

Report on the FCC and ISED Testing of the

Mueller Systems, LLC
DCOM6

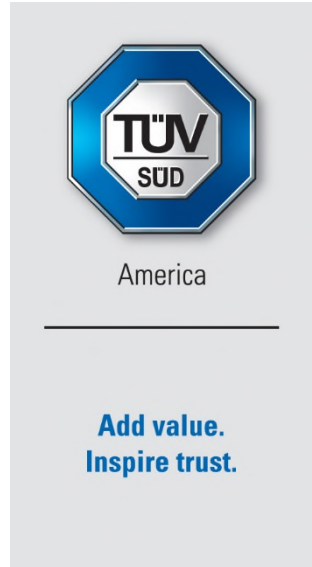
In accordance with FCC 47 CFR Part 15.247 &
ISED Canada's Radio Standards Specifications
RSS-247

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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SIGNATURE

A handwritten signature in blue ink that reads 'Pete Walsh'.

NAME	JOB TITLE	RESPONSIBLE FOR	ISSUE DATE
Pete Walsh	Service Line Manager	Authorized Signatory	2018-Aug-20

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD America, Inc. document control rules.

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Main Site Number 2087A-2 Tampa, FL Test Laboratory
Satellite Site Number: 4175C Boca Raton, FL Test Laboratory

EXECUTIVE SUMMARY

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



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TÜV SÜD America
5610 West Sligh Ave., Suite 100
Tampa, FL 33634

Phone: 813-284-2715
www.tuv-sud-america.com

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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:	LoRaWAN Hybrid Mode
Frequency Range:	902.3 MHz - 914.9 MHz
Protocols:	LoRaWAN
Number of Channels:	Less than 50
Channel Separation:	200 kHz
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 maximum of 49 channels. LoRaWAN compliance for greater or equal to 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 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. For the hopping mode, the unit uses automatically the preset configured by the customer. For continuous operation on a single channel, the power setting were reduced by a setting of 6 from the original TXP values corresponding to the following:

TXP = 5 (RF Conducted Test Sample)

TXP = 6 (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:

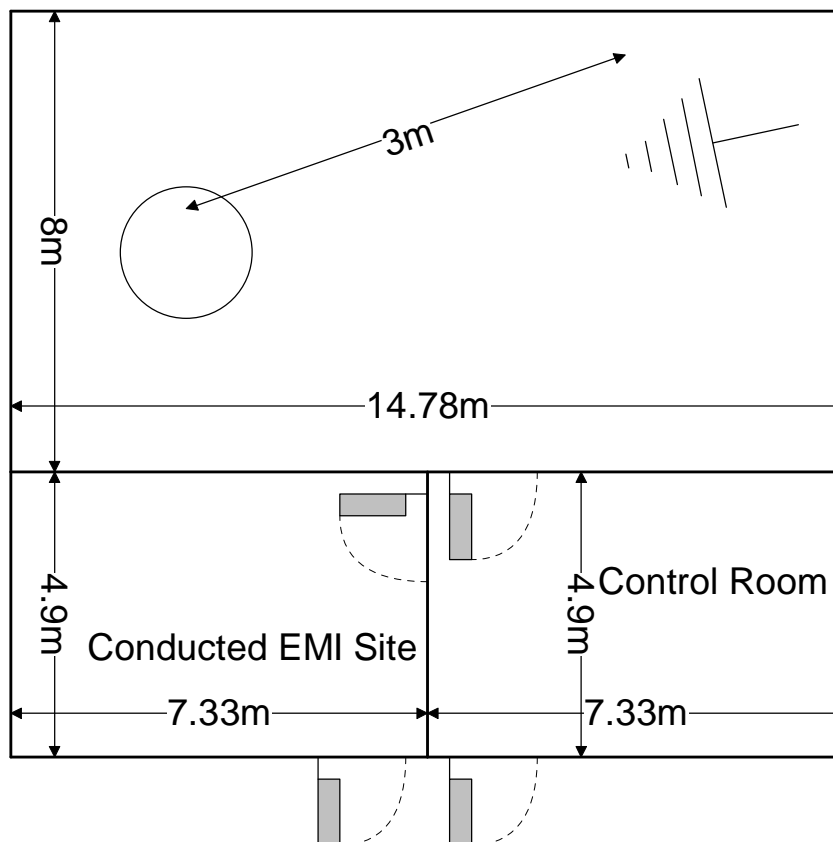


Figure 2.3.1-1: Semi-Anechoic Chamber Test Site

2.3.2 Conducted Emissions Test Site Description

The dimensions of the shielded conducted room are 7.3 x 4.9 x 3 m³. 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:

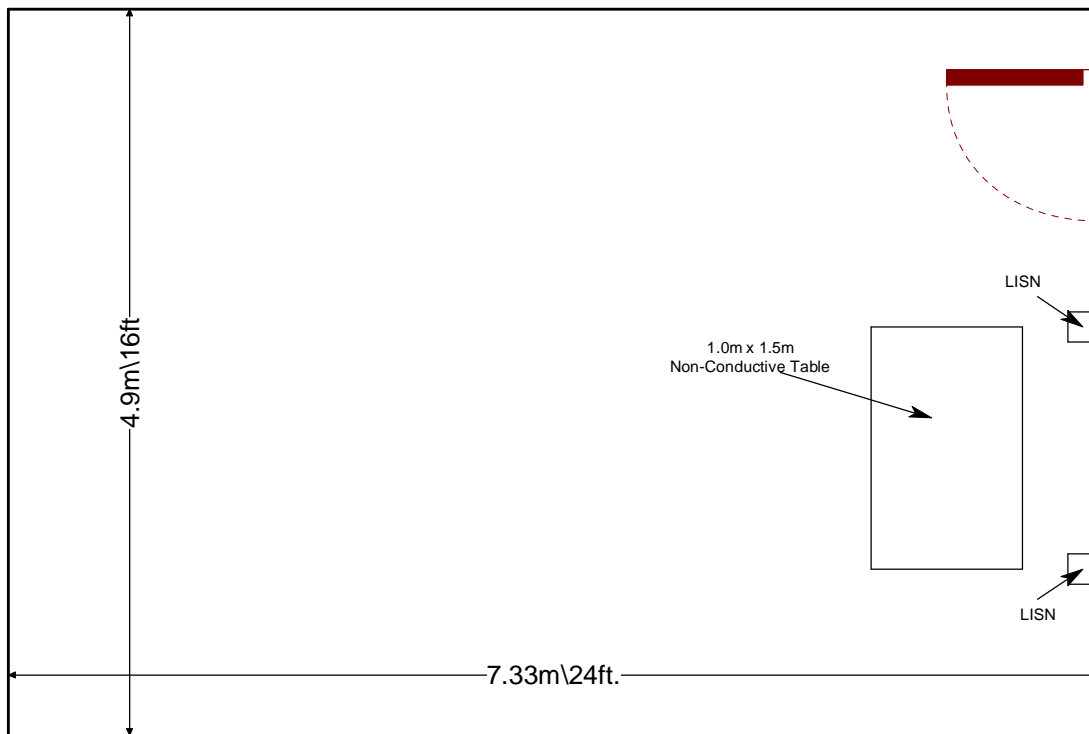


Figure 2.3.2-1: AC Mains Conducted EMI Site

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
- ❖ 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.
- ❖ FCC KDB 453039 Bluetooth Equipment, Spread Spectrum Digital Transmission System, March 23, 2007.
- ❖ 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

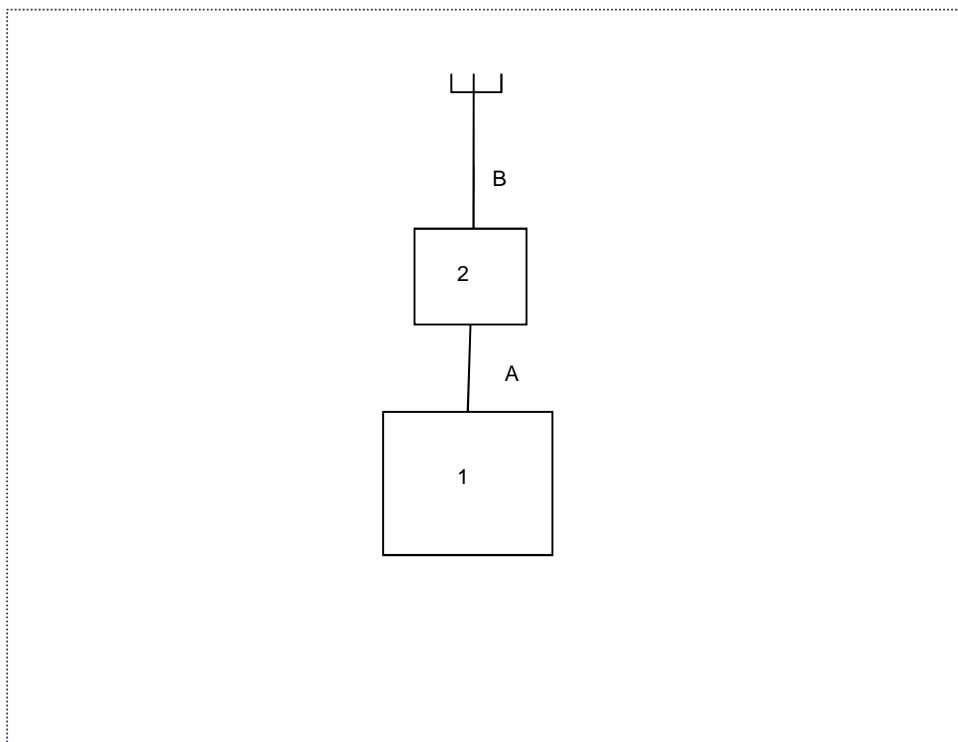


Figure 6-1: EUT and Support Equipment Block Diagram

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)	N/A
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 Spectral Density	FCC: Section 15.247(e)	ISED Canada: RSS-247 5.2(b)	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 fundamental emission output power was measured in accordance with the FCC KDB 558074 D01 DTS Meas Guidance v04 Section 9.2.2.2 Method AVGSA-1 (trace averaging with the EUT transmitting at full power throughout each sweep).

The RF output port of the EUT was directly connected to the input of the spectrum analyzer through suitable attenuation.

