



# **TEST RESULTS**

**Test Report No. : UL-RPT-RP12592099-1118A V3.0**

**Manufacturer** : Plugwise B.V.  
**Model No. / HVIN** : 106-03  
**PMN** : Tom  
**FCC ID** : ZB9-10603  
**ISED Certification No.** : IC: 24142-10603  
**Technology** : Zigbee (IEEE 802.15.4)  
**Test Standard(s)** : FCC Parts 15.209(a) & 15.247  
Innovation, Science and Economic Development Canada  
RSS-247 Issue 2 February 2017 & RSS-Gen Issue 5 April 2018

1. This test report shall not be reproduced except in full, without the written approval of UL VS LTD.
2. The results in this report apply only to the sample(s) tested.
3. This sample tested is not in compliance with the above standard(s).
4. The test results in this report are traceable to the national or international standards.
5. Version 3.0 supersedes all previous versions.

**Date of Issue:** 05 December 2019

**Checked by:**

Ben Mercer  
Senior Test Engineer, Radio Laboratory

**Company Signatory:**

Sarah Williams  
Senior Test Engineer, Radio Laboratory  
UL VS LTD



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## **UL VS LTD**

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## **1. Customer Information**

<b>Company Name:</b>	Plugwise B.V.
<b>Address:</b>	Wattstraat 56 2171TR Sassenheim The Netherlands

## **2. Summary of Testing**

### **2.1. General Information**

<b>Specification Reference:</b>	47CFR15.247
<b>Specification Title:</b>	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Section 15.247
<b>Specification Reference:</b>	47CFR15.209
<b>Specification Title:</b>	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Sections 15.209
<b>Specification Reference:</b>	RSS-Gen Issue 5 April 2018
<b>Specification Title:</b>	General Requirements for Compliance of Radio Apparatus
<b>Specification Reference:</b>	RSS-247 Issue 2 February 2017
<b>Specification Title:</b>	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
<b>FCC Site Registration:</b>	621311
<b>ISEDC Site Registration:</b>	3254B
<b>Location of Testing:</b>	UL VS LTD, Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom
<b>Test Dates:</b>	04 February 2019 to 25 September 2019

## 2.2. Summary of Test Results

FCC Reference (47CFR)	ISED Canada Reference	Measurement	Result
Part 15.247(a)(2)	RSS-Gen 8.8	Transmitter Minimum 6 dB Bandwidth	✓
N/A	RSS-Gen 6.7 / RSS-247 5.2(a)	Transmitter 99% Occupied Bandwidth	✓
Part 15.35(c)	RSS-Gen 6.10	Transmitter Duty Cycle	Note 1
Part 15.247(e)	RSS-Gen 6.7	Transmitter Power Spectral Density	Note 2
Part 15.247(b)(3)	RSS-247 5.2(b)	Transmitter Maximum Peak Output Power	✓
Part 15.247(d) / 15.209(a)	RSS-Gen 6.13 & 8.9 / RSS-247 5.5	Transmitter Radiated Emissions	✓
Part 15.247(d) / 15.209(a)	RSS-Gen 6.13 & 8.9 / RSS-247 5.5	Transmitter Band Edge Radiated Emissions	✓
Part 15.207(a)	RSS-Gen 8.8	Transmitter AC Conducted Emissions	✓

**Key to Results**

✓ = Complied    ✗ = Did not comply

### Note(s):

1. The measurement was performed to assist with the calculation of the level of average radiated emissions.
2. In accordance with FCC KDB 558074 Section 10.1 / ANSI C63.10 Section 11.10.1, PSD is not required if the maximum conducted output power is less than the PSD limit of 8 dBm / 3 kHz. The PSD level is therefore deemed to be equal to the measured total output power.

## 2.3. Methods and Procedures

<b>Reference:</b>	ANSI C63.10-2013
<b>Title:</b>	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
<b>Reference:</b>	KDB 558074 D01 DTS Meas Guidance v05r02 April 2, 2019
<b>Title:</b>	Guidance for Compliance Measurements on Digital Transmission Systems, Frequency Hopping Spread Spectrum System, and Hybrid System Devices Operating Under Section 15.247 of the FCC rules
<b>Reference:</b>	KDB 174176 D01 Line Conducted FAQ v01r01 June 3, 2015
<b>Title:</b>	AC Power-Line Conducted Emissions Frequently Asked Questions

## 2.4. Deviations from the Test Specification

For the measurements contained within this test report, there were no deviations from, additions to, or exclusions from the test specification identified above.

### **3. Equipment Under Test (EUT)**

#### **3.1. Identification of Equipment Under Test (EUT)**

<b>Brand Name:</b>	Plugwise
<b>Model No. / HVIN:</b>	106-03
<b>Test Sample Serial Number:</b>	CA1385 ( <i>Conducted Sample – Continuous transmit tests</i> )
<b>Hardware Version:</b>	106-03
<b>Software Version:</b>	ETRX_PW_R0017 / 2016-04-15T02:00:00+02:00
<b>FCC ID:</b>	ZB9-10603
<b>ISED Canada Certification No.</b>	24142-10603

<b>Brand Name:</b>	Plugwise
<b>Model No. / HVIN:</b>	106-03
<b>Test Sample Serial Number:</b>	CA1385 ( <i>Conducted Sample – Duty cycle tests</i> )
<b>Hardware Version:</b>	106-03
<b>Software Version:</b>	ETRX_PW_R0017 / 2016-04-15T02:00:00+02:00
<b>FCC ID:</b>	ZB9-10603
<b>ISED Canada Certification No.</b>	24142-10603

<b>Brand Name:</b>	Plugwise
<b>Model No. / HVIN:</b>	106-03
<b>Test Sample Serial Number:</b>	CA02F7 ( <i>Radiated Sample – Continuous transmit tests</i> )
<b>Hardware Version:</b>	106-03
<b>Software Version:</b>	ETRX_PW_R0017 / 2016-04-15T02:00:00+02:00
<b>FCC ID:</b>	ZB9-10603
<b>ISED Canada Certification No.</b>	24142-10603

<b>Brand Name:</b>	Plugwise
<b>Model No. / HVIN:</b>	106-03
<b>Test Sample Serial Number:</b>	C980D9 ( <i>Radiated Sample – AC conducted tests</i> )
<b>Hardware Version:</b>	106-03
<b>Software Version:</b>	ETRX_PW_R0017 / 2016-04-15T02:00:00+02:00
<b>FCC ID:</b>	ZB9-10603
<b>ISED Canada Certification No.</b>	24142-10603

### **3.2. Description of EUT**

The equipment under test was a wireless thermostatic radiator valve which incorporated Zigbee (IEEE802.15.4) functionality.

### **3.3. Modifications Incorporated in the EUT**

No modifications were applied to the EUT during testing.

### **3.4. Additional Information Related to Testing**

<b>Technology Tested:</b>	IEEE 802.15.4 (Digital Transmission System)		
<b>Type of Unit:</b>	Transceiver		
<b>Modulation:</b>	O-QPSK		
<b>Data Rate:</b>	250 kb/s		
<b>Power Supply Requirement(s):</b>	Nominal	3.0 VDC via 2 x AA Batteries	
<b>Maximum Conducted Output Power:</b>	5.6 dBm		
<b>Antenna Gain:</b>	5.1 dBi		
<b>Transmit Frequency Range:</b>	2405 MHz to 2480 MHz		
<b>Transmit Channels Tested:</b>	<b>Channel ID</b>	<b>Channel Number</b>	<b>Channel Frequency (MHz)</b>
	Bottom	11	2405
	Middle	19	2445
	Top	26	2480

### **3.5. Support Equipment**

The following support equipment was used to exercise the EUT during testing:

<b>Description:</b>	Laptop PC
<b>Brand Name:</b>	Acer
<b>Model Name or Number:</b>	Aspire N17Q4
<b>Serial Number:</b>	NXGVEH003820005157600

<b>Description:</b>	USB Zigbee Stick
<b>Brand Name:</b>	Plugwise
<b>Model Name or Number:</b>	Zigbee Stick
<b>Serial Number:</b>	2B11BB

<b>Description:</b>	USB Hub
<b>Brand Name:</b>	Not marked or stated
<b>Model Name or Number:</b>	Not marked or stated
<b>Serial Number:</b>	Not marked or stated

<b>Description:</b>	USB Cable. Length 3m. Quantity 1.
<b>Brand Name:</b>	Not marked or stated
<b>Model Name or Number:</b>	Not marked or stated
<b>Serial Number:</b>	Not marked or stated

<b>Description:</b>	AC USB Charger
<b>Brand Name:</b>	Huoniu
<b>Model Name or Number:</b>	HNBB050100UX
<b>Serial Number:</b>	Not marked or stated

## **4. Operation and Monitoring of the EUT during Testing**

### **4.1. Operating Modes**

The EUT was tested in the following operating mode(s):

- Continuously transmitting at maximum power on bottom, middle and top channels as required.

### **4.2. Configuration and Peripherals**

The EUT was tested in the following configuration(s):

- Powered by 2 fully charged AA batteries. The battery voltage was monitored throughout testing.
- Continuous transmitter tests: Controlled using a bespoke application on the laptop PC supplied by the customer. The application was used to enable continuous transmission and to select the test channels as required. The customer supplied a document containing setup instructions, "*Readme-RF-test mode instructions.pdf*".
- Duty cycle tests: Controlled using a bespoke application on the laptop PC supplied by the customer. The application was used to enable burst transmission and to select the test channels as required. The customer supplied a document containing setup instructions, "*Readme-RF-duty cycle.pdf*".
- Transmitter radiated spurious emissions tests were performed with the EUT in the worst case orientation/position with respect to emissions. The EUT was connected to a USB hub to populate all active ports. The USB hub was placed underneath the chamber turntable.
- For AC conducted emissions tests, the EUT was powered by a Huoni AC to DC adapter supplied with the EUT.

## **5. Measurements, Examinations and Derived Results**

### **5.1. General Comments**

Measurement uncertainties are evaluated in accordance with current best practice. Our reported expanded uncertainties are based on standard uncertainties, which are multiplied by an appropriate coverage factor to provide a statistical confidence level of approximately 95%. Please refer to *Section 6. Measurement Uncertainty* for details.

