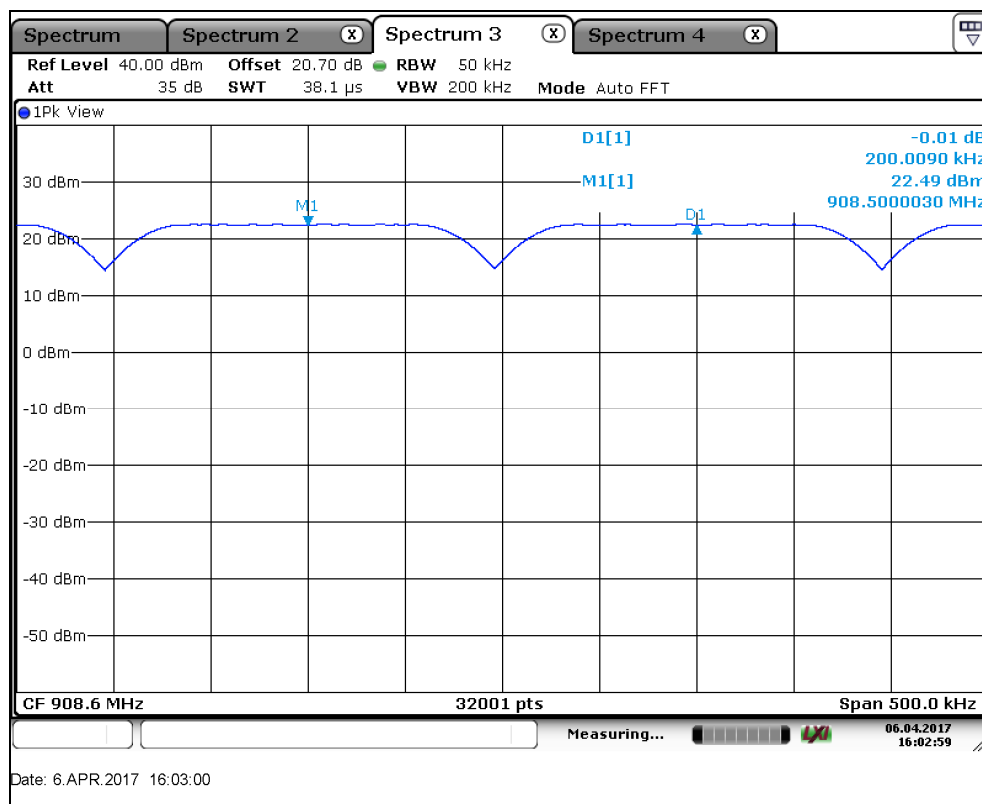


Figure 7.4.1.2-1: Frequency Separation

7.4.2 Channel Dwell Time – FCC: Section 15.247(f); ISED Canada: RSS-247 5.3**7.4.2.1 Measurement Procedure**

The EUT was not capable of producing a worst-case channel dwell time. A detailed analysis of the channel dwell time is available in the Theory of Operations accompanying this report.

7.5 Emission Levels

7.5.1 Emissions into Non-Restricted Frequency Bands – FCC: Section 15.247(d); ISD Canada: RSS-247 5.5

7.5.1.1 Measurement Procedure

The unwanted emissions into non-restricted bands were measured conducted in accordance with FCC KDB 558074 D01 DTS Meas Guidance. The RF output of the equipment under test was directly connected to the input of the spectrum analyzer applying suitable attenuation. The Resolution Bandwidth (RBW) of the spectrum analyzer was set to 100 kHz. The Video Bandwidth (VBW) was set to ≥ 300 kHz. Span was set to 1.5 times the DTS bandwidth. The trace was set to max hold with a peak detector active. The resulting spectrum analyzer peak level was used to determine the reference level with respect to the 30 dBc limit. The spectrum span was then adjusted for the measurement of spurious emissions from 30 MHz to 10 GHz, 10 times the highest fundamental frequency.

Band-edge compliance was determined using the conducted marker-delta method in which the radio frequency power that is produced by the EUT is at least 30 dB below that in the 100 kHz bandwidth within the band that contains the highest level of desired power.