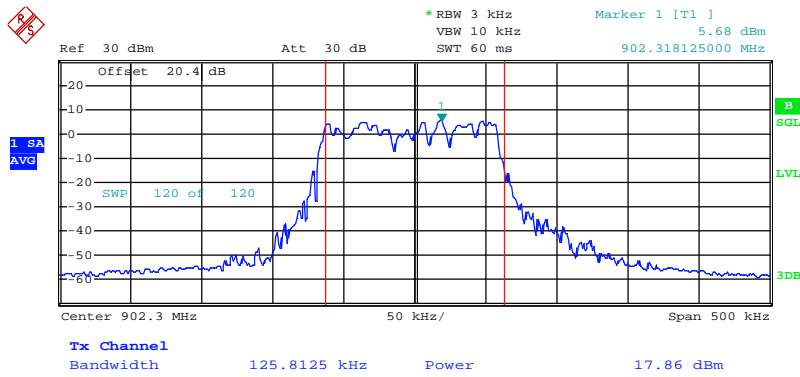
This evaluation covers to the EUT operation for LoraWAN protocol for a maximum of 49 channels. Therefore, the maximum output power allowed is 0.25 Watt (24 dBm) under the DTS procedures.

7.2.2 Measurement Results

Performed by: Thierry Jean-Charles

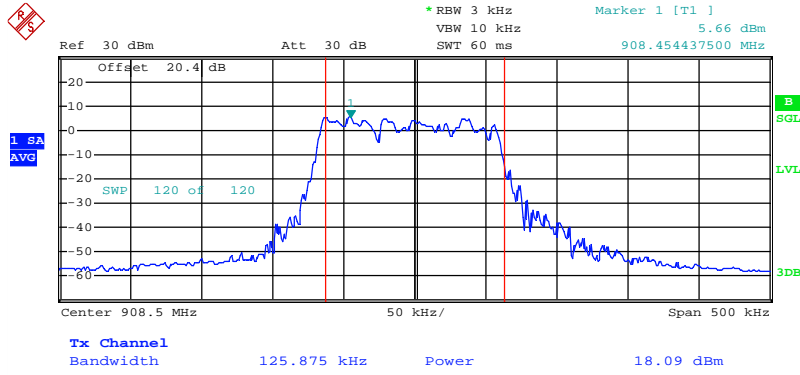
Table 7.2.2-1: RF Output Power

Frequency (MHz)	Power (dBm)
902.3	17.86
908.5	18.09
914.9	18.68



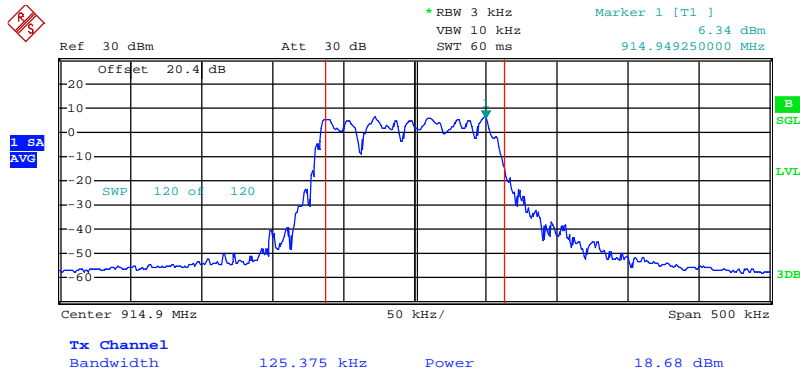
Date: 10.JUL.2018 16:41:58

Figure 7.2.2-1: RF Output Power - Low Channel



Date: 10.JUL.2018 16:36:36

Figure 7.2.2-2: RF Output Power - Middle Channel



Date: 10.JUL.2018 16:19:52

Figure 7.2.2-3: RF Output Power - High Channel

7.3 Channel Usage Requirements

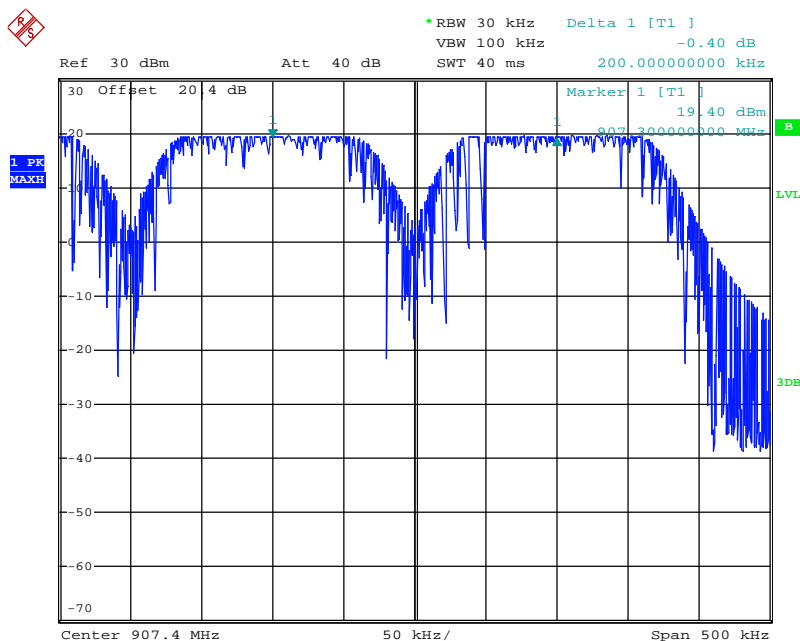
7.3.1 Carrier Frequency Separation – FCC: Section 15.247(a)(1); ISED Canada: RSS-247 5.1(b)

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.

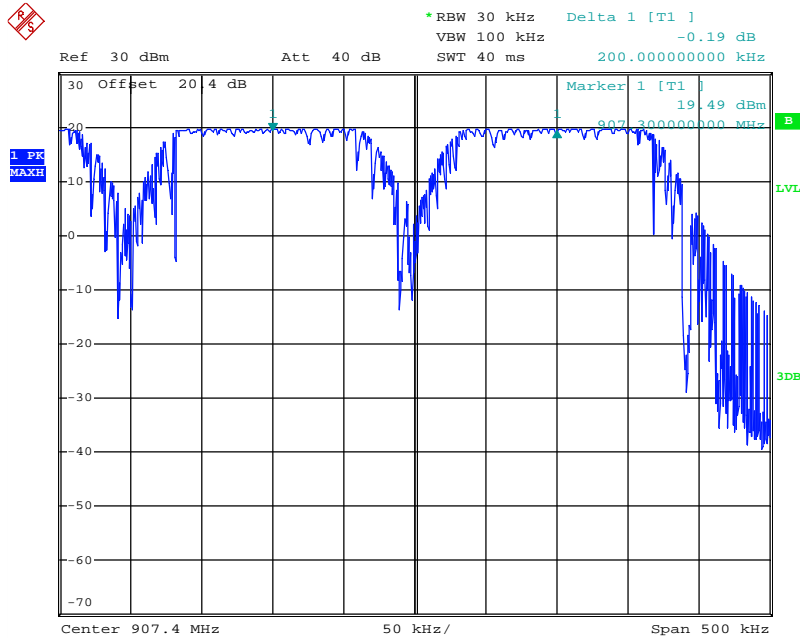
7.3.1.2 Measurement Results

Performed by: Thierry Jean-Charles



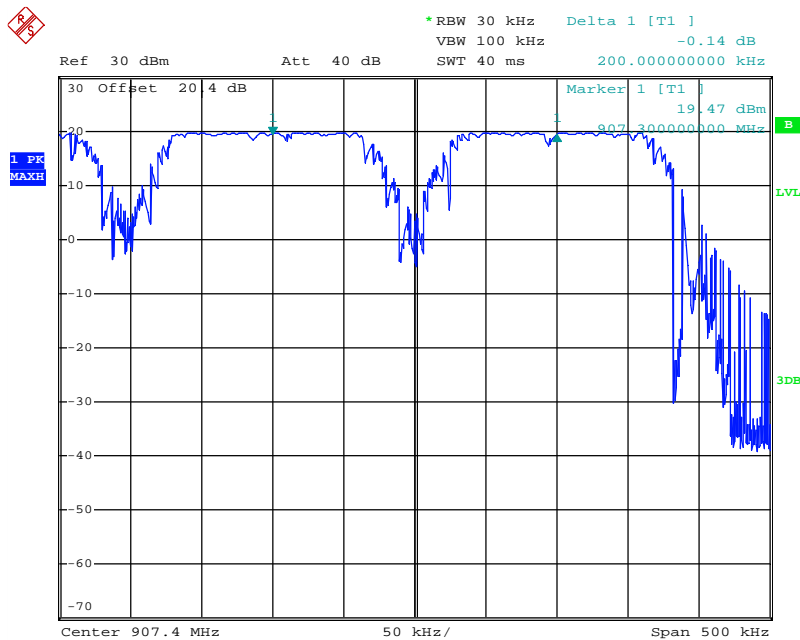
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Figure 7.3.1.2-1: Carrier Frequency Separation – LoRaWAN – SF7



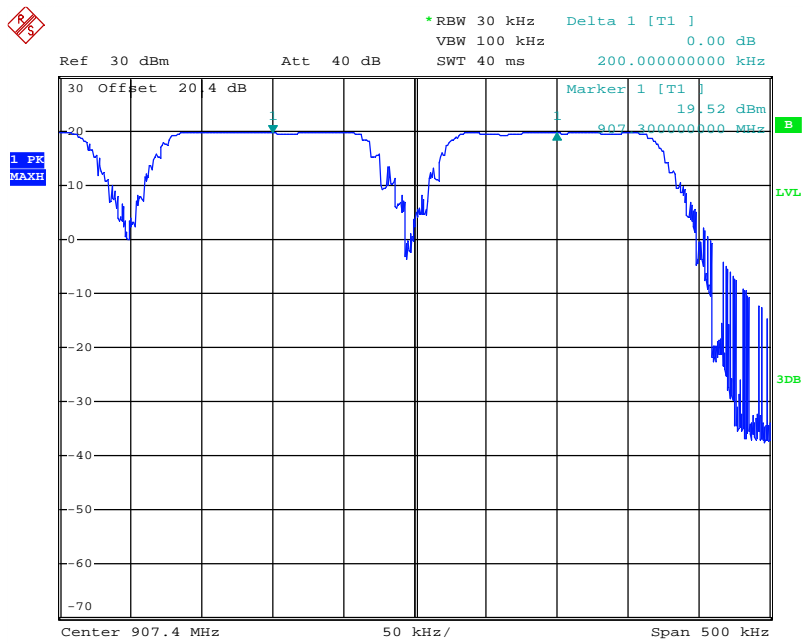
Date: 11.JUL.2018 16:10:12

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



Date: 11.JUL.2018 15:42:08

Figure 7.3.1.2-3: Carrier Frequency Separation – LoRaWAN – SF9



Date: 11.JUL.2018 15:29:31

Figure 7.3.1.2-4: 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

The number of hopping channels for the LoRaWAN can vary from 6 to 49 in the Hybrid mode. Per FCC KDB 453039 Bluetooth Equipment, Spread Spectrum Digital Transmissions System, there is no minimum number of hopping channels associated with hybrid systems under FCC Section 15.247(f)

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.

