Report on the FCC and ISED Testing of the

Mueller Systems, LLC
DCOM6

In accordance with FCC 47 CFR Part 15.247 & ISED Canada's Radio Standards Specifications RSS-247

America

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Prepared for: Mueller Systems, LLC
1200 Abernathy Road, NE , Suite 1200
Atlanta, GA, USA, 30328

FCC ID: SM6-MINODE-WATER6 IC: 9235A-MINODE6

COMMERCIAL-IN-CONFIDENCE

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EXECUTIVE SUMMARY
A sample of this product was tested and found to be compliant with FCC Part 15.247, ISED Canada's RSS-247

A2LA Cert. No. 2955.15

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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 Section 15.247 and Innovation Science and Economic Development Canada's Radio Standards Specification RSS-247 for the tests documented herein.

1.2 Applicant Information

Mueller Systems, LLC
1200 Abernathy Road, NE , Suite 1200
Atlanta, GA, USA, 30328

1.3 Product Description

The Mueller Systems MiNode-WATER6 model DCOM6 is an RF transceiver module. It operates in the unlicensed 902 to 928 MHz ISM band. The device offers both Frequency Hopping Spread Spectrum (FHSS) and Digital Transmissions Systems (DTS) modes of operation.

Technical Details

Mode of Operation:	FHSS
Frequency Range:	902.3 MHz - 927.012451 MHz
Protocols:	RFV4, LoRaWAN
Number of Channels:	50 (RFV4), 64 (LoRaWAN)
Channel Separation:	300 kHz (RFV4), 200 kHz (LoRaWAN)
Modulations:	Chip Spread Spectrum (CSS)
Antenna Type/Gain:	1/4 Wave monopole Antenna, 0 dBi
Input Power:	3.6 VDC

Model Number: DCOM6

Test Sample Serial Number(s): 4557203 Radiated Emissions, 4557305 RF Conducted Emissions

Test Sample Condition: The test samples were in good operating condition without any physical damages.

1.4 Test Methodology and Considerations

The EUT was evaluated for radiated and RF conducted measurements. Preliminary measurements were performed for all the data rates/spreading factors and protocols. Where applicable, data is provided for the worst configuration.

The EUT is battery powered only without any provision for connection to the AC Mains. The EUT is exempted from the power line conducted emissions requirements.

The LoRaWAN Mode is capable of operating from 6 to 64 channels. This document only addresses LoRaWAN mode of operation using a minimum of 50 channels. LoRaWAN compliance for less than 50 channels is documented in a separate test report.

The RF conducted measurements were performed on a sample configured with an SMA connector at the antenna port to allow direct coupling to the measuring spectrum analyzer.

For the radiated emissions evaluation, preliminary measurements were performed for the EUT set in three orthogonal orientations. The EUT set vertically on the tabletop (power leads facing down) led to the highest emissions. The evaluation was performed for the low, middle and high channels over the entire range of operation of the combined RFV4 and LoRaWAN protocols.

The EUT was also evaluated for unintentional emissions. The results are documented separately within a Supplier's Declaration of Conformity test report.

The sample power settings were pre-configured by the customer for testing. The power settings that were used for the evaluation are provided below.

TXP = 11 (RF Conducted Test Sample)
TXP = 12 (Radiated Emissions Test Sample)

2 TEST FACILITIES

2.1 Location

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

TÜV SÜD America, Inc.
3998 FAU Blvd, Suite 310
Boca Raton, Florida 33431
Phone: (561) 961-5585
Fax: (561) 961-5587
http://www.tuv-sud-america.com

Innovation, Science and Economic Development Canada Lab Code: 4175C

2.2 Laboratory Accreditations/Recognitions/Certifications

TÜV SÜD America, Inc. is accredited to ISO/IEC 17025 by American Association for Laboratory Accreditation (A2LA) and has been issued certificate number 2955.15 in recognition of this accreditation. Unless otherwise specified, all test methods described within this report are covered under the ISO/IEC 17025 scope of accreditation.

Main Site Information:

TÜV SÜD America, Inc.
5610 West Sligh Ave., Suite 100
Tampa, FL 33634
Phone: 813-284-2715
www.tuv-sud-america.com

FCC Designation Number US1063
FCC Test Firm Registration #: 160606
Innovation, Science, and Economic Development Canada Lab Code: 2087A-2

2.3 Radiated & Conducted Emissions Test Site Description

2.3.1 Semi-Anechoic Chamber Test Site

The EMC radiated test facility consists of an RF-shielded enclosure. The interior dimensions of the indoor semi-anechoic chamber are approximately 48 feet (14.6 m) long by 36 feet (10.8 m) wide by 24 feet (7.3 m) high and consist of rigid, 1/8 inch (0.32 cm) steel-clad, wood core modular panels with steel framing. In the shielded enclosure, the faces of the panels are galvanized, and the chamber is self-supporting. 8-foot RF absorbing cones are installed on 4 walls and the ceiling. The steel-clad ground plane is covered with vinyl flooring.

The turntable is driven by pneumatic motor, which can support a 2000 lb. load. The turntable is flush with the chamber floor which it is connected to, around its circumference, with a continuous metallic loaded spring. An EMCO Model 1060 Multi-device controller controls the turntable position.

A pneumatic motor is used to control antenna polarizations and height relative to the ground. The height information is displayed on the control unit EMCO Model 1050.

The control room is an RF shielded enclosure attached to the semi-anechoic chamber with two bulkhead panels for connecting RF, and control cables. The dimension of the room is 7.3 m x 4.9 m x 3 m high and the entrance doors of both control and conducted rooms are 3 feet (0.91 m) by 7 feet (2.13 m).

A diagram of the Semi-Anechoic Chamber Test Site is shown in Figure 2.3.1-1 below:

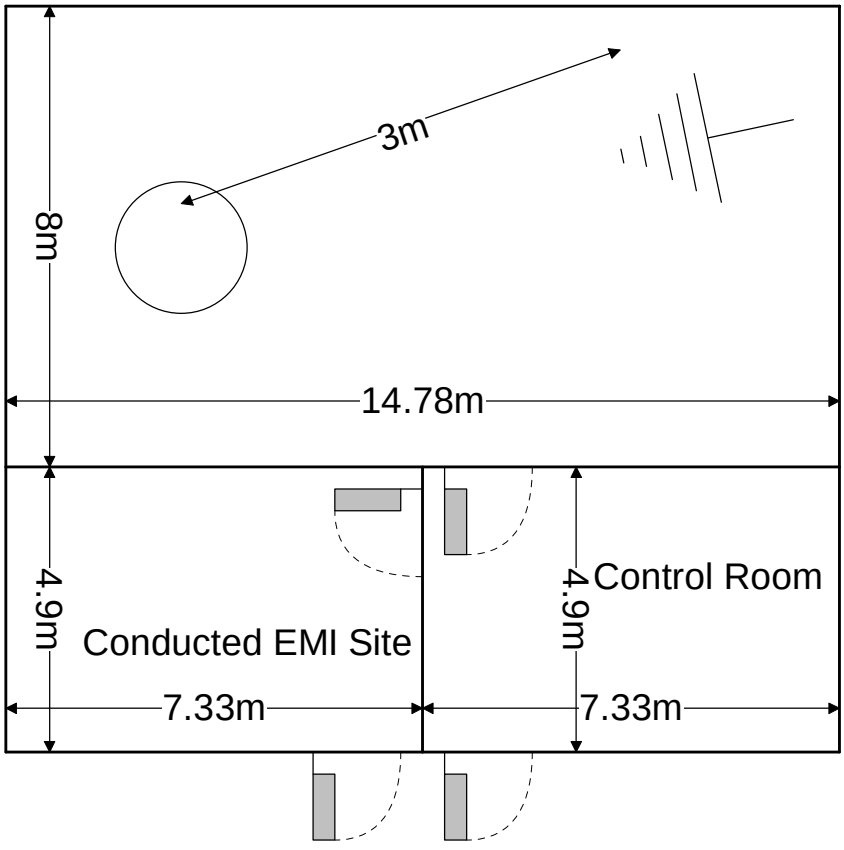


Figure 2.3.1-1: Semi-Anechoic Chamber Test Site

2.3.2 Conducted Emissions Test Site Description

The dimensions of the shielded conducted room are 7.3 x 4.9 x 3 m^3. The power line conducted emission site includes two LISNs: a Solar Model 8028-50 50 Ω/50 µH and an EMCO Model 3825/2R, which are installed as shown in the figure below. For evaluations requiring 230 V, 50 Hz AC input, a Polarad LISN (S/N 879341/048) is used in conjunction with a California Instruments signal generator Model 2001RP-OP1.

A diagram of the room is shown below in figure 2.3.2-1:

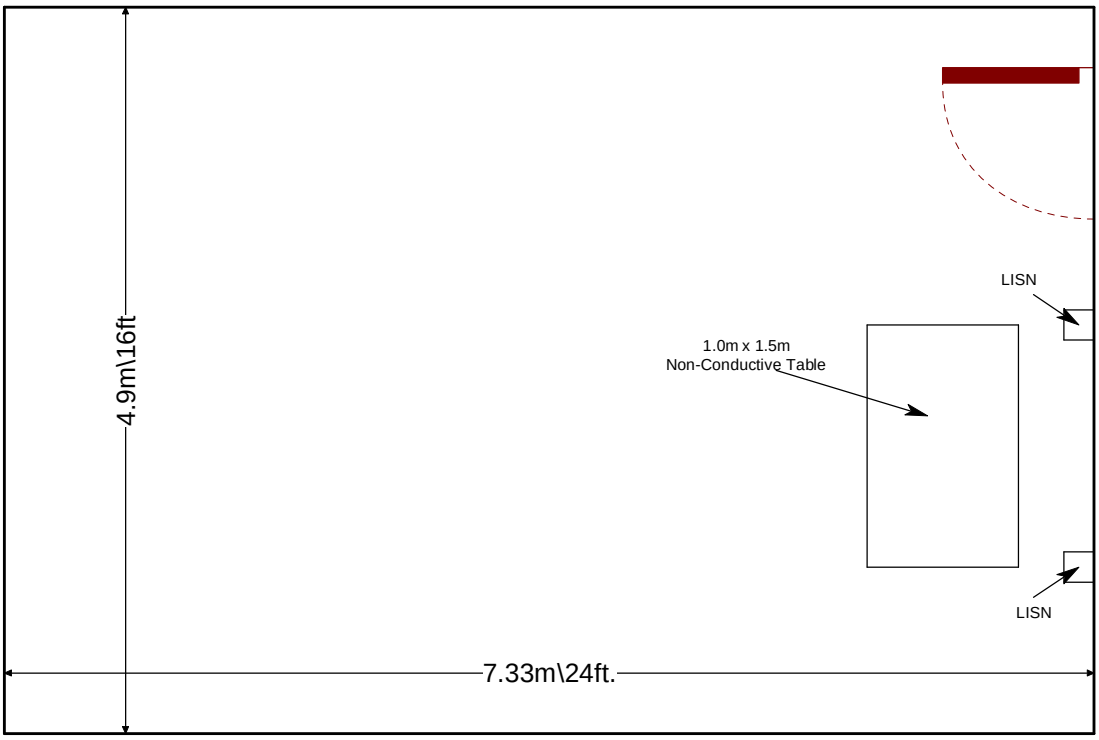


Figure 2.3.2-1: AC Mains Conducted EMI Site

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, 2018.
- US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators, 2018
- Innovation, Science and Economic Development 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, February 2017.
- Innovation, Science and Economic Development Canada Radio Standards Specification: RSS-GEN – General Requirements for Compliance of Radio Apparatus, Issue 4, Amendment 1, March 2018.

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 List

AssetID	Manufacturer	Model #	Equipment Type	Serial #	Last Calibration Date	Calibration Due Date
BEMC00078	EMCO	6502	Active Loop Antenna	9104-2608	5/9/2018	5/9/2020
BEMC00283	Rohde & Schwarz	FSP40	Spectrum Analyzer	1000033	11/28/2017	11/28/2019
BEMC00523	Agilent	E7405	9kHz-26.5GHz EMC analyzer/HYZ	MY45103293	12/9/2016	12/9/2018
BEMC02002	EMCO	3108	30 MHz to 200 MHz Biconical Antenna	2147	11/28/2017	11/30/2019
BEMC02004	EMCO	3146	200 MHz to 1 GHz Log Periodic Antenna	1385	12/27/2017	12/27/2019
BEMC02006	EMCO	3115	Linear Polarized Horn antenna, 1-18 GHz	2573	4/7/2017	4/7/2019
BEMC02011	Hewlett-Packard	HP 8447D	100 kHz to 1.3 GHz low-noise, high gain amplifier	2443A03952	10/27/2017	10/27/2018
BEMC02069	Trilithic, Inc.	7NM867/122-X1-AA	Notch Filter	200315126	2/28/2018	2/28/2019
BEMC02071	Trilithic, Inc.	4HC1400-1-KK	High Pass Filter	9643263	10/28/2017	10/28/2018
BEMC02095	ETS Lindgren	TILE4! - Version 4.2.A	Tile Automation Software	85242	NCR	NCR
BEMC02111	Aeroflex Inmet	40AH2W-20	Attenuator 20dB, 2.9 mm-M/F, DC-40GHz 2 W	2111	7/20/2017	7/20/2018
BEMC02112	Teledyne Storm Products	921-0101-036	Duratest Cable Max. frequency 26.5GHz	12-06-698	10/27/2017	10/27/2018
BEMC02121	Teledyne Storm Products	A81-0303	Radiated Cable Set	2121	7/31/2017	7/31/2018
BEMC02138	Hewlett Packard	8449B	Pre-Amplifier	3008A00320	12/1/2017	12/1/2018

Notes:

- **NCR=No Calibration Required**
- **The assets were only used during the active period of the calibration cycle.**

5 SUPPORT EQUIPMENT

Table 5-1: EUT and Support Equipment Description

Item #	Type Device	Manufacturer	Model/Part #	Serial #
1	EUT	Mueller Systems, LLC	DCOM6	4557203
2	DC Power Supply	MPJA	HY5003	003700278

Table 5-2: Cable Description – Radiated Emissions

Cable #	Cable Type	Length	Shield	Termination
A	Power Leads	3.25 m	No	EUT to Power Supply
B	Power Cord	2.3 m	No	Power Supply to AC Mains