7.5.1.2 Measurement Results

Performed by: Ryan McGann

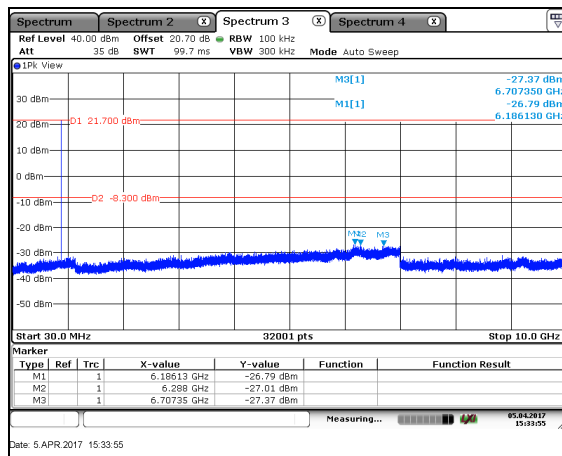


Figure 7.5.1.2-1: RF Conducted Emissions – LCH

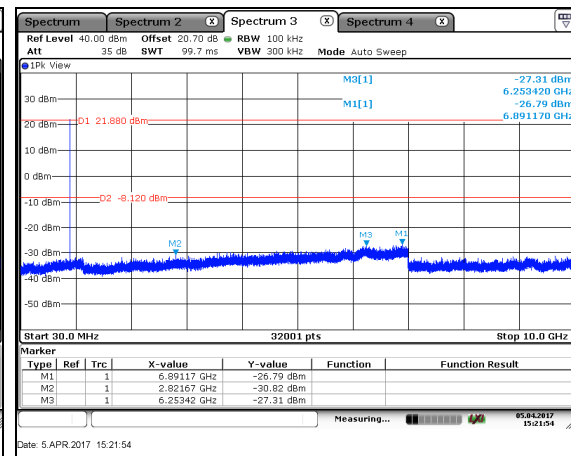


Figure 7.5.1.2-2: RF Conducted Emissions – MCH

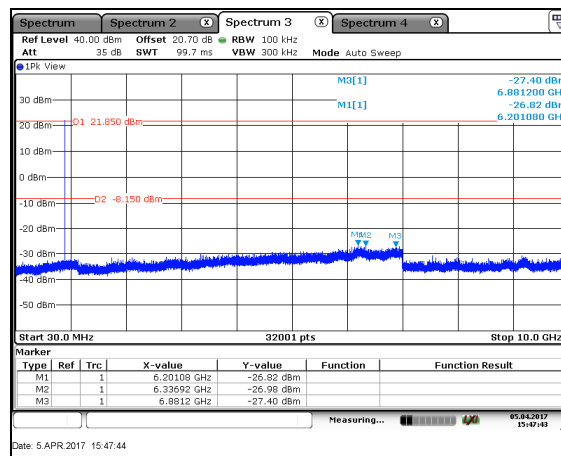


Figure 7.5.1.2-3: RF Conducted Emissions – HCH

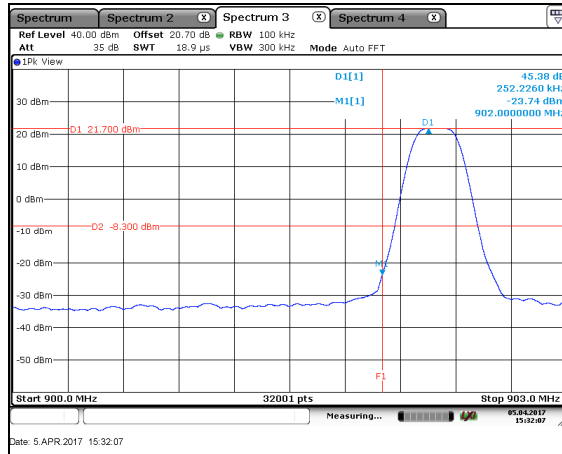


Figure 7.5.1.2-4: Lower Band-edge

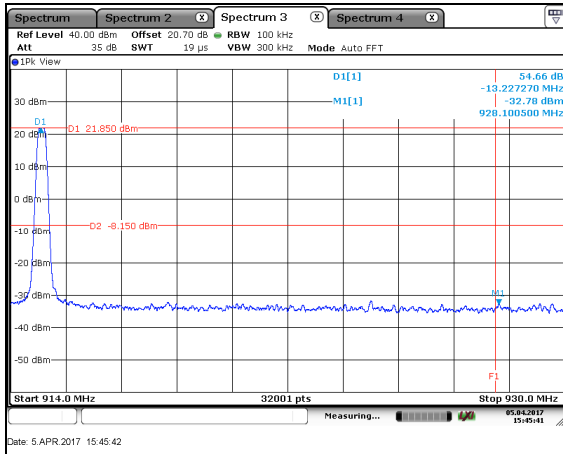


Figure 7.5.1.2-5: Upper Band-edge

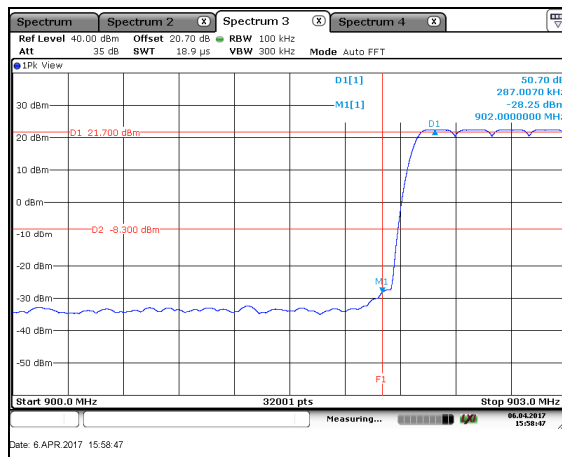


Figure 7.5.1.2-6: Lower Band-edge – Hopping

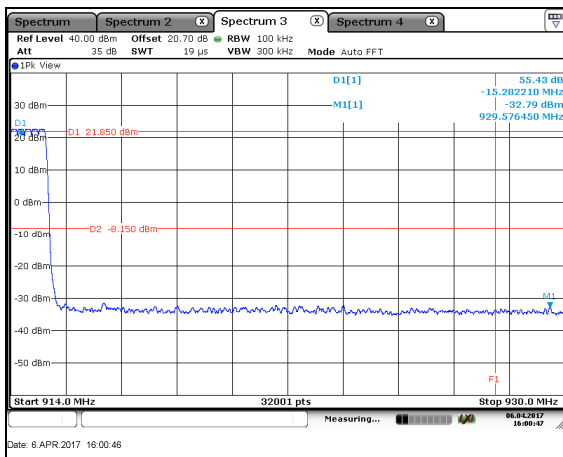


Figure 7.5.1.2-7: Upper Band-edge – Hopping

7.5.2 Emissions into Restricted Frequency Bands – FCC: Sections 15.205, 15.209; ISED Canada: RSS-Gen 8.9 / 8.10

7.5.2.1 Measurement Procedure

The unwanted emissions into restricted bands were measured radiated over the frequency range of 30 MHz to 10 GHz, 10 times the highest fundamental frequency.

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, quasi-peak measurements were made using a resolution bandwidth RBW of 120 kHz and a video bandwidth VBW of 300 kHz. For frequencies above 1000 MHz, peak and average measurements were made with RBW and VBW of 1 MHz and 3 MHz respectively.

Each emission found to be in a restricted band as defined by section 15.205, including any emission at the operational band-edge, was compared to the radiated emission limits as defined in section 15.209.

7.5.2.2 Measurement Results

Performed by: Tommy Payton

Table 7.5.2.2-1: Radiated Spurious Emissions Tabulated Data