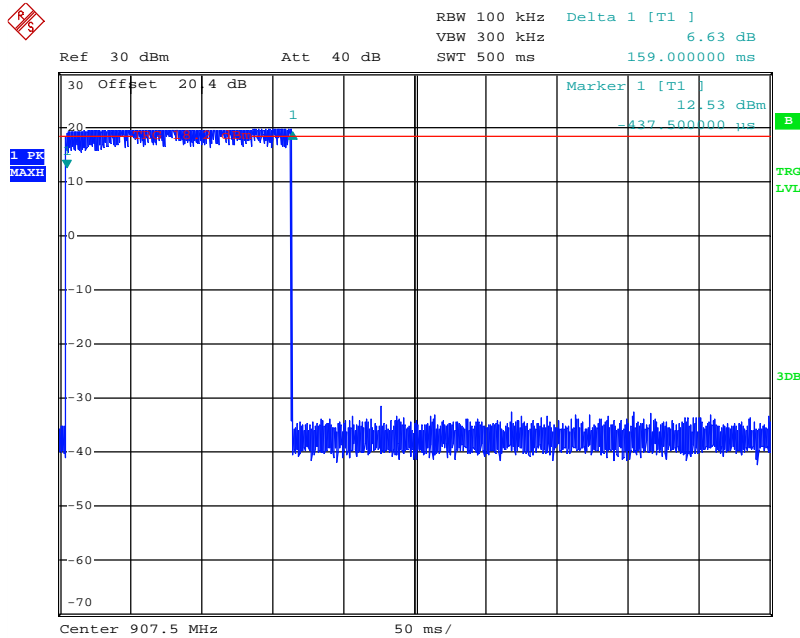
The Dwell Time was evaluated for the minimum and maximum number for channels for the Hybrid Mode over a 20 second period.

7.3.3.2 Measurement Results

Performed by: Thierry Jean-Charles

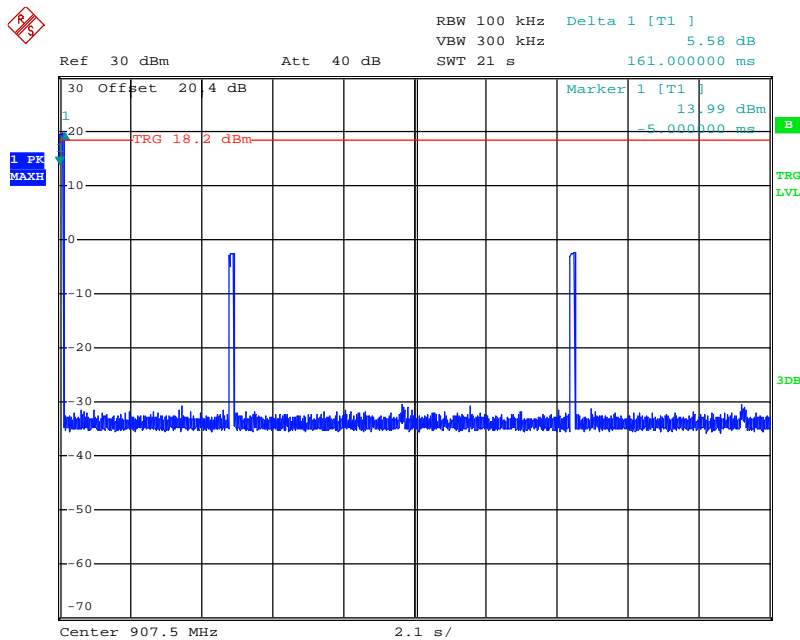
Table 7.3.3.2-1: Dwell Time on a 20 Second Cycle

Mode	Number of Hopping Channels	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
LoRaWAN	6	7	1	1	159.0000	159.0000	400	Pass
LoRaWAN	6	8	1	1	287.0625	287.0625	400	Pass
LoRaWAN	6	9	1	1	390.1875	390.1875	400	Pass
LoRaWAN	6	10	1	1	370.5000	370.5000	400	Pass
LoRaWAN	49	7	1	1	159.0000	149.0000	400	Pass
LoRaWAN	49	8	1	1	287.1250	287.1250	400	Pass
LoRaWAN	49	9	1	1	390.1250	390.1250	400	Pass
LoRaWAN	49	10	1	1	370.1250	370.1250	400	Pass



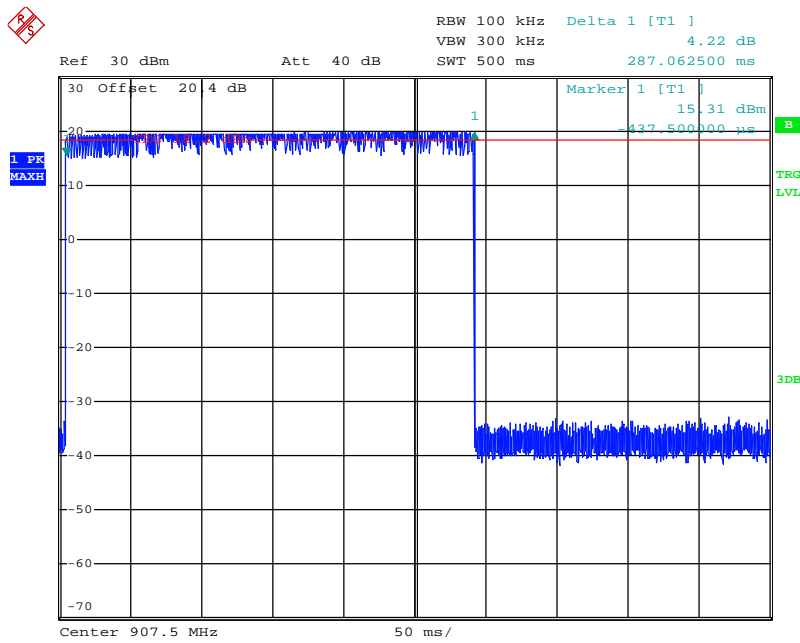
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Figure 7.3.3.2-1: Dwell Time – LoRaWAN – SF7



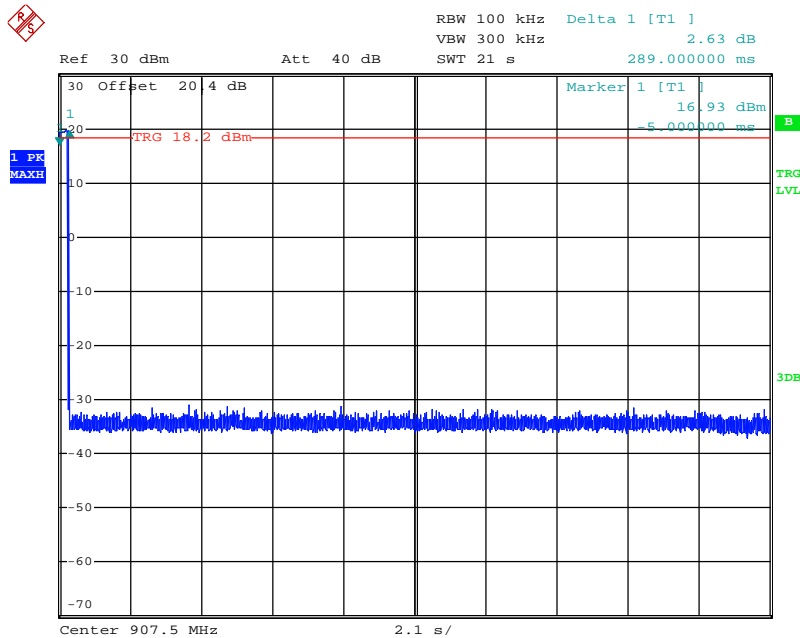
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Figure 7.3.3.2-2: Dwell Time – 20 Seconds – LoRaWAN – SF7