6 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

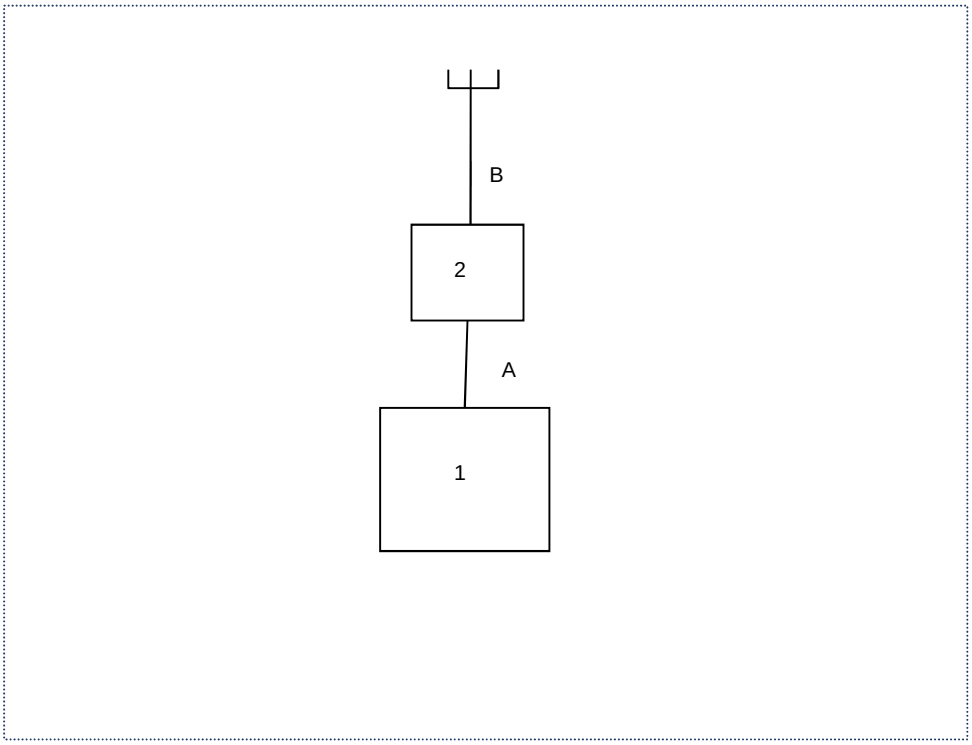


Figure 6-1: EUT and Support Equipment Block Diagram

7 SUMMARY OF TESTS

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

Test Begin Date: June 18, 2018
Test End Date: July 17, 2018

Table 7-1: Summary of Tests

Test Description	FCC 47 CFR Rule Part	ISED Canada RSS Section	Test Results
Antenna Requirements	FCC: Section 15.203		Compliant
Peak Output Power	FCC: Section 15.247(b)(2)	ISED Canada: RSS-247 5.4(a)	Compliant
Carrier Frequency Separation	FCC: Section 15.247(a)(1)	ISED Canada: RSS-247 5.1(b)	Compliant
Number of Hopping Channels	FCC: Section 15.247(a)(1)(i)	ISED Canada: RSS-247 5.1(c)	Compliant
Channel Dwell Time	FCC: Section 15.247(a)(1)(i)	ISED Canada: RSS-247 5.1(c)	Compliant
20dB / 99% Bandwidth	FCC: Section 15.247(a)(1)(i)	ISED Canada: RSS-247 5.1(c)	Compliant
Band-Edge Compliance and Spurious Emissions	FCC: 15.247(d)	ISED Canada: RSS-247 5.5	Compliant
Radiated Spurious Emissions into Restricted Frequency Bands	FCC: Sections 15.205, 15.209	ISED Canada: RSS-Gen 8.9, 8.10	Compliant
Power Line Conducted Emissions	FCC: Section 15.207	ISED Canada: RSS-Gen 8.8	N/A

7.1 Antenna Requirement – FCC: Section 15.203

The EUT uses a 0 dBi, 1/4 Wave Monopole Antenna that is directly soldered to the PCB of the module. The antenna is not detachable and thus meets the requirements of FCC 15.203.

7.2 Peak Output Power – FCC: Section 15.247(b)(2); ISED Canada: RSS-247 5.4(a)

7.2.1 Measurement Procedure (Conducted Method)

The RF output port of the EUT was directly connected to the input of the spectrum analyzer through suitable attenuation and using a Peak Detector.

This evaluation covers to the EUT operation for RFV4 (50 Channels) and LoraWAN for a minimum of 50 channels. Therefore the maximum output power allowed is 1 Watt (30 dBm).

7.2.2 Measurement Results

Performed by: Thierry Jean-Charles

Table 7.2.2-1: RF Output Power – RFV4 – SF8

Frequency (MHz)	Power (dBm)
912.310	28.70
919.512	28.97
927.012	29.19

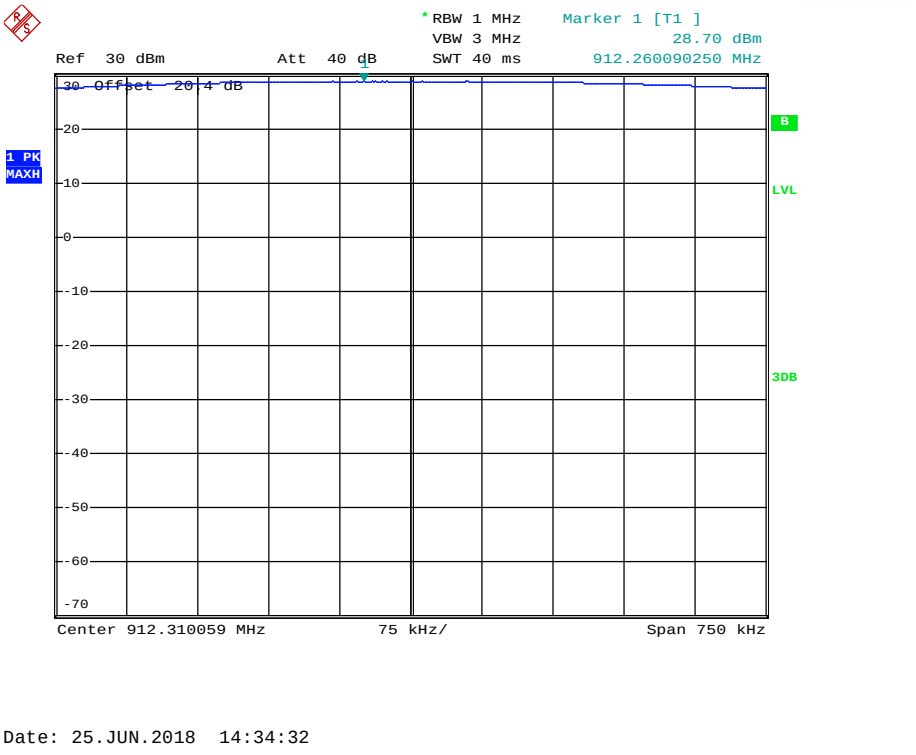
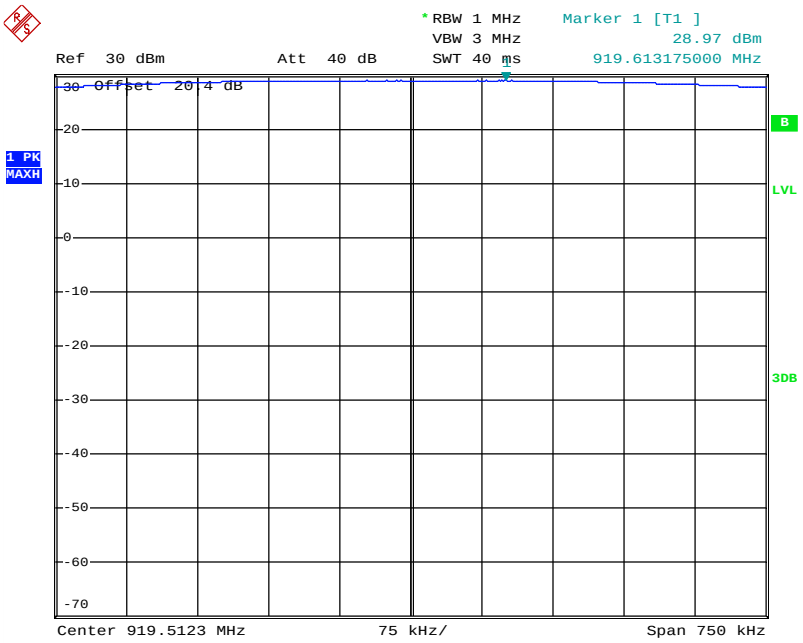
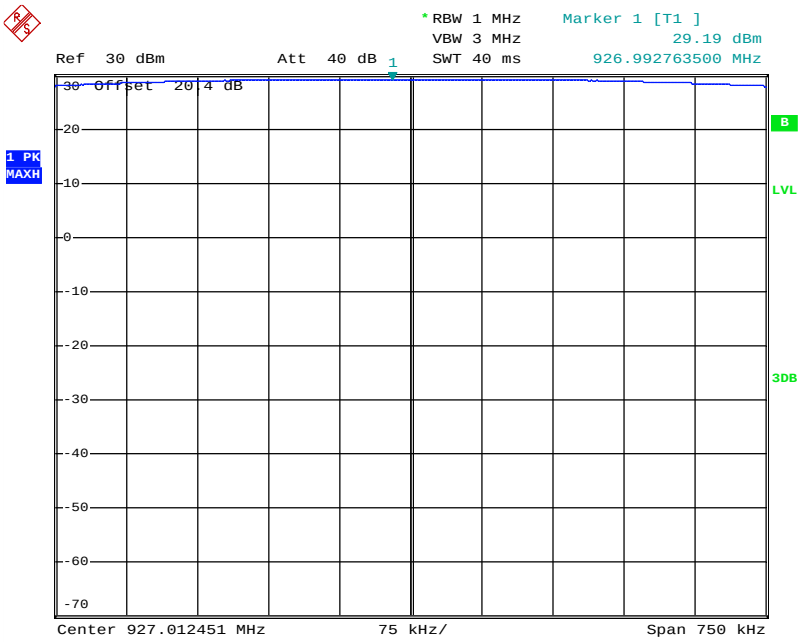


Figure 7.2.2-1: RF Output Power - Low Channel – RFV4



Date: 25.JUN.2018 15:16:10

Figure 7.2.2-2: RF Output Power - Middle Channel – RFV4



Date: 25.JUN.2018 15:54:52

Figure 7.2.2-3: RF Output Power - High Channel – RFV4

Table 7.2.2-2: RF Output Power – LoRaWAN – SF8

Frequency (MHz)	Power (dBm)
902.3	28.63
908.5	28.53
914.9	28.86

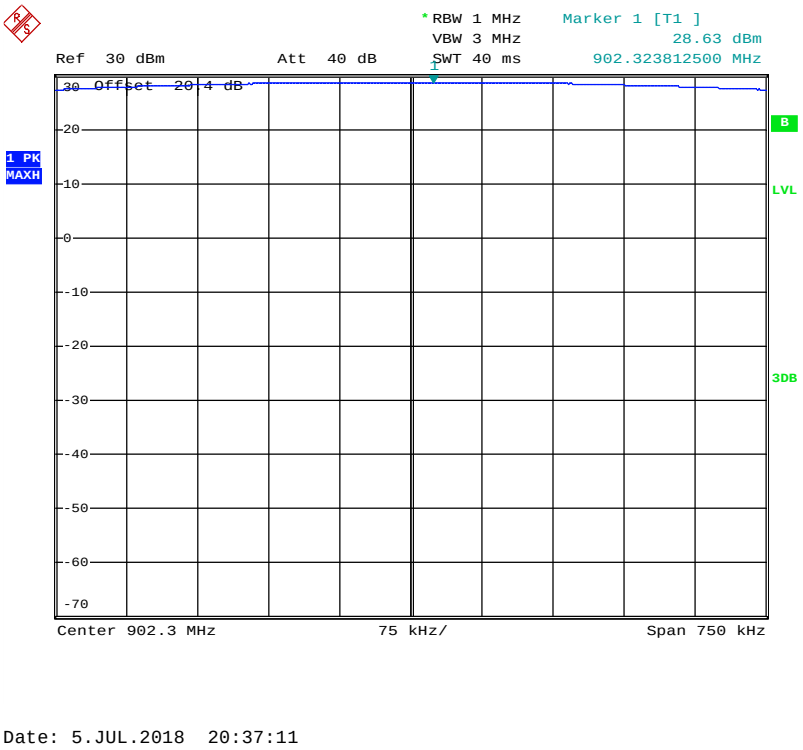


Figure 7.2.2-4: RF Output Power - Low Channel – LoRaWAN

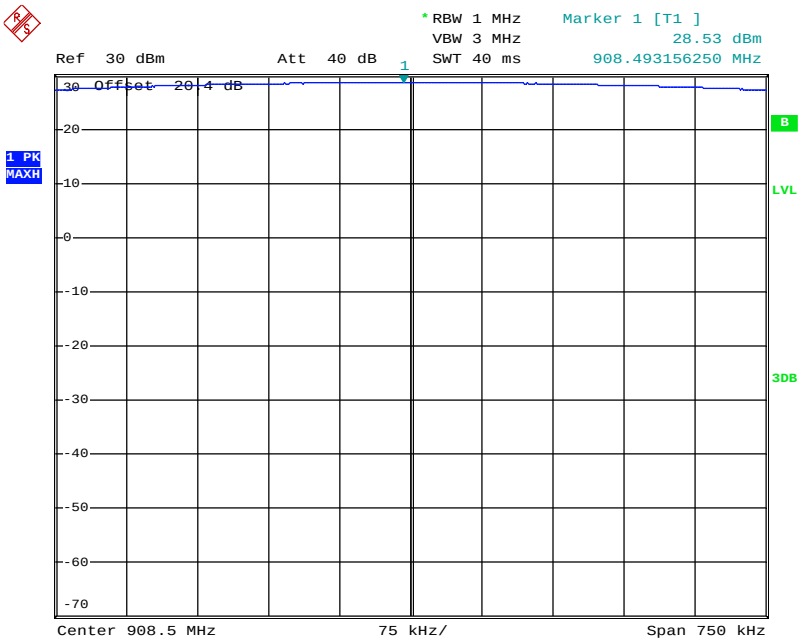


Figure 7.2.2-5: RF Output Power - Middle Channel – LoRaWAN

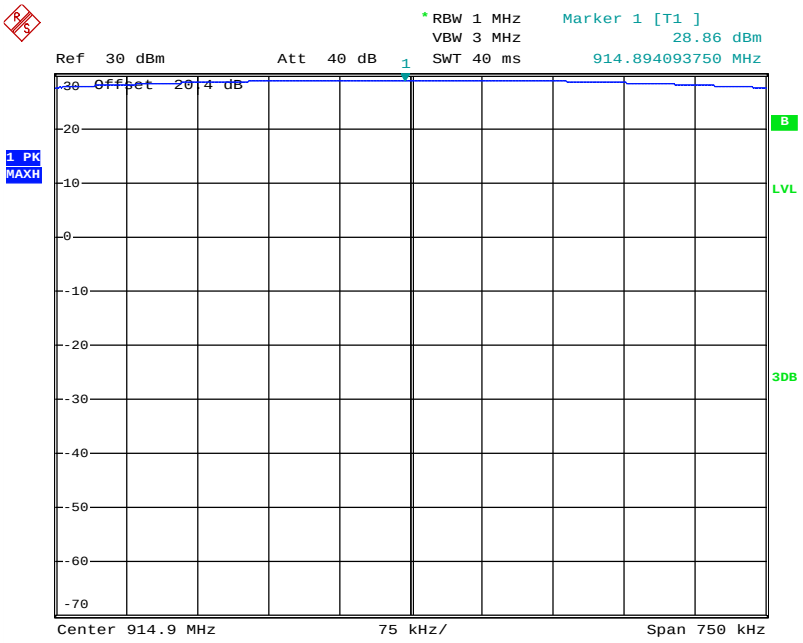


Figure 7.2.2-6: RF Output Power - High Channel – LoRaWAN

7.3 Channel Usage Requirements

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

7.3.1.1 Measurement Procedure

The RF output port of the EUT was directly connected to the input of the spectrum analyzer. The span of the spectrum analyzer was set wide enough to capture two adjacent peaks and the RBW and VBW were set to approximately 30% of the channel spacing.

