TEST REPORT

Test Report No. : UL-RPT-RP13798732-716A

Customer	:	Eliwell Controls s.r.l.
Model No. / HVIN	:	Dongle BTLE 5.0 Air
PMN	:	DONGLE BTLE 5.0 AIR
FCC ID	:	2AMLEDONGLEBTLE5
ISED Certification No.	:	IC: 9727A-DONGLEBTLE5
Technology	:	*Bluetooth* – Low Energy
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 February 2021
Test Laboratory	:	UL International (UK) Ltd, Basingstoke, Hampshire, RG24 8AH, United Kingdom

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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 1.0.

Date of Issue: 14 December 2021

Checked by:

Ben Mercer
Lead Project Engineer, Radio Laboratory

Company Signatory:

Sarah Williams
RF Operations Leader, Radio Laboratory

5772

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Customer Information

Company Name:	Eliwell Controls s.r.l.
Address:	Via dell'Industria, 15 32016 Alpago, Belluno Italy

Report Revision History

Version Number	Issue Date	Revision Details	Revised By
1.0	14/12/2021	Initial Version	Ben Mercer

Table of Contents

1 Attestation of Test Results

1.1 Description of EUT

The equipment under test was a *Bluetooth* radio 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:	47CFR15.225
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Radio Frequency Devices) - Section 15.225
Specification Reference:	RSS-Gen Issue 5 February 2021
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
Specification Reference:	RSS-210 Issue 10 April 2020
Specification Title:	Licence-exempt Radio Apparatus: Category I Equipment
Site Registration:	FCC: 685609, ISEDC: 20903
FCC Lab. Designation No.:	UK2011
ISEDC CABID:	UK0001
Location of Testing:	Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, G24 8AH, United Kingdom
Test Dates:	15 September 2021 to 07 December 2021

1.3 Summary of Test Results

FCC Reference (47CFR)	ISED Canada Reference	Measurement	Result
Part 15.35(c)	RSS-Gen 8.2	Transmitter Duty Cycle	Note 1
N/A	RSS-Gen 6.7	Transmitter 99% Occupied Bandwidth	✓
Part 15.247(a)(2)	RSS-Gen 6.7 / RSS-247 5.2(a)	Transmitter Minimum 6 dB Bandwidth	✓
Part 15.247(b)(3)	RSS-Gen 6.12 / RSS-247 5.4(d)	Transmitter Maximum Peak Output Power	✓
Part 15.247(e)	RSS-247 5.4(b)	Transmitter Power Spectral Density	Note 2
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			

Note(s):

1. The measurement was performed to assist in the calculation of the level of the emissions. The EUT cannot transmit continuously and sweep triggering/signal gating cannot be implemented.
2. In accordance with ANSI C63.10 Section 11.10.1, PSD measurements are 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 be equal to the measured output power.

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 International (UK) Ltd is accredited by the United Kingdom Accreditation Service (UKAS). UKAS is one of the signatories to the International Laboratory Accreditation Co-operation (ILAC) Arrangement for the mutual recognition of test reports. 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
Reference:	ANSI C63.4-2014
Title:	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
Reference:	FCC KDB 414788 D01 Radiated Test Site v01r01 July 12, 2018
Title:	Test Sites For Radiated Emission Measurements
Reference:	Notice 2020 - DRS0023
Title:	Guidance on magnetic field strength radiated emission measurements (9 kHz - 30 MHz)

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 & Decision Rule

Overview

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.

Decision Rule

The decision rule applied is based upon the accuracy method criteria. The measurement uncertainty is met and the result is considered in conformance with the requirement criteria if the observed value is within the prescribed limit.

Measurement Uncertainty

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
Duty Cycle	2.4 GHz to 2.4835 GHz	95%	±1.14 %
99% Occupied Bandwidth	2.4 GHz to 2.4835 GHz	95%	±3.92 %
Minimum 6 dB Bandwidth	2.4 GHz to 2.4835 GHz	95%	±4.59 %
Conducted Maximum Peak Output Power	2.4 GHz to 2.4835 GHz	95%	±1.13 dB
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 25 GHz	95%	±2.94 dB
AC Conducted Spurious Emissions	0.15 MHz to 30 MHz	95%	±1.96 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 Tests