In accordance with UKAS requirements all the measurement equipment is on a calibration schedule. All equipment was within the calibration period on the date of testing.

## **5.2. Test Results**

### **5.2.1. Transmitter Minimum 6 dB Bandwidth**

#### **Test Summary:**

<b>Test Engineer:</b>	Stefan Ho	<b>Test Date:</b>	05 February 2019
<b>Test Sample Serial Number:</b>	CA1385		

<b>FCC Reference:</b>	Part 15.247(a)(2)
<b>ISED Canada Reference:</b>	RSS-Gen 6.7 / RSS-247 5.2(a)
<b>Test Method Used:</b>	FCC KDB 558074 Section 8.2 referencing ANSI C63.10 Section 11.8.1

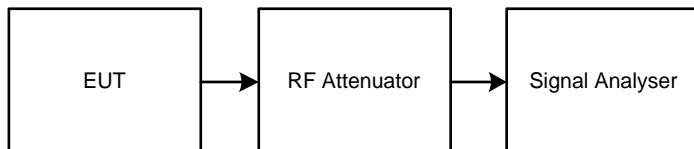
#### **Environmental Conditions:**

<b>Temperature (°C):</b>	21
<b>Relative Humidity (%):</b>	41

#### **Note(s):**

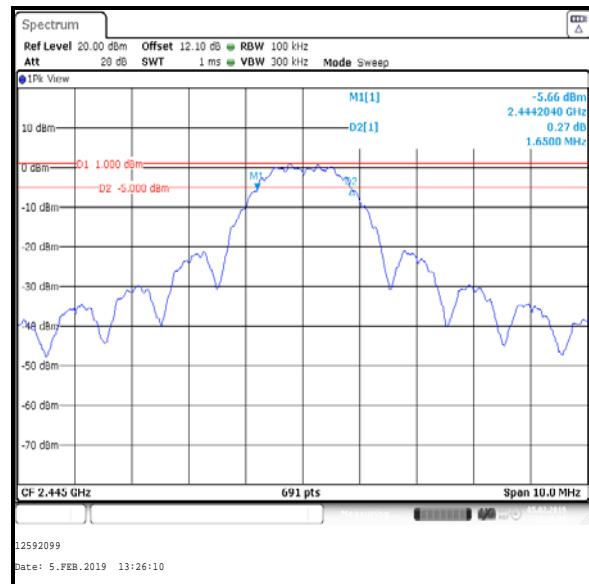
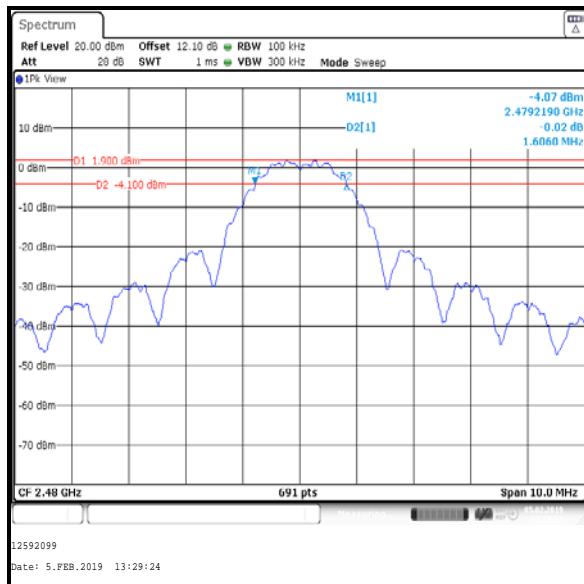
1. 6 dB DTS bandwidth tests were performed using a spectrum analyser in accordance with FCC KDB 558074 Section 8.2 measurement procedure. The spectrum analyser resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and the trace mode was Max Hold. The DTS bandwidth was measured at 6 dB down from the peak of the signal.
2. The test receiver was connected to the RF port on the EUT using suitable attenuation and RF cable.

#### **Test setup:**



**Transmitter Minimum 6 dB Bandwidth (continued)****Results:**

Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	1653.000	≥500	1153.000	Complied
Middle	1650.000	≥500	1150.000	Complied
Top	1606.000	≥500	1106.000	Complied

**Bottom Channel****Middle Channel****Top Channel**

**Transmitter Minimum 6 dB Bandwidth (continued)****Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2005	Thermohygrometer	Testo	608-H1	45046700	06 Jan 2020	12
M2036	Signal Analyser	Rohde & Schwarz	FSV30	101791	20 Apr 2019	12
G0628	Vector Signal Generator	Rohde & Schwarz	SMBV100A	261847	28 Sep 2020	36
A2524	Attenuator	AtlanTecRF	AN18W5-10	832827#2	Calibrated before use	-

### **5.2.2. Transmitter 99% Occupied Bandwidth**

#### **Test Summary:**

<b>Test Engineer:</b>	Stefan Ho	<b>Test Date:</b>	05 February 2019
<b>Test Sample Serial Number:</b>	CA1385		

<b>ISED Canada Reference:</b>	RSS-Gen 6.7
<b>Test Method Used:</b>	RSS-Gen 6.7

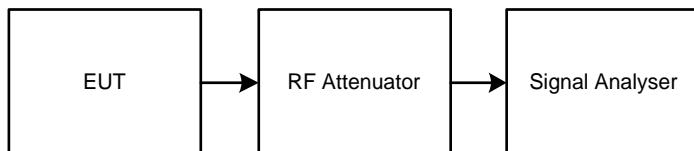
#### **Environmental Conditions:**

<b>Temperature (°C):</b>	21
<b>Relative Humidity (%):</b>	41

#### **Note(s):**

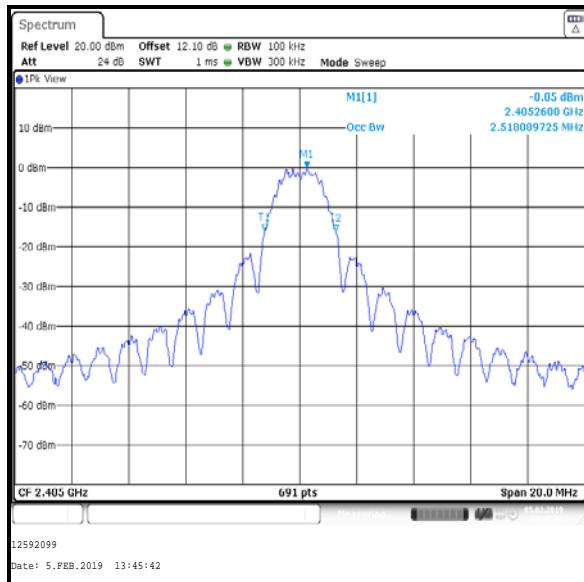
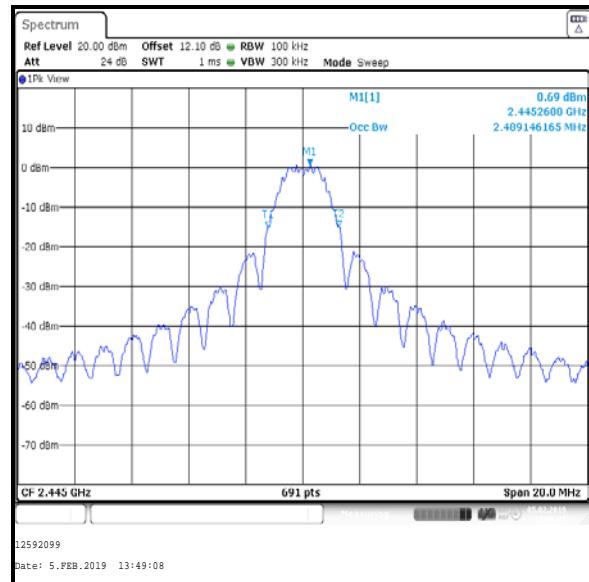
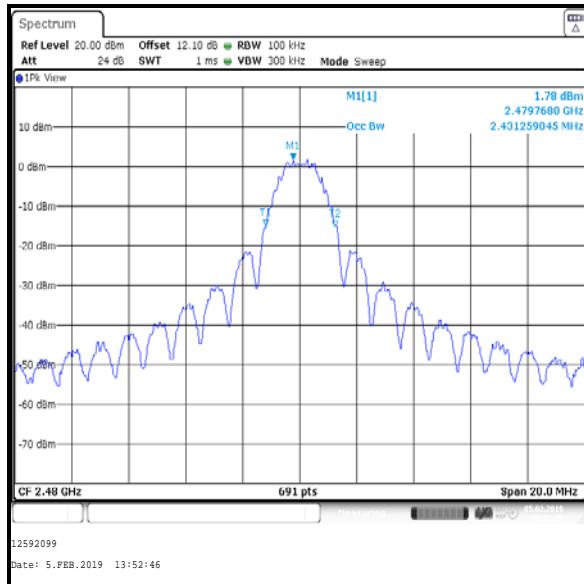
1. The 99% emission bandwidth was measured using the spectrum analyser occupied bandwidth function. The resolution bandwidth was set in the range of 1% to 5% of the occupied bandwidth and the video bandwidth set to 3 times the resolution bandwidth. The span was set to capture all products of the modulation process including emission skirts.
2. The spectrum analyser resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and the trace mode was Max Hold. The span was set to 20 MHz. The spectrum analyser function set the measurements to be made at 99% of the emission bandwidth. The results are given in the tables below.
3. The spectrum analyser was connected to the RF port on the EUT using suitable attenuation and RF cable.

#### **Test setup:**



**Transmitter 99% Occupied Bandwidth (continued)****Results:**

Channel	99% Occupied Bandwidth (kHz)
Bottom	2518.090
Middle	2489.146
Top	2431.259

**Bottom Channel****Middle Channel****Top Channel**

**Transmitter 99% Occupied Bandwidth (continued)****Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2005	Thermohygrometer	Testo	608-H1	45046700	06 Jan 2020	12
M2036	Signal Analyser	Rohde & Schwarz	FSV30	101791	20 Apr 2019	12
G0628	Vector Signal Generator	Rohde & Schwarz	SMBV100A	261847	28 Sep 2020	36
A2524	Attenuator	AtlanTecRF	AN18W5-10	832827#2	Calibrated before use	-

### **5.2.3. Transmitter Duty Cycle**

#### **Test Summary:**

<b>Test Engineer:</b>	Mohamed Toubella	<b>Test Date:</b>	02 September 2019
<b>Test Sample Serial Number:</b>	CA1385		

<b>FCC Reference:</b>	Part 15.35(c)
<b>ISED Canada Reference:</b>	RSS-Gen 6.10
<b>Test Method Used:</b>	FCC KDB 558074 Section 6.0 & 11, Answer 3 a). ANSI C63.10 Section 7.5.