7.3.1.2 Measurement Results

Performed by: Thierry Jean-Charles

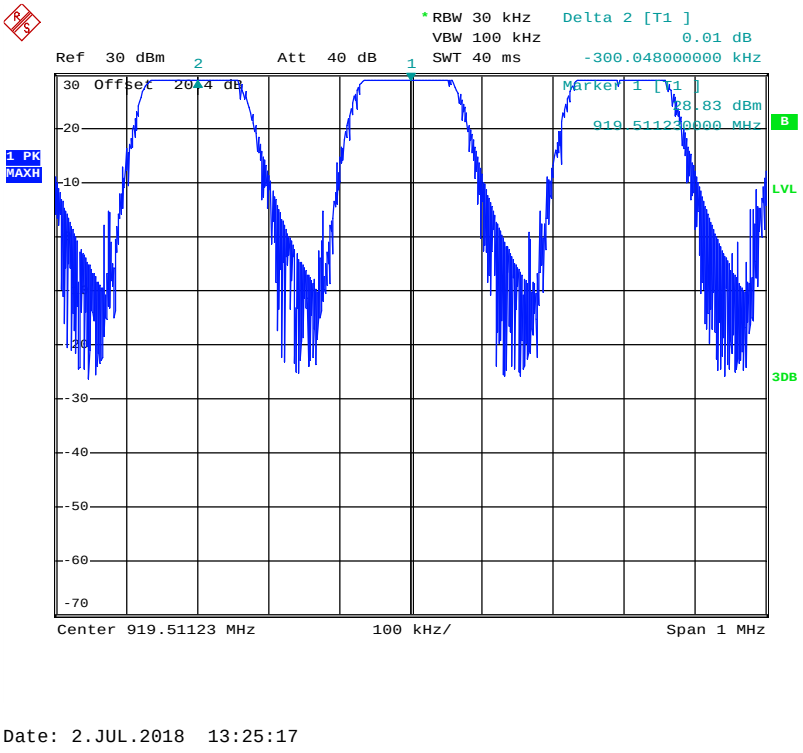


Figure 7.3.1.2-1: Carrier Frequency Separation – RFV4 – SF7

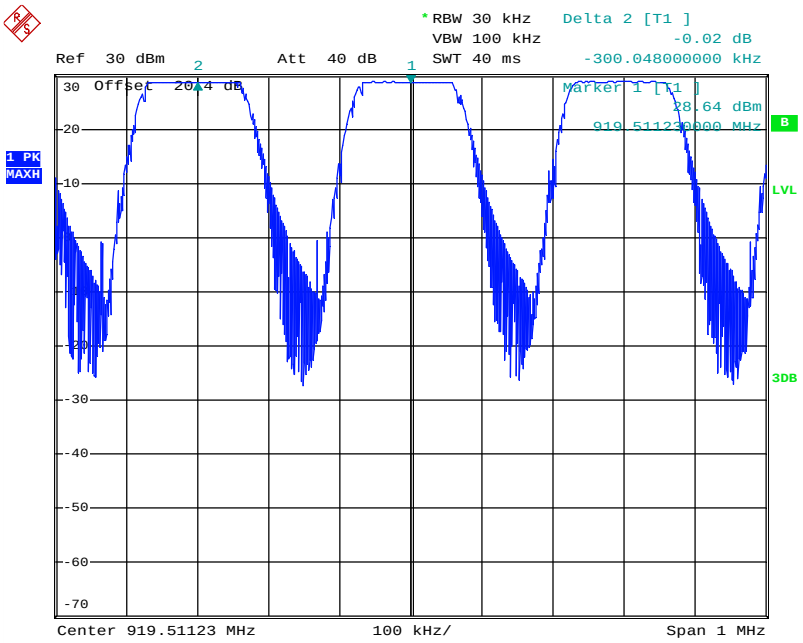


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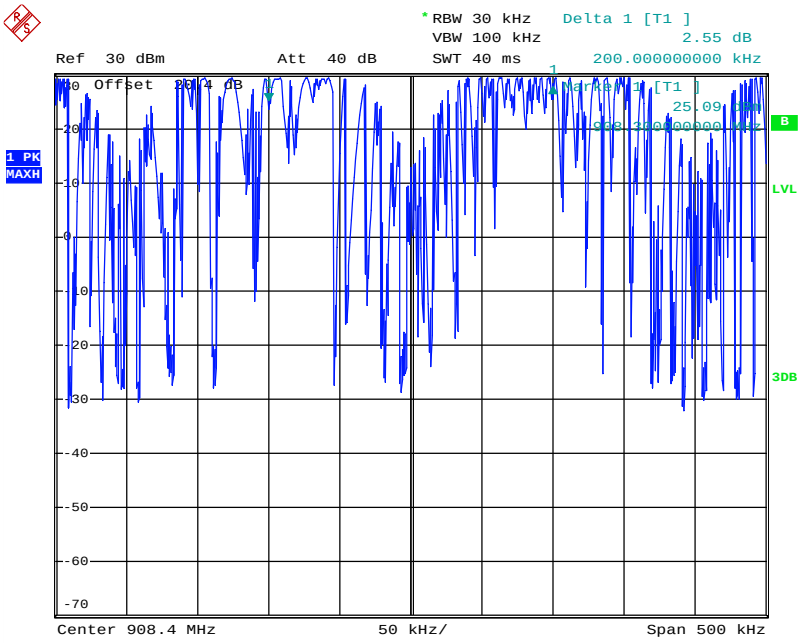
Figure 7.3.1.2-2: Carrier Frequency Separation – RFV4 – SF8



Date: 3.JUL.2018 14:30:23

Figure 7.3.1.2-3: Carrier Frequency Separation – LoRaWAN – SF7

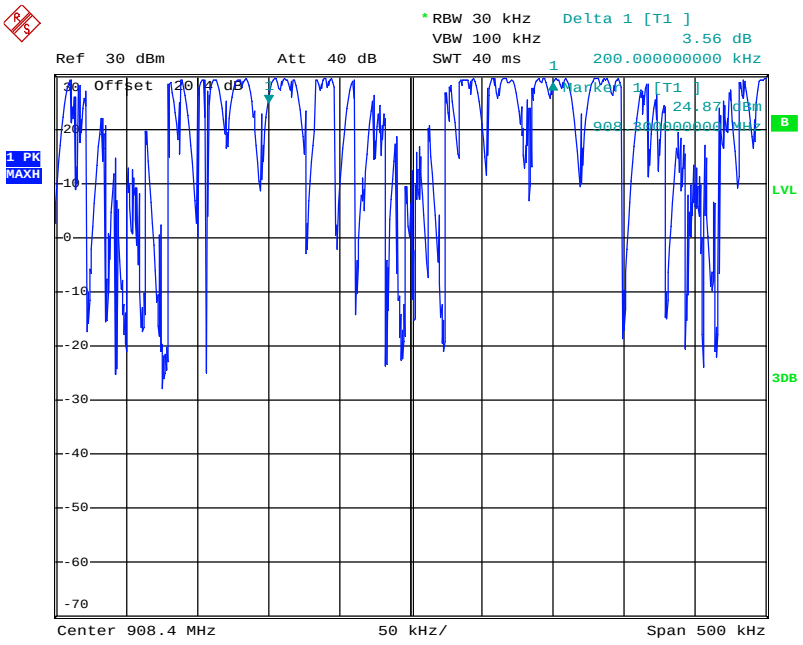


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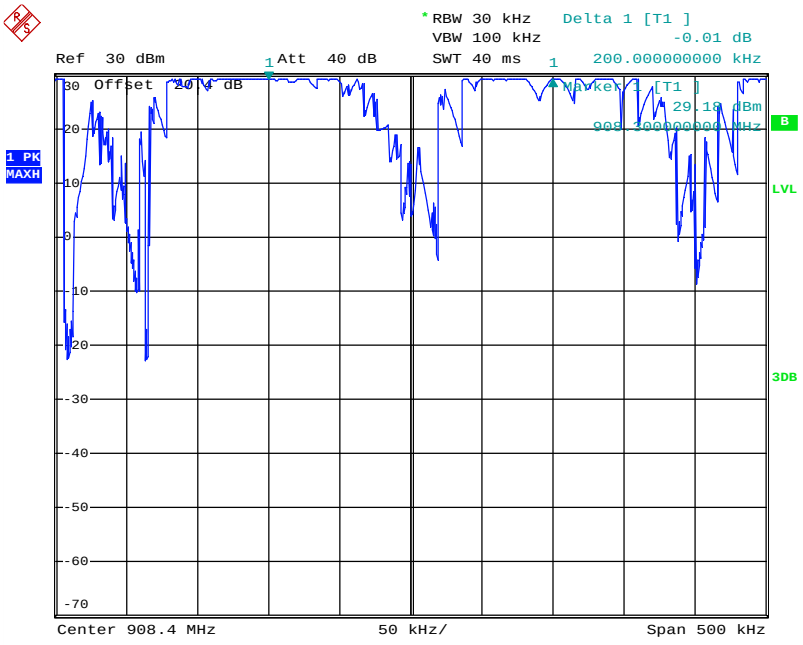
Figure 7.3.1.2-4: Carrier Frequency Separation – LoRaWAN – SF8



Date: 3.JUL.2018 15:23:23

Figure 7.3.1.2-5: Carrier Frequency Separation – LoRaWAN – SF9

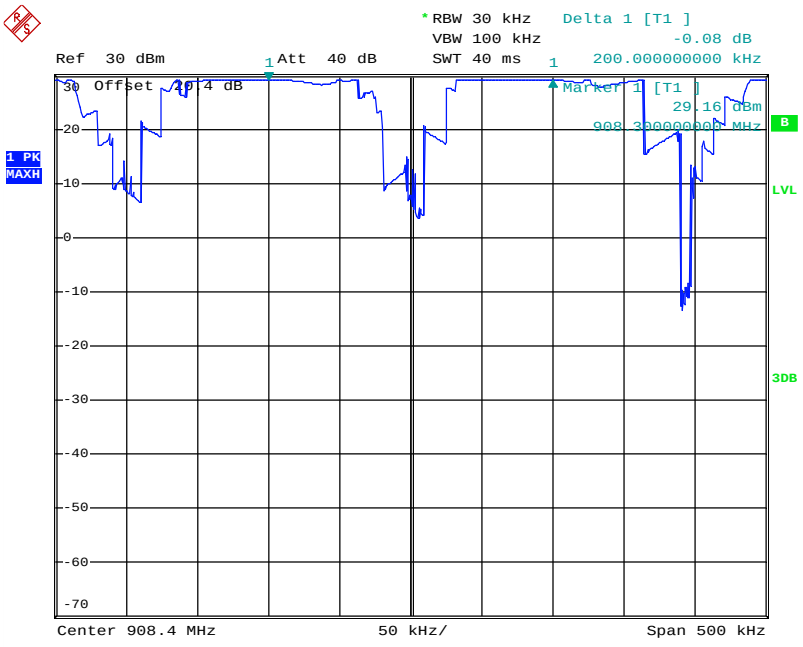


Figure 7.3.1.2-6: Carrier Frequency Separation – LoRaWAN – SF10

7.3.2 Number of Hopping Channels – FCC: Section 15.247(a)(1)(I); ISEDCanada: RSS-247 5.1(c)

7.3.2.1 Measurement Procedure

The RF output port of the EUT was directly connected to the input of the spectrum analyzer. The span of the spectrum analyzer was set wide enough to capture the number of hopping channels. The peak detector max hold function was enabled for the measurements.

7.3.2.2 Measurement Results

Performed by: Thierry Jean-Charles

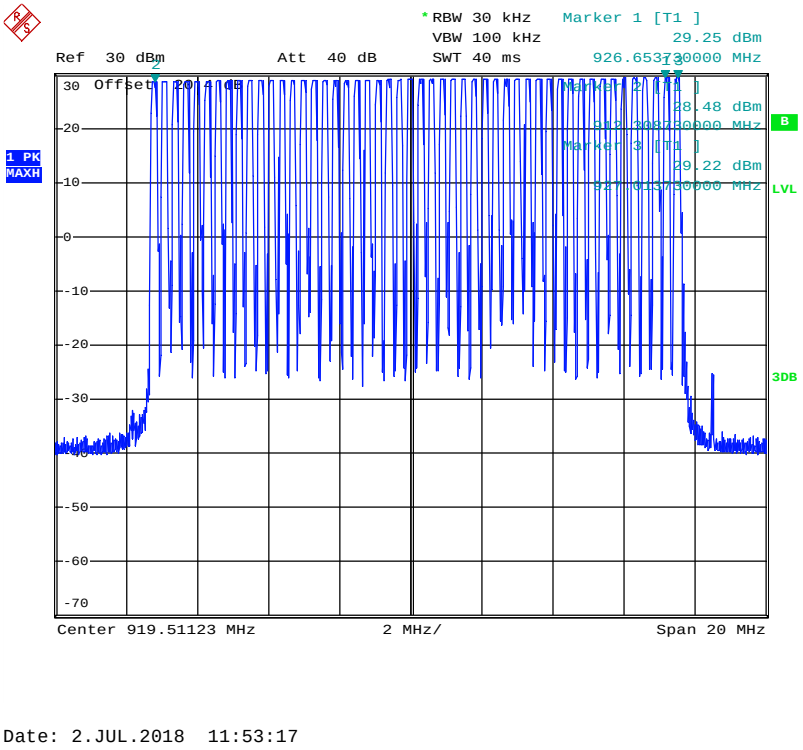


Figure 7.3.2.2-1: Number of Hopping Channels – RFV4 - SF7

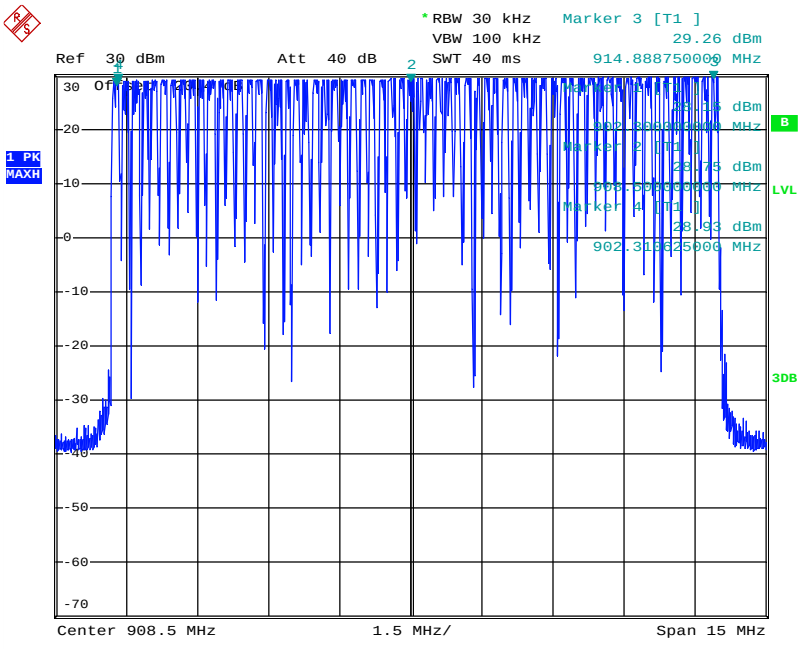


Figure 7.3.2.2-2: Number of Hopping Channels – LoRaWAN

7.3.3 Channel Dwell Time – FCC: Section 15.247(a)(1)(I); ISED Canada: RSS-247 5.1(c)

7.3.3.1 Measurement Procedure

The RF output port of the EUT was directly connected to the input of the spectrum analyzer. The span of the spectrum analyzer was set 0 Hz centered on a hopping channel. The RBW was set to less than 30% of the channel spacing and the sweep time adjusted to capture the entire dwell time per channel with peak detector max hold function.