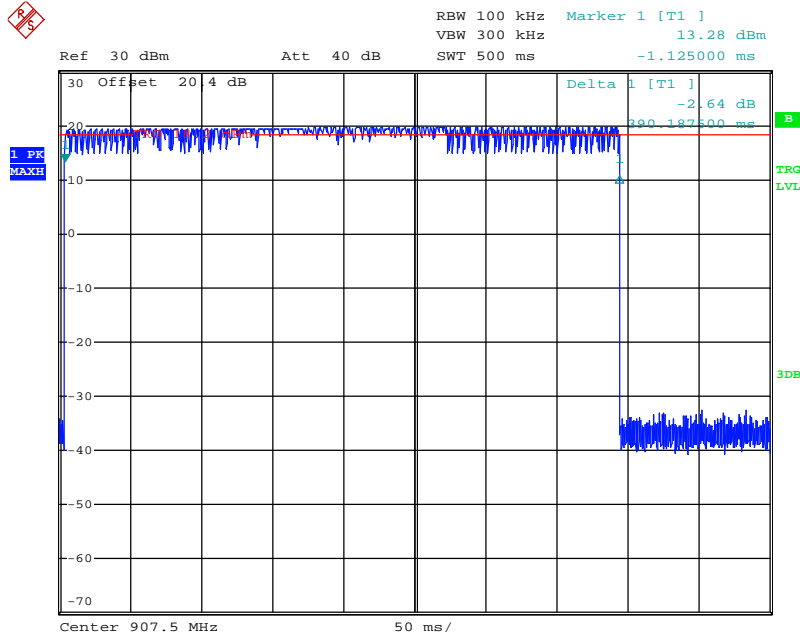
Date: 11.JUL.2018 14:15:19

Figure 7.3.3.2-3: Dwell Time – LoRaWAN – SF8



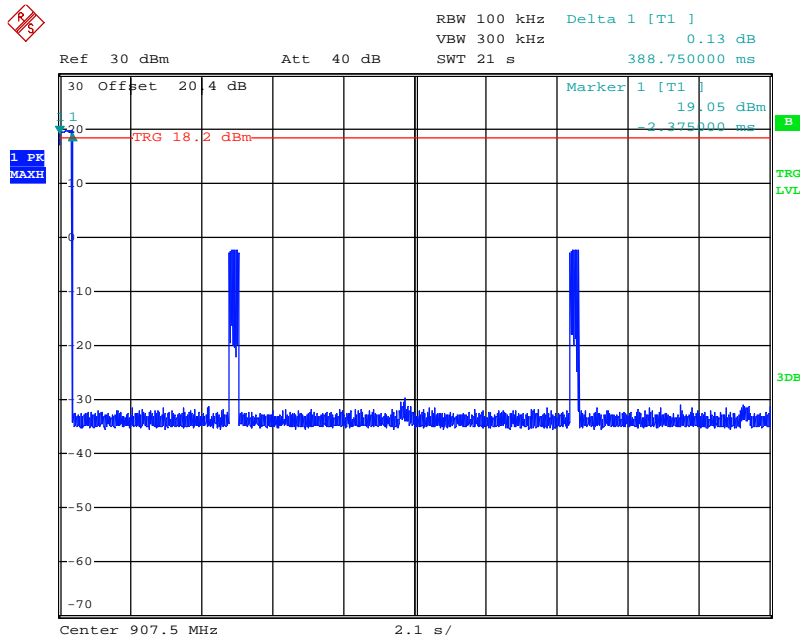
Date: 11.JUL.2018 14:17:24

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



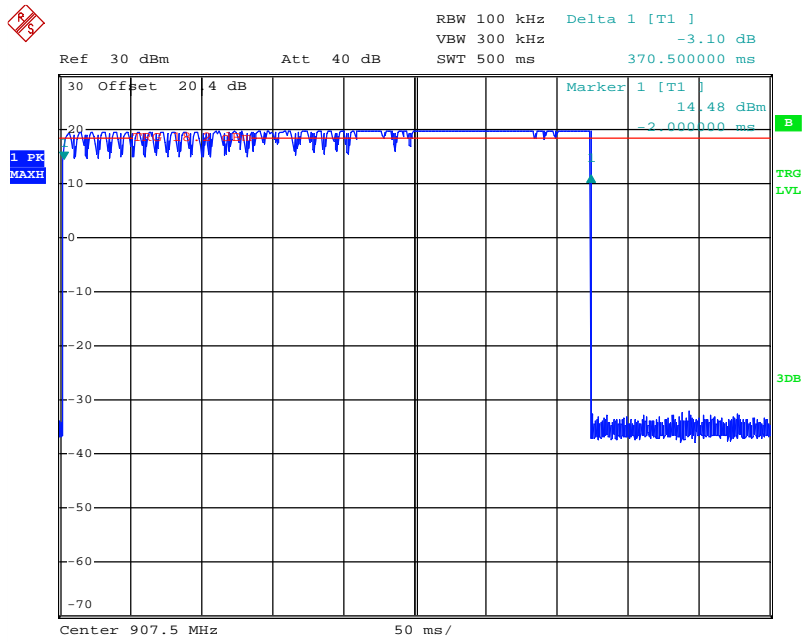
Date: 11.JUL.2018 14:29:29

Figure 7.3.3.2-5: Dwell Time – LoRaWAN – SF9



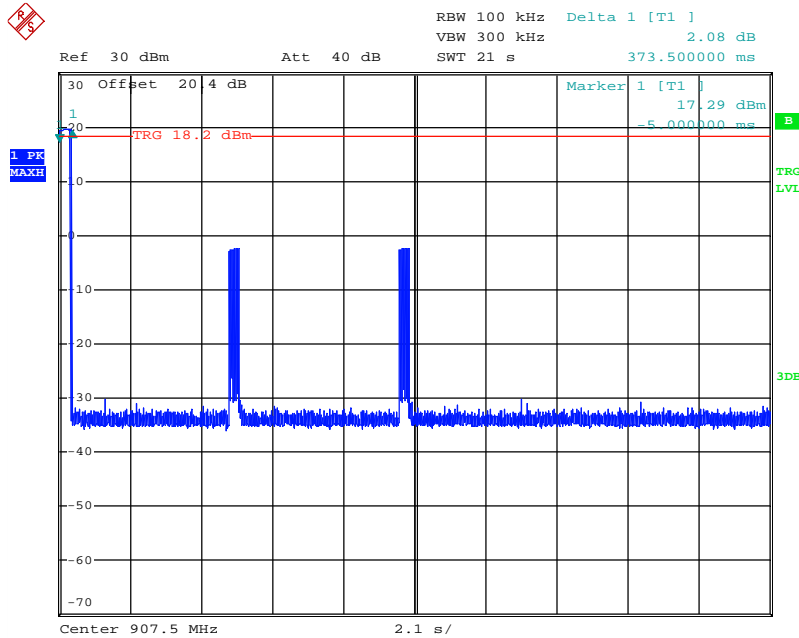
Date: 11.JUL.2018 14:27:07

Figure 7.3.3.2-6: Dwell Time – 20 Seconds – LoRaWAN – SF9



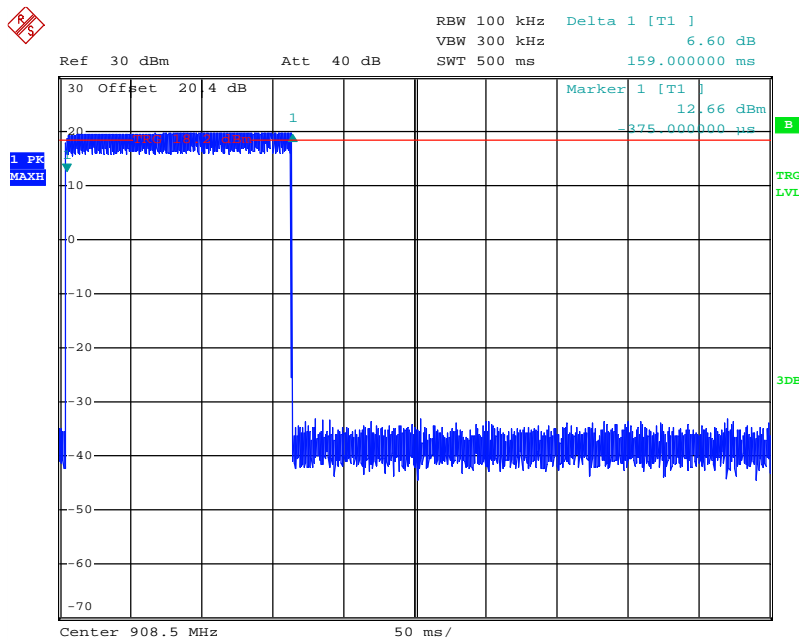
Date: 11.JUL.2018 14:44:39

Figure 7.3.3.2-7: Dwell Time – LoRaWAN – SF10



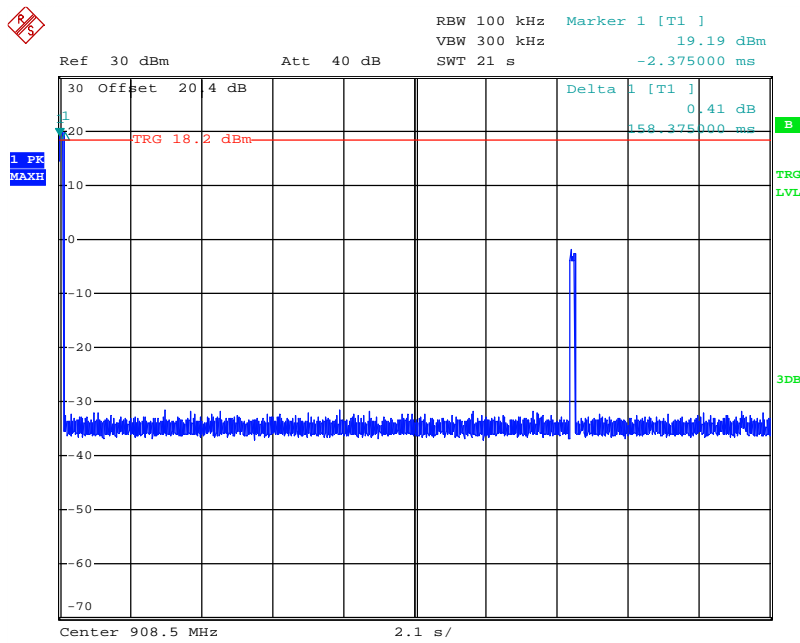
Date: 11.JUL.2018 14:48:08

Figure 7.3.3.2-8: Dwell Time – 20 Seconds – LoRaWAN – SF10



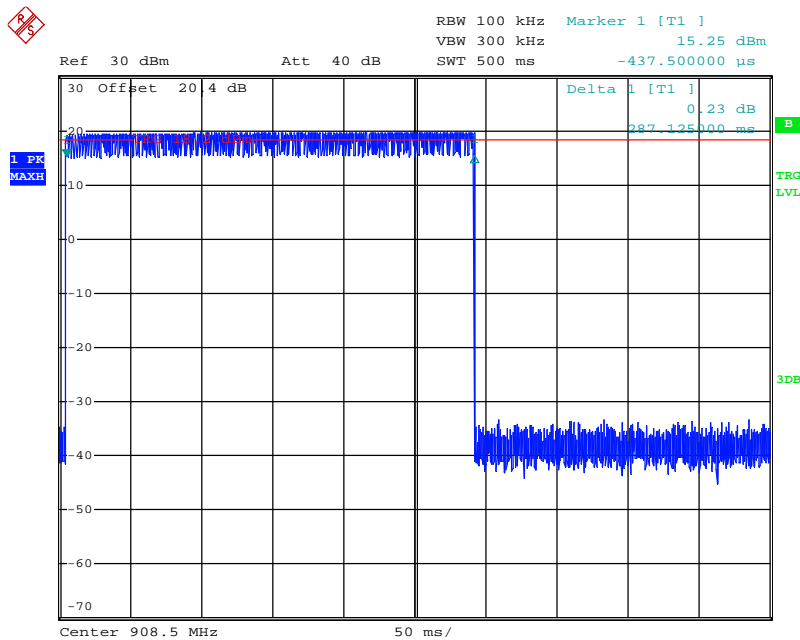
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Figure 7.3.3.2-9: Dwell Time – LoRaWAN – SF7