Frequency (MHz)	Level (dBuV)		Antenna Polarity (H/V)	Correction Factors (dB)	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	Qpk/Avg			pk	Qpk/Avg	pk	Qpk/Avg	pk	Qpk/Avg
2412 MHz										
3609.2	52.25	36.55	H	-0.98	51.27	35.57	74.0	54.0	22.7	18.4
3609.2	53.02	37.23	V	-0.98	52.04	36.25	74.0	54.0	22.0	17.8
2437 MHz										
All emissions were attenuated below the noise floor of the instrumentation										
2462 MHz										
4574.5	51.23	37.37	V	0.74	51.97	38.11	74.0	54.0	22.0	15.9

7.5.2.3 Sample Calculation:

$$R_C = R_U + CF_T$$

Where:

CF_T	=	Total Correction Factor (AF+CA+AG)-DC (Average Measurements Only)
R_U	=	Uncorrected Reading
R_C	=	Corrected Level
AF	=	Antenna Factor
CA	=	Cable Attenuation
AG	=	Amplifier Gain
DC	=	Duty Cycle Correction Factor

Example Calculation: Peak

Corrected Level: $52.25 - 0.98 = 51.27\text{dBuV/m}$

Margin: $74\text{dBuV/m} - 51.27\text{dBuV/m} = 22.7\text{dB}$

Example Calculation: Average

Corrected Level: $40.41 - 0.98 - 0 = 35.57\text{dBuV}$

Margin: $54\text{dBuV} - 35.57\text{dBuV} = 18.4\text{dB}$

7.6 Maximum Power Spectral Density in the Fundamental Emission – FCC: Section 15.247(e) ISED Canada: RSS-247 5.2(b)

7.6.1 Measurement Procedure

The power spectral density was measured in accordance with the FCC KDB 558074 D01 DTS Meas Guidance utilizing the AVGPSSD-1 method. The RF output of the equipment under test was directly connected to the input of the spectrum analyzer applying suitable attenuation. The Resolution Bandwidth (RBW) of the spectrum analyzer was set to 3 kHz. The Video Bandwidth (VBW) was set to 10 kHz. Span was set to 1.5 times the Occupied Bandwidth. Trace averaging was applied over a minimum of 100 traces with an RMS detector active.