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2002	Thermohygrometer	Testo	608-H1	45041825	10 Dec 2021	12
M2036	Signal Analyser	Rohde & Schwarz	FSV30	101791	21 May 2022	12
A3117	Attenuator	AtlanTecRF	AN18-10	237378#1	Calibrated before use	-
G0615	Signal Generator	Rohde & Schwarz	SMBV100A	260473	03 Mar 2023	36

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	10 Dec 2021	12
K0001	3m RSE Chamber	Rainford EMC	N/A	N/A	06 Sep 2022	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	29 Apr 2022	12
A2523	Attenuator	AtlanTecRF	AN18W5-10	832827#1	03 Feb 2022	12
A3155	Pre-Amplifier	Com-Power	PAM-118A	18040037	24 Aug 2022	12
A3138	Antenna	Schwarzbeck	BBHA 9120B	00702	27 Aug 2022	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	09 Dec 2021	12
A649	LISN	Rohde & Schwarz	ESH3-Z5	825562/008	04 Aug 2022	12
A1830	Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100668	21 Apr 2022	12
M1273	Test Receiver	Rohde & Schwarz	ESIB 26	100275	14 Dec 2021	12

Test Measurement Software/Firmware Used:

Name	Version	Release Date
Rohde & Schwarz EMC32	6.30.0	2018

Test and Measurement Equipment (continued)

Test Equipment Used for Transmitter Radiated Emissions Tests

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2040	Thermohygrometer	Testo	608-H1	45124934	20 Dec 2021	12
K0001	3m RSE Chamber	Rainford EMC	N/A	N/A	06 Sep 2022	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	29 Apr 2022	12
A3154	Pre-Amplifier	Com-Power	PAM-103	18020012	24 Aug 2022	12
A3155	Pre-Amplifier	Com-Power	PAM-118A	18040037	24 Aug 2022	12
A3141	Pre-Amplifier	Schwarzbeck	BBV 9718 B	00021	24 Aug 2022	12
A2893	Pre-Amplifier	Schwarzbeck	BBV 9721	9721-021	29 Oct 2021	12
A553	Antenna	Chase	CBL6111A	1593	15 Mar 2022	12
A3138	Antenna	Schwarzbeck	BBHA 9120 B	702	27 Aug 2022	12
A3139	Antenna	Schwarzbeck	HWRD750	27	27 Aug 2022	12
A2895	Antenna	Schwarzbeck	BBHA 9170	9170-728	16 Feb 2022	12
A2892	Antenna	Schwarzbeck	BBHA 9170	9170-727	30 Oct 2021	12
A3093	High Pass Filter	AtlanTecRF	AFH-03000	18051800077	03 Feb 2022	12
A3095	High Pass Filter	AtlanTecRF	AFH-07000	1601900001	01 Feb 2022	12
A2523	Attenuator	AtlanTecRF	AN18W5-10	832827#1	03 Feb 2022	12
K0017	3m RSE Chamber	Rainford EMC	N/A	N/A	26 Oct 2022	12
M2003	Thermohygrometer	Testo	608-H1	45046641	10 Dec 2021	12
M1874	Test Receiver	Rohde & Schwarz	ESU26	100553	19 May 2022	12
A2948	Pre-Amplifier	Com-Power	PAM-118A	551087	20 Oct 2022	12
A2889	Antenna	Schwarzbeck	BBHA 9120 B	00653	26 Oct 2022	12
A2916	Attenuator	AtlanTecRF	AN18W5-10	832827#2	01 Feb 2022	12
A2914	High Pass Filter	AtlanTecRF	AFH-03000	2155	01 Feb 2022	12
A2947	High Pass Filter	AtlanTecRF	AFH-07000	1601900001	01 Feb 2022	12
A2893	Pre-Amplifier	Schwarzbeck	BBV 9721	9721-021	29 Oct 2021	12
A2890	Antenna	Schwarzbeck	HWRD 750	014	29 Oct 2021	12
A3142	Pre-Amplifier	Schwarzbeck	BBV 9718 B	00020	20 Oct 2022	12
A490	Antenna	Chase	CBL6111A	1590	14 Sep 2022	12
A2951	Pre-Amplifier	Com-Power	PAM-103	441141	25 Jan 2022	12
A3198	Mag Loop Antenna	ETS-Lindgren	6502	00221887	12 Aug 2022	12

