



TEST REPORT

Test Report No. : UL-RPT-RP13194272-1416A V2.0

Manufacturer : Disruptive Technologies Research AS
Model No. : DT-RFIO-Module (US)
PMN : DT-RFIO-Module (US)
HVIN : 101941
FCC ID : 2ATFX-101941
ISED Certification No. : IC: 25087-101941
Technology : FHSS
Test Standard(s) : FCC Parts 15.207, 15.209(a) & 15.247;
Innovation, Science and Economic Development Canada
RSS-247 Issue 2 February 2017 & RSS-Gen Issue 5 March 2019

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2. The results in this report apply only to the sample(s) tested.
3. The sample tested is in compliance with the above standard(s).
4. The test results in this report are traceable to the national or international standards.
5. Version 2.0 supersedes all previous versions.

Date of Issue: 11 August 2020

Checked by:

Ian Watch
Senior Test Engineer, Radio Laboratory

Company Signatory:

Sarah Williams
RF Operations Leader, Radio Laboratory



This laboratory is accredited by UKAS.
The tests reported herein have been
performed in accordance with its terms
of accreditation.

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Customer Information

Company Name:	Disruptive Technologies Research AS
Address:	Strandveien 17 1366 Lysaker Norway

Report Revision History

Version Number	Issue Date	Revision Details	Revised By
1.0	04/08/2020	Initial version	Ian Watch
2.0	11/08/2020	Page 9, updated test equipment calibration due dates. Page 37, corrected frequency range, test method used and Note 5	Ian Watch

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1. Attestation of Test Results

1.1. Description of EUT

The Equipment Under Test was a wireless 900 MHz SRD transceiver module.

1.2. General Information

Specification Reference:	47CFR15.247
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Section 15.247
Specification Reference:	47CFR15.207 and 47CFR15.209
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Sections 15.207 and 15.209
Specification Reference:	RSS-Gen Issue 5 March 2019
Specification Title:	General Requirements for Compliance of Radio Apparatus
Specification Reference:	RSS-247 Issue 2 February 2017
Specification Title:	Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
FCC Site Registration:	621311
ISED Site Registration:	20903
Location of Testing:	UL VS LTD, Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom
Test Dates:	22 June 2020 to 01 August 2020

1.3. Summary of Test Results

FCC Reference (47CFR)	ISED Canada Reference	Measurement	Result
Part 15.247(a)(1)(i)	RSS-Gen 6.7 / RSS-247 5.1(a)	Transmitter 20 dB Bandwidth	
N/A	RSS-Gen 6.7	Transmitter 99% Occupied Bandwidth	
Part 15.247(a)(1)	RSS-247 5.1(b)	Transmitter Carrier Frequency Separation	
Part 15.247(a)(1)(i)	RSS-247 5.1(c)	Transmitter Number of Hopping Frequencies and Average Time of Occupancy	
Part 15.247(b)(2)	RSS-Gen 6.12 / RSS-247 5.4(b)	Transmitter Maximum Peak Output Power	
Part 15.247(d) / 15.209(a)	RSS-Gen 6.13 / RSS-247 5.5	Transmitter Radiated Emissions	
Part 15.247(d) / 15.209(a)	RSS-Gen 6.13 / RSS-247 5.5	Transmitter Band Edge Radiated Emissions	
Part 15.207	RSS-Gen 8.8	Transmitter AC Conducted Emissions	
Key to Results  = Complied  = Did not comply			

1.4. 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.

2. Summary of Testing

2.1. Facilities and Accreditation

The test site and measurement facilities used to collect data are located at Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom. The following table identifies which facilities were utilised for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

Site 1	X
Site 2	-
Site 17	X

UL VS LTD is accredited by UKAS. The tests reported herein have been performed in accordance with its terms of accreditation.

2.2. Methods and Procedures

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

2.3. Calibration and Uncertainty

Measuring Instrument Calibration

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.

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	902 MHz to 928 MHz	95%	±1.13 dB
Carrier Frequency Separation	902 MHz to 928 MHz	95%	±4.59 %
Average Time of Occupancy	902 MHz to 928 MHz	95%	±3.53 ns
20 dB Bandwidth	902 MHz to 928 MHz	95%	±4.59 %
99% Occupied Bandwidth	902 MHz to 928 MHz	95%	±3.92 %
Radiated Spurious Emissions	9 kHz to 30 MHz	95%	±5.32 dB
Radiated Spurious Emissions	30 MHz to 1 GHz	95%	±3.30 dB
Radiated Spurious Emissions	1 GHz to 9.3 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.

2.4. Test and Measurement Equipment

Test Equipment Used for Transmitter Conducted Testing

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2001	Thermohygrometer	Testo	608-H1	45041824	05 Jan 2021	12
M1825	Signal Analyser	Rohde & Schwarz	FSV30	103050	14 Apr 2021	12
G0614	Signal Generator	Rohde & Schwarz	SMB100A	177687	19 May 2023	36
A2921	Attenuator	AtlanTecRF	AN18W5-20	832828#4	Calibrated before use	-

Test Equipment Used for Transmitter Radiated Emissions Tests

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2003	Thermohygrometer	Testo	608-H1	45046641	07 Jan 2021	12
K0017	3m RSE Chamber	Rainford	N/A	N/A	01 Nov 2020	12
M1273	Test Receiver	Rohde & Schwarz	ESIB26	100275	03 Dec 2020	12
M1995	Test Receiver	Rohde & Schwarz	ESU40	100428	20 Jan 2021	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	09 Apr 2021	12
A3167	Pre Amplifier	Com-Power	PAM-103	18020010	01 Nov 2020	12
A2863	Pre Amplifier	Agilent	8449B	3008A02100	01 Nov 2020	12
A3224	Pre Amplifier	Schwarzbeck	BBV 9718 C	00071	24 Apr 2021	12
A3161	Antenna	Teseq	CBL6111D	50859	07 Jan 2021	12
A2889	Antenna	Schwarzbeck	BBHA 9120 B	00653	01 Nov 2020	12
A2890	Antenna	Schwarzbeck	HWRD 750	014	01 Nov 2020	12
A3113	Attenuator	AtlanTecRF	AN18-06	219706#3	07 Jan 2021	12
A2908	High Pass Filter	Wainwright Instruments	WHJE5-920-1000-4000-60EE	3	05 Jan 2021	12
A2914	High Pass Filter	AtlanTecRF	AFH-03000	2155	06 Feb 2021	12
A2947	High Pass Filter	AtlanTecRF	AFH-07000	1601900001	06 Feb 2021	12
M2040	Thermohygrometer	Testo	608-H1	45124934	07 Jan 2021	12
K0001	3m RSE Chamber	Rainford EMC	N/A	N/A	15 Oct 2020	12
M1874	Test Receiver	Rohde & Schwarz	ESU	100046	28 Feb 2021	12
A3198	Magnetic Loop Antenna	ETS-Lindgren	6502	00221887	01 Apr 2021	12

Test and Measurement Equipment (continued)**Test Equipment Used for Transmitter Band Edge Radiated Emissions Tests**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2040	Thermohygrometer	Testo	608-H1	45124934	07 Jan 2021	12
K0001	3m Semi-Anechoic Chamber	Rainford EMC	N/A	N/A	16 Oct 2020	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	09 Apr 2021	12
A3154	Pre Amplifier	Com-Power	PAM-103	18020012	04 Oct 2020	12
A553	Antenna	Chase	CBL6111A	1593	14 Oct 2020	12
A3112	Attenuator	AtlanTecRF	AN18-06	219706#2	14 Oct 2020	12
A2924	Attenuator	AtlanTecRF	AN18W5-20	832828#7	21 Feb 2021	12

Test Equipment Used for Transmitter AC Conducted Spurious Emissions:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2037	Thermohygrometer	Testo	608-H1	45124925	07 Jan 2021	12
A067	LISN	Rohde & Schwarz	ESH3-Z5	890603/002	14 Nov 2020	12
A1830	Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100668	07 Apr 2021	12
M1273	Test Receiver	Rohde & Schwarz	ESIB 26	100275	03 Dec 2020	12
S011	Bench Power Supply	INSTEK	PR-3010H	9401270	Calibrated before use	-
M1229	Digital Multimeter	Fluke	Fluke 179	87640015	09 Apr 2021	12

Test Measurement Software/Firmware Used for AC Conducted Tests:

Name	Version	Release Date
Rohde & Schwarz EMC32	6.30.0	2008

3. Equipment Under Test (EUT)

3.1. Identification of Equipment Under Test (EUT)

Brand Name:	Disruptive Technologies
Model Name or Number:	DT-RFIO-Module (US)
Test Sample Serial Number:	Bn1vc90g0000uc1c4kig
Hardware Version:	0.0
Software Version:	master/101630-v1.1-3-gcd9ebcb+b57:firstboot-dev
Firmware Version:	balenaOS 2.38.0+rev4
FCC ID:	2ATFX-101941
ISED Certification Number:	IC: 25087-101941

Brand Name:	Disruptive Technologies
Model Name or Number:	DT-RFIO-Module (US)
Test Sample Serial Number:	bptivi4c0001ks2ak1mg
Hardware Version:	0.0
Software Version:	master/101630-v1.1-3-gcd9ebcb+b57:firstboot-dev
Firmware Version:	balenaOS 2.38.0+rev4
FCC ID:	2ATFX-101941
ISED Certification Number:	IC: 25087-101941

3.2. Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

3.3. Additional Information Related to Testing

Tested Technology:	902-928 MHz (FHSS) Boost Mode	
Power Supply Requirement:	Nominal	5 VDC via AC Power Adaptor
Type of Unit:	Transceiver	
Modulation:	Frequency Shift Key (FSK)	
Data Rate	25 kbit/s	
Maximum Output Power:	24.8 dBm	
Transmit Frequency Range:	902 MHz to 928 MHz	
Transmit Channels Tested:	Channel ID	Channel Frequency (MHz)
	Bottom	902.775
	Middle	915.000
	Top	927.225

3.4. Description of Available Antennas

The radio utilizes two integrated antennas, with the following maximum gain:

Frequency Range (MHz)	Antenna Gain (dBi)
902-928	0.0

3.5. Description of Test Setup

Support Equipment

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

Description:	Laptop PC
Brand Name:	Apple
Model Name or Number:	MacBook Pro
Serial Number:	C02TR3HLHV29

Description:	Connector-Main Breakout development board
Brand Name:	Disruptive Technologies
Model Name or Number:	10064-2.0.1
Serial Number:	Not marked or stated

Description:	POE Switch
Brand Name:	Linksys
Model Name or Number:	LGS108P
Serial Number:	13U20F15902490

Description:	Wireless Modem Router
Brand Name:	ASUS
Model Name or Number:	ASUS-4G-AC53U
Serial Number:	K61U27000306

Description:	AC/DC Adaptor for Wireless Modem Router
Brand Name:	Asian Power Device Inc.
Model Name or Number:	WA-24Q12R
Serial Number:	Y8709ML002914