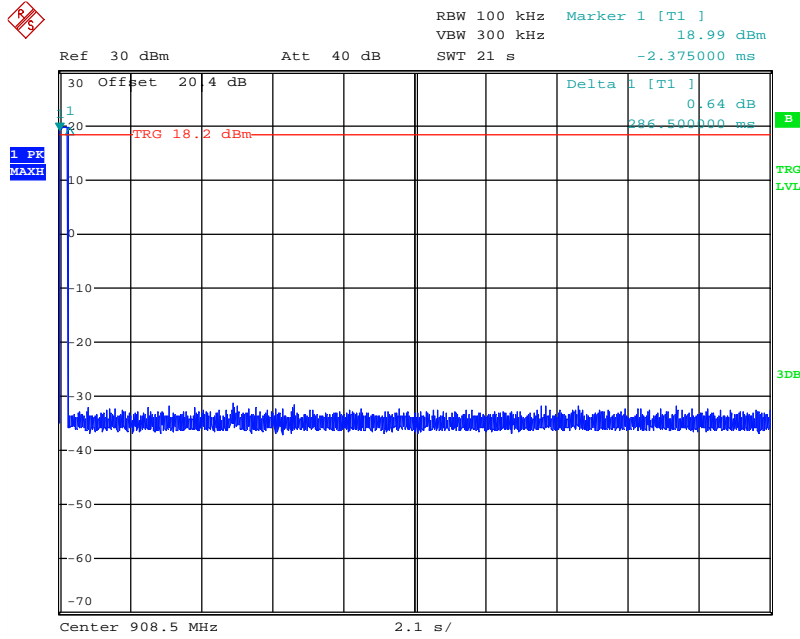
Date: 11.JUL.2018 13:37:20

Figure 7.3.3.2-10: Dwell Time – 20 Seconds – LoRaWAN – SF7



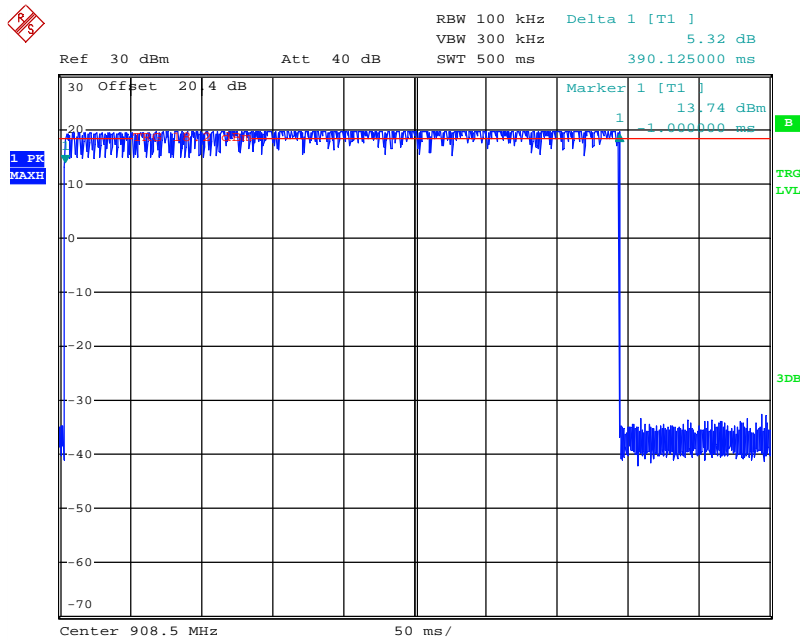
Date: 11.JUL.2018 13:29:10

Figure 7.3.3.2-11: Dwell Time – LoRaWAN – SF8



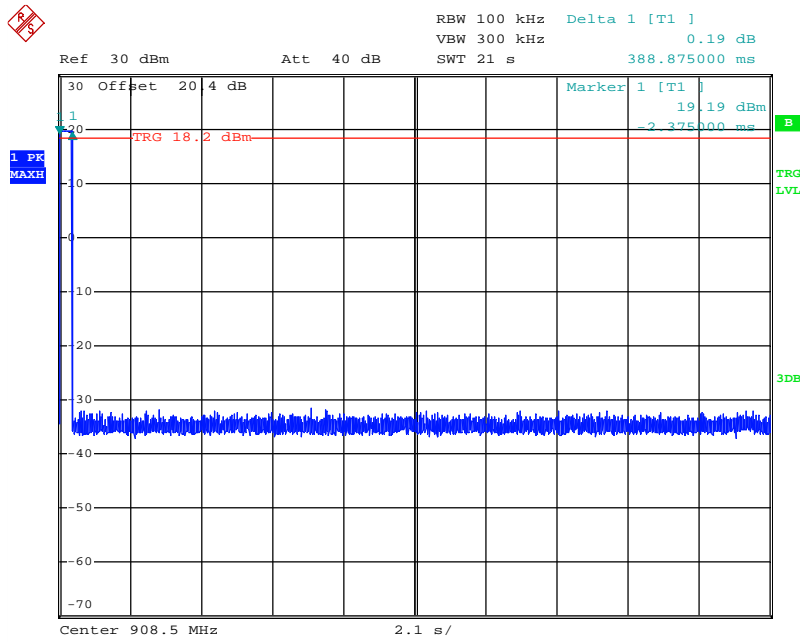
Date: 11.JUL.2018 13:16:42

Figure 7.3.3.2-12: Dwell Time – 20 Seconds – LoRaWAN – SF8



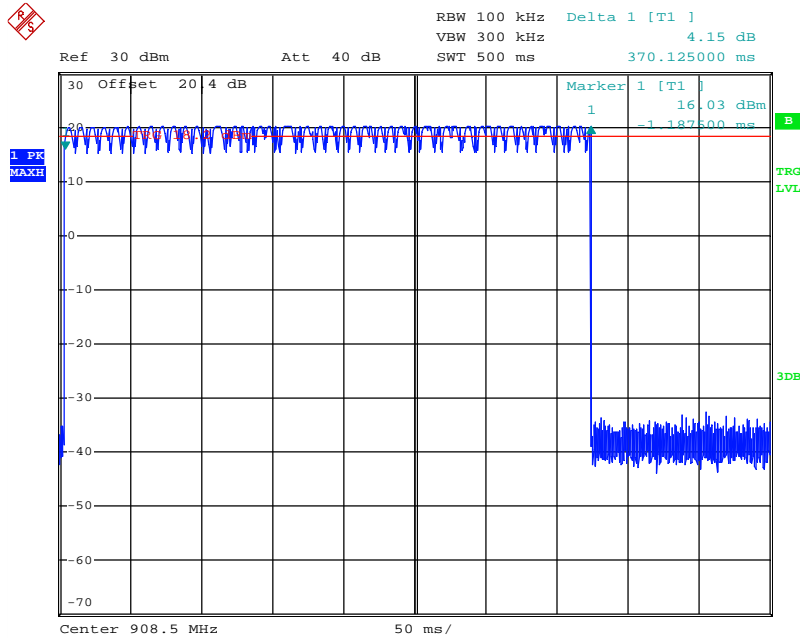
Date: 11.JUL.2018 12:26:04

Figure 7.3.3.2-13: Dwell Time – LoRaWAN – SF9



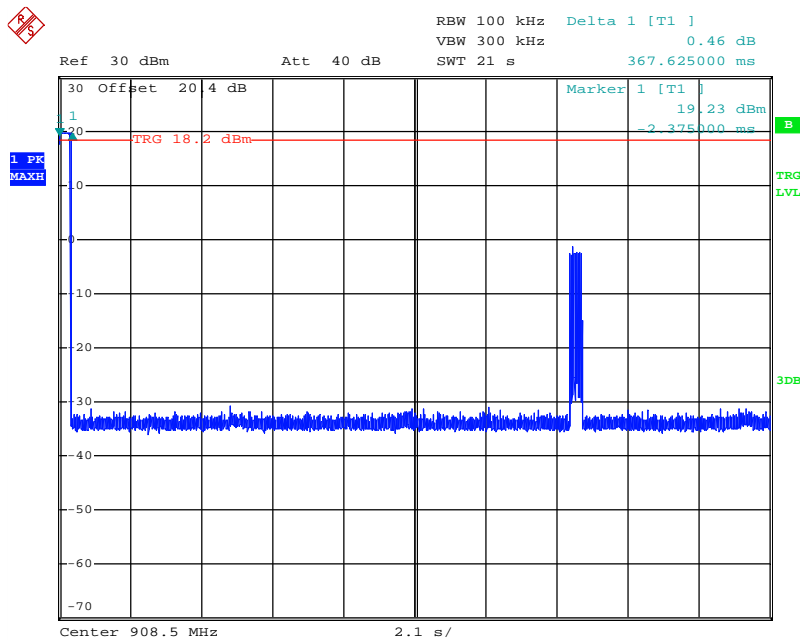
Date: 11.JUL.2018 12:37:52

Figure 7.3.3.2-14: Dwell Time – 20 Seconds – LoRaWAN – SF9



Date: 17.JUL.2018 14:00:55

Figure 7.3.3.2-15: Dwell Time – LoRaWAN – SF10



Date: 11.JUL.2018 11:46:00

Figure 7.3.3.2-16: 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.

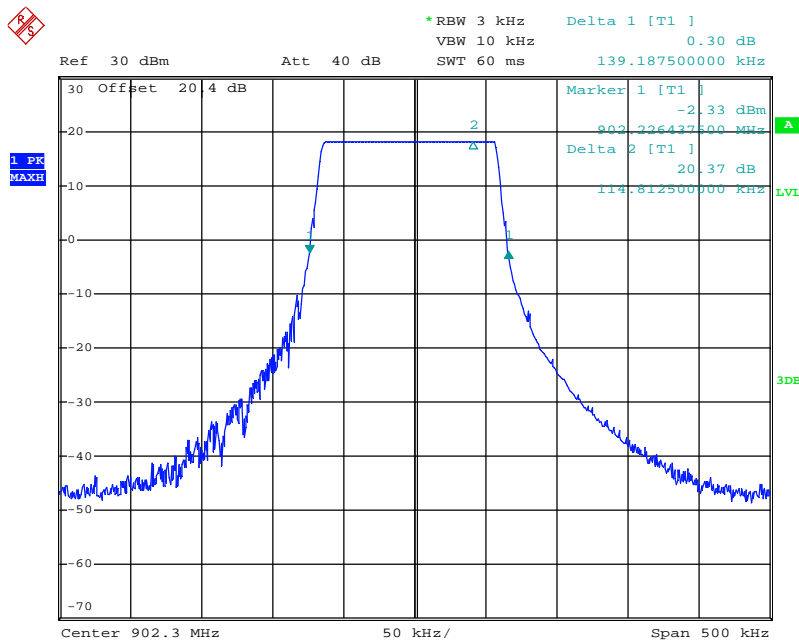
The 99% occupied bandwidth was measured with the spectrum analyzer span set to fully display the emission. The RBW was set to 1% to 5% of the approximated bandwidth. The occupied 99% bandwidth was measured by using the 99% bandwidth equipment function of the spectrum analyzer.