7.6.2 Measurement Results

Performed by: Ryan McGann

Table 7.6.2-1: Power Spectral Density

Frequency [MHz]	PSD Level [dBm]
902.3	7.42
908.7	7.46
914.9	7.90

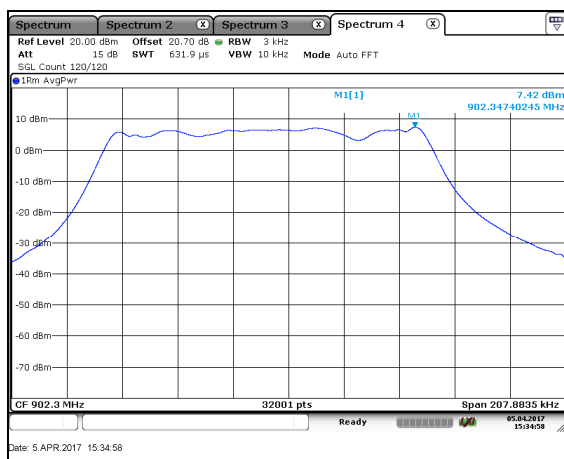


Figure 7.6.2-1: Power Spectral Density – LCH

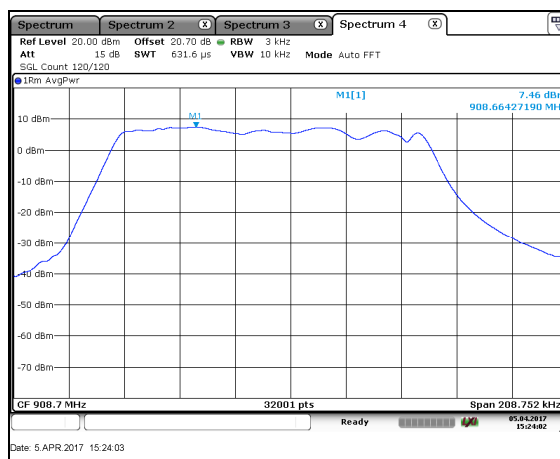


Figure 7.6.2-2: Power Spectral Density – MCH

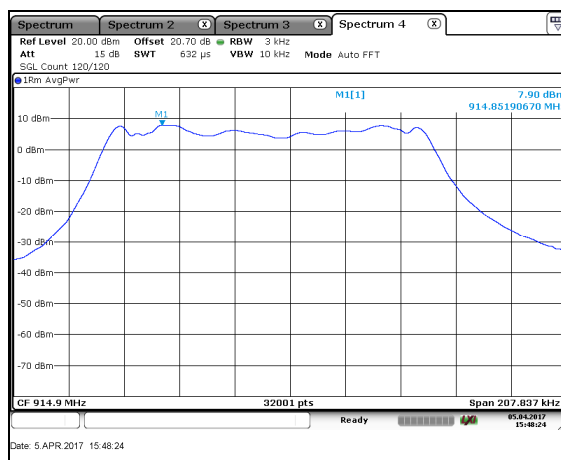


Figure 7.6.2-3: Power Spectral Density – HCH

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	$\pm 0.009 \%$
RF Conducted Output Power	$\pm 0.349 \text{ dB}$
Power Spectral Density	$\pm 0.372 \text{ dB}$
Antenna Port Conducted Emissions	$\pm 1.264 \text{ dB}$
Radiated Emissions $\leq 1 \text{ GHz}$	$\pm 5.814 \text{ dB}$
Radiated Emissions $> 1 \text{ GHz}$	$\pm 4.318 \text{ dB}$
Temperature	$\pm 0.860 \text{ }^{\circ}\text{C}$
Radio Frequency	$\pm 2.832 \times 10^{-8}$
AC Power Line Conducted Emissions	$\pm 3.360 \text{ dB}$

9 CONCLUSION

In the opinion of TÜV SÜD America, Inc. the L900M, manufactured by Neptune Technology Group meets the requirements of FCC Part 15 subpart C and Innovation, Science, and Economic Development Canada's Radio Standards Specification RSS-247 for the tests documented in this test report.

END REPORT