Operating Modes

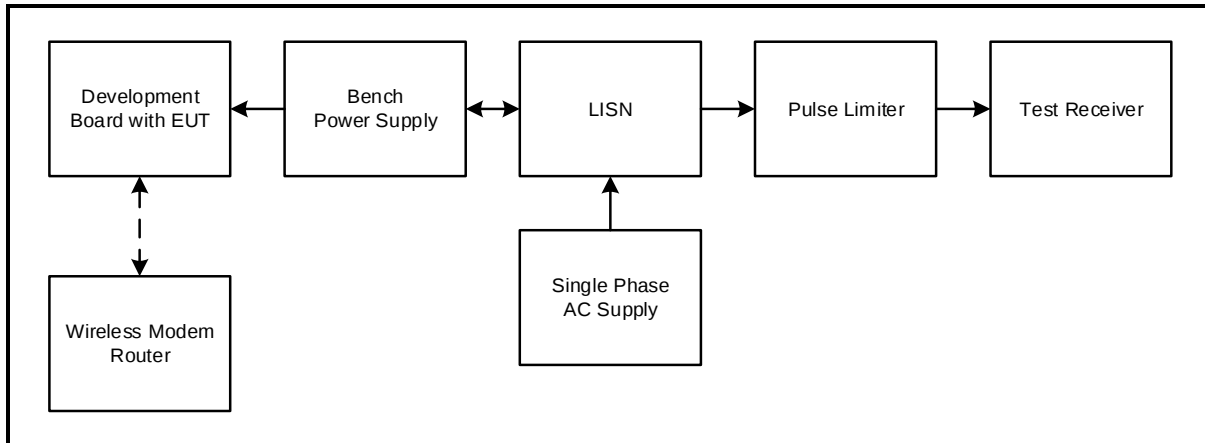
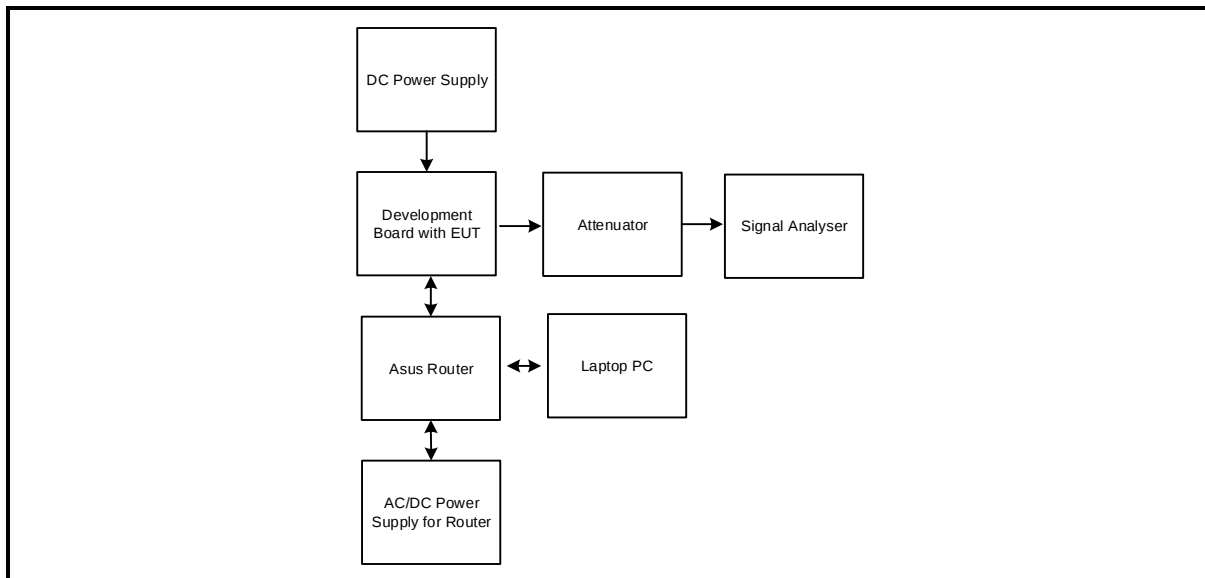
The EUT was tested in the following operating mode(s):

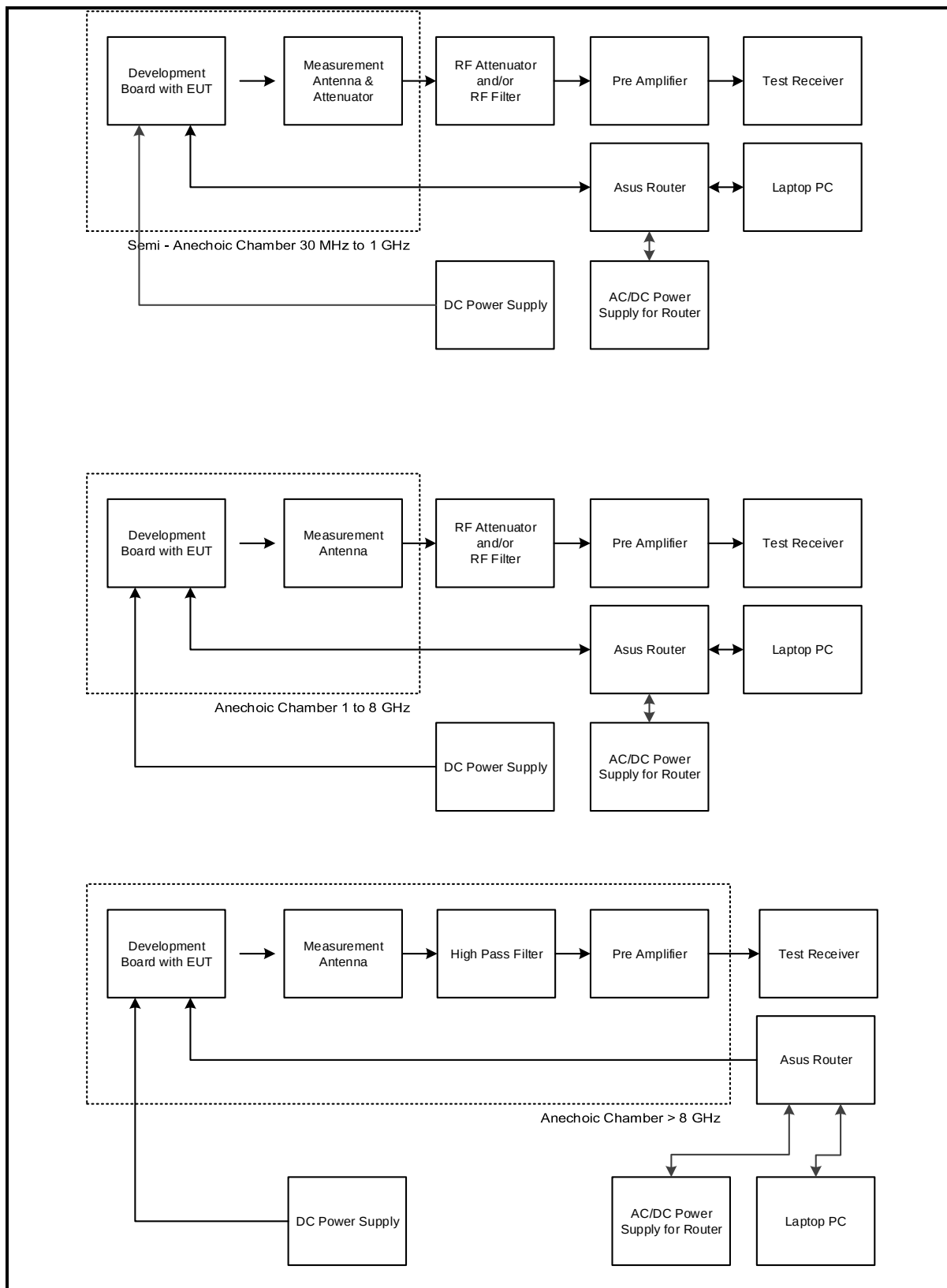
- Continuously transmitting at maximum power with modulated carrier on bottom, middle and top channels as required.
- Continuously transmitting at maximum power with modulated carrier in static and hopping mode.

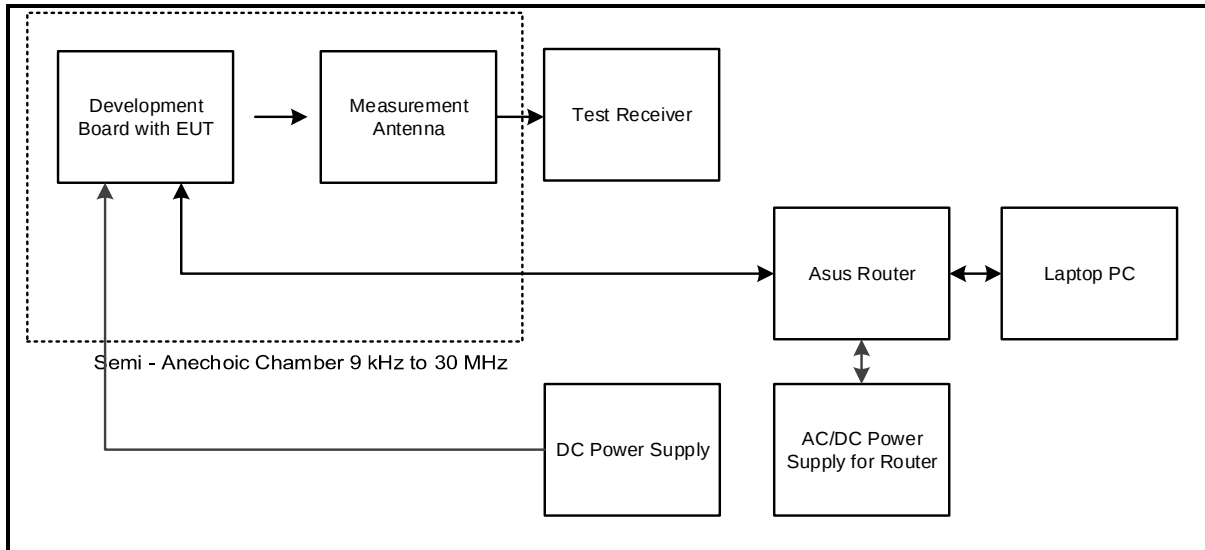
Configuration and Peripherals

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

- The EUT was mounted on a Disruptive Technologies Connector-Main Breakout development board during all tests.
- A terminal application running on the laptop PC was used to configure the EUT as required. The customer supplied a document containing the setup instructions '2020-06-02 Instructions for UL to operate CCON US 4G.pdf', Issue Date: 2020-06-02 and 'Test_proposal_form_FCC_ISSED_DT_MODULE_v2.pdf', Date: 2020-06-26 .
- Two hopping sequences are selectable in test mode, the lower hopping sequence enables frequency hopping down to and including the bottom channel but does not extend to the top channel and the higher hopping sequence enables frequency hopping up to and including the top channel but does not extend to the bottom channel. A combination of both hopping sequences were used during testing to ensure all channels within the 902-928 MHz band were covered.
- The EUT has two antennas (antenna 1 and antenna 2). Tests were performed on both antennas where required.

Test Setup Diagrams**Conducted Tests:****Test Setup for Transmitter AC Conducted Spurious Emissions****Test Setup for Bandwidth, Frequency Separation, Hopping Frequencies, Average Time of Occupancy, Duty Cycle & Maximum Peak Output Power**

Radiated Tests:**Test Setup for Transmitter Radiated Emissions**

Radiated Tests:**Test Setup for Transmitter Radiated Emissions**

4. Antenna Port Test Results

4.1. Transmitter 20 dB Bandwidth

Test Summary:

Test Engineer:	Matthew Botfield	Test Date:	24 June 2020
Test Sample Serial Number:	bn1vc90g0000uc1c4kig		

FCC Reference:	Part 15.247(a)(1)(i)
ISED Canada Reference:	RSS-Gen 6.7 / RSS-247 5.1(a)
Test Method Used:	ANSI C63.10 Section 6.9.2

Environmental Conditions:

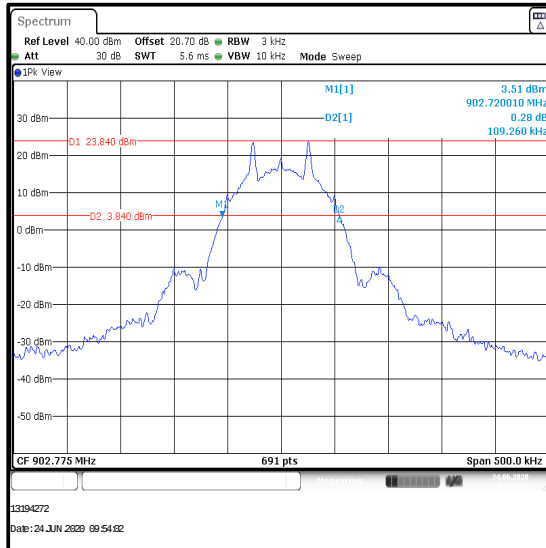
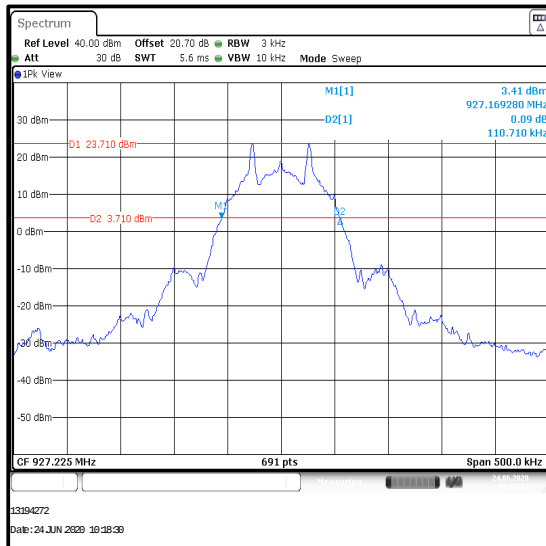
Temperature (°C):	23
Relative Humidity (%):	39

Note(s):

1. The signal analyser resolution bandwidth was set to 3 kHz and video bandwidth 10 kHz. A peak detector was used, sweep time was set to auto and the trace mode was Max Hold. The span was set to 500 kHz. Normal and delta markers were placed 20 dB down from the peak of the carrier. These results are documented in the table below.
2. The signal analyser was connected to the RF port on the EUT using suitable attenuation and RF adaptor/cables.