3 Equipment Under Test (EUT)

3.1 Identification of Equipment Under Test (EUT)

Brand Name:	Eliwell
Model Name or Number / HVIN:	Dongle BTLE 5.0 AIR
PMN:	DONGLE BTLE 5.0 AIR
Test Sample Serial Number:	0053840B *(Conducted sample #1)*
Hardware Version:	111908
Software Version:	TelevisAirV3-DTM-220421
FCC ID:	2AMLEDONGLEBTLE5
ISED Canada Certification Number:	9727A-DONGLEBTLE5

Brand Name:	Eliwell
Model Name or Number / HVIN:	Dongle BTLE 5.0 AIR
PMN:	DONGLE BTLE 5.0 AIR
Test Sample Serial Number:	0053826B *(Radiated sample #1)*
Hardware Version:	111908
Software Version:	TelevisAirV3-DTM-220421
FCC ID:	2AMLEDONGLEBTLE5
ISED Canada Certification Number:	9727A-DONGLEBTLE5

3.2 Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

3.3 Additional Information Related to Testing

Technology Tested:	*Bluetooth* Low Energy (Digital Transmission System)		
Type of Unit:	Transceiver		
Channel Spacing:	2 MHz		
Modulation:	GFSK		
Data Rate: LE	1 Mbps		
Data Rate: LE2M	2 Mbps		
Power Supply Requirement(s):	Nominal	3.3 VDC	
Maximum Conducted Output Power:	4.5 dBm		
Transmit Frequency Range:	2402 MHz to 2480 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Bottom	37	2402
	Middle	17	2440
	Top	39	2480

3.4 Description of Available Antennas

The radio utilizes an integrated antenna, with the following maximum gain:

Manufacturer	Model	Type	Frequency Range (MHz)	Antenna Gain (dBi)
Johanson	2450AT18A100	Chip	2400-2480	0.5

3.5 Description of Test Setup

Support Equipment

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

Description:	Test Laptop
Brand Name:	Lenovo
Model Name or Number:	ThinkPad L470
Serial Number:	PF10T3JS

Description:	Test Laptop
Brand Name:	Lenovo
Model Name or Number:	Thinkpad L470
Serial Number:	PF10T3HL

Description:	USB to UART Cable
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Description:	Test Laptop
Brand Name:	Lenovo
Model Name or Number:	Thinkpad
Serial Number:	20LTS12D0F

Operating Modes

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

- Transmitting at maximum power in *Bluetooth* LE mode with modulation, maximum possible data length available and Pseudorandom Bit Sequence 9.
- Transmitting at maximum power in *Bluetooth* LE2M mode with modulation, maximum possible data length available and Pseudorandom Bit Sequence 9.

Configuration and Peripherals

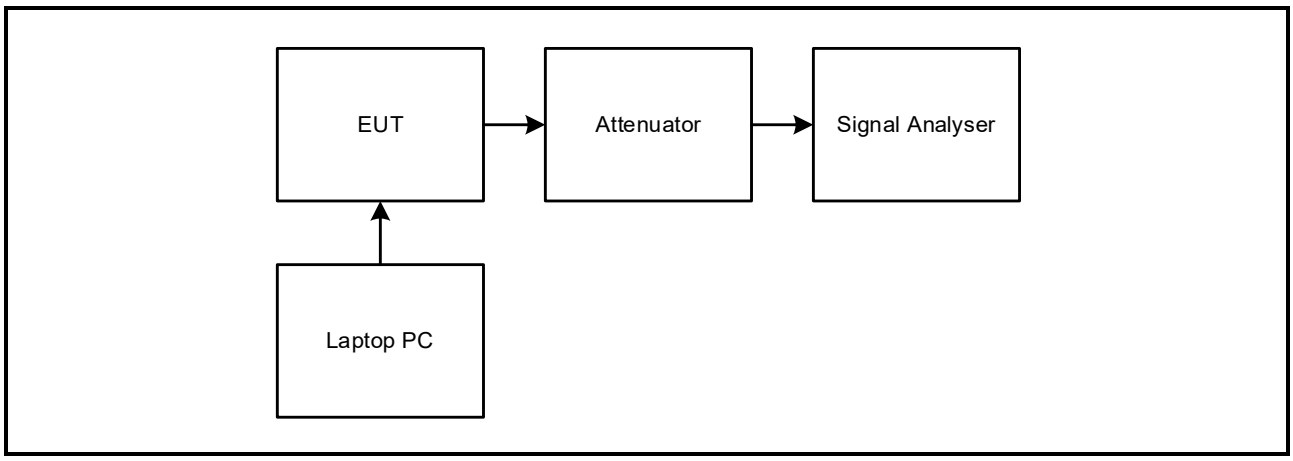
The EUT was tested in the following configuration(s):