7.3.3.2 Measurement Results

Performed by: Thierry Jean-Charles

Table 7.3.3.2-1: Dwell Time on a 20 Second Cycle

Mode	Spreading Factor	Number of Hops per Channel Per Sec. (NHPCPS)	Number of Hop on a 20 Sec. Cycle (NHPC)	Measured Dwell Times (ms)	Dwell Time on a 20 s Cycle (ms)	Limit (ms)	Status
RFV4	7	1	1	242.125	242.125	400	Pass
RFV4	8	1	1	385.85	385.85	400	Pass
LoRaWAN	7	1	1	159.05	159.05	400	Pass
LoRaWAN	8	1	1	287.4	287.4	400	Pass
LoRaWAN	9	1	1	390.2	390.2	400	Pass
LoraWAN	10	1	1	370.7	370.7	400	Pass

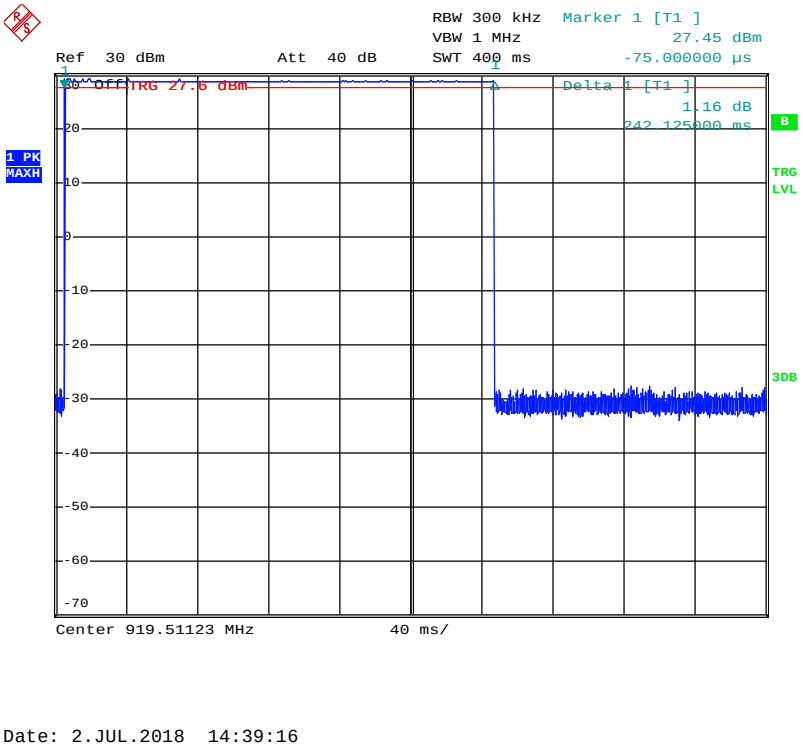


Figure 7.3.3.2-1: Dwell Time – RFV4 – SF7

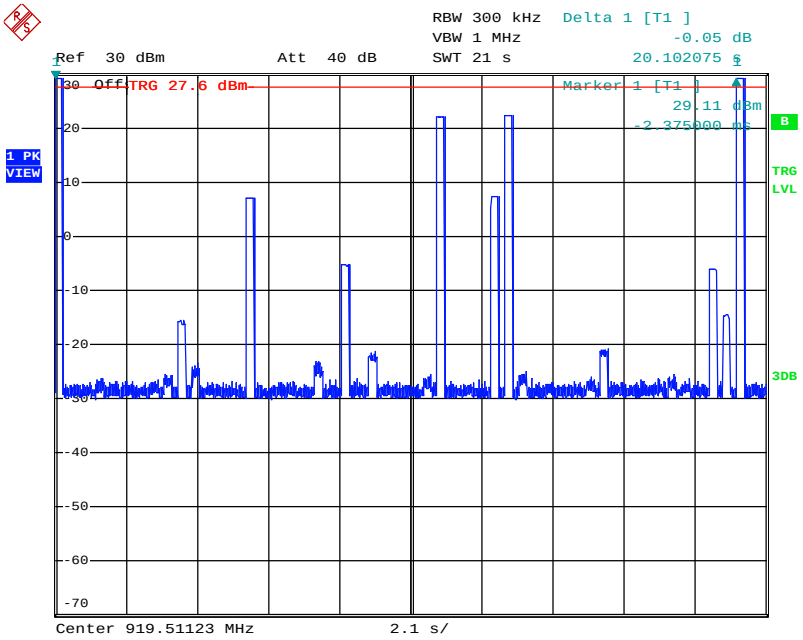


Figure 7.3.3.2-2: Dwell Time – 20 Seconds – RFV4 – SF7

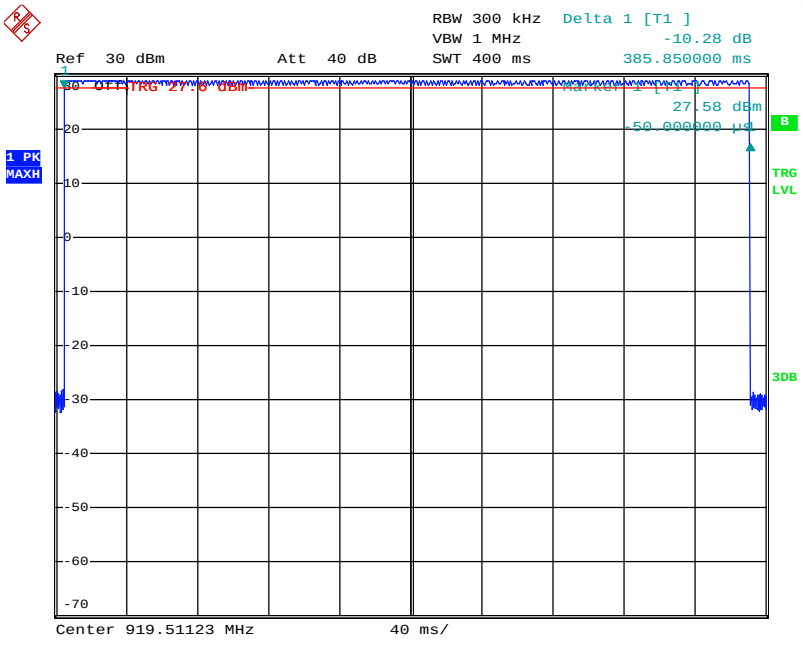
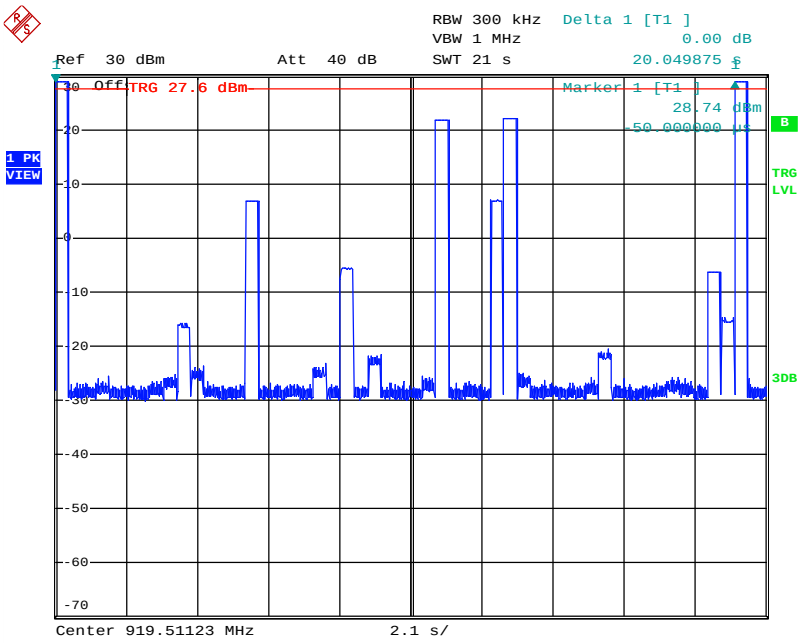
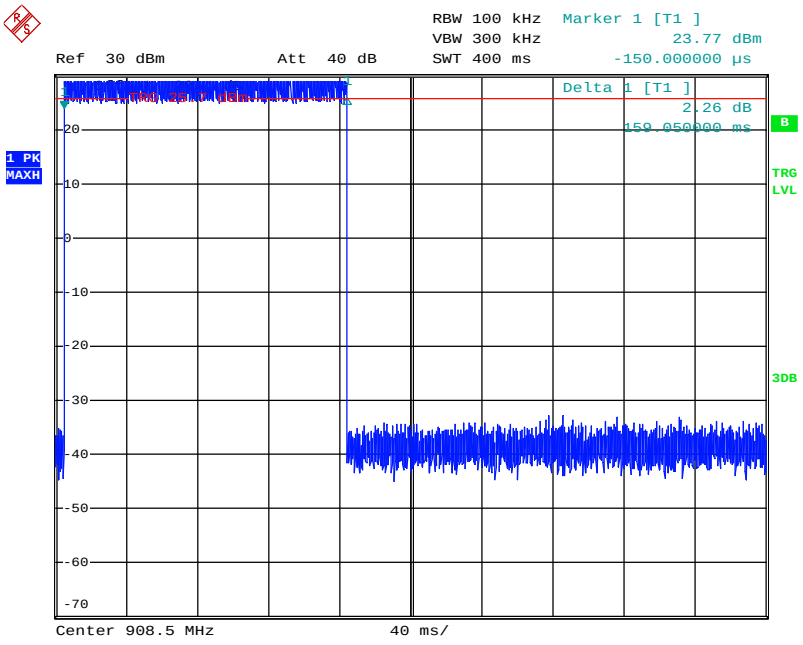