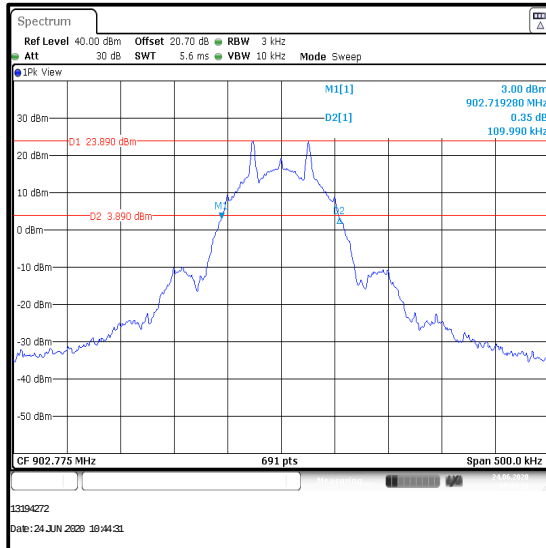
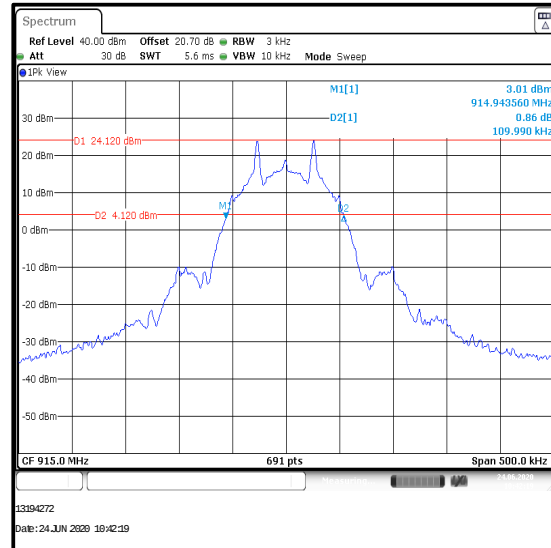
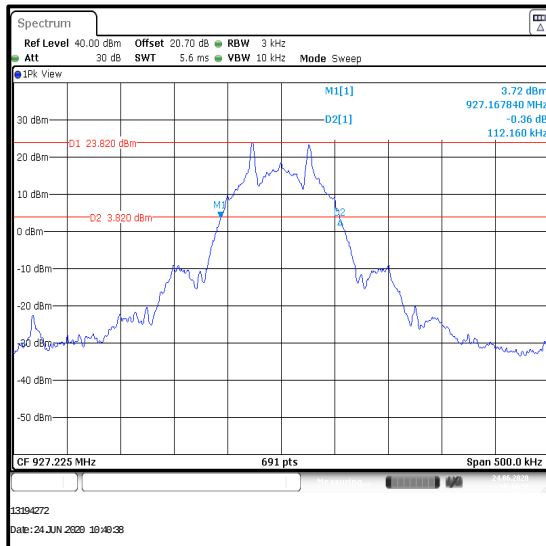
Transmitter 20 dB Bandwidth (continued)**Results: Antenna 1**

Channel	20 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	109.260	≤500	390.740	Complied
Middle	109.990	≤500	390.010	Complied
Top	111.710	≤500	388.290	Complied

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

Transmitter 20 dB Bandwidth (continued)**Results: Antenna 2**

Channel	20 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	109.990	≤500	390.010	Complied
Middle	109.990	≤500	390.010	Complied
Top	112.160	≤500	387.840	Complied

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

4.2. Transmitter 99% Occupied Bandwidth

Test Summary:

Test Engineer:	Matthew Botfield	Test Date:	24 June 2020
Test Sample Serial Number:	bn1vc90g0000uc1c4kig		

ISED Canada Reference:	RSS-Gen 6.7
Test Method Used:	RSS-Gen 6.7

Environmental Conditions:

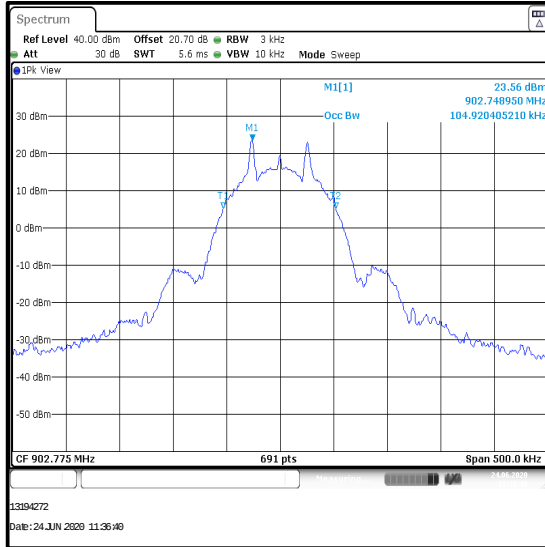
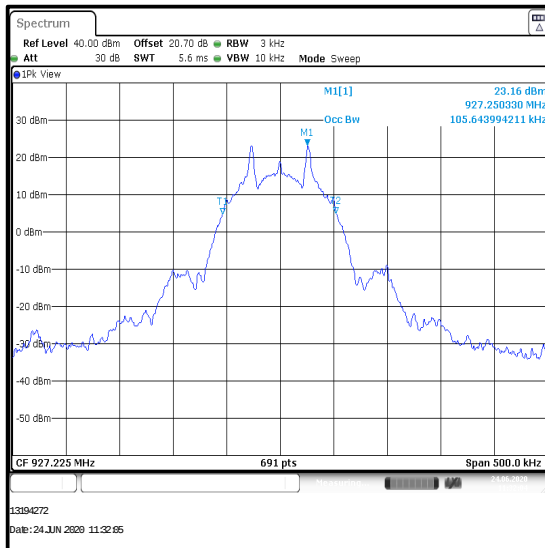
Temperature (°C):	23
Relative Humidity (%):	44

Note(s):

1. The 99% emission bandwidth was measured using the signal 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 signal analyser resolution bandwidth was set to 3 kHz and video bandwidth 10 kHz. A peak detector was used, sweep time was set to auto and the trace mode was Max Hold. The span was set to 500 kHz. The signal analyser function set the measurements to be made at 99% of the emission bandwidth. The results are given in the tables below.
3. The signal analyser was connected to the RF port on the EUT using suitable attenuation and RF adaptor/cables.

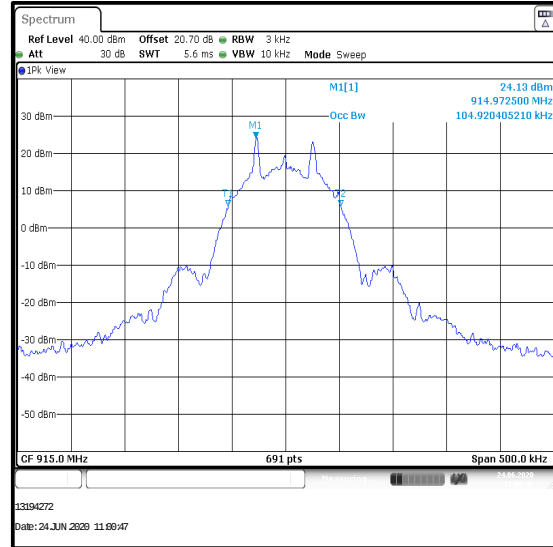
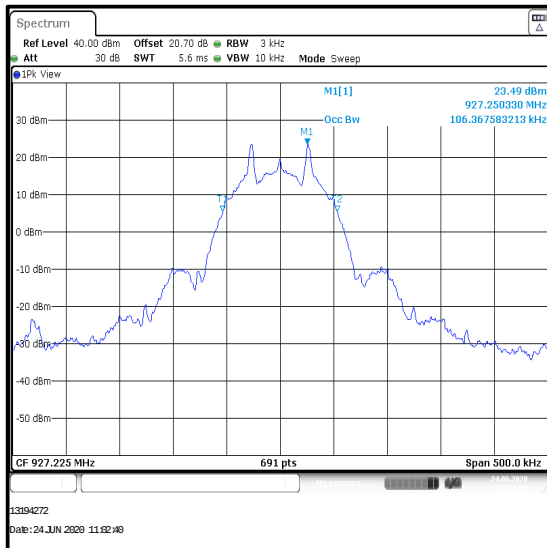
Transmitter 99% Occupied Bandwidth (continued)**Results: Antenna 1**

Channel	99% Occupied Bandwidth (kHz)
Bottom	104.920
Middle	104.920
Top	105.644

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

Transmitter 99% Occupied Bandwidth (continued)**Results: Antenna 2**

Channel	99% Occupied Bandwidth (kHz)
Bottom	104.197
Middle	104.920
Top	106.368

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

4.3. Transmitter Carrier Frequency Separation**Test Summary:**

Test Engineer:	Matthew Botfield	Test Dates:	24 June 2020 & 25 June 2020
Test Sample Serial Number:	bn1vc90g0000uc1c4kig		

FCC Reference:	Part 15.247(a)(1)
ISED Canada Reference:	RSS-247 5.1(b)
Test Method Used:	ANSI C63.10 Section 7.8.2

Environmental Conditions:

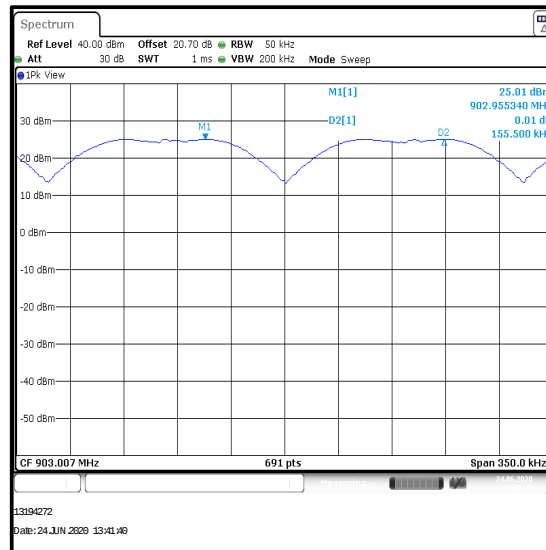
Temperature (°C):	22 to 23
Relative Humidity (%):	39 to 53

Note(s):

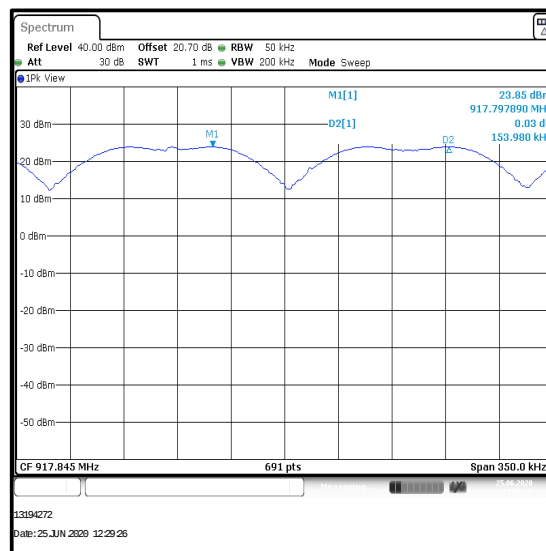
1. The 20 dB bandwidth measured for the top channel was used as the limit.
2. The signal analyser resolution bandwidth was set to 50 kHz and video bandwidth of 200 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The span was set to 350 kHz. A marker was placed at the centre of one signal and then a delta marker was placed in the corresponding point on the second signal, the results are recorded in the table below.
3. The signal analyser was connected to the RF port on the EUT using suitable attenuation and RF adaptor/cables.