#### **Environmental Conditions:**

<b>Temperature (°C):</b>	24
<b>Relative Humidity (%):</b>	46

#### **Note(s):**

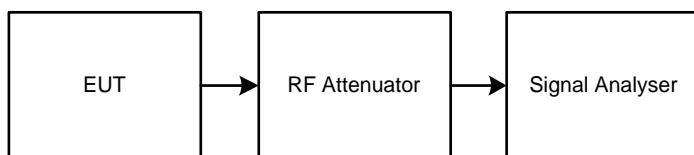
1. In order to assist with the determination of the average level of spurious emissions field strength, measurements were made of duty cycle to determine the transmission duration and the silent period time of the transmitter. The transmitter duty cycle was measured using a test receiver in the time domain and calculated by using the following calculation:

$$20 \log (1 / (\text{On Time} / [\text{Period or } 100 \text{ ms whichever is the lesser}])).$$

$$20 \log (1 / (512.821 \mu\text{s} / 100 \text{ ms})) = 45.8 \text{ dB}$$

2. The duty cycle correction cannot be greater than 20 dB, therefore 20 dB has been applied to all average measurements.

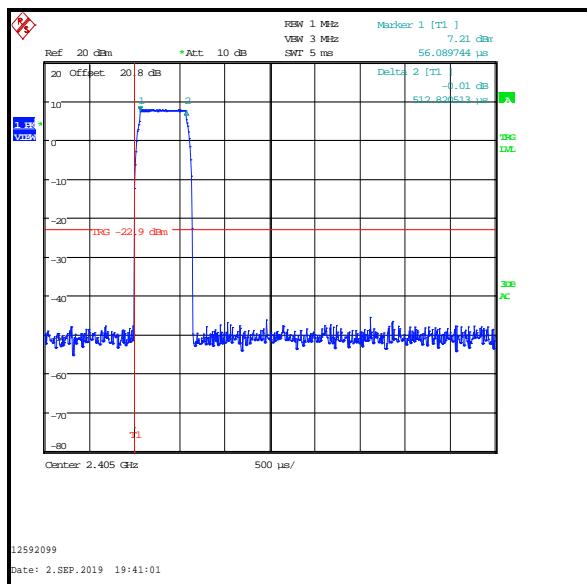
#### **Test setup:**



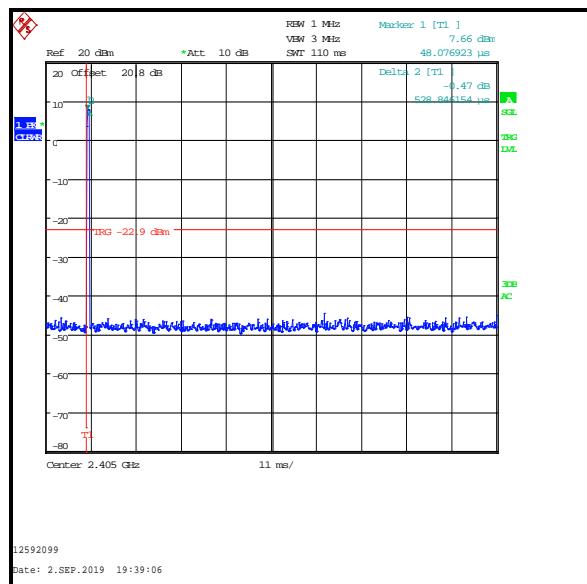
#### **Results:**

<b>Pulse Duration (μs)</b>	<b>Period (s)</b>	<b>Duty Cycle (dB)</b>
512.821	10.038	20.0

## Transmitter Duty Cycle (continued)



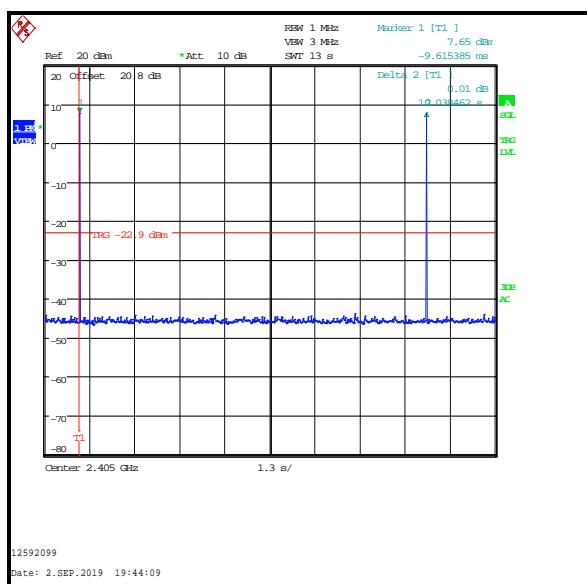
12592099  
Date: 2.SEP.2019 19:41:01



12592099  
Date: 2.SEP.2019 19:39:06

**Tx on within 5 ms**

**Period over 110 ms**



12592099  
Date: 2.SEP.2019 19:44:09

**Period over 12 s**

## Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2005	Thermohygrometer	Testo	608-H1	45046700	06 Jan 2020	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	01 Apr 2020	12
A2924	Attenuator	AtlanTecRF	AN18W5-20	832828#7	Calibrated before use	-

### **5.2.4. Transmitter Maximum Peak Output Power**

#### **Test Summary:**

<b>Test Engineer:</b>	Stefan Ho	<b>Test Date:</b>	05 February 2019
<b>Test Sample Serial Number:</b>	CA1385		

<b>FCC Reference:</b>	Part 15.247(b)(3)
<b>ISED Canada Reference:</b>	RSS-Gen 6.12 / RSS-247 5.4(d)
<b>Test Method Used:</b>	FCC KDB 558074 Section 8.3.1.1 referencing ANSI C63.10 Section 11.9.1.1

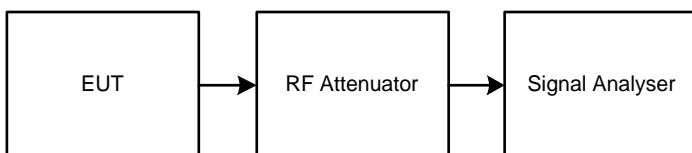
#### **Environmental Conditions:**

<b>Temperature (°C):</b>	21
<b>Relative Humidity (%):</b>	41

#### **Note(s):**

1. Conducted power tests were performed using a spectrum analyser in accordance with FCC KDB 558074 Section 8.3.1.1 Measurement Procedure Option RBW>OBW.
2. The signal analyser resolution bandwidth was set to 3 MHz and video bandwidth of 10 MHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The span was set to 10 MHz. A marker was placed at the peak of the signal and the results recorded in the table below.
3. The spectrum analyser was connected to the RF port on the EUT using suitable attenuation and RF cable. An RF level offset was entered on the spectrum analyser to compensate for the loss of the attenuator and RF cable. A loss of 0.5 dB was also added to the measured value compensate for the loss of the EUT SMA cable.
4. The conducted power was added to the declared antenna gain to obtain the EIRP.

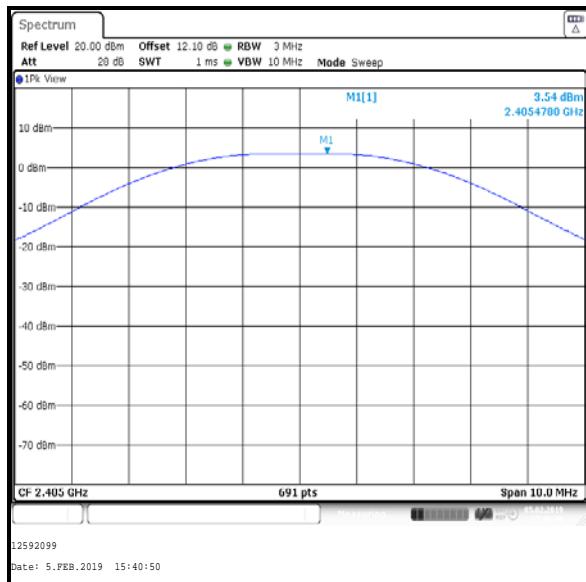
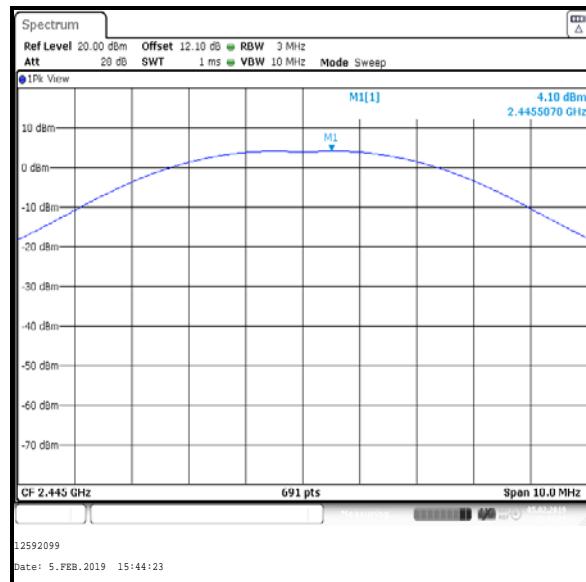
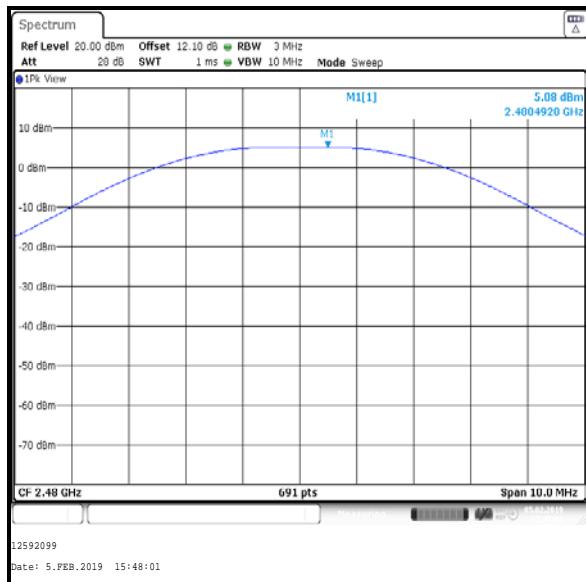
#### **Test setup:**