Figure 7.3.3.2-3: Dwell Time – RFV4 – SF8



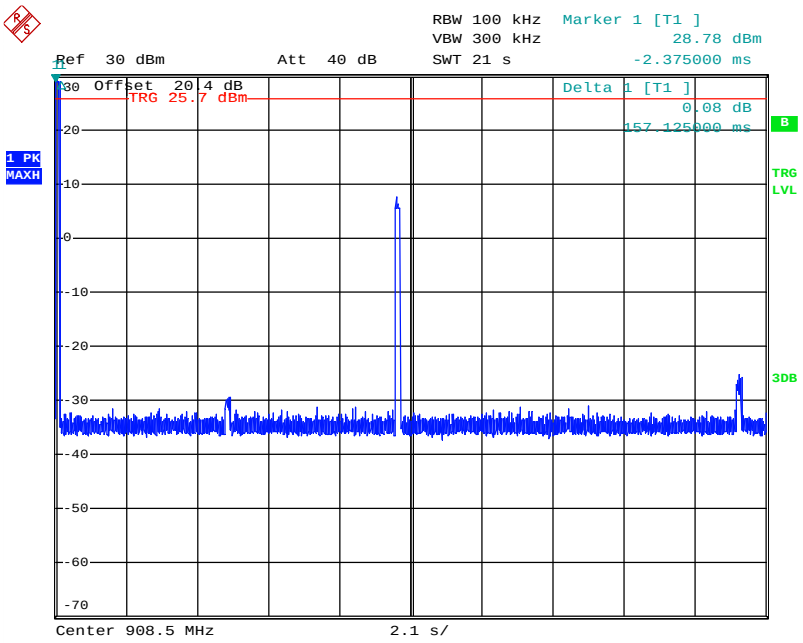
Date: 2.JUL.2018 14:31:32

Figure 7.3.3.2-4: Dwell Time – 20 Seconds – RFV4 – SF8



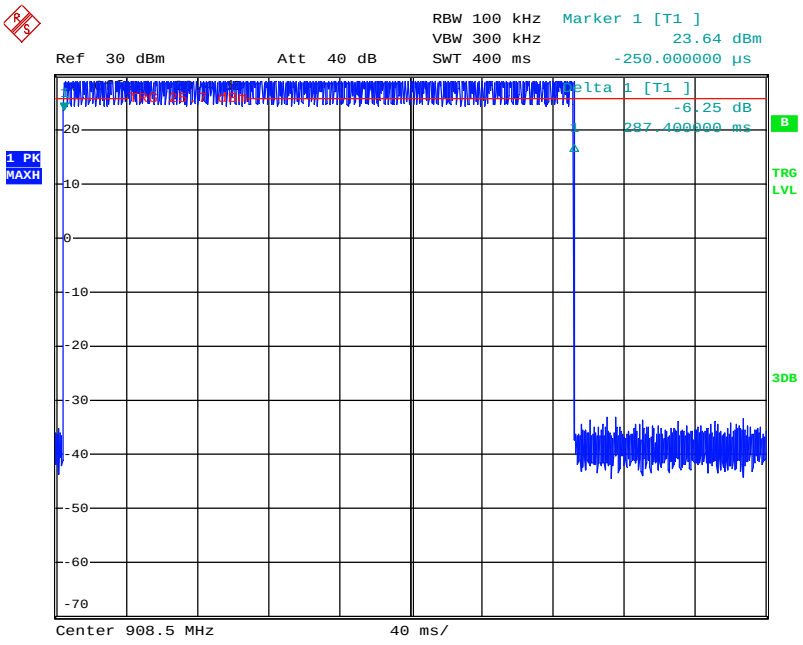
Date: 2.JUL.2018 19:05:04

Figure 7.3.3.2-5: Dwell Time – LoRaWAN – SF7



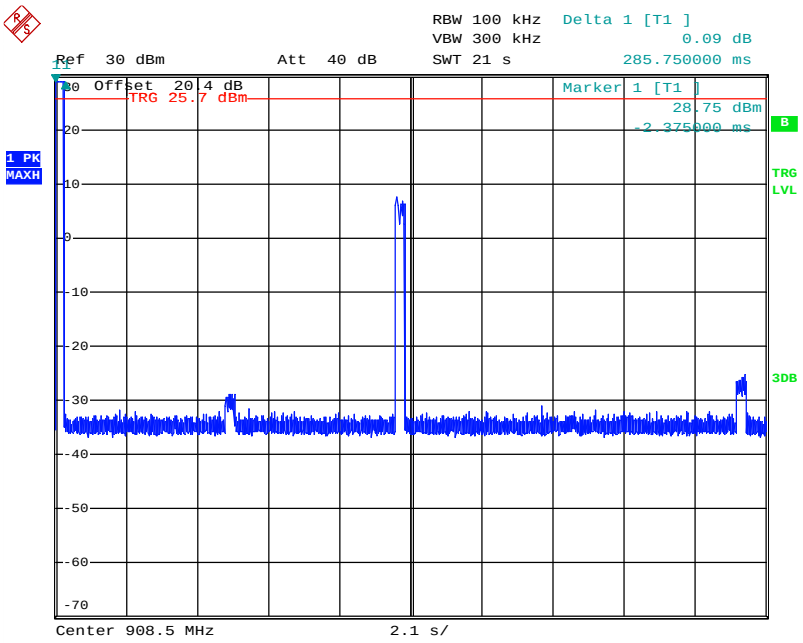
Date: 2.JUL.2018 19:58:23

Figure 7.3.3.2-6: Dwell Time – 20 Seconds – LoRaWAN – SF7



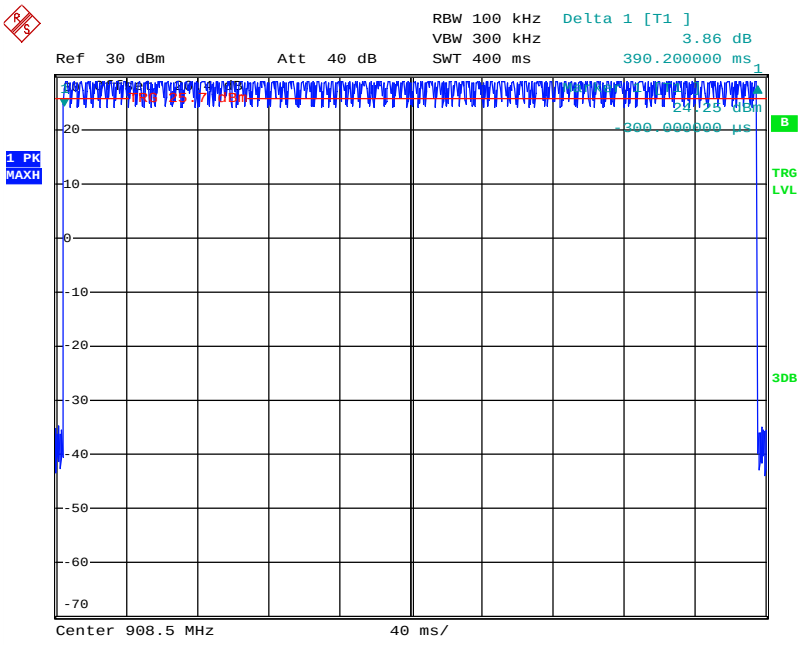
Date: 2.JUL.2018 19:10:41

Figure 7.3.3.2-7: Dwell Time – LoRaWAN – SF8



Date: 2.JUL.2018 20:09:38

Figure 7.3.3.2-8: Dwell Time – 20 Seconds – LoRaWAN – SF8



Date: 2.JUL.2018 19:16:19

Figure 7.3.3.2-9: Dwell Time – LoRaWAN – SF9

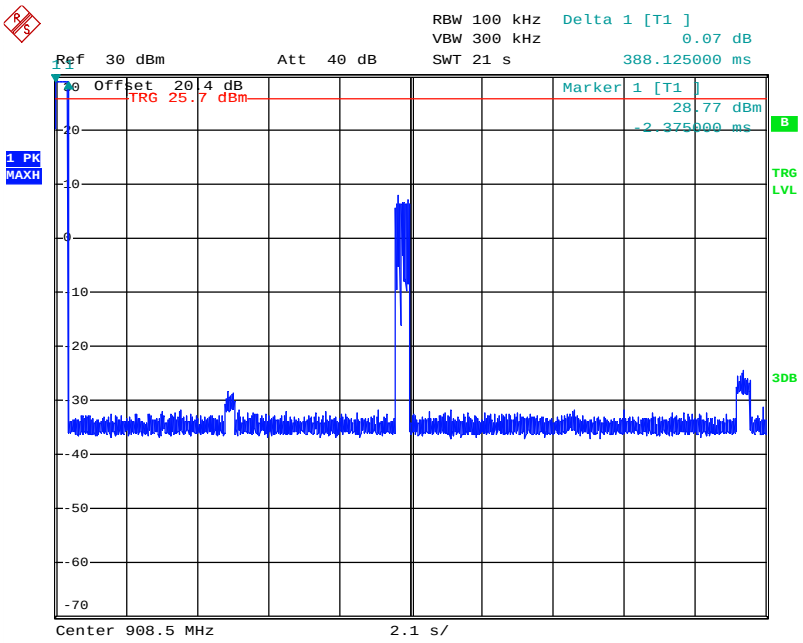


Figure 7.3.3.2-10: Dwell Time – 20 Seconds – LoRaWAN – SF9

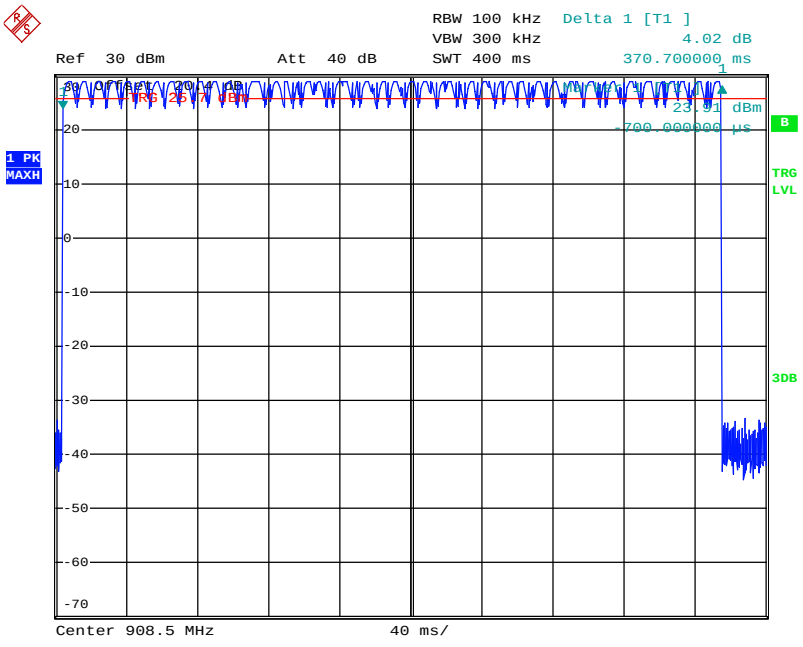
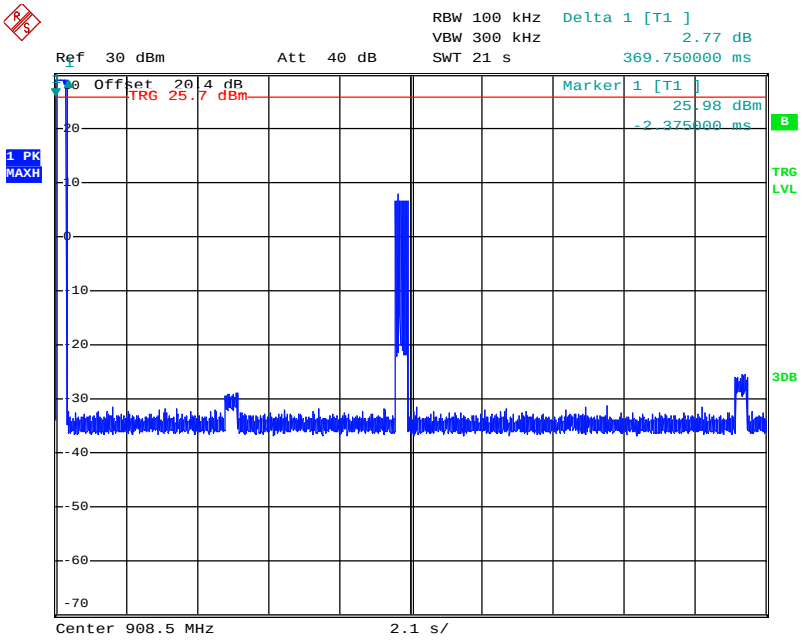


Figure 7.3.3.2-11: Dwell Time – LoRaWAN – SF10



Date: 2.JUL.2018 20:22:55

Figure 7.3.3.2-12: Dwell Time – 20 Seconds – LoRaWAN – SF10

7.3.4 20dB / 99% Bandwidth - FCC: Section 15.247(a)(1)(i); ISED Canada: RSS-247 5.1(c)

7.3.4.1 Measurement Procedure

The RF output port of the EUT was directly connected to the input of the spectrum analyzer. The spectrum analyzer span was set to 2 to 5 times the estimated bandwidth of the emission. The RBW was set to 1% to 5% of the estimated emission bandwidth. The trace was set to max hold with a peak detector active. The Delta function of the analyzer was utilized to determine the 20-dB bandwidth of the emissions.

The 99% occupied bandwidth was measured with the spectrum analyzer span set to fully display the emission. The RBW was set to 1% to 5% of the approximated bandwidth. The occupied 99% bandwidth was measured by using the 99% bandwidth equipment function of the spectrum analyzer.

7.3.4.2 Measurement Results

Performed by: Thierry Jean-Charles

Table 7.3.4.2-1: 20dB / 99% Bandwidth – RFV4

Frequency (MHz)	20dB Bandwidth (kHz)	99% Bandwidth (kHz)
912.310	140.0625	126.0000
919.512	138.9375	125.6875
927.012	142.0000	126.1250