Transmitter Carrier Frequency Separation (continued)**Results: Antenna 1 / Lower Hopping Sequence**

Carrier Frequency Separation (kHz)	Limit (kHz)	Margin (kHz)	Result
155.500	112.160	43.340	Complied

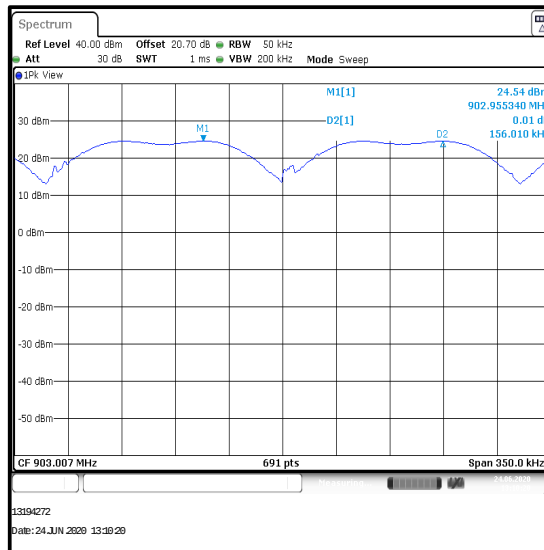
**Results: Antenna 1 / Upper Hopping Sequence**

Carrier Frequency Separation (kHz)	Limit (kHz)	Margin (kHz)	Result
153.980	112.160	41.820	Complied

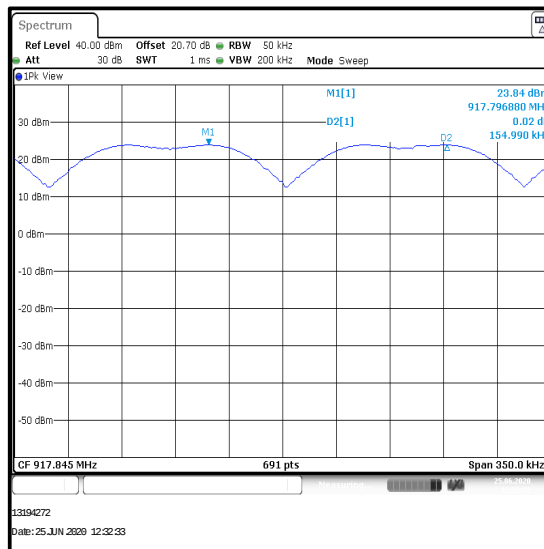


Transmitter Carrier Frequency Separation (continued)**Results: Antenna 2 / Lower Hopping Sequence**

Carrier Frequency Separation (kHz)	Limit (kHz)	Margin (kHz)	Result
156.010	112.160	43.850	Complied

**Results: Antenna 2 / Upper Hopping Sequence**

Carrier Frequency Separation (kHz)	Limit (kHz)	Margin (kHz)	Result
154.990	112.160	42.83	Complied



4.4. Transmitter Number of Hopping Frequencies and Average Time of Occupancy**Test Summary:**

Test Engineer:	Matthew Botfield	Test Date:	25 June 2020
Test Sample Serial Number:	bn1vc90g0000uc1c4kig		

Test Summary:

FCC Reference:	Part 15.247(a)(1)(i)
ISED Canada Reference:	RSS-247 5.1(c)
Test Method Used:	ANSI C63.10 Sections 7.8.3 & 7.8.4

Environmental Conditions:

Temperature (°C):	22
Relative Humidity (%):	53

Note(s):

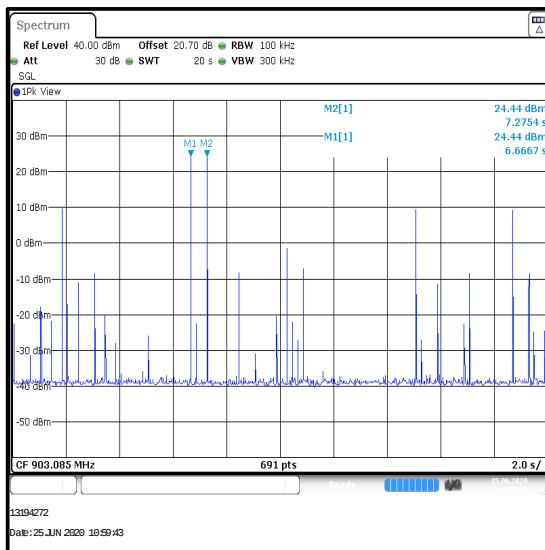
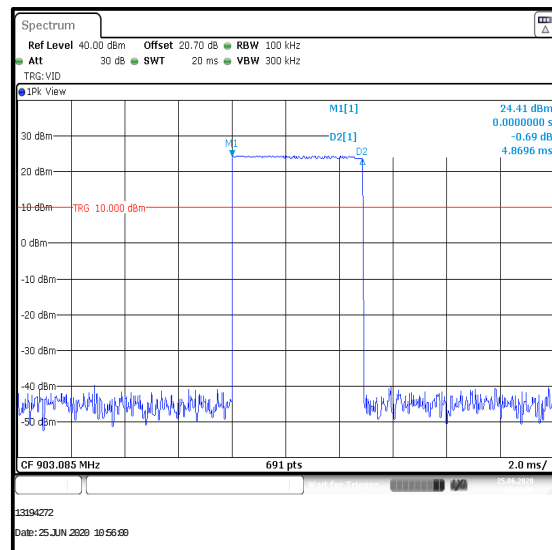
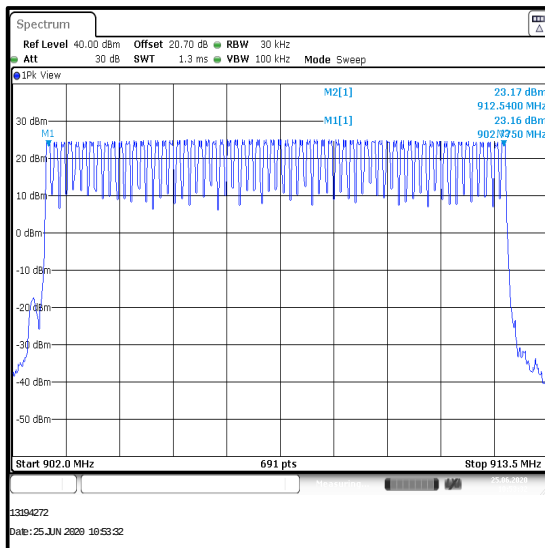
1. For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of the occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period.
2. The signal analyser was set up for the number of hopping frequencies in 20 seconds measurement as follows: the resolution bandwidth was set to 100 kHz and video bandwidth of 300 kHz. A peak detector was used, sweep time set to 20 seconds with a span of zero Hz.
3. The signal analyser was set up for the emission width measurement as follows; the resolution bandwidth was set to 100 kHz and video bandwidth of 300 kHz. A peak detector was used, sweep time set to 20 ms with a span of zero Hz, the emission width is recorded in the tables below.
4. The signal analyser was set up for the number of hopping frequencies measurement as follows: the resolution bandwidth was set to 30 kHz and video bandwidth of 100 kHz. A peak detector was used, sweep time was set to auto and trace was max Hold.
5. The signal analyser was connected to the RF port on the EUT using suitable attenuation and RF adaptor/cables.

Transmitter Number of Hopping Frequencies and Average Time of Occupancy (continued)**Results: Number of Hopping Frequencies: / Lower Hopping Sequence / Antenna 1**

Number of Hops	Limit (Hops)	Note	Result
64	≥50	1	Complied

Results: Average Time of Occupancy

Emission Width (ms)	Average Time of Occupancy (ms)	Limit (ms)	Margin (ms)	Result
4.8696	9.74	400	390.26	Complied

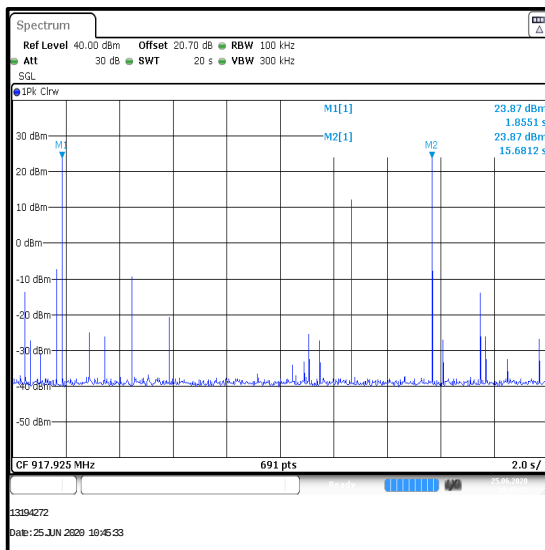
**TX on time in 20 second period****TX on period****Number Of Hopping Channels**

Transmitter Number of Hopping Frequencies and Average Time of Occupancy (continued)**Results: Number of Hopping Frequencies / Upper Hopping Sequence / Antenna 1**

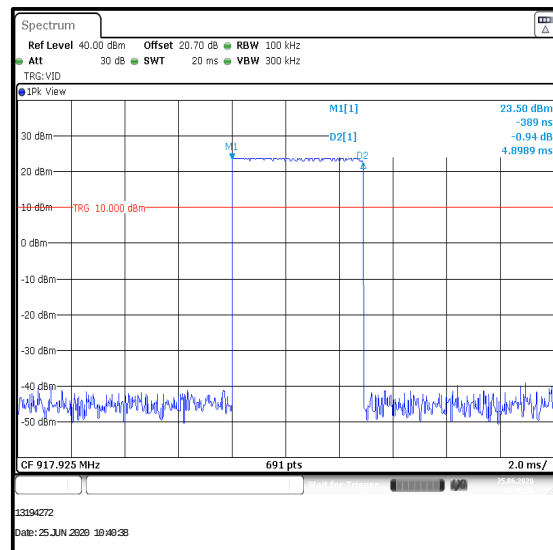
Number of Hops	Limit (Hops)	Note	Result
64	≥50	1	Complied

Results: Average Time of Occupancy

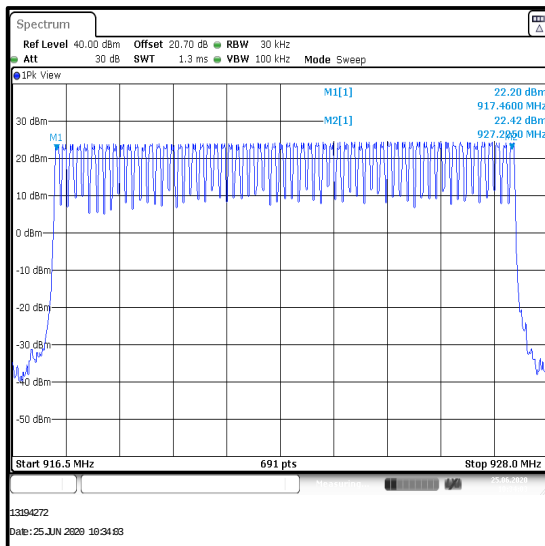
Emission Width (ms)	Average Time of Occupancy (ms)	Limit (ms)	Margin (ms)	Result
4.8989	9.80	400	390.20	Complied