**Transmitter Maximum Peak Output Power (continued)****Results:**

Channel	Measured Peak Power (dBm)	SMA loss (dB)	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	3.5	0.5	4.0	30.0	26.0	Complied
Middle	4.1	0.5	4.6	30.0	25.4	Complied
Top	5.1	0.5	5.6	30.0	24.4	Complied

Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	4.0	5.1	9.1	36.0	26.9	Complied
Middle	4.6	5.1	9.7	36.0	26.3	Complied
Top	5.6	5.1	10.7	36.0	25.3	Complied

**Transmitter Maximum Peak Output Power (continued)****Bottom Channel****Middle Channel****Top Channel****Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2005	Thermohygrometer	Testo	608-H1	45046700	06 Jan 2020	12
M2036	Signal Analyser	Rohde & Schwarz	FSV30	101791	20 Apr 2019	12
G0628	Vector Signal Generator	Rohde & Schwarz	SMBV100A	261847	28 Sep 2020	36
A2524	Attenuator	AtlanTecRF	AN18W5-10	832827#2	Calibrated before use	-

### **5.2.5. Transmitter Radiated Emissions**

#### **Test Summary:**

<b>Test Engineer:</b>	Mohamed Toubella	<b>Test Date:</b>	11 February 2019 to 24 September 2019
<b>Test Sample Serial Number:</b>	CA02F7		

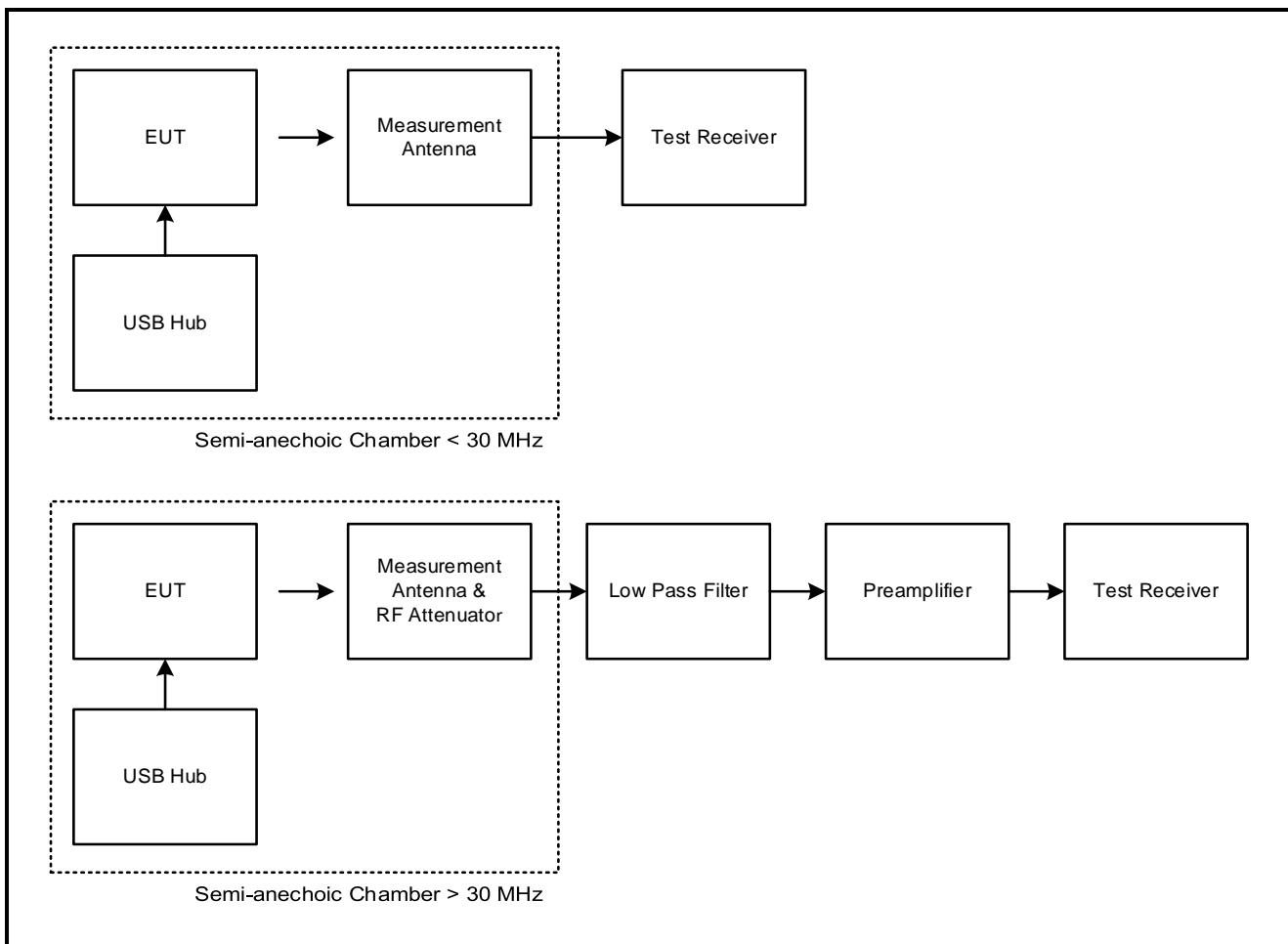
<b>FCC Reference:</b>	Parts 15.247(d) & 15.209(a)
<b>ISED Canada Reference:</b>	RSS-Gen 6.13 & 8.9 / RSS-247 5.5
<b>Test Method Used:</b>	ANSI C63.10 Sections 6.3, 6.4 and 6.5
<b>Frequency Range</b>	9 kHz to 1000 MHz

#### **Environmental Conditions:**

<b>Temperature (°C):</b>	21 to 24
<b>Relative Humidity (%):</b>	36 to 45

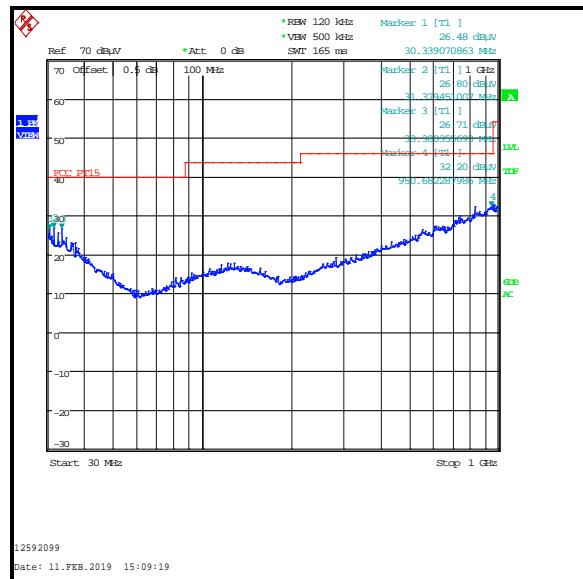
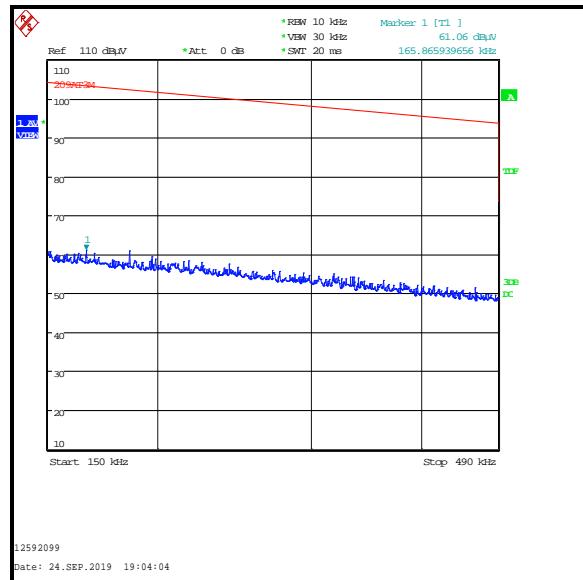
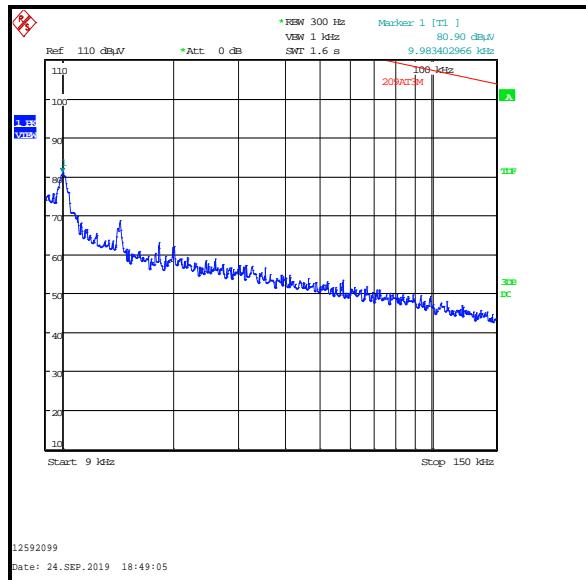
#### **Note(s):**

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. The preliminary scans showed similar emission levels below 1 GHz, for each channel of operation. Therefore final radiated emissions measurements were performed with the EUT set to the middle channel only.
3. All emissions shown on the pre-scan plots were investigated and found to be ambient, or >20 dB below the applicable limit or below the measurement system noise floor. Therefore the highest peak noise floor reading of the measuring receiver was recorded in the table below
4. Measurements below 30 MHz were performed in a semi-anechoic chamber (Asset Number K0001) at 3 metres. The EUT was placed at a height of 80 cm above the reference ground plane in the centre of the chamber turntable. The limit was extrapolated to 3 metres in accordance with ANSI C63.10 Section 6.4.4.2. Correlation data between the semi-anechoic chamber and an open-field test site is available upon request.
5. Pre-scans were performed and markers placed on the highest measured levels. The test receiver resolution bandwidth was set to 10 kHz and video bandwidth 30 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The test receiver was configured as follows: For 9 kHz to 150 kHz, the resolution bandwidth was set to 300 Hz and video bandwidth 1 kHz. A peak detector was used and trace mode was Max Hold. For 150 kHz to 490 kHz, the resolution bandwidth was set to 10 kHz and video bandwidth 30 kHz. An average detector was used and trace mode was Max Hold. For 490 kHz to 30 MHz, the resolution bandwidth was set to 10 kHz and video bandwidth 30 kHz. A peak detector was used and trace mode was Max Hold.
6. Measurements between 30 MHz and 1 GHz were performed in a semi-anechoic chamber (Asset Number K0001) at a distance of 3 metres. The EUT was placed at a height of 80 cm above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 metre to 4 metres.
7. Pre-scans were performed and markers placed on the highest measured levels. The test receiver resolution bandwidth was set to 120 kHz and video bandwidth 500 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold.