7.3.4.2 Measurement Results

Performed by: Thierry Jean-Charles

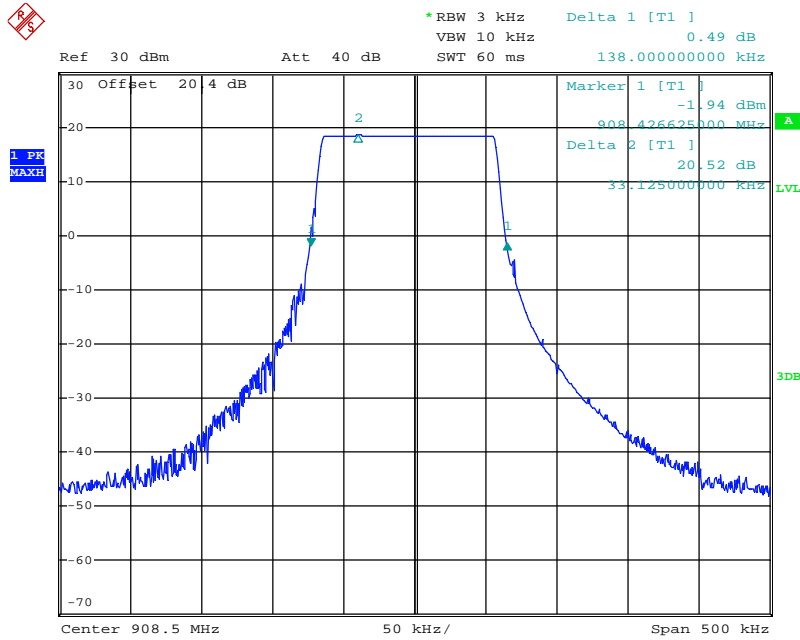
Table 7.3.4.2-1: 20dB / 99% Bandwidth – RFV4

Frequency (MHz)	20dB Bandwidth (kHz)	99% Bandwidth (kHz)
902.3	139.1875	125.8125
908.5	138.0000	125.8750
914.9	138.6875	125.3750



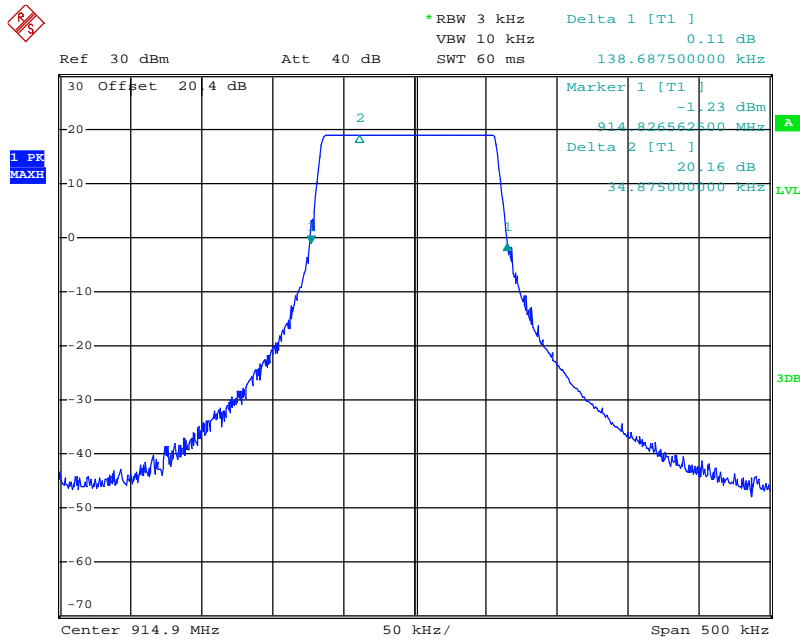
Date: 10.JUL.2018 14:51:05

Figure 7.3.4.2-1: 20 dB BW – Low Channel



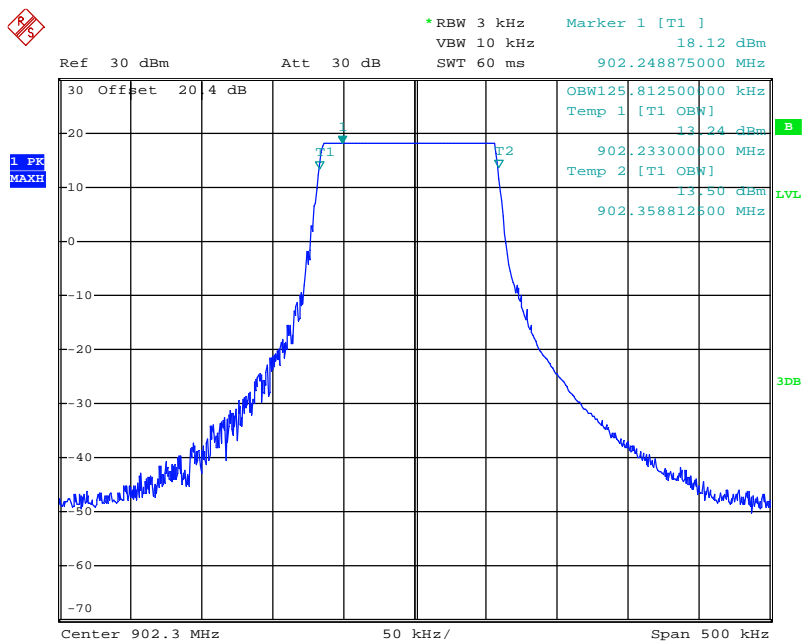
Date: 10.JUL.2018 15:41:48

Figure 7.3.4.2-2: 20 dB BW – Middle Channel



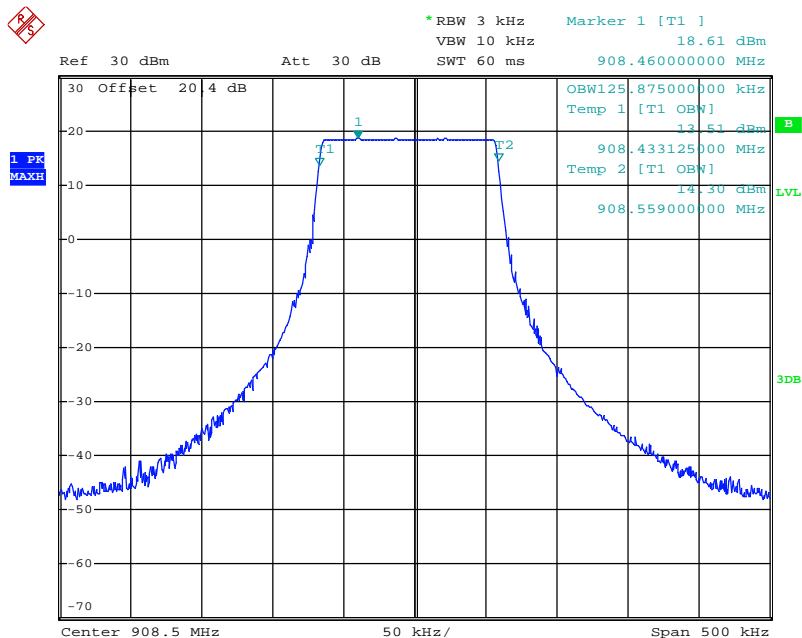
Date: 10.JUL.2018 16:05:01

Figure 7.3.4.2-3: 20 dB BW – High Channel



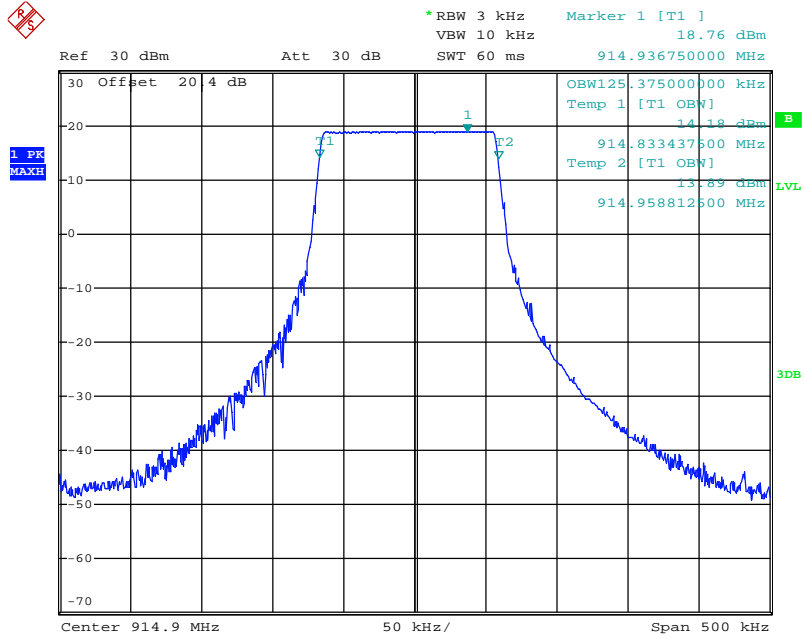
Date: 10.JUL.2018 14:57:58

Figure 7.3.4.2-4: 99% BW – Low Channel



Date: 10.JUL.2018 15:34:32

Figure 7.3.4.2-5: 99% BW – Middle Channel



Date: 10.JUL.2018 16:12:53

Figure 7.3.4.2-6: 99% BW – High Channel

7.4 Band-Edge Compliance and Spurious Emissions

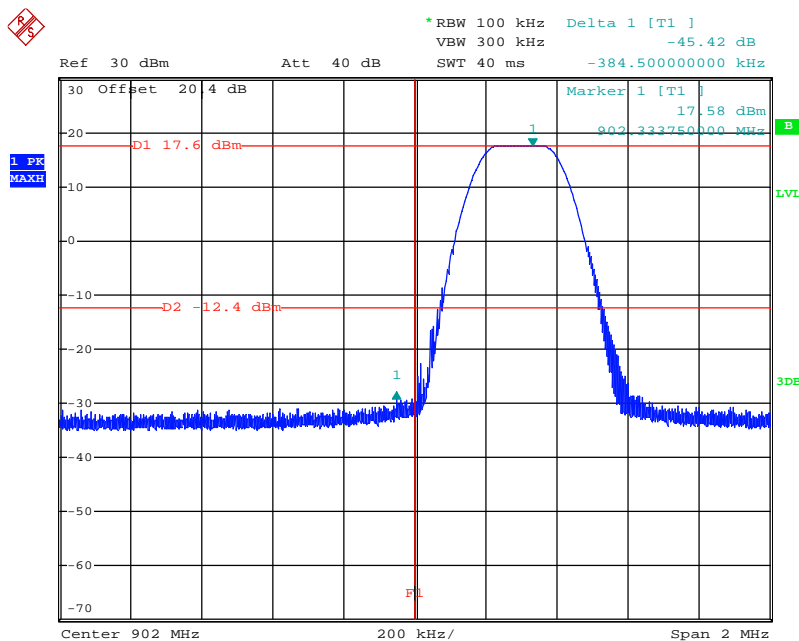
7.4.1 Band-Edge Compliance of RF Conducted Emissions – FCC: Section 15.247(d); ISED Canada: RSS-247 5.5

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.