- Controlled in test mode using a software application on the EUT. The application was used to enable a continuous transmission and to select the test channels as required. The customer supplied a document containing the setup instructions ‘Dongle DTM Procedure.docx’. The laptop PC was connected to the EUT via USB to UART cable.
- The EUT was powered from a test laptop via the USB to UART cable. The test laptop was powered from a 120 VAC single phase main supply via an AC to DC adapter.
- Transmitter radiated spurious emissions tests were performed with the EUT in the worst-case orientation with respect to emissions. The test laptop was connected to the EUT via the USB to UART cable.

Test Setup Diagrams

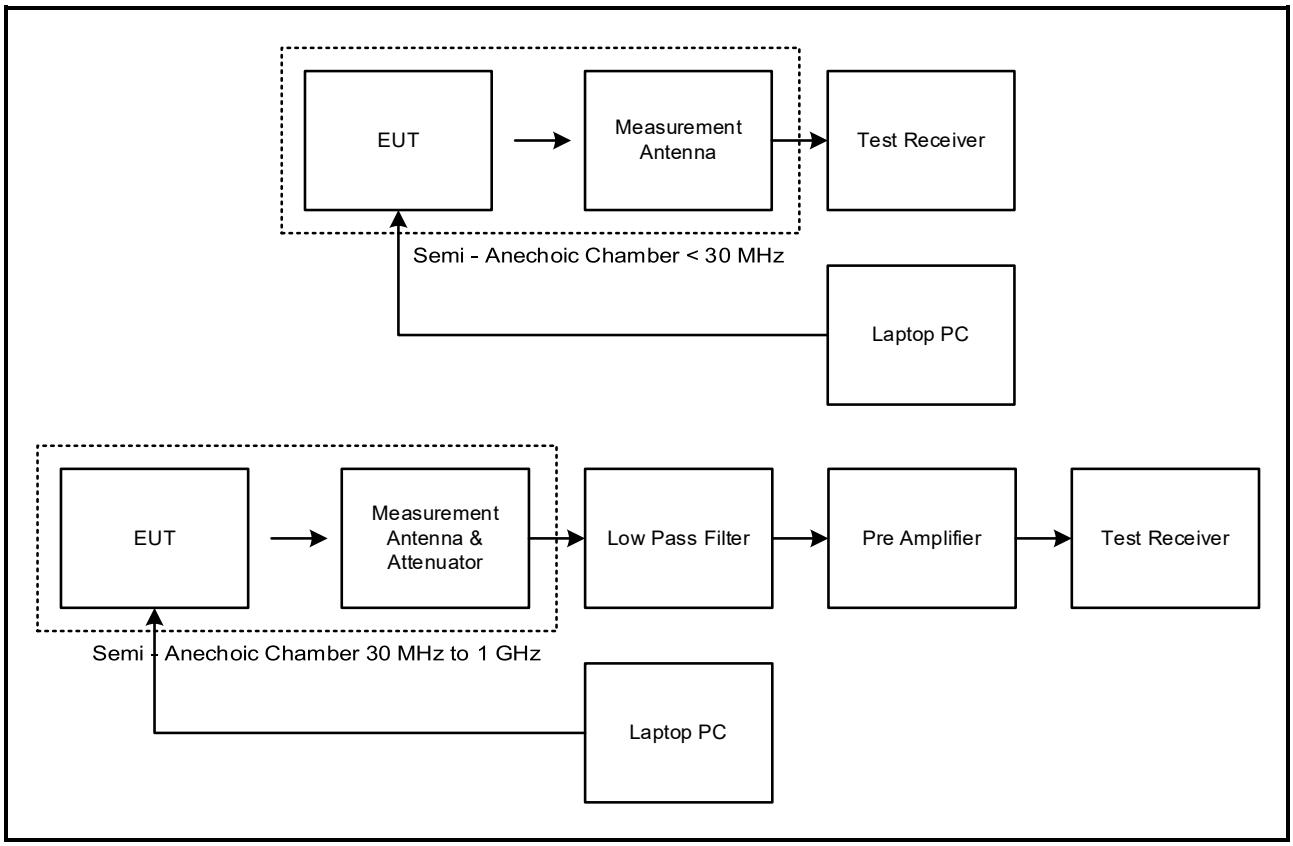
Conducted Tests:

Test Setup for Transmitter Conducted Tests

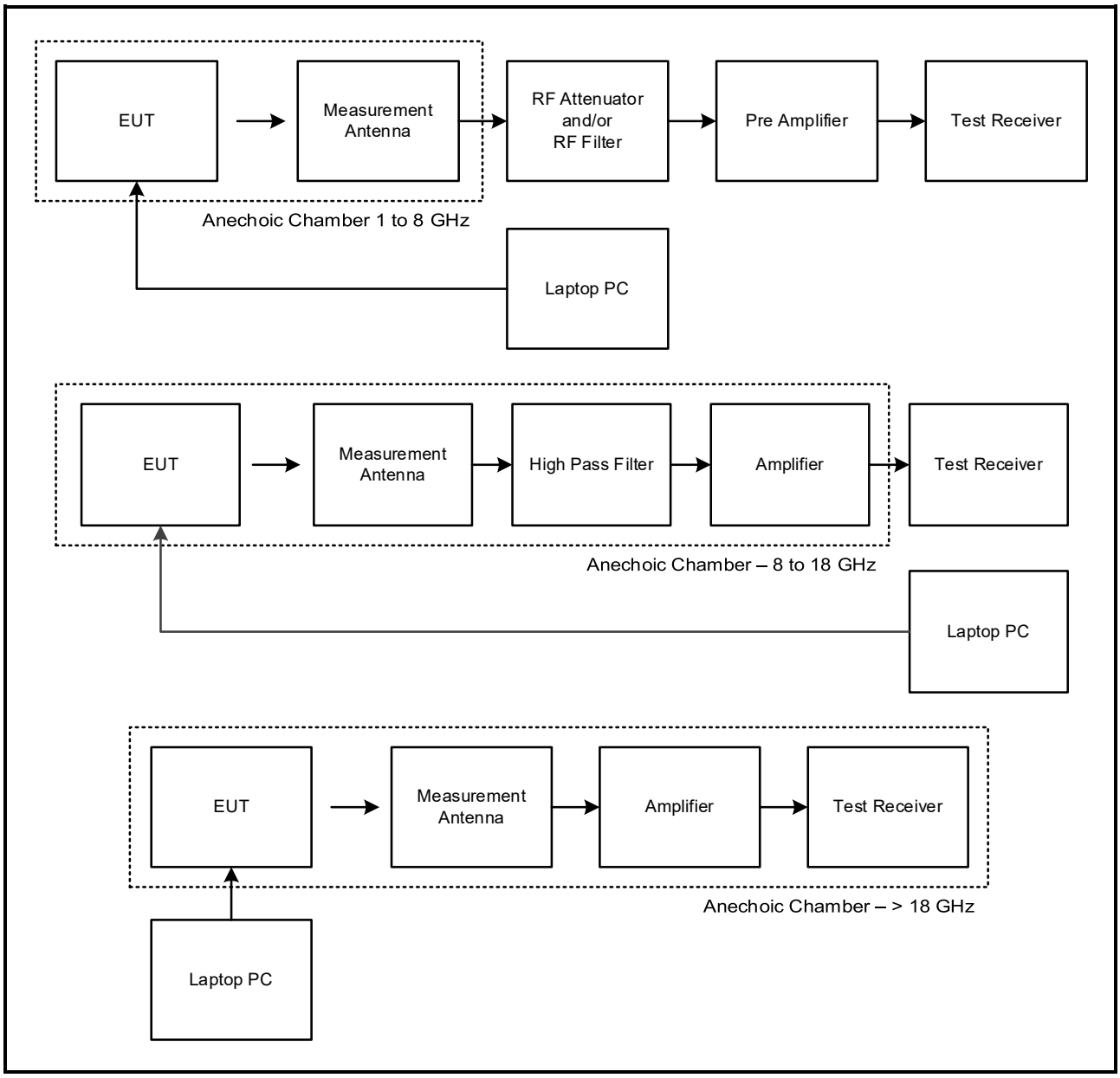


Radiated Tests:

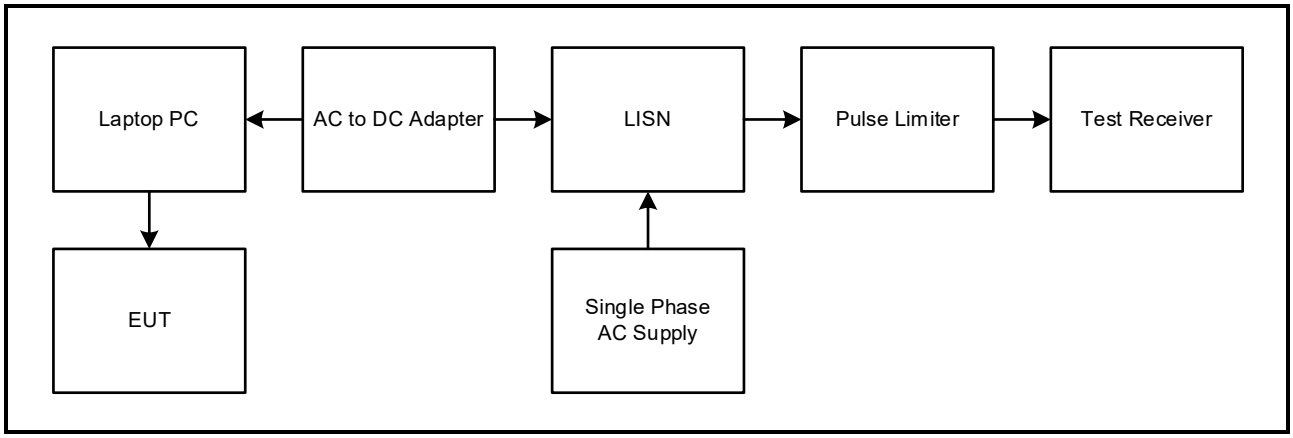
Test Setup for Transmitter Radiated Emissions



Test Setup Diagrams (continued)



Test Setup for Transmitter AC Conducted Spurious Emissions



4 Antenna Port Test Results

4.1 Transmitter Duty Cycle

Test Summary:

Test Engineer:	Chanthu Thevarajah	**Test Dates:**	16 September 2021 & 21 September 2021
Test Sample Serial Number:	0053840B		

FCC Reference:	Part 15.35(c)
ISED Canada Reference:	RSS-Gen 8.2
Test Method Used:	FCC KDB 558074 Section 6 referencing ANSI C63.10 Section 11.6

Environmental Conditions:

Temperature (°C):	23 to 24
Relative Humidity (%):	50 to 56

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 spectrum/signal analyser in the time domain and calculated by using the following calculation:

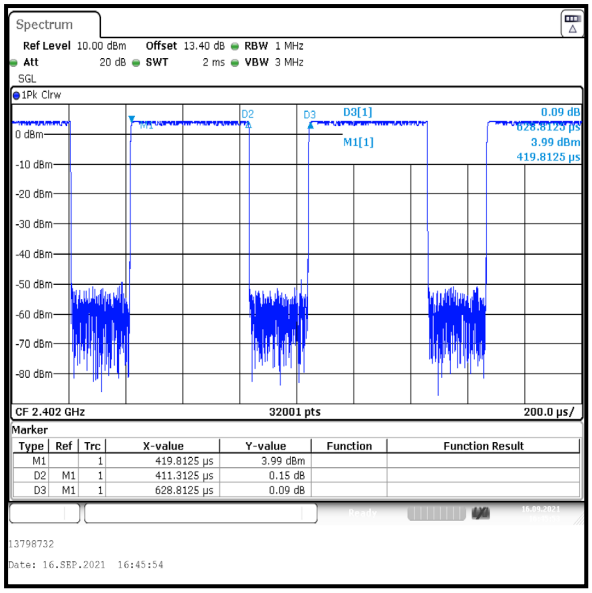
10 log (1 / (On Time / [Period or 100 ms whichever is the lesser])).