**Transmitter Radiated Emissions (continued)****Test setup for radiated measurements:**

**Transmitter Radiated Emissions (continued)****Results: Middle Channel**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
950.682	Vertical	32.2	46.0	13.8	Complied



**Transmitter Radiated Emissions (continued)****Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2040	Thermohygrometer	Testo	608-H1	45124934	06 Jan 2020	12
K0001	5m RSE Chamber	Rainford EMC	N/A	N/A	04 Oct 2019	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	17 Apr 2019	12
M1630	Test Receiver	Rohde & Schwarz	ESU40	100233	20 Sep 2019	12
A3154	Pre-Amplifier	Com-Power	PAM-103	18020012	14 Sep 2019	12
A553	Antenna	Chase	CBL6111A	1593	08 Oct 2019	12
A3112	Attenuator	AtlanTecRF	AN18-06	219706#2	08 Oct 2019	12
A3085	Low Pass Filter	AtlanTecRF	AFL-02000	18051600014	09 Apr 2020	12
A3198	Magnetic Loop Antenna	ETS-Lindgren	6502	00221887	27 Mar 2020	12

**Transmitter Radiated Emissions (continued)****Test Summary:**

<b>Test Engineers:</b>	Mohamed Toubella & Andrew Harding	<b>Test Dates:</b>	07 February 2019 to 03 September 2019
<b>Test Sample Serial Number:</b>	CA02F7		

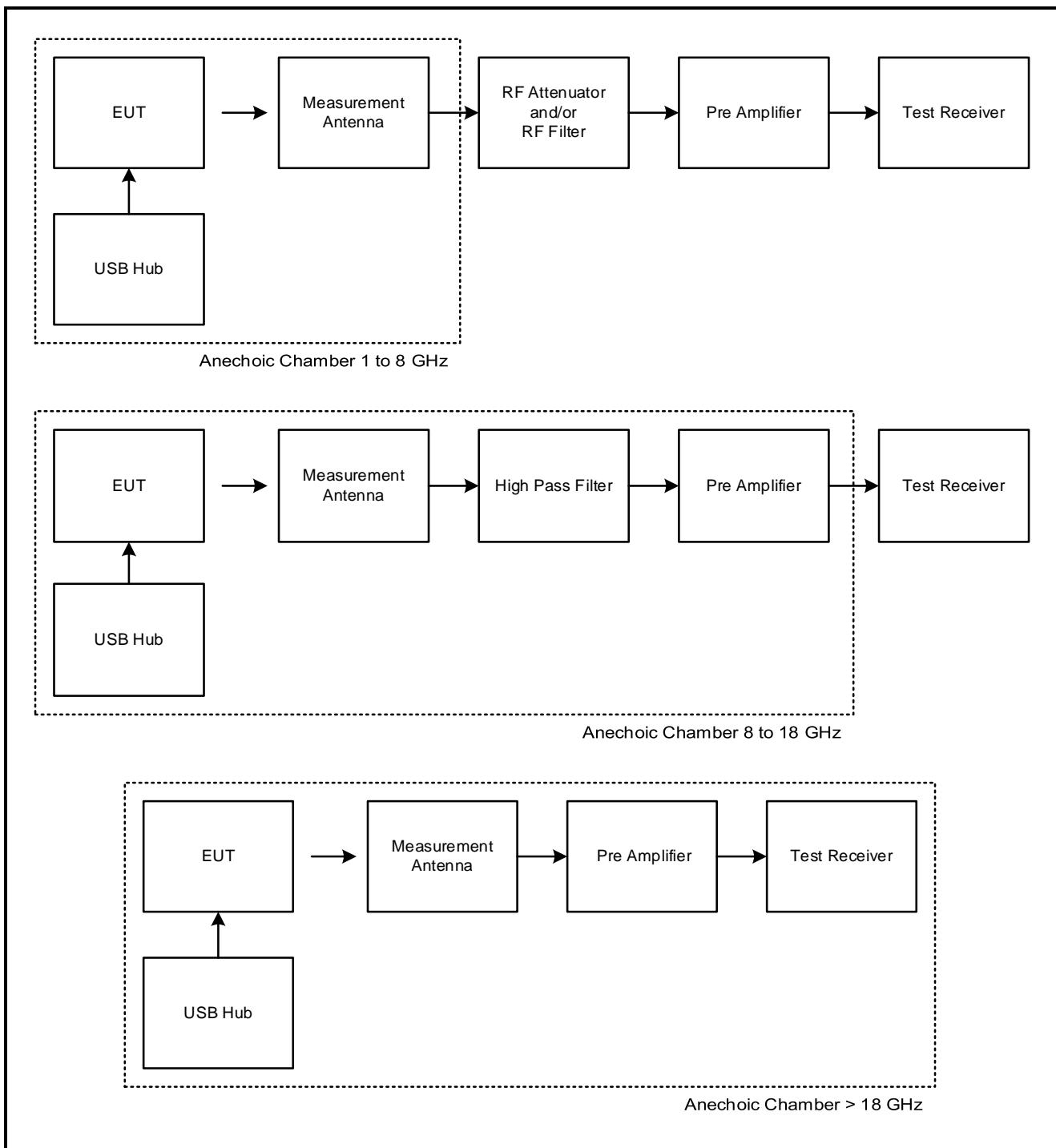
<b>FCC Reference:</b>	Parts 15.247(d) & 15.209(a)
<b>ISED Canada Reference:</b>	RSS-Gen 6.13, 8.9 & 8.10 / RSS-247 5.5
<b>Test Method Used:</b>	FCC KDB 558074 Sections 8.1 c)3), 8.5 & 8.6 referencing ANSI C63.10 Sections 6.3, 6.6, 11.11 & 11.12
<b>Frequency Range</b>	1 GHz to 25 GHz

**Environmental Conditions:**

<b>Temperature (°C):</b>	21 to 24
<b>Relative Humidity (%):</b>	36 to 54

**Note(s):**

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. All other emissions shown on the pre-scan plot were investigated and found to be ambient, >20 dB below the applicable limit or below the measurement system noise floor.
3. The emission shown on the 1 GHz to 3 GHz plot is the EUT fundamental.
4. Pre-scans above 1 GHz were performed in a fully anechoic chamber (Asset Number K0001) at a distance of 3 metres. The EUT was placed at a height of 1.5 metres above the test chamber floor in the centre of the chamber turntable. All measurement antennas were placed at a fixed height of 1.5 metres above the test chamber floor, in line with the EUT. Final measurements above 1 GHz were performed in a fully anechoic chamber (Asset Number K0017) at a distance of 3 metres. The EUT was placed at a height of 1.5 m above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 metre to 4 metres.
5. Pre-scans were performed and markers placed on the highest measured levels. The test receiver resolution bandwidth was set to 1 MHz and video bandwidth 3 MHz, with the sweep time set to auto. Peak and average measurements were performed with their respective detectors during the pre-scan measurements.
6. \*In accordance with ANSI C63.10 Section 6.6.4.3, Note 1, if the peak measured value complies with the average limit, it is unnecessary to perform an average measurement.
7. \*\* -20 dBc limit.
8. \*\*\*Duty cycle correction can be applied to a peak measurement in order to calculate the average emission level. The duty cycle was measured as 20.0 dB, therefore 20.0 dB has been subtracted from the measured peak levels in order to obtain the average emission levels stated in the result tables below.

**Transmitter Radiated Emissions (continued)****Test setup for radiated measurements:**

**Transmitter Radiated Emissions (continued)****Results: Peak / Bottom Channel**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
4810.962	Vertical	49.4	54.0*	4.6	Complied
7216.529	Vertical	57.8	75.5**	17.7	Complied

**Results: Peak / Middle Channel**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
4891.0833	Vertical	61.2	74.0	12.8	Complied
7333.359	Vertical	62.4	74.0	11.6	Complied

**Results: Average / Middle Channel**

Frequency (MHz)	Antenna Polarity	Peak Level (dB $\mu$ V/m)	Duty cycle correction (dB)	Corrected Average Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
4891.083	Vertical	61.2	20.0***	41.2	54.0	12.8	Complied
7333.359	Vertical	62.4	20.0***	42.4	54.0	11.6	Complied