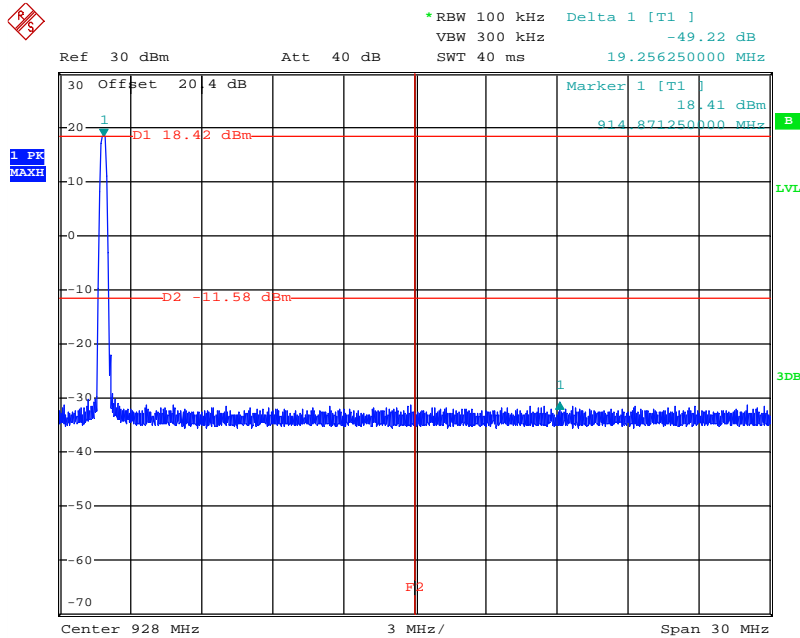
7.4.1.2 Measurement Results

Performed by: Thierry Jean-Charles



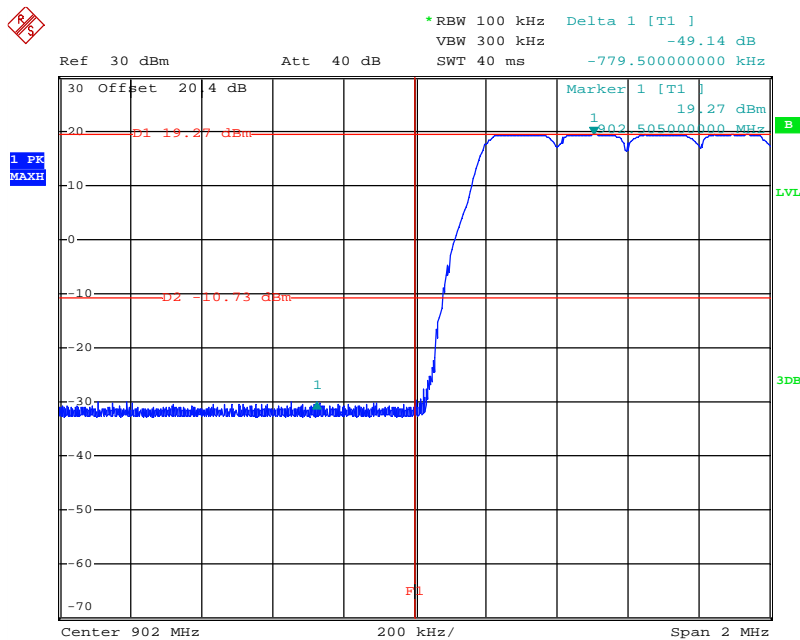
Date: 10.JUL.2018 17:24:19

Figure 7.4.1.2-1: Lower Band-edge



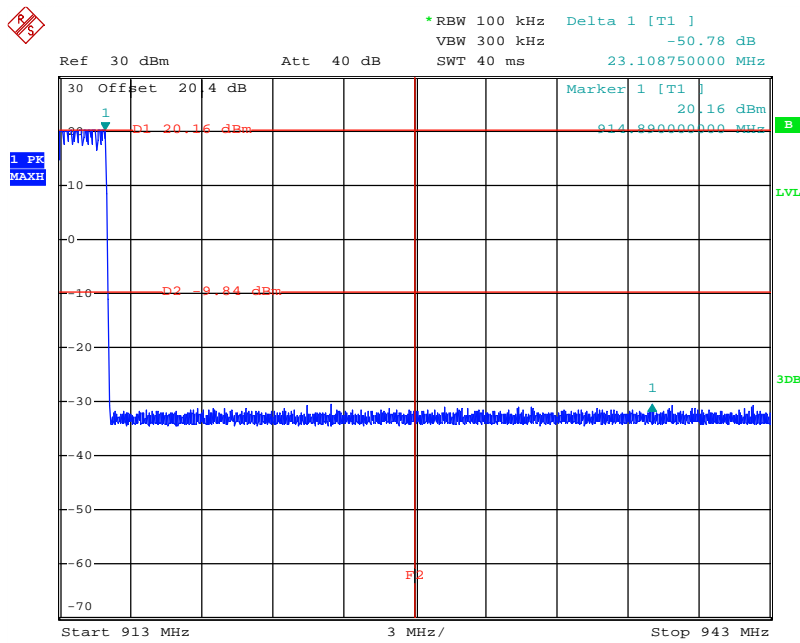
Date: 10.JUL.2018 17:43:53

Figure 7.4.1.2-2: Upper Band-edge



Date: 11.JUL.2018 08:47:29

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



Date: 11.JUL.2018 09:12:19

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

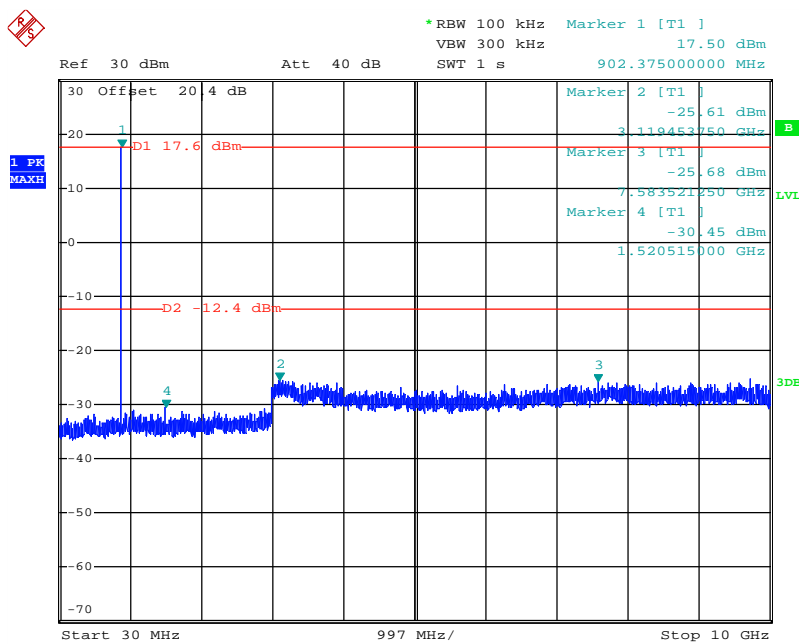
7.4.2 RF Conducted Spurious Emissions – FCC: Section 15.247(d); ISED Canada: RSS-247 5.5

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.