TX on time in 20 second period



TX on period



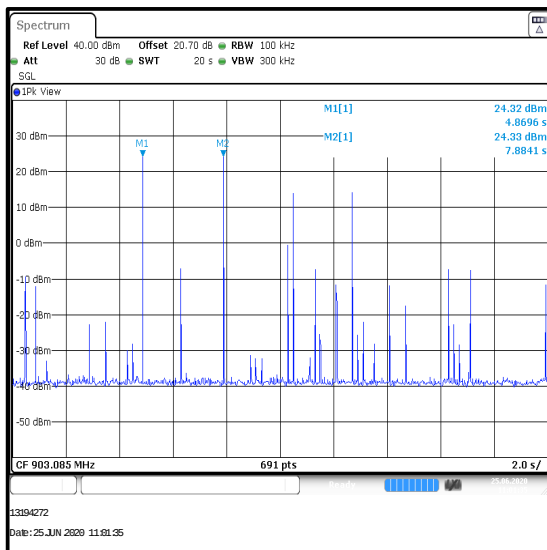
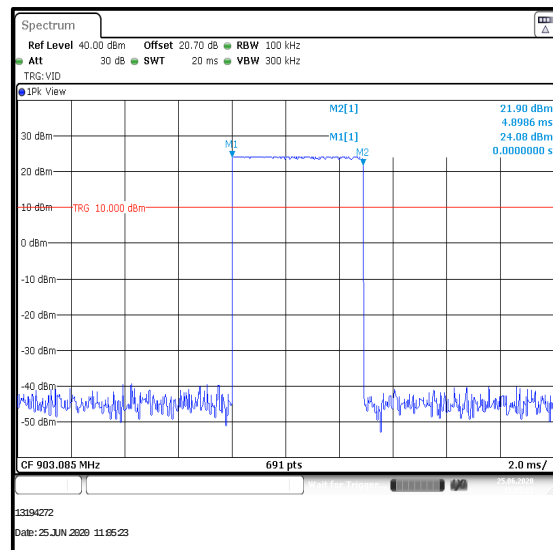
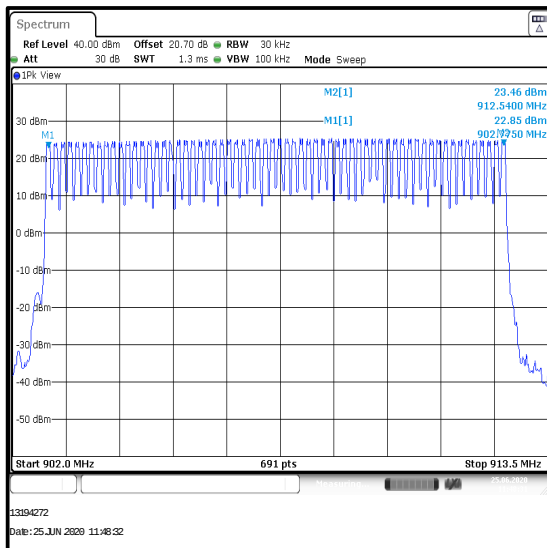
Number Of Hopping Channels

Transmitter Number of Hopping Frequencies and Average Time of Occupancy (continued)**Results: Number of Hopping Frequencies: / Lower Hopping Sequence / Antenna 2**

Number of Hops	Limit (Hops)	Note	Result
64	≥50	1	Complied

Results: Average Time of Occupancy

Emission Width (ms)	Average Time of Occupancy (ms)	Limit (ms)	Margin (ms)	Result
4.8986	9.80	400	390.20	Complied

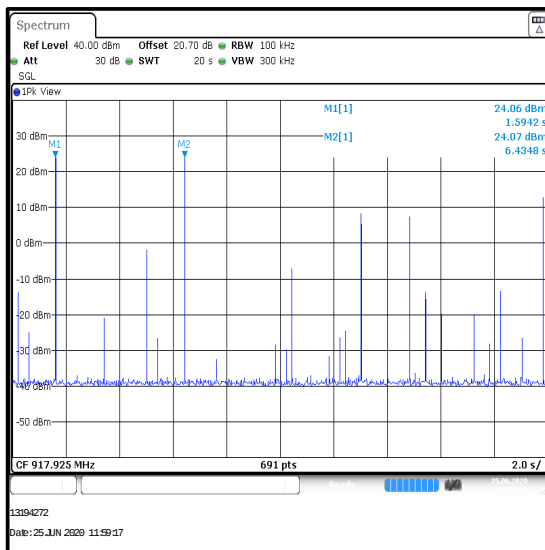
**TX on time in 20 second period****TX on period****Number Of Hopping Channels**

Transmitter Number of Hopping Frequencies and Average Time of Occupancy (continued)**Results: Number of Hopping Frequencies: / Upper Hopping Sequence / Antenna 2**

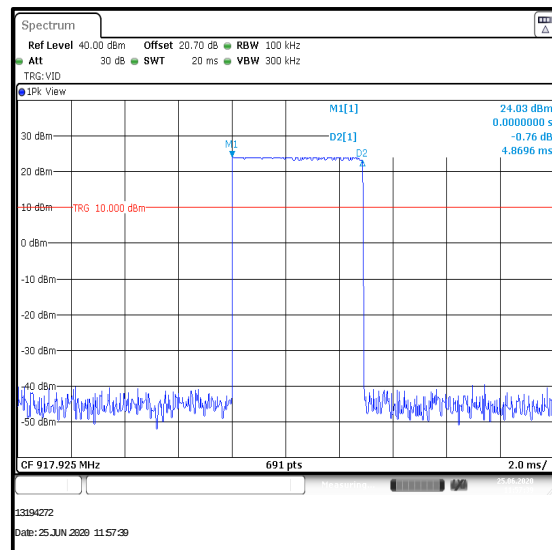
Number of Hops	Limit (Hops)	Note	Result
64	≥50	1	Complied

Results: Average Time of Occupancy

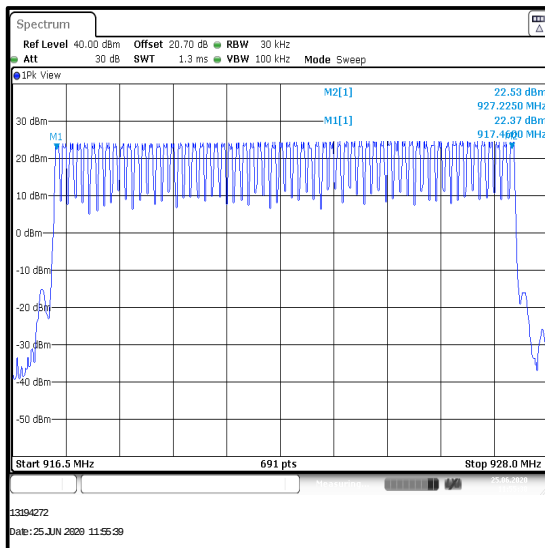
Emission Width (ms)	Average Time of Occupancy (ms)	Limit (ms)	Margin (ms)	Result
4.8696	9.74	400	390.26	Complied



TX on time in 20 second period



TX on period



Number Of Hopping Channels

4.5. Transmitter Maximum Peak Output Power**Test Summary:**

Test Engineer:	Matthew Botfield	Test Date:	24 June 2020
Test Sample Serial Number:	bn1vc90g0000uc1c4kig		

FCC Reference:	Part 15.247(b)(2)
ISED Canada Reference:	RSS-Gen 6.12 / RSS-247 5.4(a)
Test Method Used:	ANSI C63.10 Section 7.8.5

Environmental Conditions:

Temperature (°C):	23
Relative Humidity (%):	39

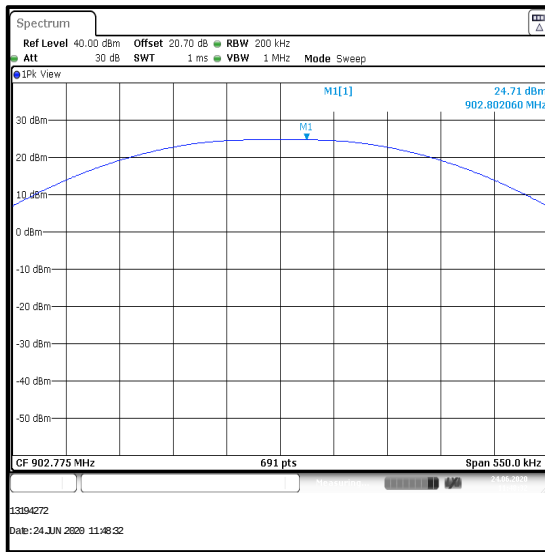
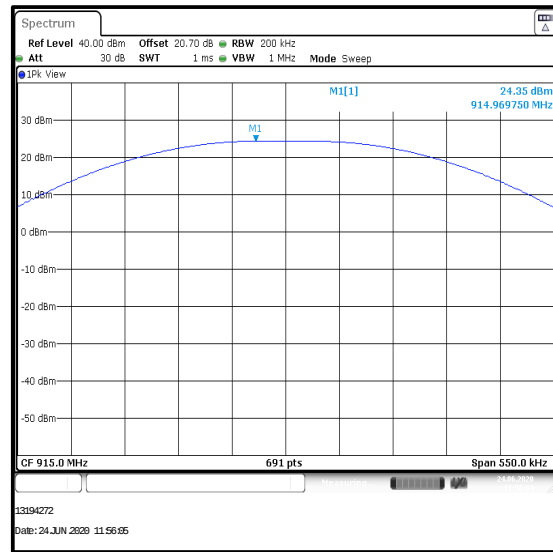
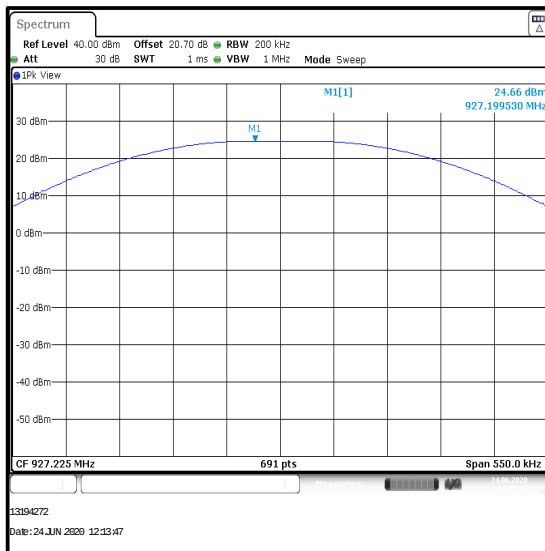
Note(s):

1. The signal analyser resolution bandwidth was set to 200 kHz and video bandwidth of 1 MHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The span was set to 550 kHz. A marker was placed at the peak of the signal and the results recorded in the table below.
2. The declared antenna gain was added to the conducted peak power to obtain the EIRP.
3. The signal analyser was connected to the RF port on the EUT using suitable attenuation and RF adaptor/cables. An RF offset level was entered on the signal analyser to compensate for the loss of the attenuator and RF cable.