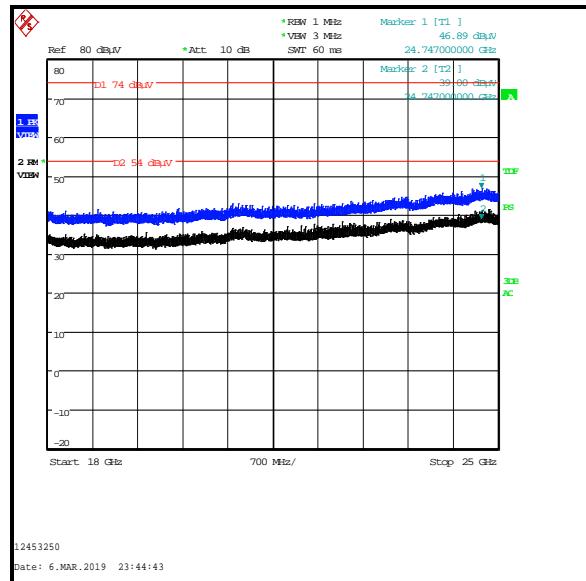
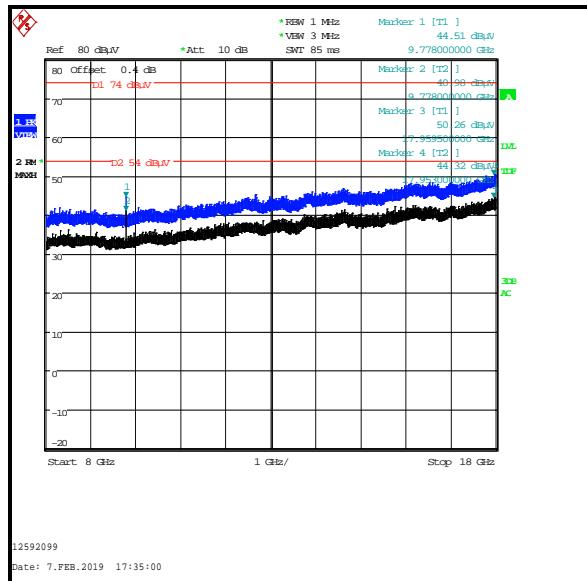
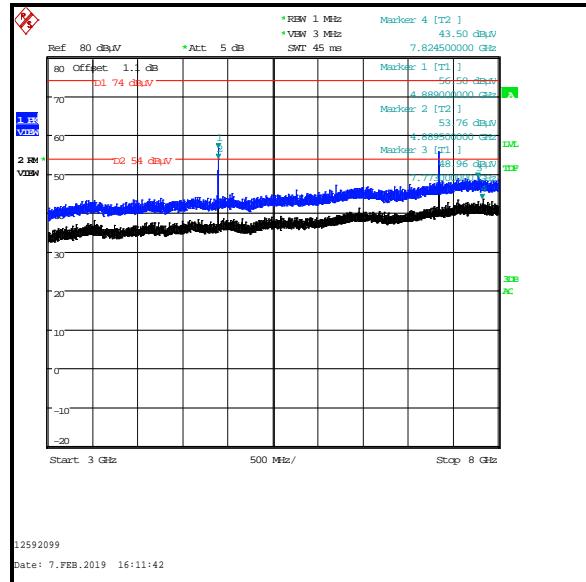
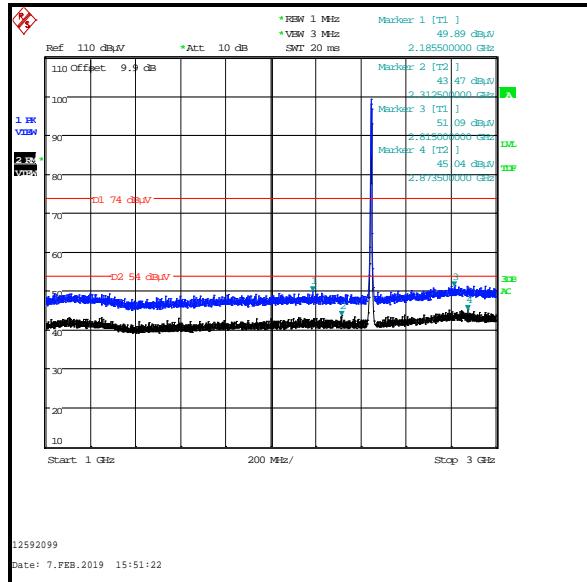
**Results: Peak / Top Channel**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
4960.997	Vertical	58.9	74.0	15.1	Complied
7438.429	Vertical	55.3	74.0	18.7	Complied

**Results: Average / Top Channel**

Frequency (MHz)	Antenna Polarity	Peak Level (dB $\mu$ V/m)	Duty cycle correction (dB)	Corrected Average Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
4960.997	Vertical	58.9	20.0***	38.9	54.0	15.1	Complied
7441.506	Vertical	55.3	20.0***	35.3	54.0	18.7	Complied

## Transmitter Radiated Emissions (continued)



Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.

**Transmitter Radiated Emissions (continued)****Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2040	Thermohygrometer	Testo	608-H1	45124934	06 Jan 2020	12
K0001	5m RSE Chamber	Rainford EMC	N/A	N/A	04 Oct 2019	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	01 Apr 2020	12
A3155	Pre-Amplifier	Com-Power	PAM-118A	18040037	14 Sep 2019	12
A3141	Pre-Amplifier	Schwarzbeck	BBV 9718 B	00021	21 Nov 2019	12
A2896	Pre-Amplifier	Schwarzbeck	BBV 9721	9721-023	08 Feb 2020	12
A3138	Antenna	Schwarzbeck	BBHA 9120 B	00702	03 Oct 2019	12
A3139	Antenna	Schwarzbeck	HWRD750	00027	04 Oct 2019	12
A2895	Antenna	Schwarzbeck	BBHA 9170	9170-728	08 Feb 2020	12
A2523	Attenuator	AtlanTecRF	AN18W5-10	832827#1	04 Mar 2020	12
A3093	High Pass Filter	AtlanTecRF	AFH-03000	18051800077	09 Apr 2020	12
A3094	High Pass Filter	AtlanTecRF	AFH-07000	18051600011	09 Apr 2020	12
M2003	Thermohygrometer	Testo	608-H1	45046641	06 Jan 2020	12
K0017	3m RSE Chamber	Rainford EMC	N/A	N/A	16 Feb 2020	12
M1995	Test Receiver	Rohde & Schwarz	ESU40	100428	08 May 2020	12
A2863	Pre-Amplifier	Agilent	8449B	3008A02100	12 Feb 2020	12
A2889	Antenna	Schwarzbeck	BBHA 9120 B	BBHA 9120 B 653	12 Feb 2020	12
A2914	High Pass Filter	AtlanTecRF	AFH-03000	2155	20 Feb 2020	12

### **5.2.6. Transmitter Band Edge Radiated Emissions**

#### **Test Summary:**

<b>Test Engineer:</b>	Mohamed Toubella	<b>Test Dates:</b>	04 February 2019 & 05 February 2019
<b>Test Sample Serial Number:</b>	CA02F7		

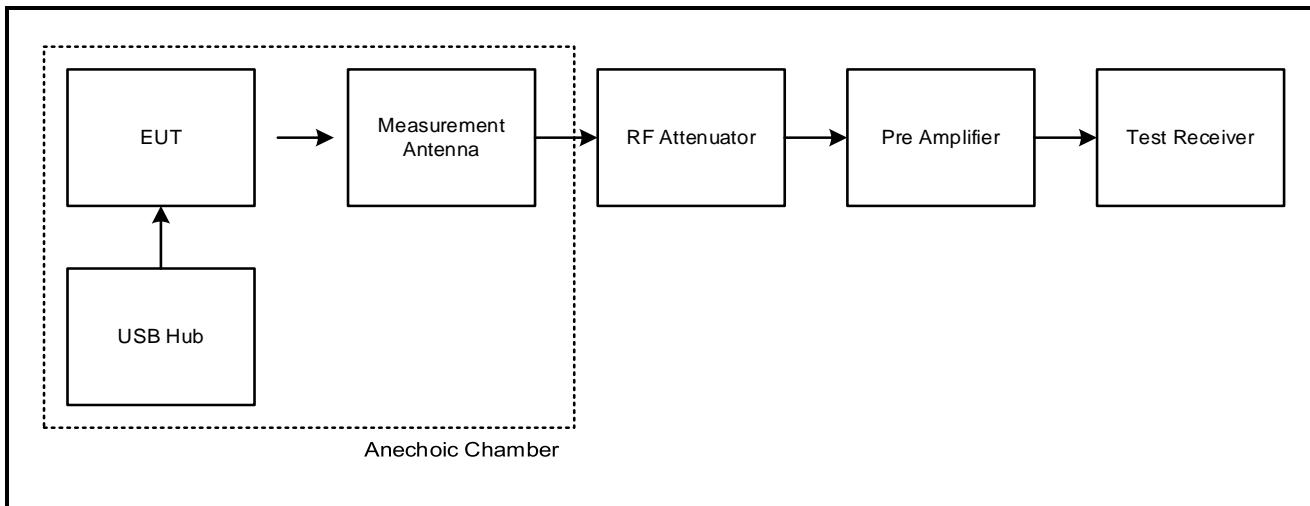
<b>FCC Reference:</b>	Parts 15.247(d) & 15.209(a)
<b>ISED Canada Reference:</b>	RSS-Gen 6.13, 8.9 & 8.10 / RSS-247 5.5
<b>Test Method Used:</b>	FCC KDB 558074 Sections 8.5 and 8.6 referencing ANSI C63.10 Sections 6.3, 6.6 11.11 and 11.12

#### **Environmental Conditions:**

<b>Temperature (°C):</b>	21
<b>Relative Humidity (%):</b>	36

#### **Note(s):**

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. The maximum peak conducted output power was previously measured. In accordance with FCC KDB 558074 Section 11.1(a), the lower band edge measurement was performed with a peak detector and the -20 dBc limit applied.
3. As the lower band edge is adjacent to a non-restricted band, only peak measurements are required. In accordance with ANSI C63.10 Section 11.11.1, the test method in Section 11.11.3 was followed: the test receiver resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The test receiver was left to sweep for a sufficient length of time in order to maximise the carrier level and out-of-band emissions. A marker and corresponding reference level line were placed on the peak of the carrier. As the maximum peak conducted output power was measured using an peak detector in accordance with ANSI C63.10 Section 11.9.1.1 an out-of-band limit line was placed 20 dB (ANSI C63.10 Section 11.11.1(a)) below the peak level. A marker was placed on the band edge spot frequencies. Marker frequency and levels were recorded.
4. As the upper band edge is adjacent to a restricted band both peak and average measurements were recorded by placing a marker at the edge of the band. For peak measurements the test receiver resolution bandwidth was set to 1 MHz and the video bandwidth 3 MHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. For average measurements the test receiver resolution bandwidth was set to 1 MHz and the video bandwidth 3 MHz. An RMS detector was used, sweep time was set to auto and trace mode was trace averaging over 300 sweeps. A marker was placed on the band edge spot frequencies and a second marker placed on the highest emission level in the adjacent restricted band of operation (where a higher level emission was present). Marker frequencies and levels were recorded
5. There is a restricted band 10 MHz below the lower band edge. The test receiver was set up as follows: the RBW set to 1 MHz, the VBW set to 3 MHz, with the sweep time set to auto couple. Peak and average measurements were performed with their respective detectors. Markers were placed on the highest point on each trace.
6. \* -20 dBc limit.
7. \*\* For improved accuracy the upper band edge average measurement was tested using the integration method stated in ANSI C63.10 Section 11.13.3.