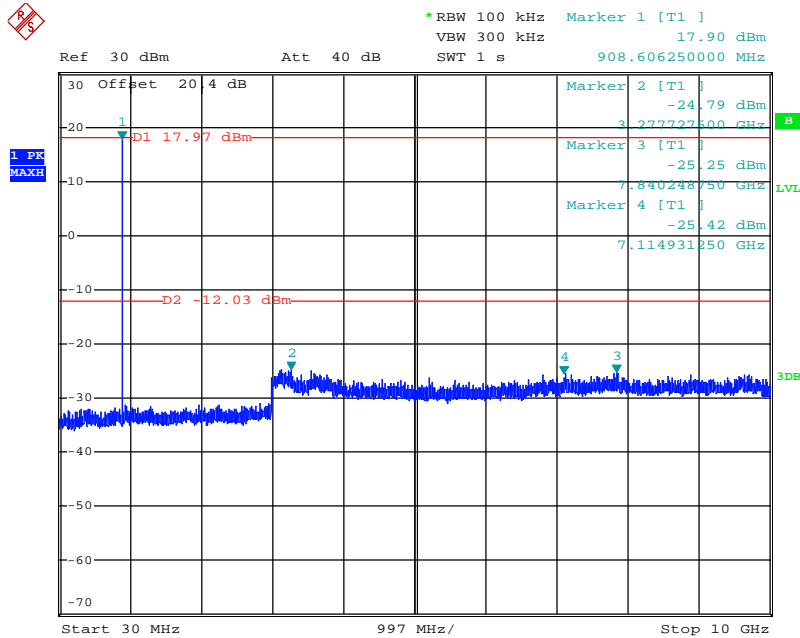
7.4.2.2 Measurement Results

Performed by: Thierry Jean-Charles



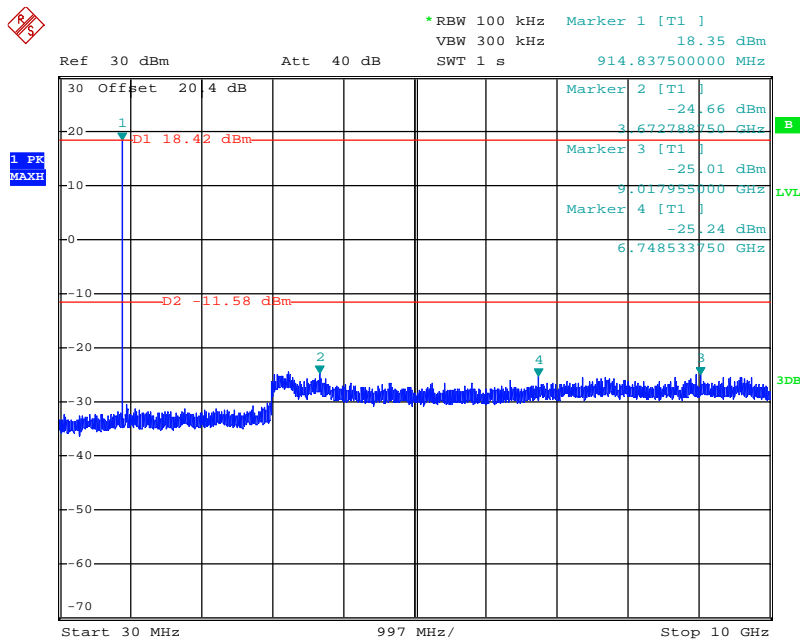
Date: 10.JUL.2018 17:26:24

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



Date: 10.JUL.2018 17:34:59

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



Date: 10.JUL.2018 17:48:04

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

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 (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
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 SF8: 908.5 MHz)										
2725.5	45.32	39.94	H	2.40	47.72	42.34	74.0	54.0	26.3	11.7
2725.5	43.44	36.17	V	2.40	45.84	38.57	74.0	54.0	28.2	15.4
3634	40.27	29.92	H	5.99	46.26	35.91	74.0	54.0	27.7	18.1
3634	40.23	29.57	V	5.99	46.22	35.56	74.0	54.0	27.8	18.4
4542.5	38.94	28.72	H	7.97	46.91	36.69	74.0	54.0	27.1	17.3
4542.5	40.37	31.00	V	7.97	48.34	38.97	74.0	54.0	25.7	15.0
5451	38.08	24.88	H	10.66	48.74	35.54	74.0	54.0	25.3	18.5
5451	37.74	24.35	V	10.66	48.40	35.01	74.0	54.0	25.6	19.0
7268	43.69	35.86	H	13.93	57.62	49.79	74.0	54.0	16.4	4.2
7268	42.61	32.02	V	13.93	56.54	45.95	74.0	54.0	17.5	8.1
8176.5	40.61	26.86	H	15.10	55.71	41.96	74.0	54.0	18.3	12.0
8176.5	39.64	24.80	V	15.10	54.74	39.90	74.0	54.0	19.3	14.1
High 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

Notes:

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

7.4.4 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: PeakCorrected Level: $45.86 + 2.31 = 48.17$ dB μ V/mMargin: 74 dB μ V/m $- 48.17$ dB μ V/m = 25.83 dB**Example Calculation: Average**Corrected Level: $40.39 + 2.31 = 42.7$ dB μ V/mMargin: 54 dB μ V/m $- 42.7$ dB μ V/m = 11.3 dB

7.5 Power Spectral Density – FCC: Section 15.247(e); ISED Canada: RSS-247 5.2(b)

7.5.1 PSD Measurement Procedure (Conducted Method)

The power spectral density was measured in accordance with the FCC KDB 558074 D01 DTS Meas Guidance v04 Section 10.3 Method AVGPS-1 (trace averaging with EUT transmitting at full power throughout each sweep). The RF output port of the EUT was directly connected to the input of the spectrum analyzer. Offset values were input for cable and external attenuation. The spectrum analyzer RBW was set to 3 kHz and VBW to 10 kHz. The Span was adjusted to greater than 1.5 times the 99% bandwidth (OBW) and the sweep time was set to auto. The measurements were performed using an RSM power averaging detector.

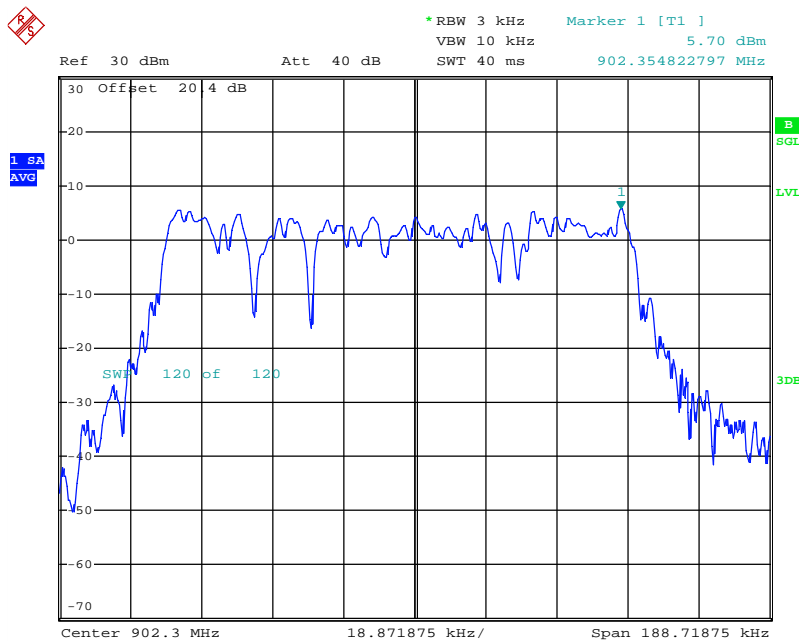
7.5.2 Measurement Results

Performed by: Thierry Jean-Charles

Results are shown below.

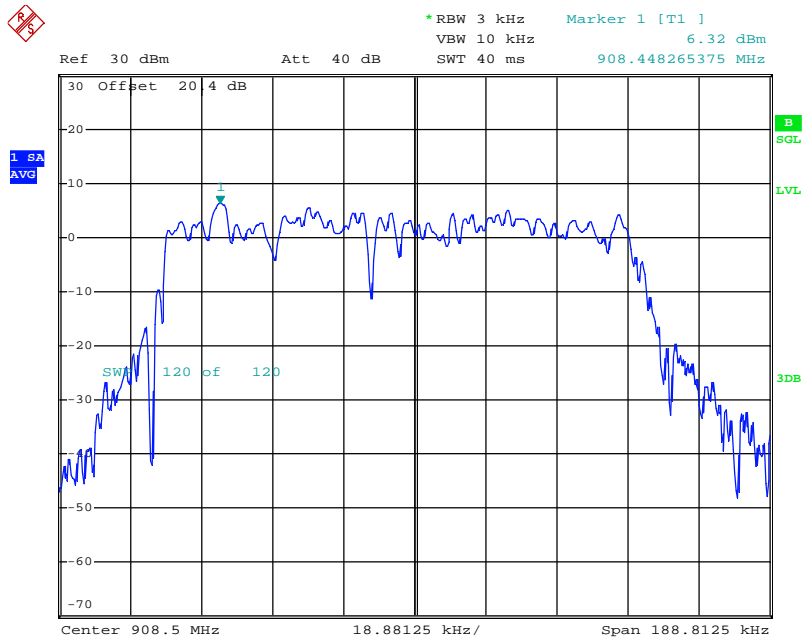
Table 7.5.2-1: Power Spectral Density

Frequency (MHz)	PSD (dBm)	Limit (dBm)	Margin (dB)
902.3	5.70	8.0	2.30
908.5	6.32	8.0	1.68
914.9	6.55	8.0	1.45



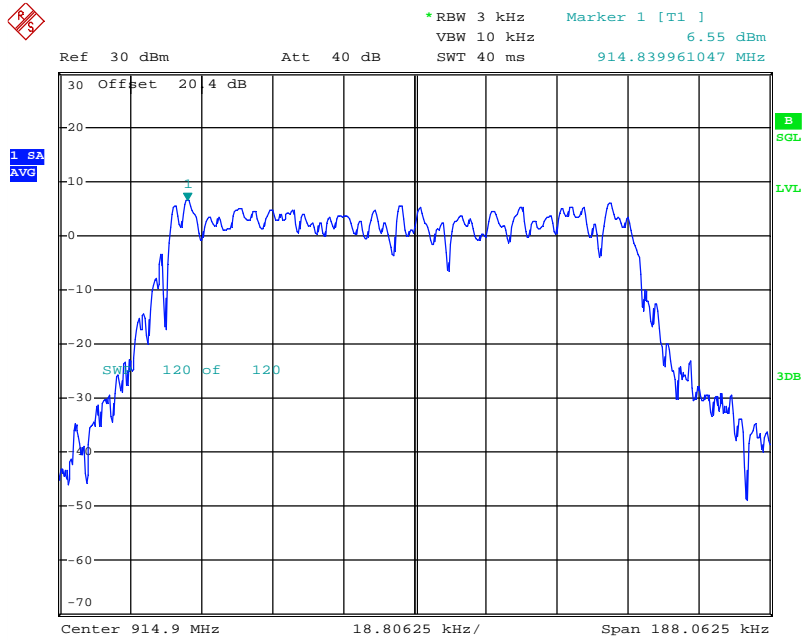
Date: 10.JUL.2018 16:45:26

Figure 7.5.2-1: Power Spectral Density - Low Channel



Date: 10.JUL.2018 16:33:22

Figure 7.5.2-2: Power Spectral Density - Middle Channel



Date: 10.JUL.2018 16:29:39

Figure 7.5.2-3: Power Spectral Density – High Channel

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	$\pm 0.009 \%$
RF Conducted Output Power	$\pm 1.15 \text{ dB}$
Power Spectral Density	$\pm 1.15 \text{ dB}$
Antenna Port Conducted Emissions	$\pm 1.15 \text{ dB}$
Radiated Emissions $\leq 1\text{GHz}$	$\pm 5.86 \text{ dB}$
Radiated Emissions $> 1\text{GHz}$	$\pm 4.65 \text{ dB}$
Temperature	$\pm 0.860 \text{ }^\circ\text{C}$
Radio Frequency	$\pm 2.832 \times 10^{-8}$
AC Power Line Conducted Emissions	$\pm 3.72 \text{ dB}$

9 CONCLUSION

In the opinion of TÜV SÜD America, Inc. the models 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