LE duty cycle: 10 log (1 / (411.313 µs / 628.813 µs)) = 1.8 dB
LE2M duty cycle: 10 log (1 / (227.625 µs / 625.563 µs)) = 4.4 dB

Transmitter Duty Cycle (continued)

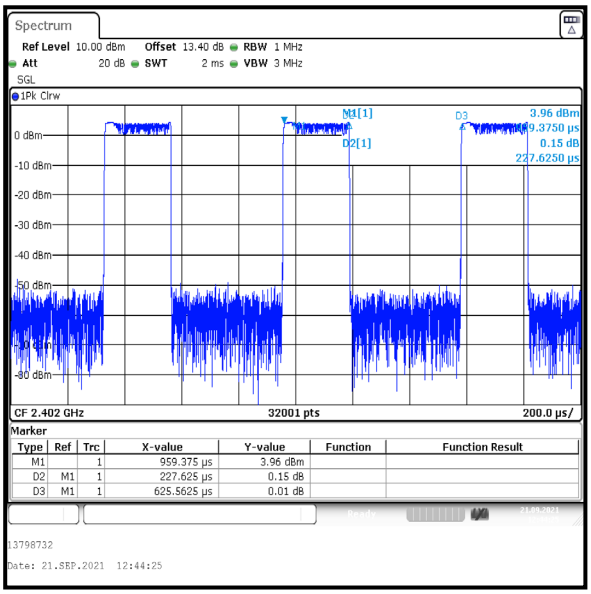
Results: LE

Pulse Duration (µs)	Period (µs)	Duty Cycle (dB)
411.313	628.813	1.8



Results: LE2M

Pulse Duration (µs)	Period (µs)	Duty Cycle (dB)
227.625	625.563	4.4



4.2 Transmitter 99% Occupied Bandwidth

Test Summary:

Test Engineer:	Chanthu Thevarajah	**Test Date:**	16 September 2021
Test Sample Serial Number:	0053840B		

FCC Reference:	N/A
ISED Canada Reference:	RSS-Gen 6.7
Test Method Used:	RSS-Gen 6.7 and Notes below

Environmental Conditions:

Temperature (°C):	24
Relative Humidity (%):	56

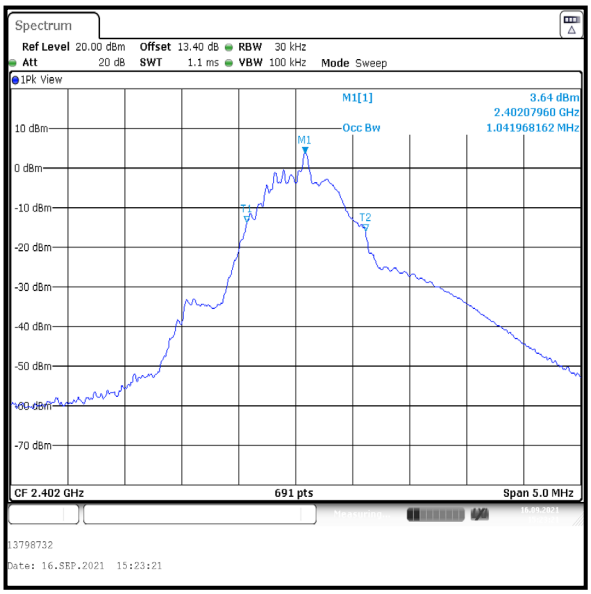
Note(s):

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 30 kHz and video bandwidth 100 kHz. A peak detector was used, sweep time was set to auto and the trace mode was Max Hold. The span was set to 5 MHz. 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 coax cable.

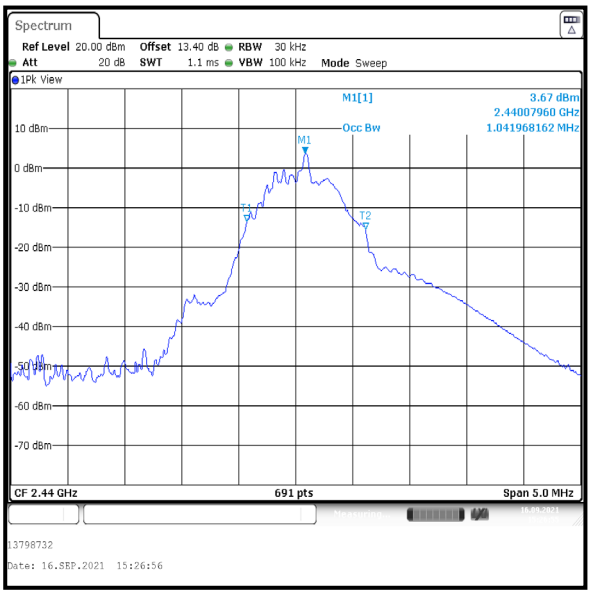
Transmitter 99% Occupied Bandwidth (continued)