**Transmitter Band Edge Radiated Emissions (continued)****Test setup for radiated measurements:****Results: Peak**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
2400.000	Vertical	54.6	75.5*	20.9	Complied
2483.500	Vertical	65.7	74.0	8.3	Complied

**Results: Average**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
2483.500	Vertical	51.5**	54.0	2.5	Complied

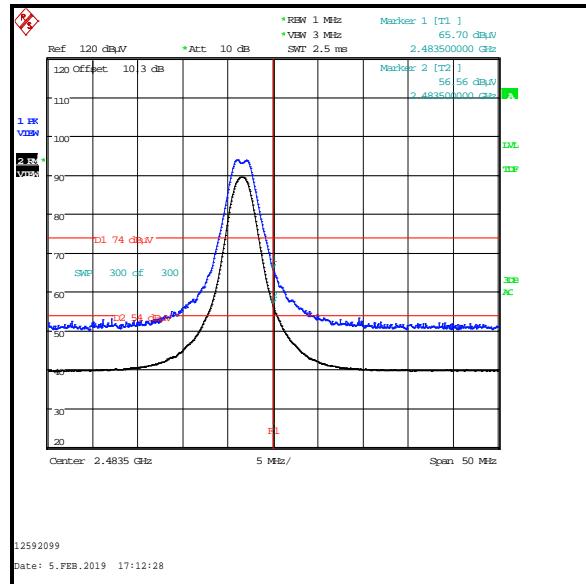
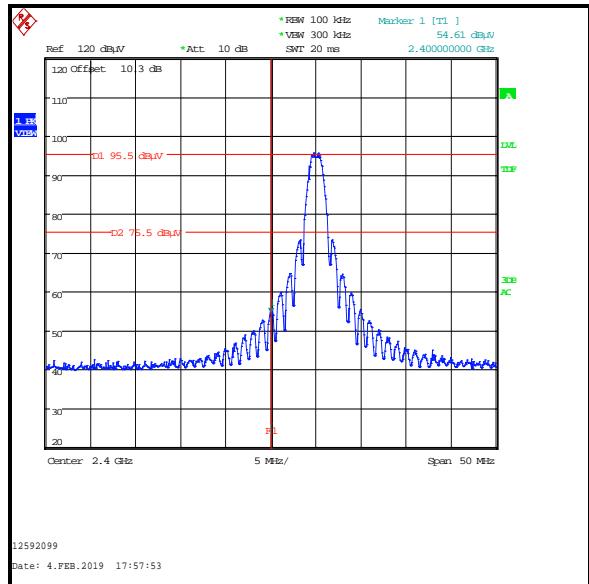
**Results: 2310 MHz to 2390 MHz Restricted Band / Peak**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
2344.487	Vertical	52.7	74.0	21.3	Complied

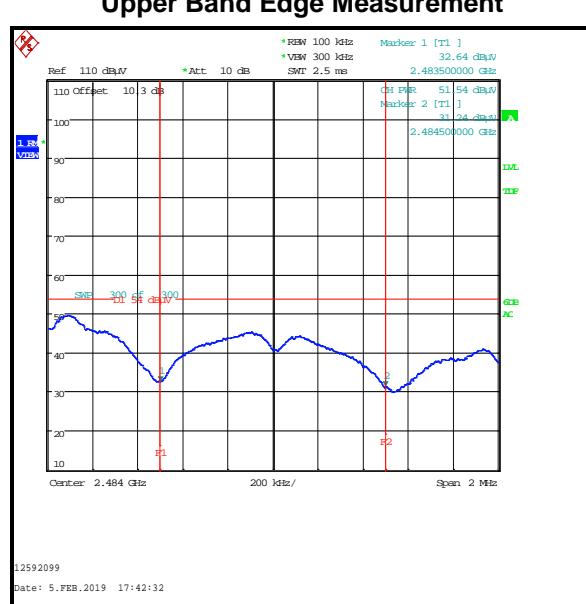
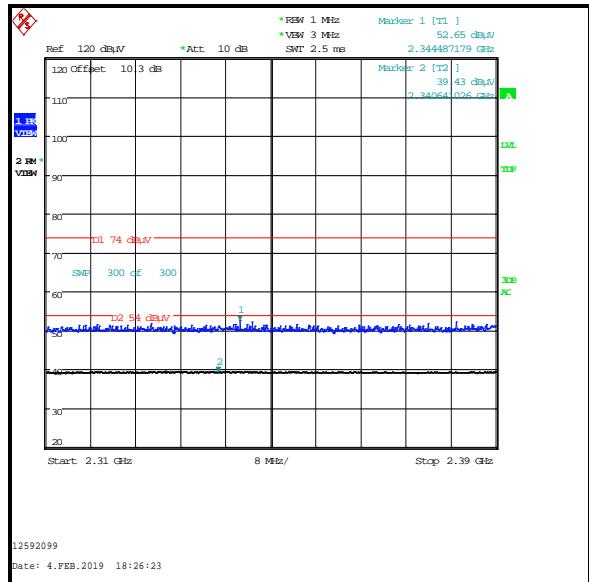
**Results: 2310 MHz to 2390 MHz Restricted Band / Average**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
2340.641	Vertical	39.4	54.0	14.6	Complied

### Transmitter Band Edge Radiated Emissions (continued)



### Lower Band Edge Peak Measurement



### 2310 MHz to 2390 MHz Restricted Band Plot

### Upper Band Edge Average Measurement – Integration Method

**Transmitter Band Edge Radiated Emissions (continued)****Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2040	Thermohygrometer	Testo	608-H1	45124934	06 Jan 2020	12
K0001	5m RSE Chamber	Rainford EMC	N/A	N/A	04 Oct 2019	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	01 Apr 2020	12
A3155	Pre-Amplifier	Com-Power	PAM-118A	18040037	14 Sep 2019	12
A3138	Antenna	Schwarzbeck	BBHA 9120 B	00702	03 Oct 2019	12
A2523	Attenuator	AtlanTecRF	AN18W5-10	832827#1	04 Mar 2020	12

### **5.2.7. Transmitter AC Conducted Spurious Emissions**

#### **Test Summary:**

<b>Test Engineer:</b>	Alison Johnston	<b>Test Date:</b>	25 September 2019
<b>Test Sample Serial Number:</b>	C980D9		

<b>FCC Reference:</b>	Part 15.207(a)
<b>ISED Canada Reference:</b>	RSS-Gen 8.8
<b>Test Method Used:</b>	ANSI C63.10 Section 6.2, FCC KDB 174176 and notes below

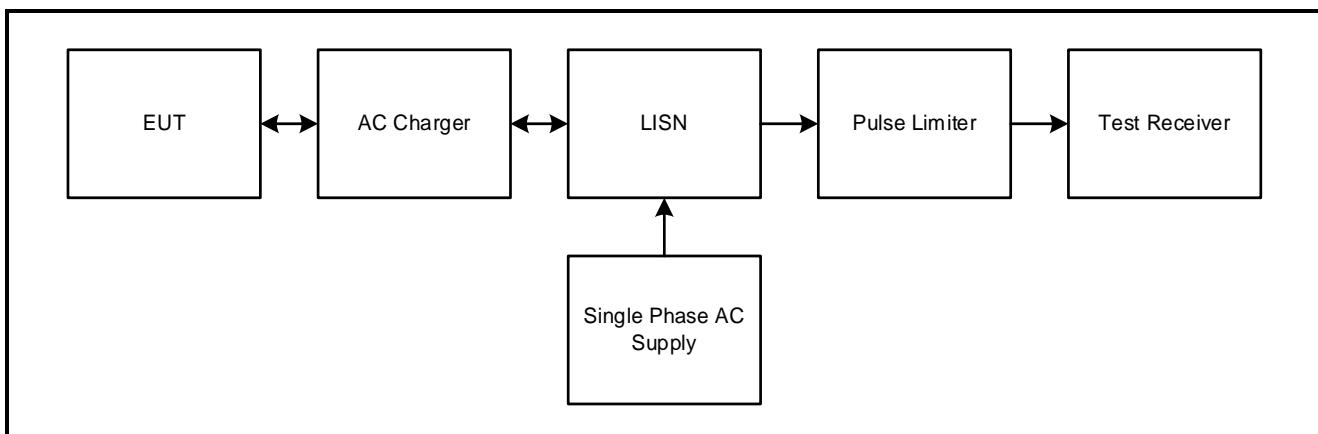
#### **Environmental Conditions:**

<b>Temperature (°C):</b>	23
<b>Relative Humidity (%):</b>	65

#### **Note(s):**

1. The EUT was connected to an AC charger via a USB cable. The AC charger was connected to 120 VAC 60 Hz single phase supply via a LISN.
2. In accordance with FCC KDB 174176 Q4, tests were performed with a 240 VAC 60 Hz single phase supply as this was within the voltage range marked on the Huoniu AC charger.
3. A pulse limiter was fitted between the LISN and the test receiver.
4. Pre-scans were performed and markers placed on the highest live and neutral measured levels. Final measurements were performed on the marker frequencies and the results entered into the tables below.