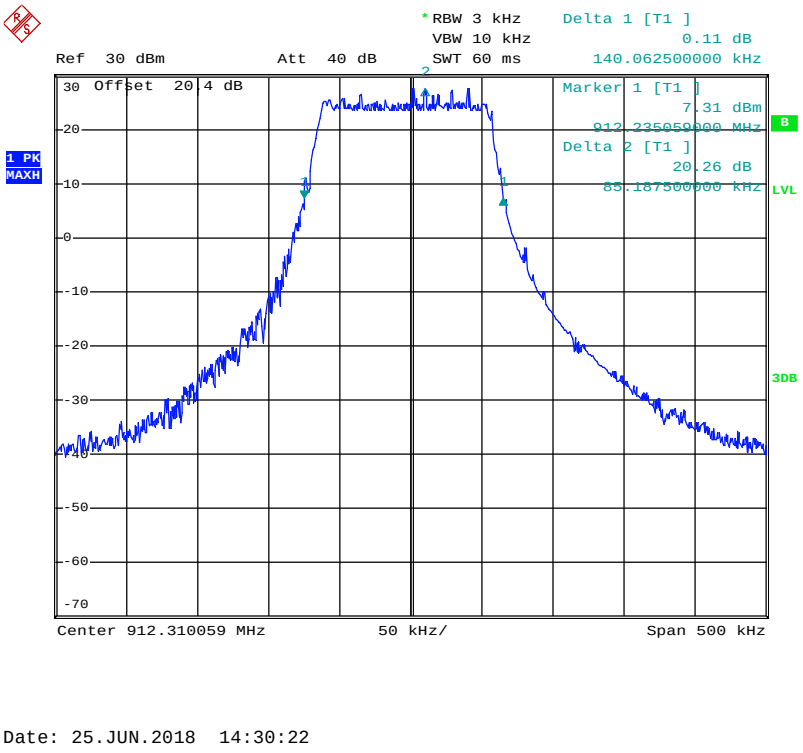


Figure 7.3.4.2-1: 20 dB BW – Low Channel – RFV4

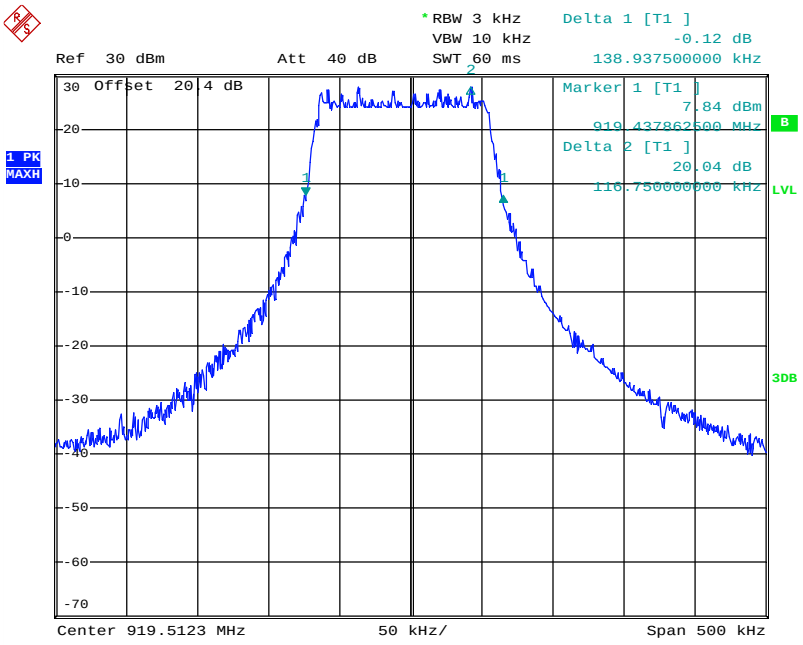


Figure 7.3.4.2-2: 20 dB BW – Middle Channel – RFV4

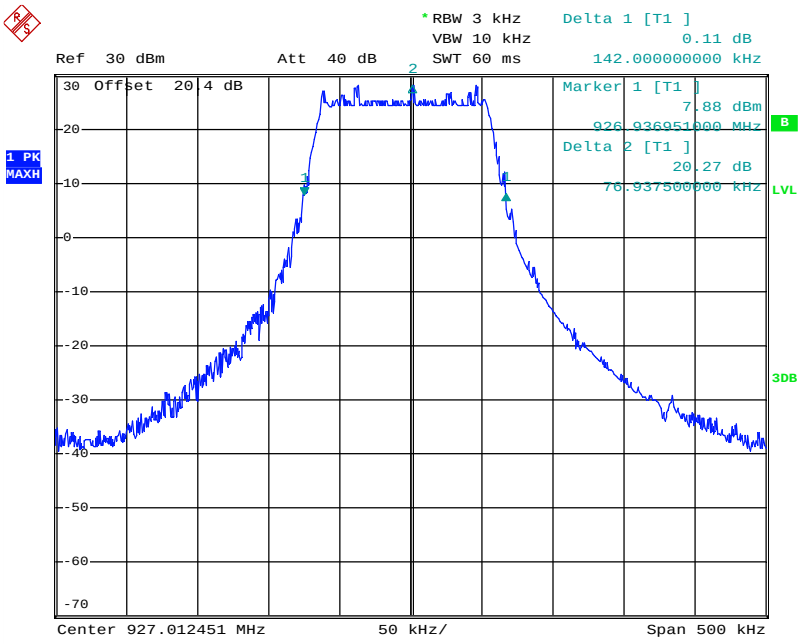


Figure 7.3.4.2-3: 20 dB BW – High Channel – RFV4

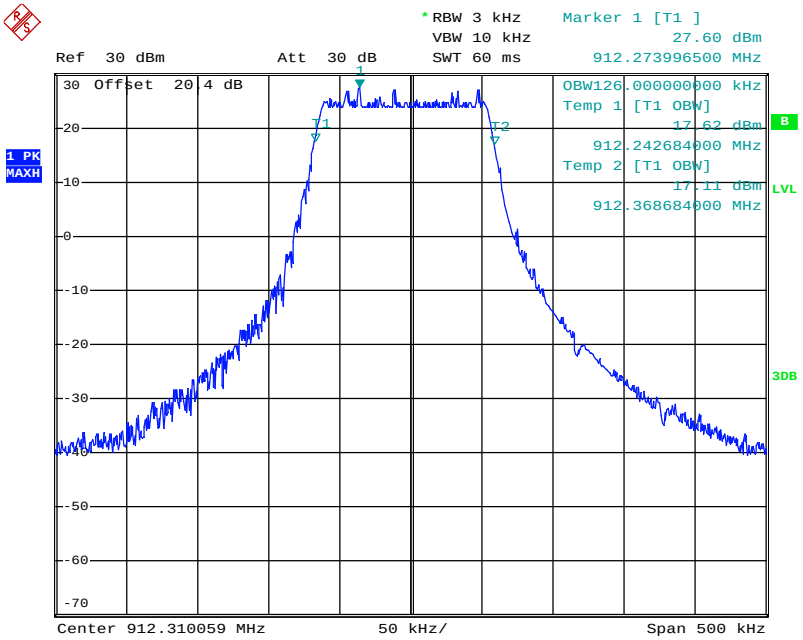


Figure 7.3.4.2-4: 99% BW – Low Channel – RFV4

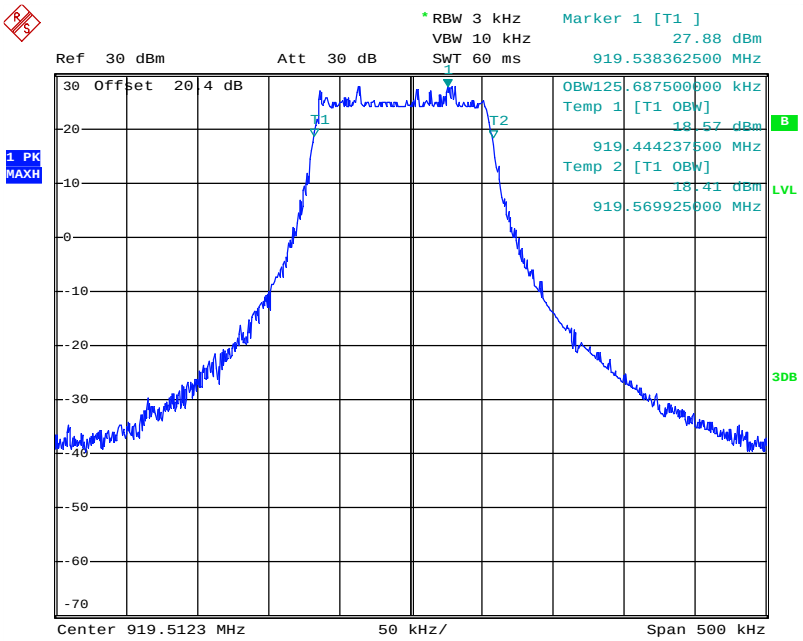


Figure 7.3.4.2-5: 99% BW – Middle Channel – RFV4

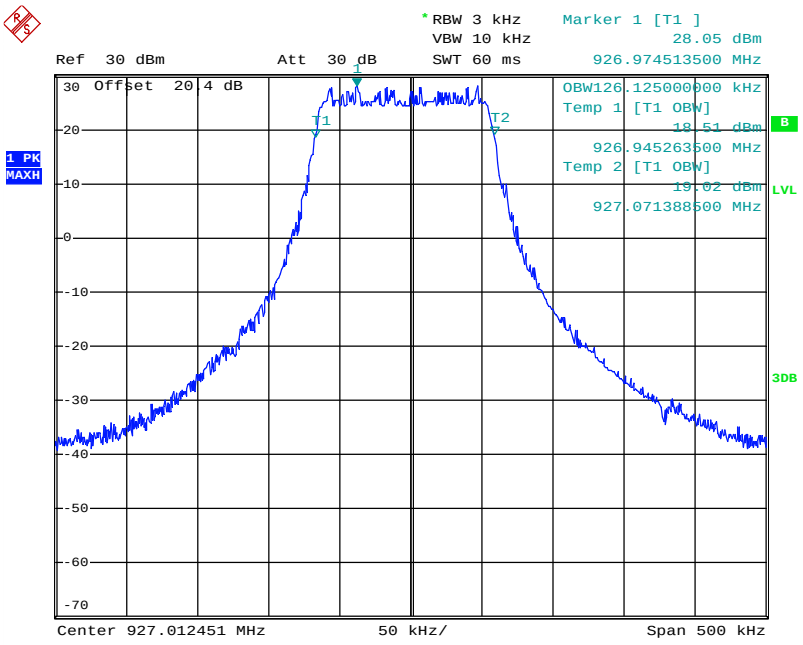


Figure 7.3.4.2-6: 99% BW – High Channel – RFV4

Table 7.3.4.2-2: 20dB / 99% Bandwidth – LoRaWAN

Frequency (MHz)	20dB Bandwidth (kHz)	99% Bandwidth (kHz)
902.3	143.5000	125.0625
908.5	141.5000	125.5625
914.9	142.5000	126.6250

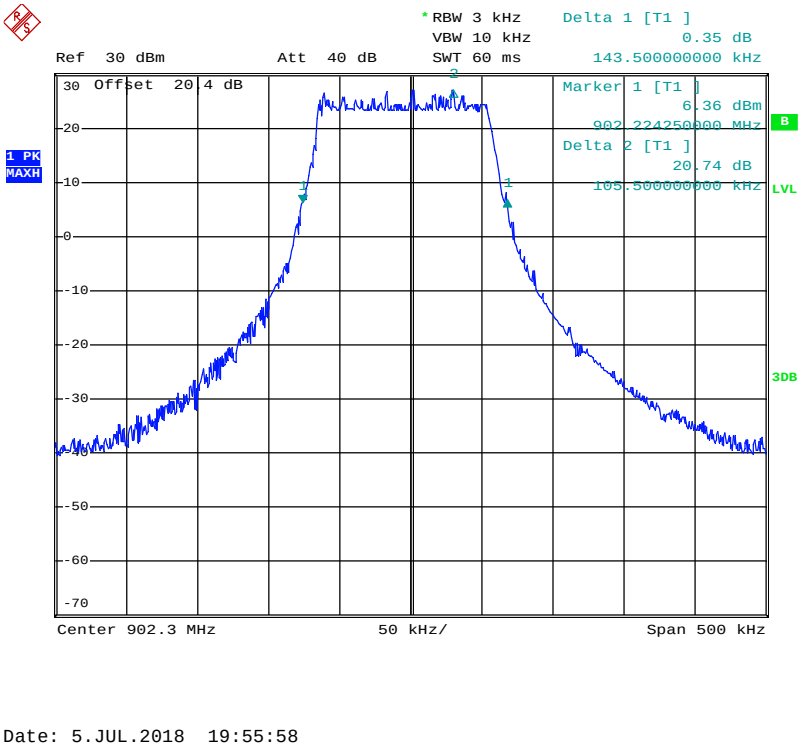
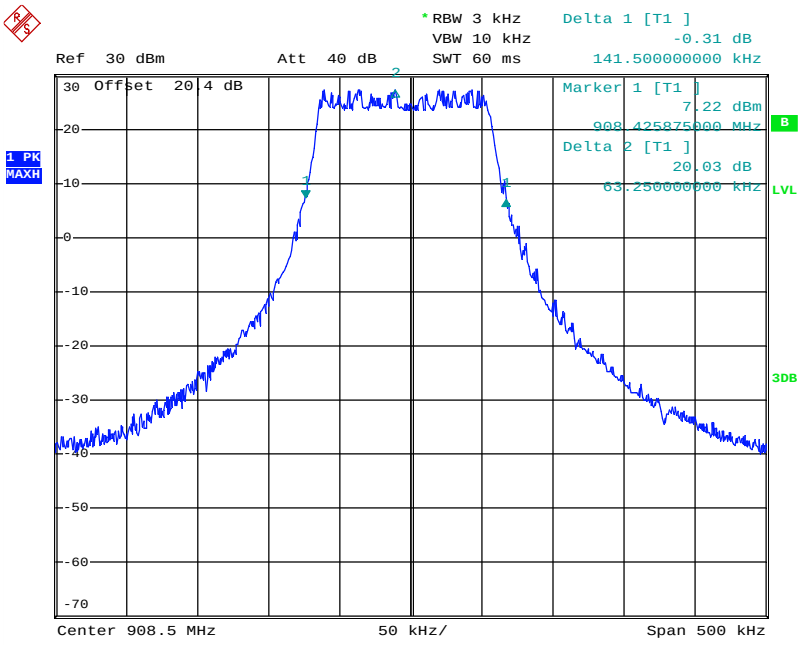
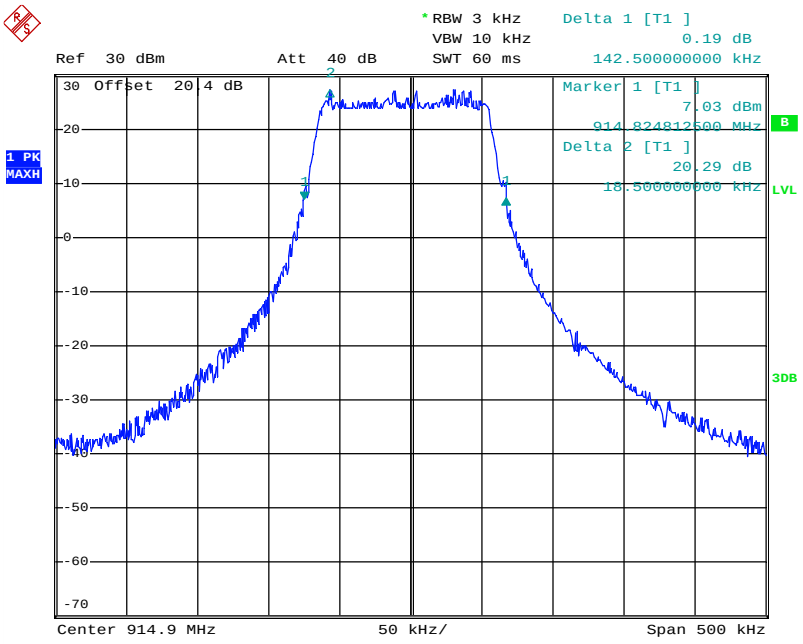


Figure 7.3.4.2-7: 20 dB BW – Low Channel – LoRaWAN



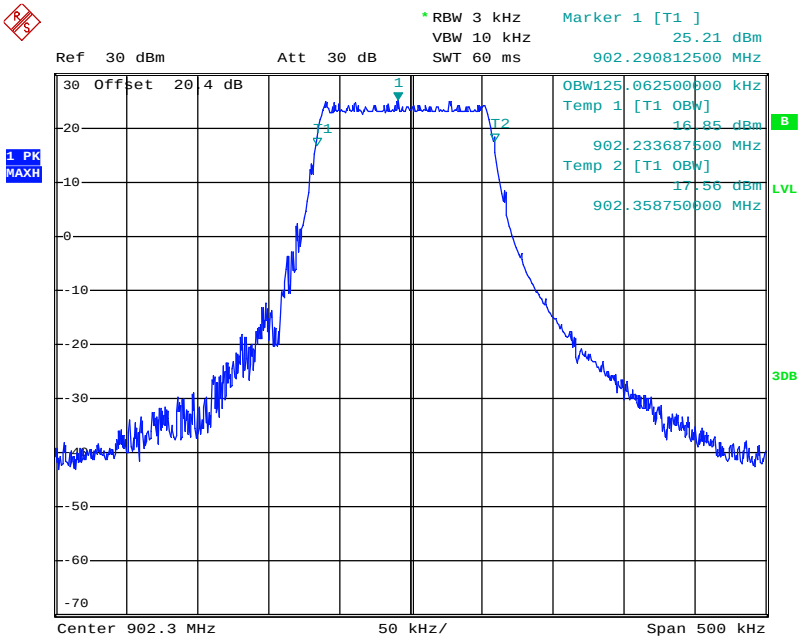
Date: 25.JUN.2018 16:59:08

Figure 7.3.4.2-8: 20 dB BW – Middle Channel – LoRaWAN



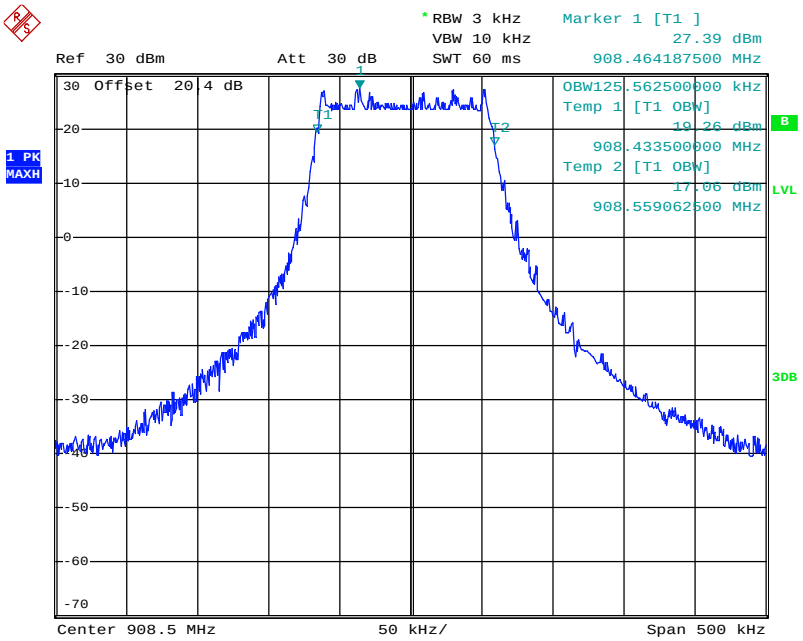
Date: 5.JUL.2018 20:09:37

Figure 7.3.4.2-9: 20 dB BW – High Channel – LoRaWAN



Date: 5.JUL.2018 20:00:16

Figure 7.3.4.2-10: 99% BW – Low Channel – LoRaWAN



Date: 25.JUN.2018 16:50:40

Figure 7.3.4.2-11: 99% BW – Middle Channel – LoRaWAN

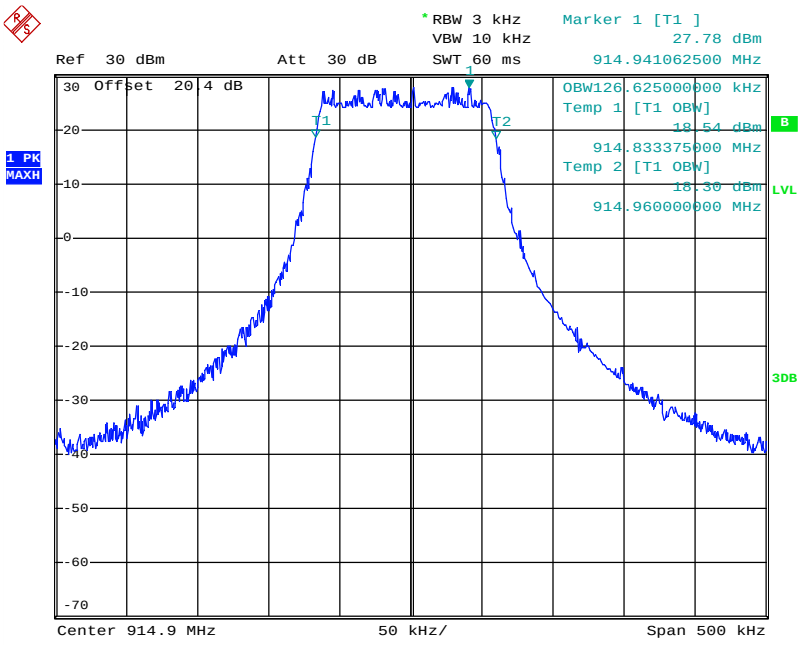


Figure 7.3.4.2-12: 99% BW – High Channel – LoRaWAN

7.4 Band-Edge Compliance and Spurious Emissions

7.4.1 Band-Edge Compliance of RF Conducted Emissions – FCC: Section 15.247(d); ISED Canada: RSS-247 5.5

7.4.1.1 Measurement Procedure

The RF output port of the EUT was connected to the input of the spectrum analyzer through suitable attenuation. The EUT was investigated at the lowest and highest channel available to determine band-edge compliance. For each measurement the spectrum analyzer's RBW was set to 100 kHz, and the VBW was set to >= 300 kHz.