Transmitter Maximum Peak Output Power (continued)**Results: Antenna 1**

Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	24.7	30.0	5.3	Complied
Middle	24.4	30.0	5.6	Complied
Top	24.7	30.0	5.3	Complied

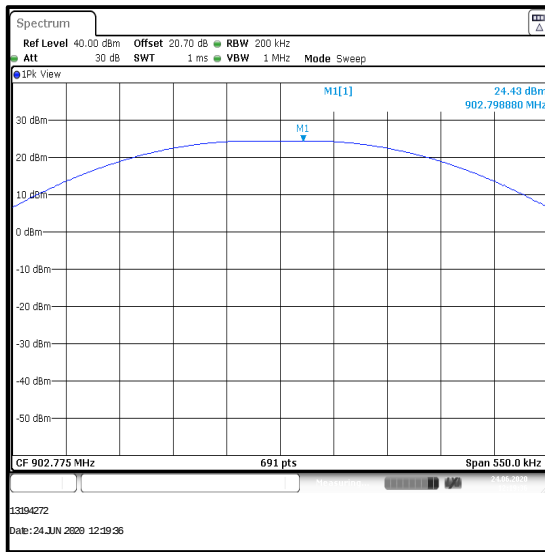
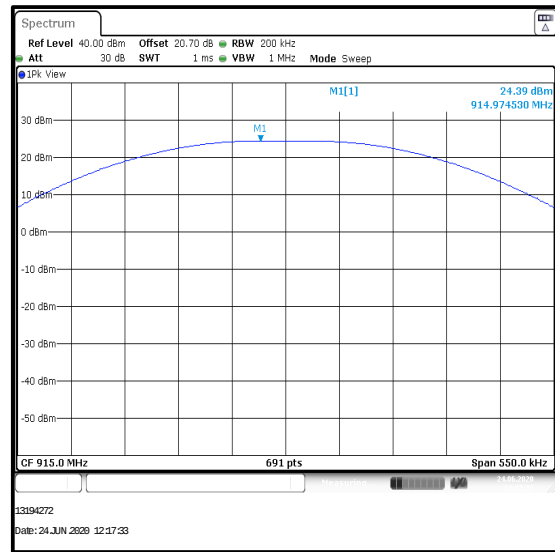
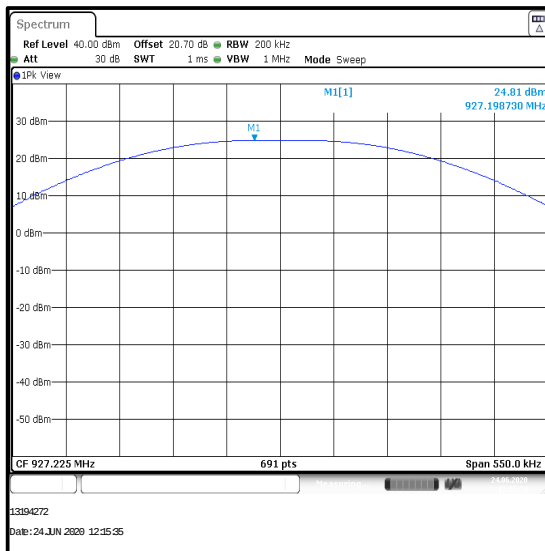
Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	24.7	0.0	24.7	36.0	11.3	Complied
Middle	24.4	0.0	24.4	36.0	11.6	Complied
Top	24.7	0.0	24.7	36.0	11.3	Complied

Transmitter Maximum Peak Output Power (continued)**Bottom Channel****Middle Channel****Top Channel**

Transmitter Maximum Peak Output Power (continued)**Results: Antenna 2**

Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	24.4	30.0	5.6	Complied
Middle	24.4	30.0	5.6	Complied
Top	24.8	30.0	5.2	Complied

Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	24.4	0.0	24.4	36.0	11.6	Complied
Middle	24.4	0.0	24.4	36.0	11.6	Complied
Top	24.8	0.0	24.8	36.0	11.2	Complied

Transmitter Maximum Peak Output Power (continued)**Bottom Channel****Middle Channel****Top Channel**

5. Radiated Test Results

5.1. Transmitter Radiated Emissions <1 GHz

Test Summary:

Test Engineers:	Jose Bayona & Mohamed Toubella	Test Date:	26 June 2020 & 01 August 2020
Test Sample Serial Number:	bn1vc90g0000uc1c4kig		

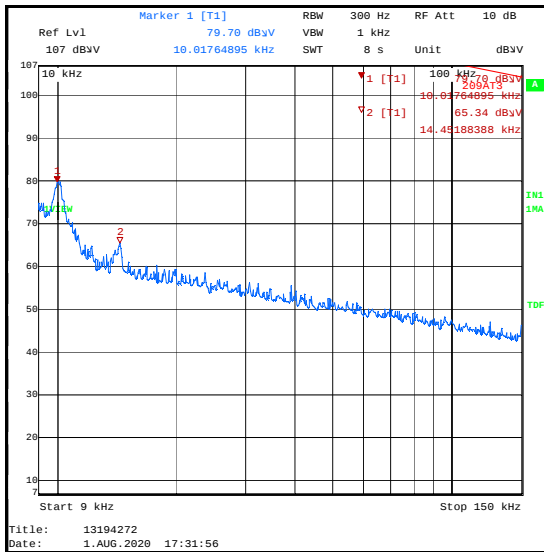
FCC Reference:	Parts 15.247(d) & 15.209(a)
ISED Canada Reference:	RSS-Gen 6.13 / RSS-247 5.5
Test Method Used:	ANSI C63.10 Sections 6.3, 6.4 and 6.5
Frequency Range	9 kHz to 1000 MHz

Environmental Conditions:

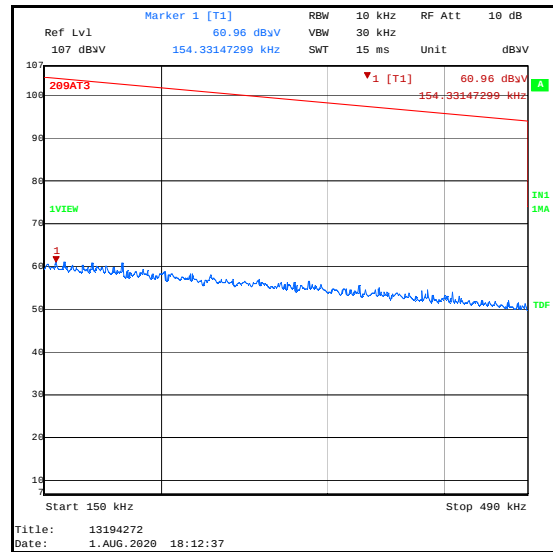
Temperature (°C):	23 to 24
Relative Humidity (%):	44 to 48

Note(s):

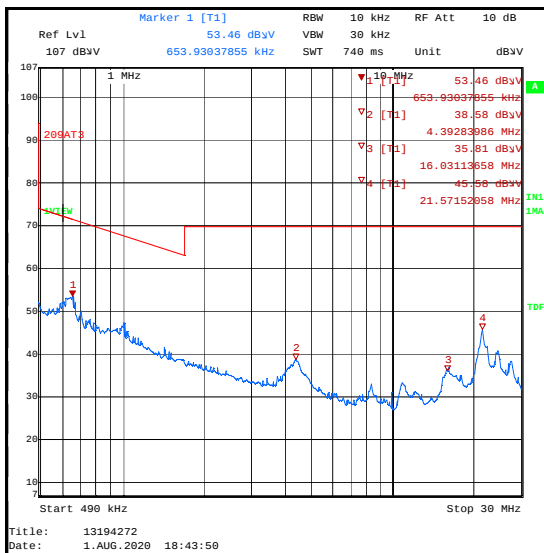
1. The emission at approximately 902.775 MHz is the EUT fundamental.
2. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
3. The preliminary scans showed similar emission levels below 1 GHz, for each channel of operation. Therefore final radiated emissions measurements were performed with the EUT set to the bottom channel only.
4. All other 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.
5. Measurements between 9 kHz and 30 MHz 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. Emission levels were determined by rotating the EUT and measurement antenna. Only noise floor and ambient emissions were observed. Comparisons between radiated measurements below 30 MHz in a semi-anechoic chamber and open field test site are archived on the UL VS LTD IT server and available for inspection on request.
6. Measurements between 30 MHz and 1 GHz were performed in a semi-anechoic chamber (Asset Number K0017) 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. Prescans were performed and markers placed on the highest measured levels. The test receiver resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. The sweep time was set to auto. A peak detector was used, sweep time was set to auto and trace mode was Max Hold.
7. Final measurements were performed on the marker frequencies and the results entered into the table below. The test receiver resolution bandwidth was set to 120 kHz, using a CISPR quasi-peak detector and span wide enough to see the whole emission.

Transmitter Radiated Emissions <1 GHz (continued)

9 kHz to 150 kHz / peak detector / measured in a semi-anechoic chamber at 3 metres



150 kHz to 490 kHz / peak detector / measured in a semi-anechoic chamber at 3 metres



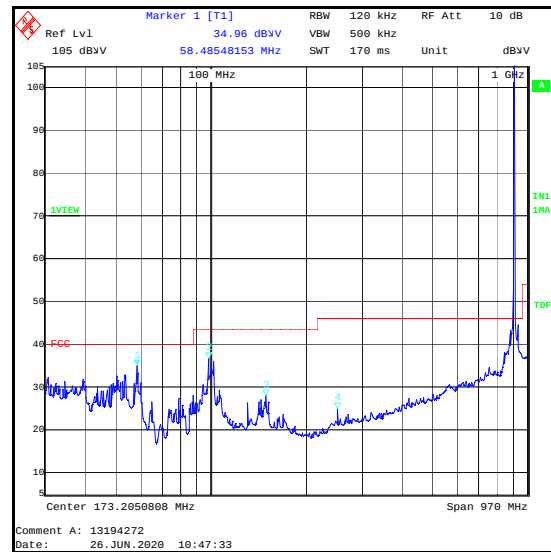
490 kHz to 30 MHz / peak detector / measured in a semi-anechoic chamber at 3 metres

Transmitter Radiated Emissions <1 GHz (continued)**Results: Antenna 1 / Quasi-Peak**

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
249.980	Horizontal	28.4	46.0	17.6	Complied

Results: Antenna 2 / Quasi-Peak

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
249.980	Horizontal	28.4	46.0	17.6	Complied

**Antenna 1****Antenna 2**

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

5.2. Transmitter Radiated Emissions >1 GHz

Test Summary:

Test Engineer:	Jose Bayona	Test Dates:	24 June 2020 & 25 June 2020
Test Sample Serial Number:	bn1vc90g0000uc1c4kig		

FCC Reference:	Parts 15.247(d) & 15.209(a)
ISED Canada Reference:	RSS-Gen 6.13 / RSS-247 5.5
Test Method Used:	ANSI C63.10 Sections 6.3 and 6.6
Frequency Range	1 GHz to 9.3 GHz

Environmental Conditions:

Temperature (°C):	23 to 24
Relative Humidity (%):	42 to 44

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 plots were investigated and found to be ambient or >20 dB below the applicable limit or below the measurement system noise floor.
3. 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 metres above the test chamber floor in the centre of the chamber turntable. During prescans, 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 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.
4. Pre-scans were performed and a marker placed on the highest measured emission level. The test receiver resolution bandwidth was set to 1 MHz and video bandwidth 3 MHz. The sweep time was set to auto.
5. 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.

Transmitter Radiated Emissions >1 GHz (continued)**Results: Bottom Channel / Antenna 1**

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
2708.392	Horizontal	47.7	54.0	6.3	Complied

Results: Middle Channel / Antenna 1

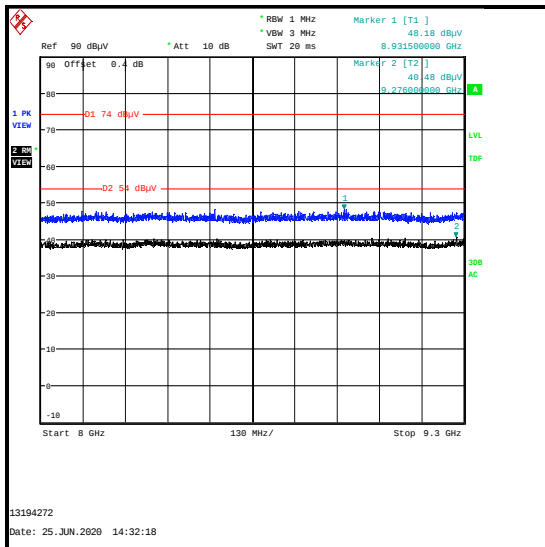
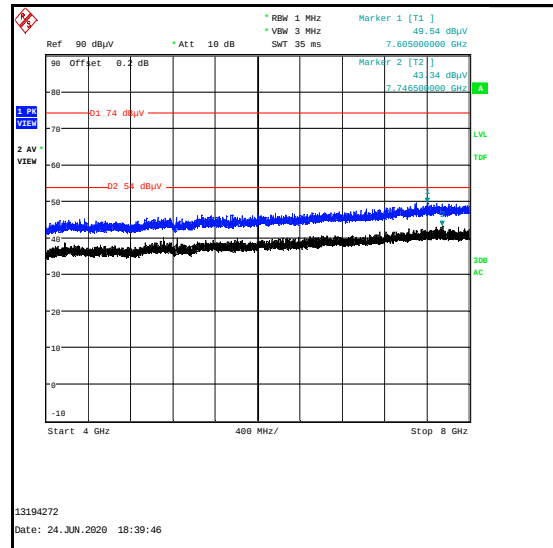
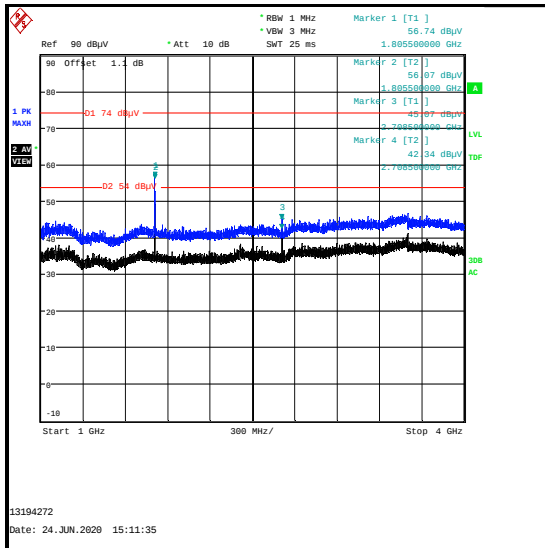
Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
2745.157	Horizontal	45.5	54.0	8.5	Complied