#### **Test setup:**



**Transmitter AC Conducted Spurious Emissions (continued)****Results: Live / Quasi Peak / 120 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.375000	Live	37.4	58.4	21.0	Complied
0.532500	Live	32.6	56.0	23.4	Complied
0.622500	Live	33.2	56.0	22.8	Complied
0.919500	Live	28.7	56.0	27.3	Complied
1.365000	Live	27.7	56.0	28.3	Complied
1.779000	Live	27.2	56.0	28.8	Complied

**Results: Live / Average / 120 VAC 60 Hz**

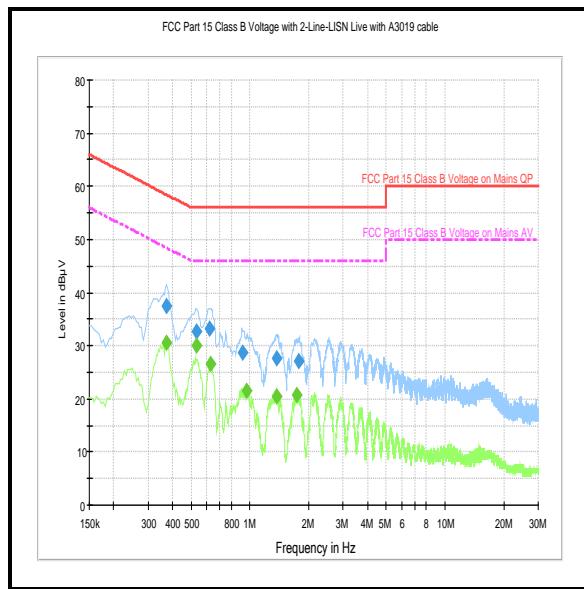
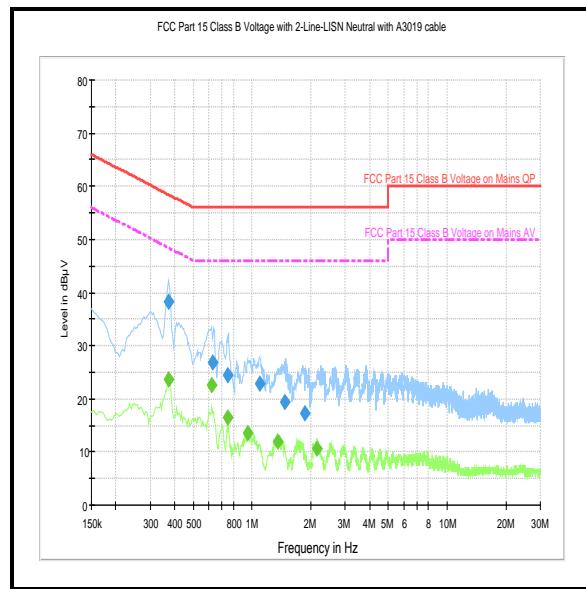
Frequency (MHz)	Line	Level (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.375000	Live	30.6	48.4	17.8	Complied
0.532500	Live	30.0	46.0	16.0	Complied
0.627000	Live	26.6	46.0	19.4	Complied
0.964500	Live	21.4	46.0	24.6	Complied
1.369500	Live	20.6	46.0	25.4	Complied
1.725000	Live	20.6	46.0	25.4	Complied

**Results: Neutral / Quasi Peak / 120 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.375000	Neutral	38.4	58.4	20.0	Complied
0.627000	Neutral	26.8	56.0	29.2	Complied
0.748500	Neutral	24.5	56.0	31.5	Complied
1.090500	Neutral	22.8	56.0	33.2	Complied
1.473000	Neutral	19.3	56.0	36.7	Complied
1.860000	Neutral	17.2	56.0	38.8	Complied

**Results: Neutral / Average / 120 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.375000	Neutral	23.8	48.4	24.6	Complied
0.622500	Neutral	22.7	46.0	23.3	Complied
0.753000	Neutral	16.5	46.0	29.5	Complied
0.946500	Neutral	13.6	46.0	32.4	Complied
1.360500	Neutral	11.9	46.0	34.1	Complied
2.143500	Neutral	10.8	46.0	35.2	Complied

**Transmitter AC Conducted Spurious Emissions (continued)****Results: 120 VAC 60 Hz****Live****Neutral**

*Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.*

**Transmitter AC Conducted Spurious Emissions (continued)****Results: Live / Quasi Peak / 240 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.357000	Live	40.6	18.2	58.8	Complied
0.505500	Live	35.7	20.3	56.0	Complied
0.622500	Live	33.9	22.1	56.0	Complied
1.117500	Live	33.7	22.3	56.0	Complied
1.963500	Live	32.2	23.8	56.0	Complied
2.782500	Live	30.6	25.4	56.0	Complied

**Results: Live / Average / 240 VAC 60 Hz**

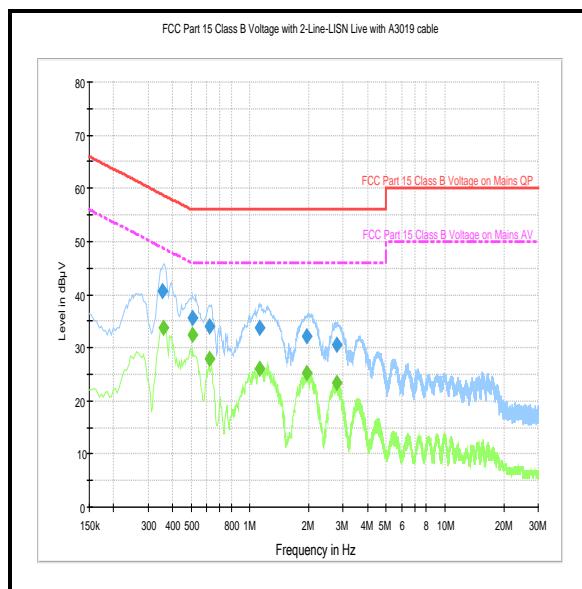
Frequency (MHz)	Line	Level (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.361500	Live	33.8	48.7	14.9	Complied
0.510000	Live	32.4	46.0	13.6	Complied
0.622500	Live	27.9	46.0	18.1	Complied
1.117500	Live	26.0	46.0	20.0	Complied
1.945500	Live	25.3	46.0	20.7	Complied
2.782500	Live	23.4	46.0	22.6	Complied

**Results: Neutral / Quasi Peak / 240 VAC 60 Hz**

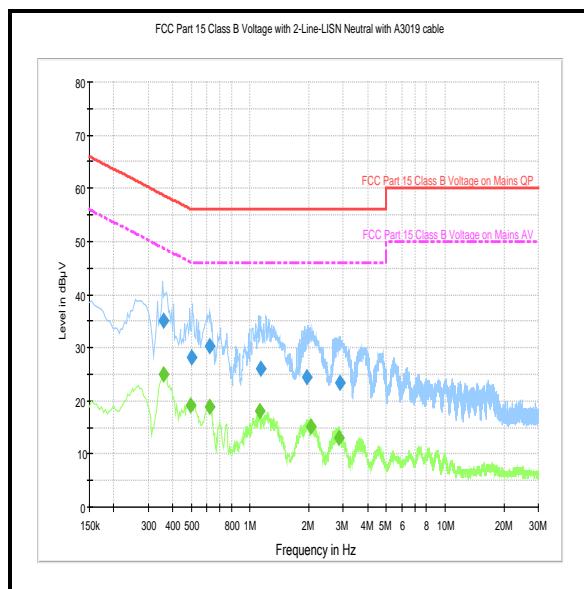
Frequency (MHz)	Line	Level (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.361500	Neutral	35.1	58.7	23.6	Complied
0.501000	Neutral	28.1	56.0	27.9	Complied
0.618000	Neutral	30.4	56.0	25.6	Complied
1.131000	Neutral	26.1	56.0	29.9	Complied
1.963500	Neutral	24.5	56.0	31.5	Complied
2.877000	Neutral	23.3	56.0	32.7	Complied

**Results: Neutral / Average / 240 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB $\mu$ V)	Limit (dB $\mu$ V)	Margin (dB)	Result
0.361500	Neutral	24.9	48.7	23.8	Complied
0.496500	Neutral	19.1	46.1	27.0	Complied
0.618000	Neutral	18.8	46.0	27.2	Complied
1.122000	Neutral	18.1	46.0	27.9	Complied
2.049000	Neutral	15.2	46.0	30.8	Complied
2.845500	Neutral	13.0	46.0	33.0	Complied

**Transmitter AC Conducted Spurious Emissions (continued)****Results: 240 VAC 60 Hz**

Live



Neutral

*Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.*

**Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2037	Thermohygrometer	Testo	608-H1	45124925	06 Jan 2020	12
A649	LISN	Rohde & Schwarz	ESH3-Z5	825562/008	08 Aug 2020	12
A1830	Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100668	10 Apr 2020	12
M1273	Test Receiver	Rohde & Schwarz	ESIB 26	100275	18 Dec 2019	12
A2953	Power Supply 240 VAC 60 Hz	Tacima	SC 5467	Not stated	Calibrated before use	-
M1269	Multimeter	Fluke	179	90250210	17 Apr 2020	12

**Test Measurement Software/Firmware Used:**

Name	Version	Release Date
Rohde & Schwarz EMC32	6.30.0	2008

## **6. Measurement Uncertainty**

No measurement or test can ever be perfect and the imperfections give rise to error of measurement in the results. Consequently the result of a measurement is only an approximation to the value of the measurand (the specific quantity subject to measurement) and is only complete when accompanied by a statement of the uncertainty of the approximation.

The expression of uncertainty of a measurement result allows realistic comparison of results with reference values and limits given in specifications and standards.

The uncertainty of the result may need to be taken into account when interpreting the measurement results.

The reported expanded uncertainties below are based on a standard uncertainty multiplied by an appropriate coverage factor such that a confidence level of approximately 95% is maintained. For the purposes of this document "approximately" is interpreted as meaning "effectively" or "for most practical purposes".

Measurement Type	Range	Confidence Level (%)	Calculated Uncertainty
AC Conducted Spurious Emissions	0.15 MHz to 30 MHz	95%	±1.96 dB
Conducted Maximum Peak Output Power	2.4 GHz to 2.4835 GHz	95%	±1.13 dB
Minimum 6 dB Bandwidth	2.4 GHz to 2.4835 GHz	95%	±4.59 %
99% Occupied Bandwidth	2.4 GHz to 2.4835 GHz	95%	±3.92 %
Duty Cycle	2.4 GHz to 2.4835 GHz	95%	±1.14 %
Radiated Spurious Emissions	9 kHz to 30 MHz	95%	±4.39 dB
Radiated Spurious Emissions	30 MHz to 1 GHz	95%	±4.65 dB
Radiated Spurious Emissions	1 GHz to 25 GHz	95%	±2.94 dB

The methods used to calculate the above uncertainties are in line with those recommended within the various measurement specifications. Where measurement specifications do not include guidelines for the evaluation of measurement uncertainty the published guidance of the appropriate accreditation body is followed.

## **7. Report Revision History**

Version Number	Revision Details		
	Page No(s)	Clause	Details
1.0	-	-	Initial Version
2.0	-	5.2.7	AC Conducted Emissions results added.
	-	-	Editorial updates.
3.0	-	6	Measurement uncertainty added for AC Conducted Emissions

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