7.4.1.2 Measurement Results

Performed by: Thierry Jean-Charles

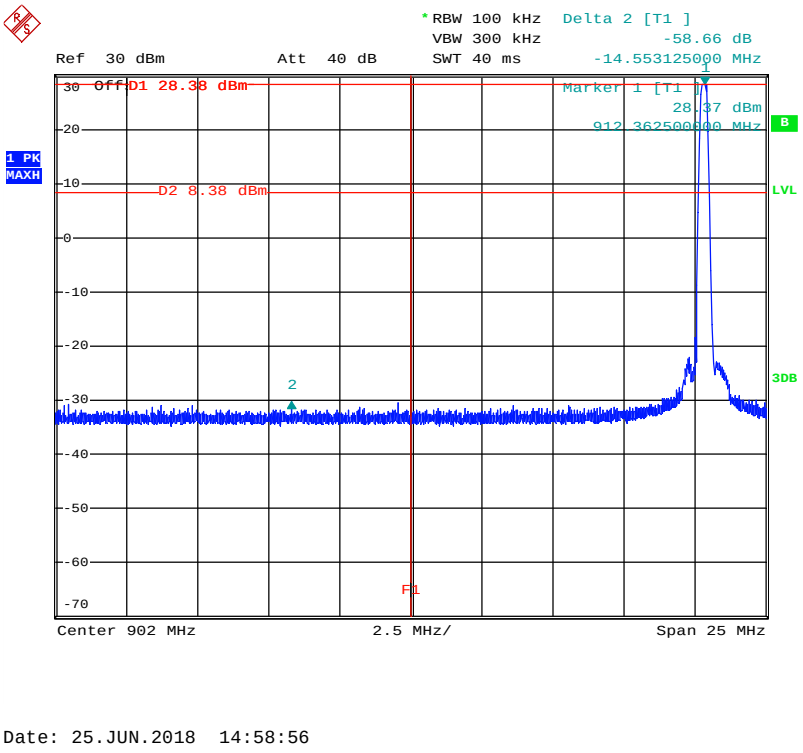
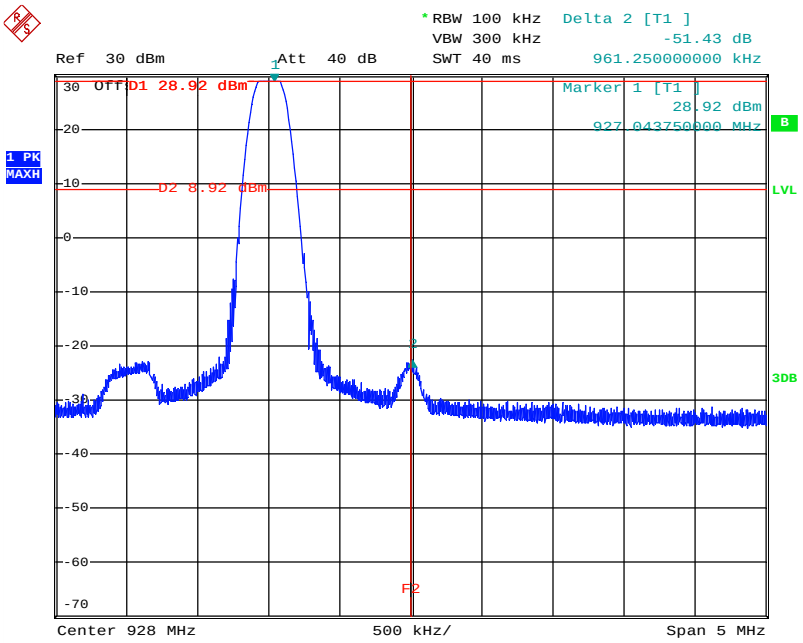
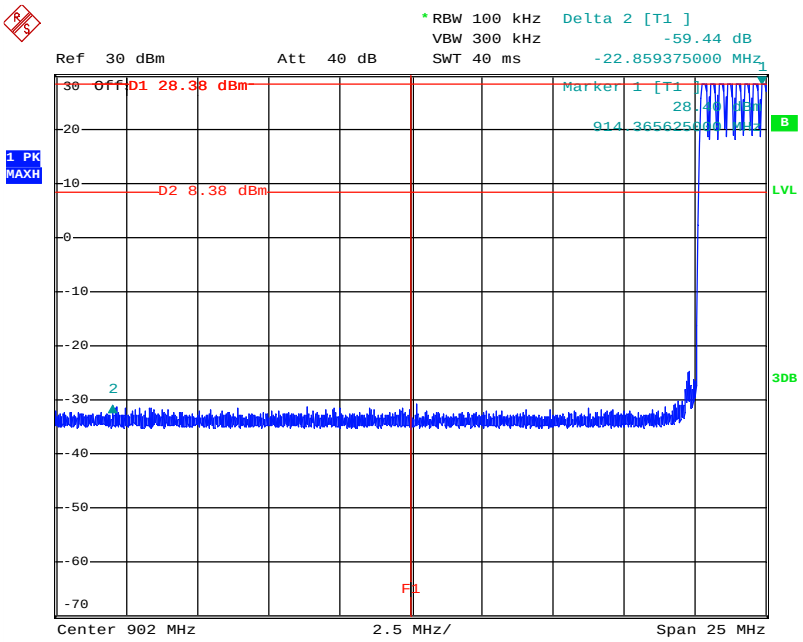


Figure 7.4.1.2-1: Lower Band-edge – RFV4



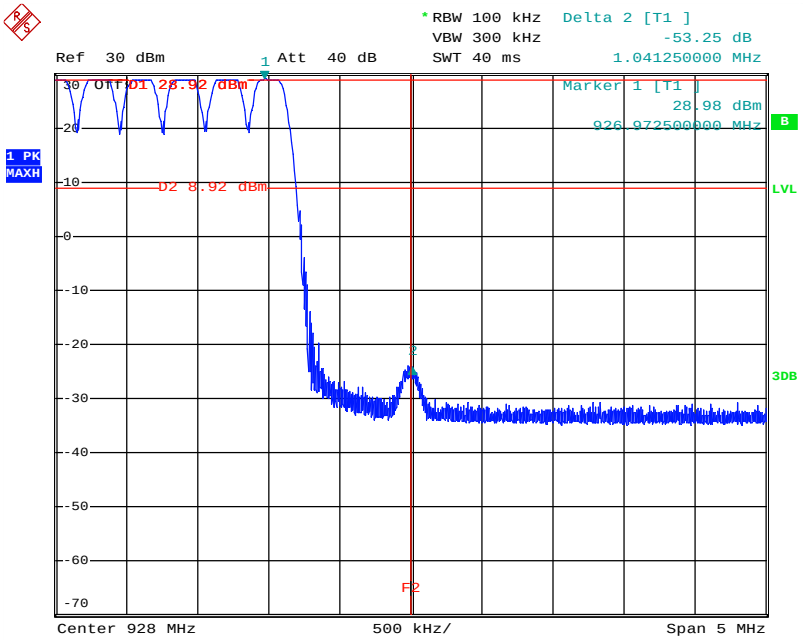
Date: 25.JUN.2018 16:10:55

Figure 7.4.1.2-2: Upper Band-edge – RFV4



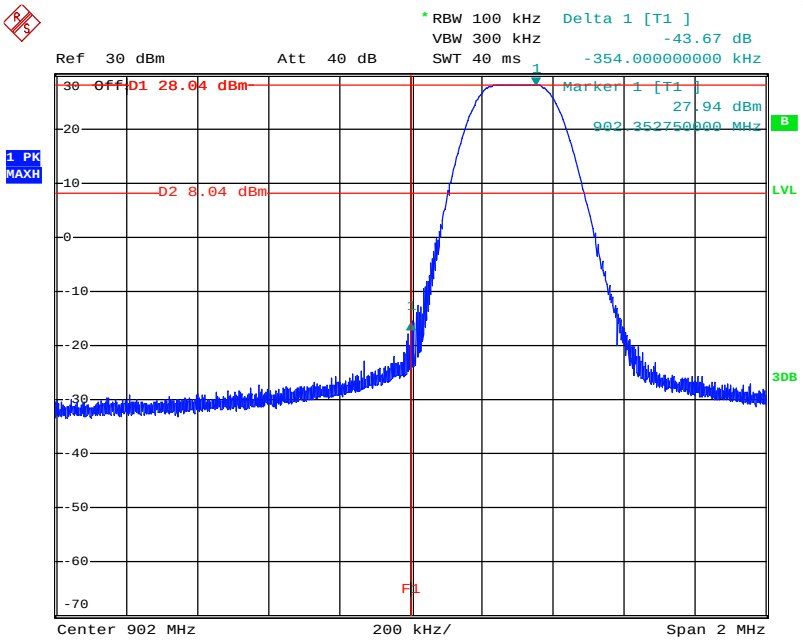
Date: 2.JUL.2018 14:11:59

Figure 7.4.1.2-3: Lower Band-edge – Hopping Mode – RFV4



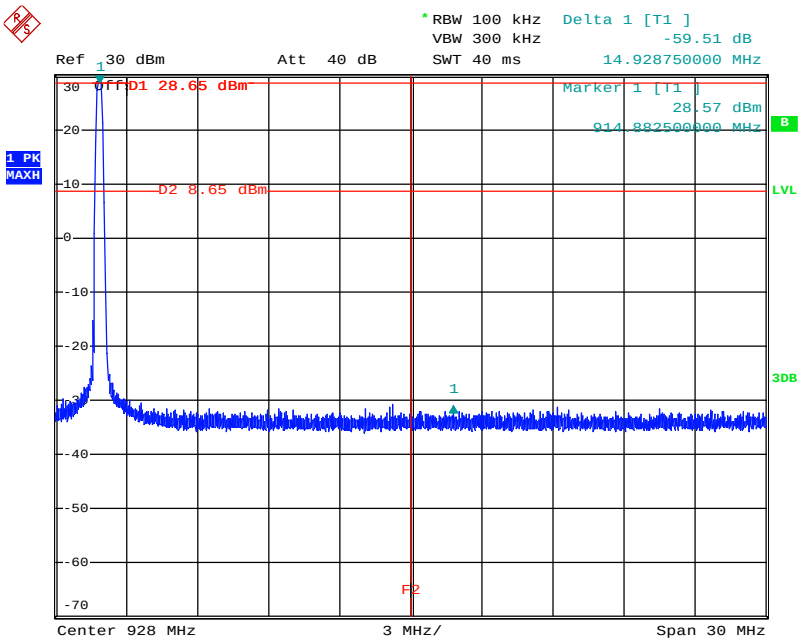
Date: 2.JUL.2018 14:20:45

Figure 7.4.1.2-4: Upper Band-edge – Hopping Mode – RFV4



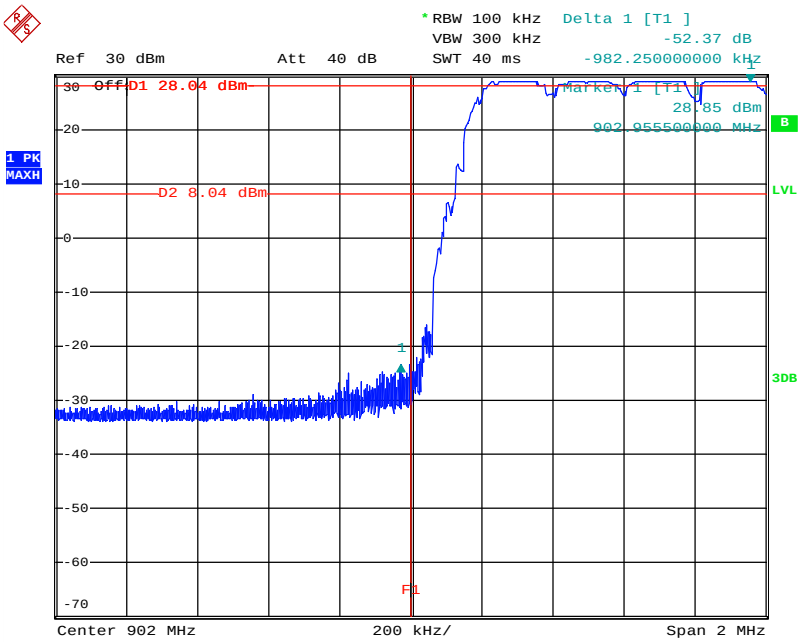
Date: 5.JUL.2018 20:44:59

Figure 7.4.1.2-5: Lower Band-edge – LoRaWAN



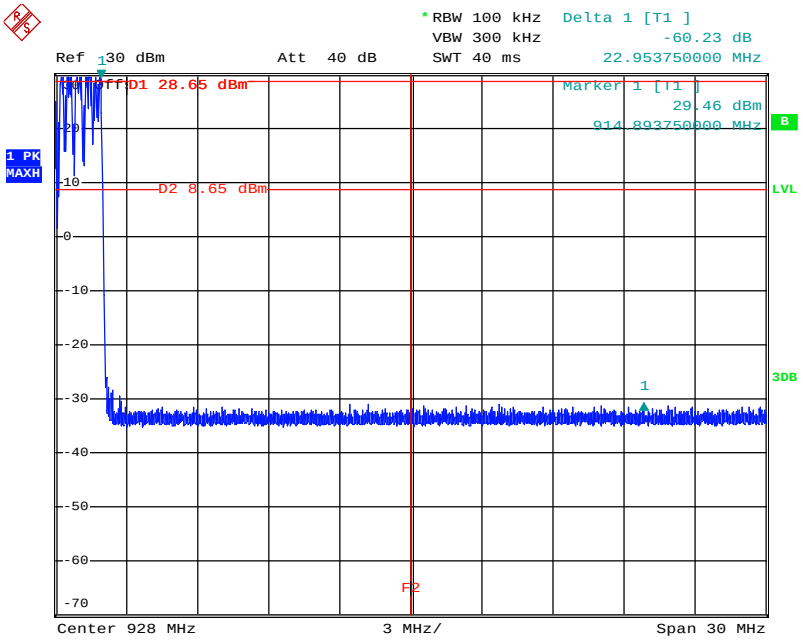
Date: 5.JUL.2018 20:52:20

Figure 7.4.1.2-6: Upper Band-edge – LoRaWAN



Date: 5.JUL.2018 21:56:19

Figure 7.4.1.2-7: Lower Band-edge – Hopping Mode – LoRaWAN



Date: 5.JUL.2018 21:00:23

Figure 7.4.1.2-8: Upper Band-edge – Hopping Mode – LoRaWAN

7.4.2 RF Conducted Spurious Emissions – FCC: Section 15.247(d); ISED Canada: RSS-247 5.5

7.4.2.1 Measurement Procedure

The RF Conducted Spurious Emissions were measured in accordance with ANSI C63.10 Section 7.8.8. The RF output port of the equipment under test was directly connected to the input of the spectrum analyzer. The EUT was investigated for conducted spurious emissions from 30 MHz to 10 GHz, 10 times the highest fundamental frequency. Measurements were made at the low, center and high channels of the EUT. For each measurement, the spectrum analyzer's RBW was set to 100 kHz and the VBW was set to 300 kHz. The peak Max Hold function of the analyzer was utilized.