Results: Top Channel / Antenna 1

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
2781.642	Horizontal	45.7	54.0	8.3	Complied

Results: Hopping Mode / Antenna 1

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
2720.867	Horizontal	49.5	54.0	4.5	Complied

Transmitter Radiated Emissions >1 GHz (continued)**Results: Antenna 1**

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

Transmitter Radiated Emissions >1 GHz (continued)**Results: Bottom Channel / Antenna 2**

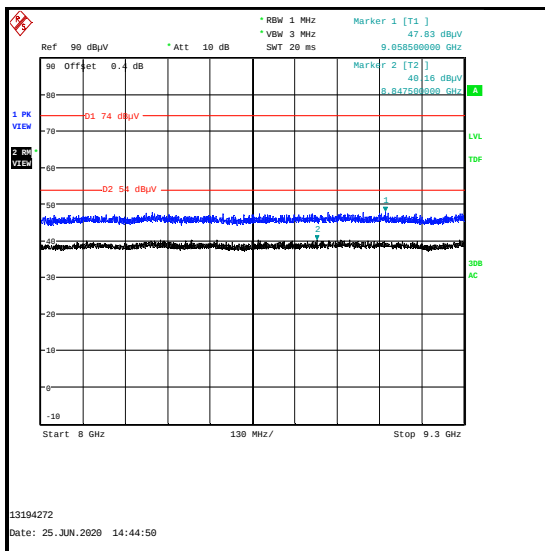
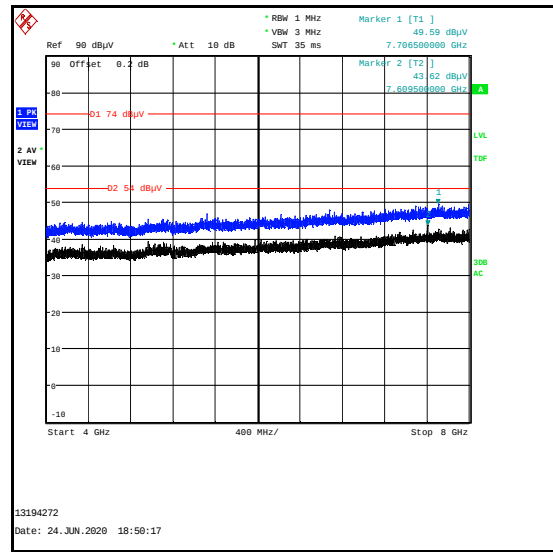
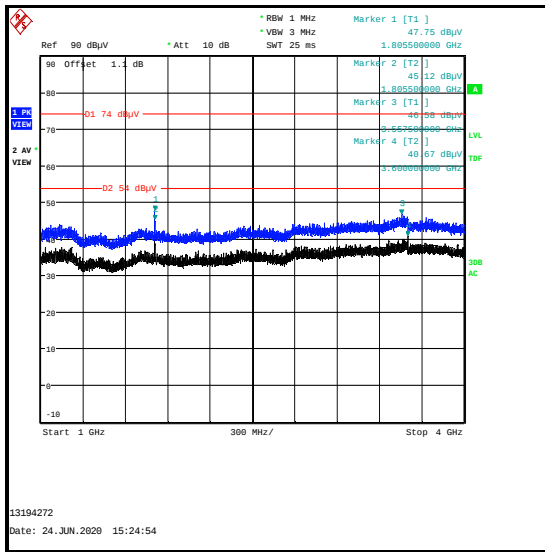
Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
See Note 2					

Results: Middle Channel / Antenna 2

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
7706.500	Horizontal	49.6	54.0	4.4	Complied

Results: Top Channel / Antenna 2

Frequency (MHz)	Antenna Polarity	Peak Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
See Note 2					

Transmitter Radiated Emissions >1 GHz (continued)

5.3. Transmitter Band Edge Radiated Emissions

Test Summary:

Test Engineers:	Andrew Edwards & Jose Bayona	Test Date:	22 June 2020
Test Sample Serial Number:	bn1vc90g0000uc1c4kig		

FCC Reference:	Parts 15.247(d) & 15.209(a)
ISED Canada Reference:	RSS-Gen 6.13 / RSS-247 5.5
Test Method Used:	ANSI C63.10 Section 6.10

Environmental Conditions:

Temperature (°C):	24
Relative Humidity (%):	44

Note(s):

1. As both band edges are adjacent to non-restricted bands, only peak measurements are required. 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. A marker was placed on the band edge spot frequencies and a second marker placed on the highest emission level in the adjacent band (where a higher level emission was present). Marker frequencies and levels were recorded.
2. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.

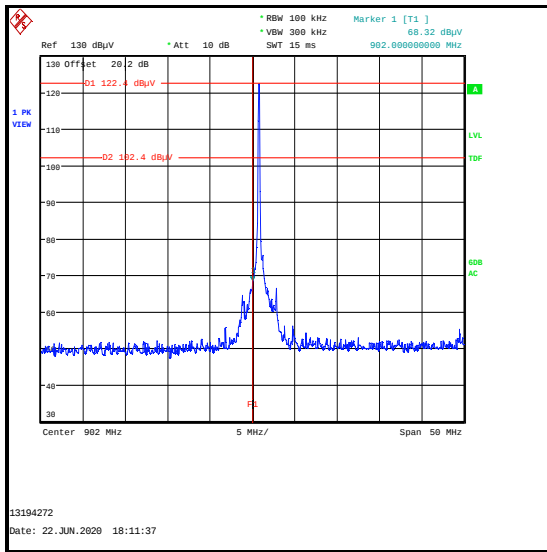
Transmitter Band Edge Radiated Emissions (continued)**Results: Static Mode / Antenna 1**

Frequency (MHz)	Peak Level (dB μ V/m)	-20 dBc Limit (dB μ V/m)	Margin (dB)	Result
902.000	68.3	102.4	34.1	Complied
928.000	64.8	102.9	38.1	Complied

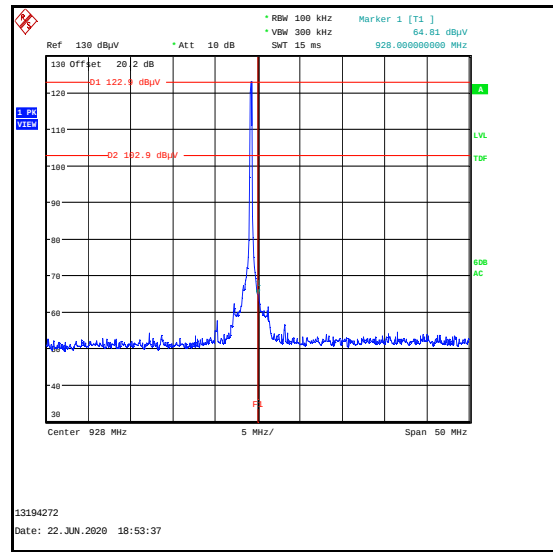
Results: Hopping Mode / Antenna 1

Frequency (MHz)	Peak Level (dB μ V/m)	-20 dBc Limit (dB μ V/m)	Margin (dB)	Result
901.519	66.3	103.6	37.3	Complied
902.000	62.6	103.6	41.0	Complied
928.000	60.4	103.2	42.8	Complied
928.080	69.0	103.2	34.2	Complied

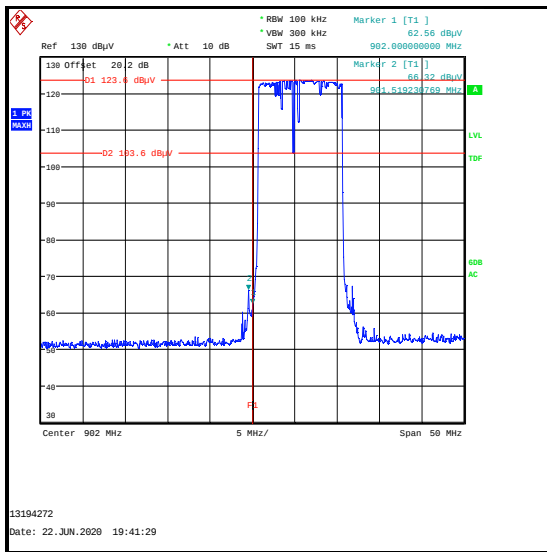
Transmitter Band Edge Radiated Emissions (continued)



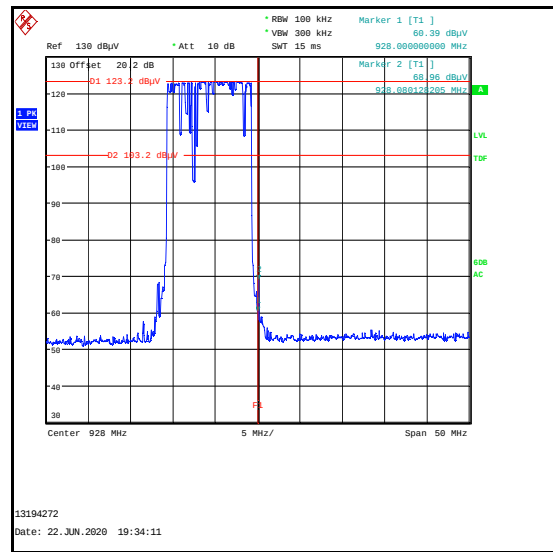
**Lower Band Edge / Bottom Channel /
Static / Antenna 1**