7.4.2.2 Measurement Results

Performed by: Thierry Jean-Charles

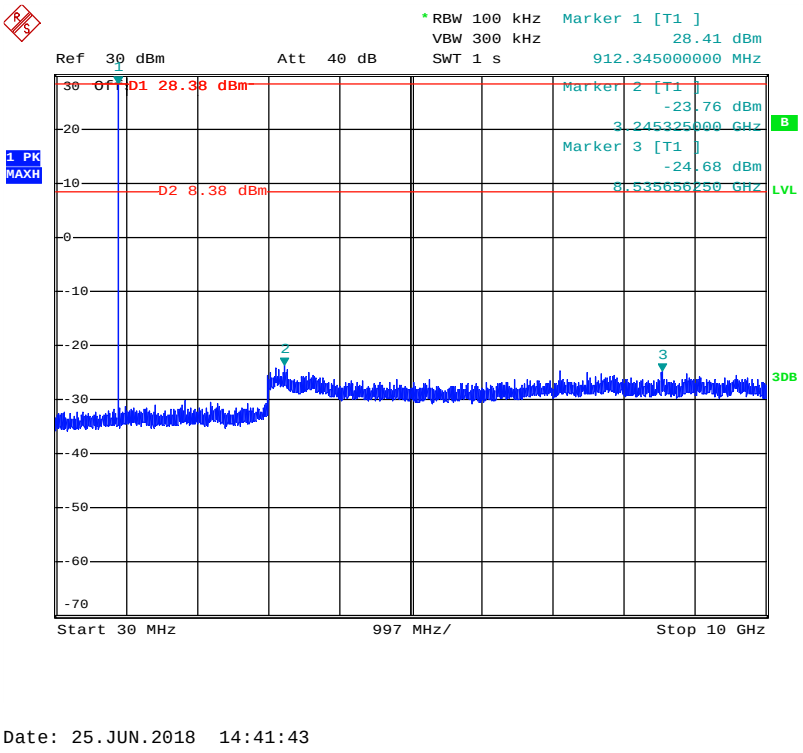


Figure 7.4.2.2-1: 30 MHz – 10 GHz – Low Channel – RFV4

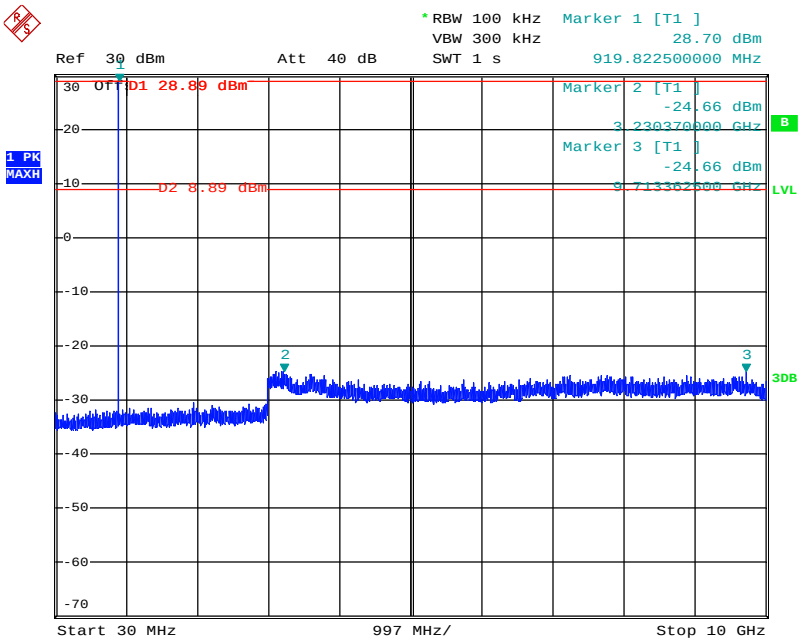


Figure 7.4.2.2-2: 30 MHz – 10 GHz – Middle Channel – RFV4

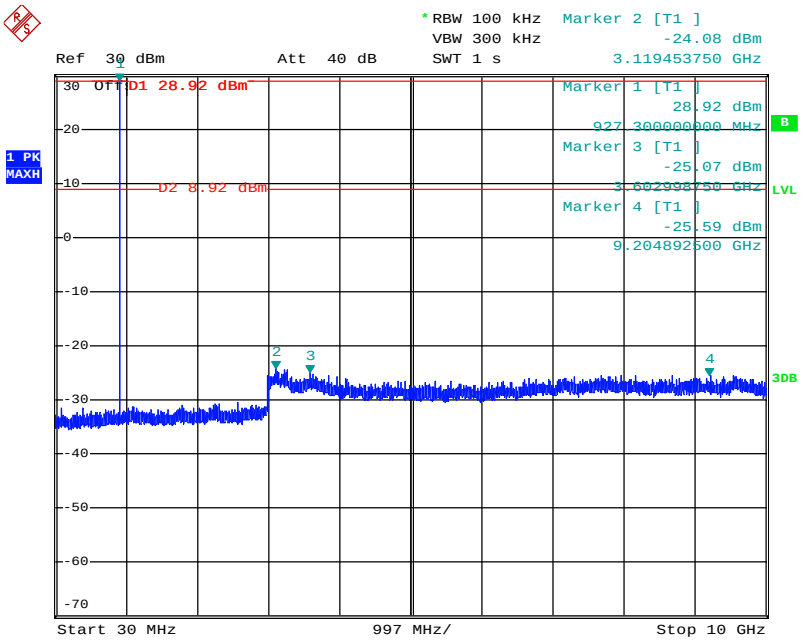
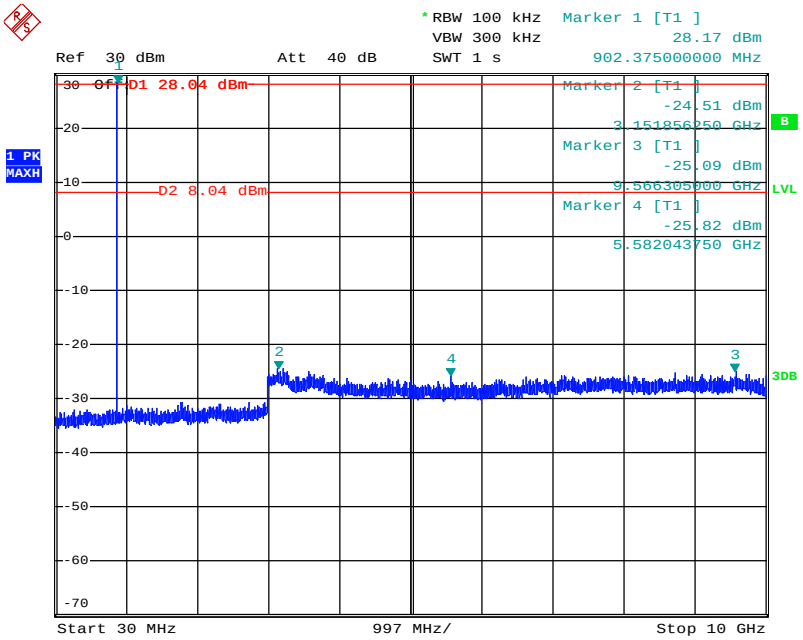
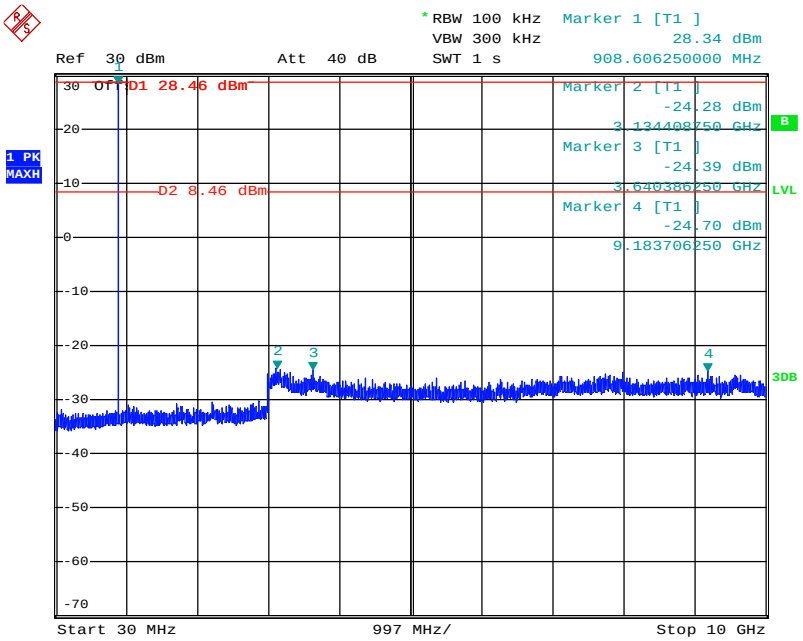


Figure 7.4.2.2-3: 30 MHz – 10 GHz – High Channel – RFV4



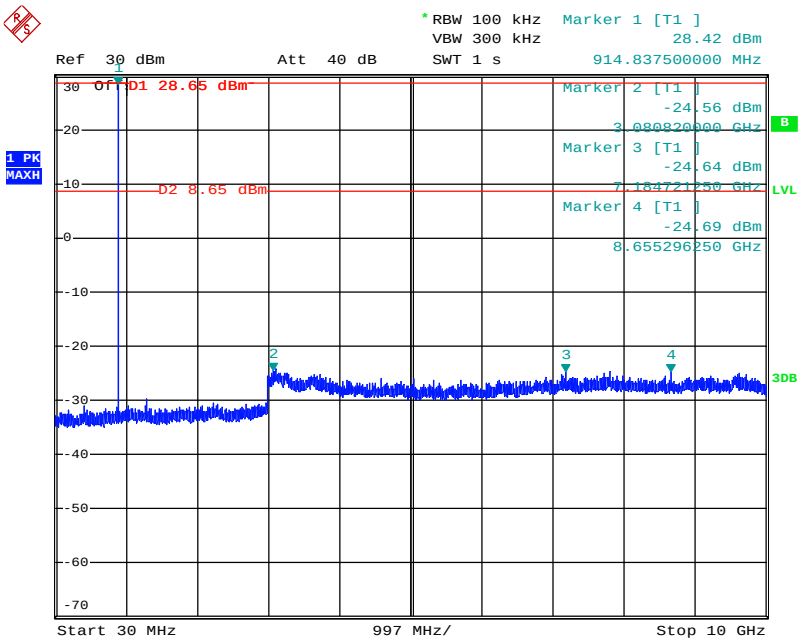
Date: 13.JUL.2018 18:59:56

Figure 7.4.2.2-4: 30 MHz – 10 GHz – Low Channel – LoRaWAN



Date: 5.JUL.2018 19:48:00

Figure 7.4.2.2-5: 30 MHz – 10 GHz – Middle Channel – LoRaWAN



Date: 13.JUL.2018 19:15:08

Figure 7.4.2.2-6: 30 MHz – 10 GHz – High Channel – LoRaWAN 1

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

7.4.3.1 Measurement Procedure

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

For measurements below 30 MHz, the receive antenna height was set to 1 m and the EUT was rotated through 360 degrees. The resolution bandwidth was set to 200 Hz below 150 kHz and to 9 kHz above 150 kHz.

The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m 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 measurements are made with RBW of 1 MHz and VBW of 3 MHz. Average measurements are performed in the linear scale using VBW of 30 Hz.

7.4.3.2 Measurement Results

Performed by: Jean Rene

Radiated band-edge and spurious emissions found in the restricted frequency bands of 9 kHz to 10 GHz are reported in the tables below.

Table 7.4.3.2-1: Radiated Spurious Emissions Tabulated Data

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
Low Channel (LoRaWAN SF 8: 902.3 MHz)										
2706.9	45.86	40.39	H	2.31	48.17	42.70	74.0	54.0	25.8	11.3
2706.9	43.79	36.77	V	2.31	46.10	39.08	74.0	54.0	27.9	14.9
3609.2	44.27	38.16	H	5.88	50.15	44.04	74.0	54.0	23.8	10.0
3609.2	44.67	39.07	V	5.88	50.55	44.95	74.0	54.0	23.4	9.0
4511.5	41.42	32.81	H	7.87	49.29	40.68	74.0	54.0	24.7	13.3
4511.5	42.83	36.20	V	7.87	50.70	44.07	74.0	54.0	23.3	9.9
5413.8	39.47	28.01	H	10.57	50.04	38.58	74.0	54.0	24.0	15.4
5413.8	39.76	29.04	V	10.57	50.33	39.61	74.0	54.0	23.7	14.4
8120.7	39.97	27.01	H	15.04	55.01	42.05	74.0	54.0	19.0	12.0
8120.7	39.68	25.53	V	15.04	54.72	40.57	74.0	54.0	19.3	13.4
Middle Channel (LoRaWAN SF 8: 914.9 MHz)										
2744.7	47.49	43.41	H	2.49	49.98	45.90	74.0	54.0	24.0	8.1
2744.7	45.24	39.04	V	2.49	47.73	41.53	74.0	54.0	26.3	12.5
3659.6	42.28	35.42	H	6.09	48.37	41.51	74.0	54.0	25.6	12.5
3659.6	43.74	36.27	V	6.09	49.83	42.36	74.0	54.0	24.2	11.6
4574.5	39.93	30.71	H	8.08	48.01	38.79	74.0	54.0	26.0	15.2
4574.5	39.57	30.20	V	8.08	47.65	38.28	74.0	54.0	26.4	15.7
7319.2	45.56	38.93	H	14.07	59.63	53.00	74.0	54.0	14.4	1.0
7319.2	43.60	35.21	V	14.07	57.67	49.28	74.0	54.0	16.3	4.7
8234.1	40.94	30.38	H	15.16	56.10	45.54	74.0	54.0	17.9	8.5
8234.1	39.78	26.10	V	15.16	54.94	41.26	74.0	54.0	19.1	12.7
9149	40.00	26.57	H	15.65	55.65	42.22	74.0	54.0	18.3	11.8
9149	39.84	26.12	V	15.65	55.49	41.77	74.0	54.0	18.5	12.2
High Channel (RFV4 SF 7: 927.01245 MHz)										
2781.0372	48.47	44.79	H	2.66	51.13	47.45	74.0	54.0	22.9	6.6
2781.0372	45.29	39.81	V	2.66	47.95	42.47	74.0	54.0	26.1	11.5
3708.0496	44.49	38.13	H	6.29	50.78	44.42	74.0	54.0	23.2	9.6
3708.0496	42.68	35.29	V	6.29	48.97	41.58	74.0	54.0	25.0	12.4
4635.062	41.10	33.63	H	8.28	49.38	41.91	74.0	54.0	24.6	12.1
4635.062	40.53	31.90	V	8.28	48.81	40.18	74.0	54.0	25.2	13.8
7416.0992	44.11	36.04	H	14.35	58.46	50.39	74.0	54.0	15.5	3.6
7416.0992	42.85	33.14	V	14.35	57.20	47.49	74.0	54.0	16.8	6.5
8343.1116	40.29	28.26	H	15.28	55.57	43.54	74.0	54.0	18.4	10.5
8343.1116	38.98	24.81	V	15.28	54.26	40.09	74.0	54.0	19.7	13.9

Notes:

All emissions above 9.15 GHz were attenuated below the limits and the noise floor of the measurement equipment.

7.4.4 Sample Calculations

$R_C = R_U + CF_T$

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: 45.86 + 2.31 = 48.17 dBµV/m
Margin: 74 dBµV/m – 48.17 dBµV/m = 25.83 dB

Example Calculation: Average
Corrected Level: 40.39 + 2.31 = 42.7 dBµV/m
Margin: 54 dBµV/m – 42.7 dBµV/m = 11.3 dB

8 MEASUREMENT UNCERTAINTIES

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: Measurement Uncertainties

Parameter	U_{lab}
Occupied Channel Bandwidth	± 0.009 %
RF Conducted Output Power	± 1.15 dB
Power Spectral Density	± 1.15 dB
Antenna Port Conducted Emissions	± 1.15 dB
Radiated Emissions ≤ 1GHz	± 5.86 dB
Radiated Emissions > 1GHz	± 4.65 dB
Temperature	± 0.860 °C
Radio Frequency	$\pm 2.832 \times 10^{-8}$
AC Power Line Conducted Emissions	±3.72 dB

9 CONCLUSION

In the opinion of TÜV SÜD America, Inc. the model DCOM6, manufactured by Mueller Systems, LLC, meets the requirements of FCC Part 15.247 and Industry Canada's Radio Standards Specification RSS-247 for the tests documented herein.

END REPORT