**Upper Band Edge / Top Channel /
Static / Antenna 1**



Lower Band Edge / Hopping / Antenna 1



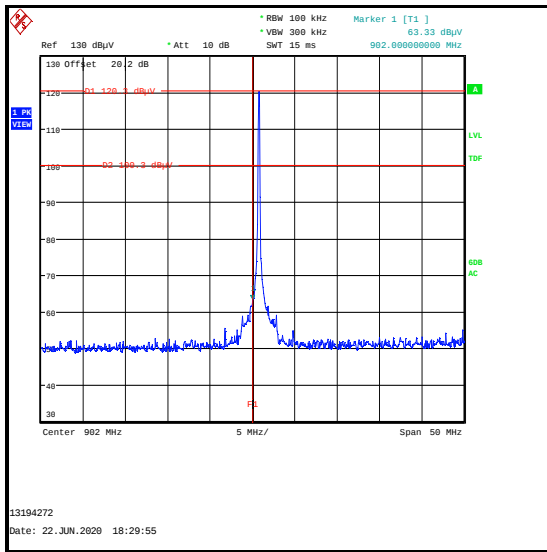
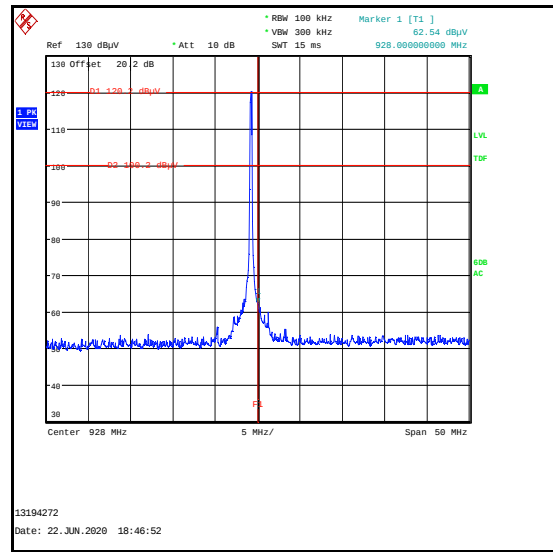
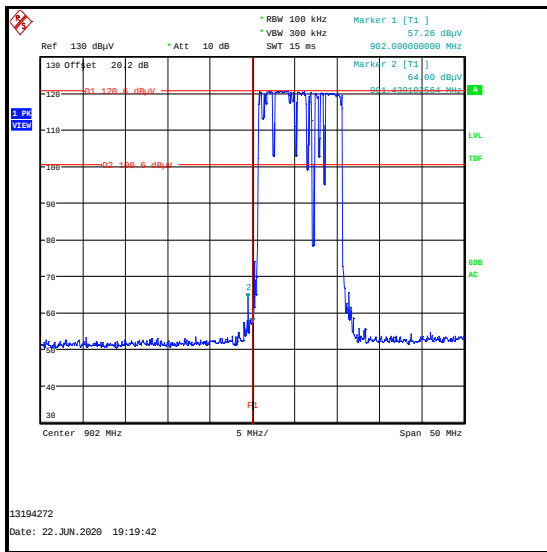
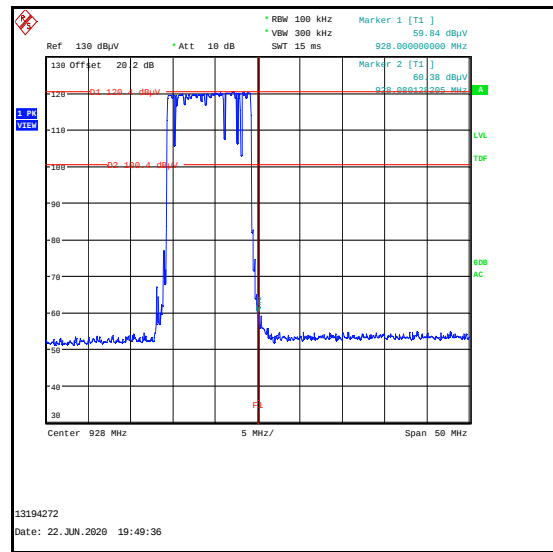
Upper Band Edge / Hopping / Antenna 1

Transmitter Band Edge Radiated Emissions (continued)**Results: Static Mode / Antenna 2**

Frequency (MHz)	Peak Level (dB μ V/m)	-20 dBc Limit (dB μ V/m)	Margin (dB)	Result
902.000	63.3	100.3	37.0	Complied
928.000	62.5	100.2	37.7	Complied

Results: Hopping Mode / Antenna 2

Frequency (MHz)	Peak Level (dB μ V/m)	-20 dBc Limit (dB μ V/m)	Margin (dB)	Result
901.439	64.0	100.6	36.6	Complied
902.000	57.3	100.6	43.3	Complied
928.000	59.8	100.4	40.6	Complied
928.080	60.4	100.4	40.0	Complied

Transmitter Band Edge Radiated Emissions (continued)**Lower Band Edge / Bottom Channel /
Static / Antenna 2****Upper Band Edge / Top Channel /
Static / Antenna 2****Lower Band Edge / Hopping / Antenna 2****Upper Band Edge / Hopping / Antenna 2**

6. AC Power Line Conducted Emissions Test Results

6.1. Transmitter AC Conducted Spurious Emissions

Test Summary:

Test Engineer:	Alison Johnston	Test Dates:	21 July 2020 & 22 July 2020
Test Sample Serial Number:	bptivi4c0001ks2ak1mg		

FCC Reference:	Part 15.207
ISED Canada Reference:	RSS-Gen 8.8
Test Method Used:	ANSI C63.10 Section 6.2

Environmental Conditions:

Temperature (°C):	24
Relative Humidity (%):	42

Note(s):

1. The development board/EUT were powered from a bench power supply. The input to the power supply was connected to a single phase mains supply via a LISN.
2. 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.
3. A pulse limiter was fitted between the LISN and the test receiver.

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

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.402000	Live	45.1	57.8	12.7	Complied
4.780500	Live	33.2	56.0	22.8	Complied
13.420500	Live	39.5	60.0	20.5	Complied
14.212500	Live	41.9	60.0	18.1	Complied
15.616500	Live	39.6	60.0	20.4	Complied
16.228500	Live	40.7	60.0	19.3	Complied

Results: Live / Average / 120V

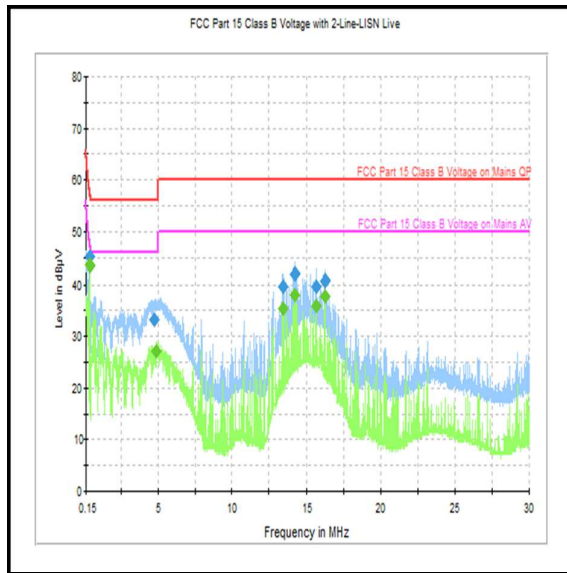
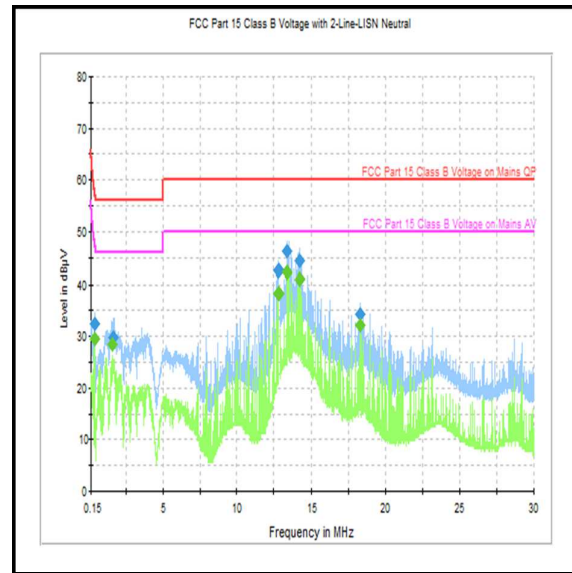
Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.406500	Live	43.5	47.7	4.2	Complied
4.866000	Live	27.0	46.0	19.0	Complied
13.420500	Live	35.4	50.0	14.6	Complied
14.212500	Live	38.1	50.0	11.9	Complied
15.616500	Live	35.8	50.0	14.2	Complied
16.228500	Live	37.7	50.0	12.3	Complied

Results: Neutral / Quasi Peak / 120v

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.402000	Neutral	32.4	57.8	25.4	Complied
1.693500	Neutral	29.6	56.0	26.4	Complied
12.808500	Neutral	42.5	60.0	17.5	Complied
13.357500	Neutral	46.2	60.0	13.8	Complied
14.212500	Neutral	44.4	60.0	15.6	Complied
18.244500	Neutral	34.4	60.0	25.6	Complied

Results: Neutral / Average / 120v

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.402000	Neutral	29.6	47.8	18.2	Complied
1.590000	Neutral	28.4	46.0	17.6	Complied
12.808500	Neutral	38.2	50.0	11.8	Complied
13.357500	Neutral	42.3	50.0	7.7	Complied
14.212500	Neutral	40.8	50.0	9.2	Complied
18.244500	Neutral	32.1	50.0	17.9	Complied

Transmitter AC Conducted Spurious Emissions (continued)**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 / 240V**

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.402000	Live	39.4	57.8	18.4	Complied
1.194000	Live	33.9	56.0	22.1	Complied
12.808500	Live	40.9	60.0	19.1	Complied
13.357500	Live	47.3	60.0	12.7	Complied
14.212500	Live	47.3	60.0	12.7	Complied
16.228500	Live	41.5	60.0	18.5	Complied

Results: Live / Average / 240V

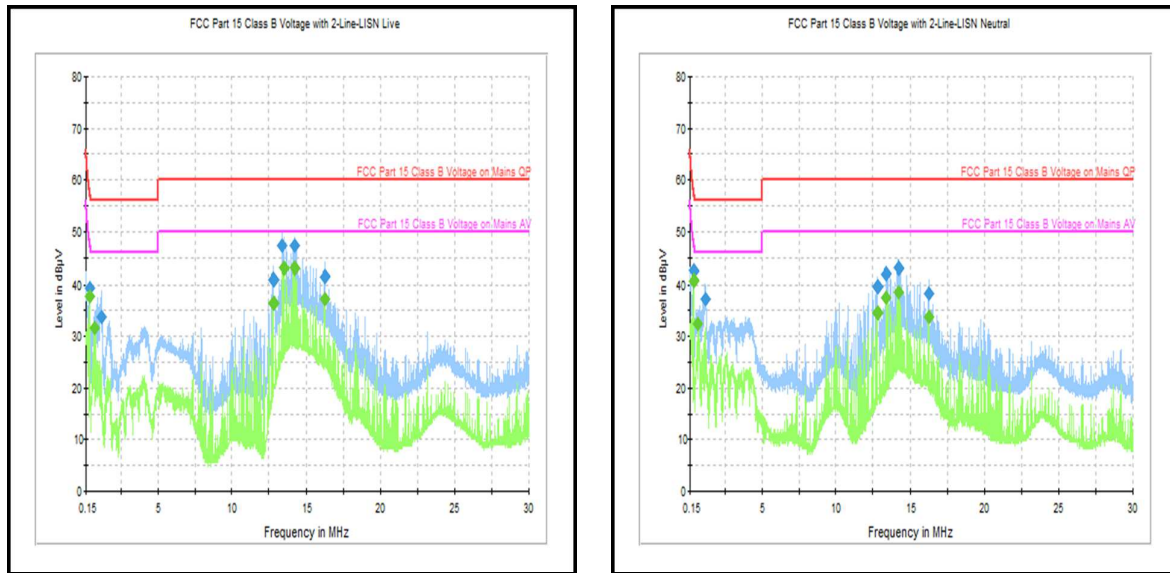
Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.406500	Live	37.8	47.7	9.9	Complied
0.748500	Live	31.5	46.0	14.5	Complied
12.808500	Live	36.3	50.0	13.7	Complied
13.479000	Live	43.1	50.0	6.9	Complied
14.212500	Live	43.1	50.0	6.9	Complied
16.228500	Live	37.1	50.0	12.9	Complied

Results: Neutral / Quasi Peak / 240v

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.406500	Neutral	42.4	57.7	15.3	Complied
1.185000	Neutral	37.1	56.0	18.9	Complied
12.808500	Neutral	39.7	60.0	20.3	Complied
13.357500	Neutral	41.9	60.0	18.1	Complied
14.212500	Neutral	43.0	60.0	17.0	Complied
16.228500	Neutral	38.2	60.0	21.8	Complied

Results: Neutral / Average / 240v

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.406500	Neutral	40.7	47.7	7.0	Complied
0.708000	Neutral	32.3	46.0	13.7	Complied
12.808500	Neutral	34.5	50.0	15.5	Complied
13.357500	Neutral	37.4	50.0	12.6	Complied
14.212500	Neutral	38.5	50.0	11.5	Complied
16.228500	Neutral	33.6	50.0	16.4	Complied

Transmitter AC Conducted Spurious Emissions (continued)**Live****Neutral**

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

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