Results: LE

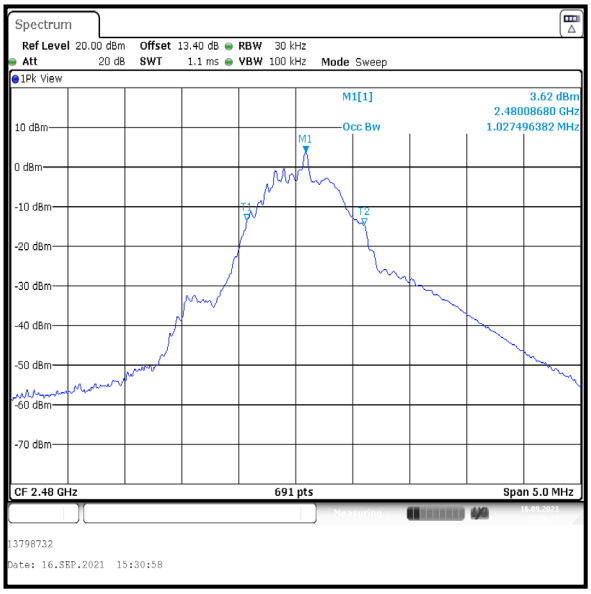
Channel	99% Occupied Bandwidth (kHz)
Bottom	1041.968
Middle	1041.968
Top	1027.496



Bottom Channel



Middle Channel

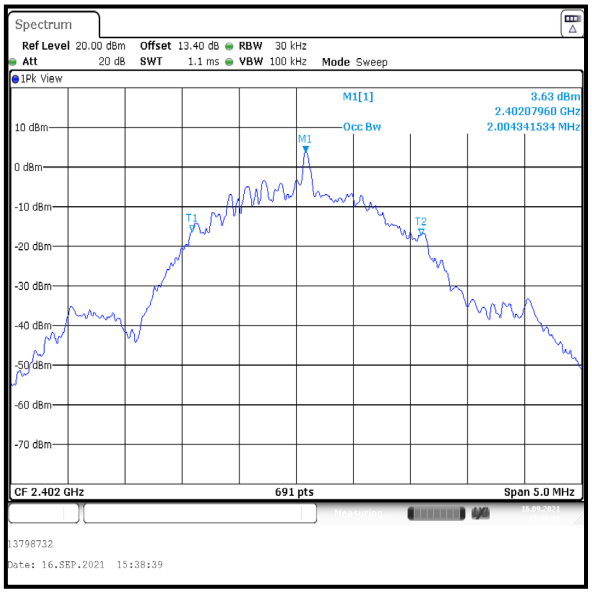


Top Channel

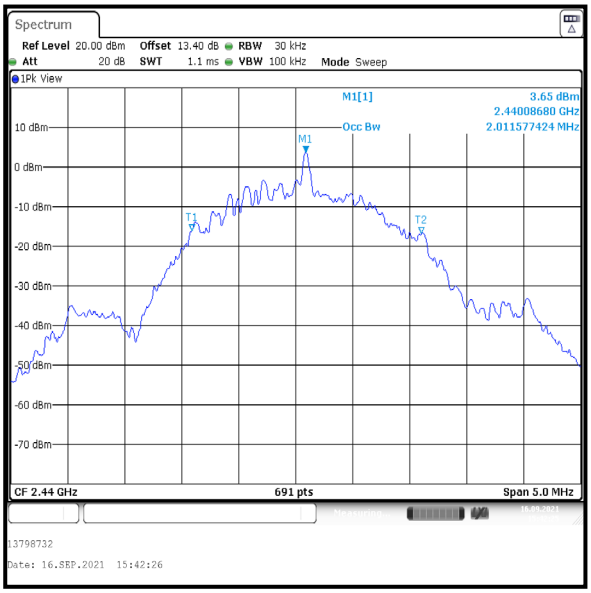
Transmitter 99% Occupied Bandwidth (continued)

Results: LE2M

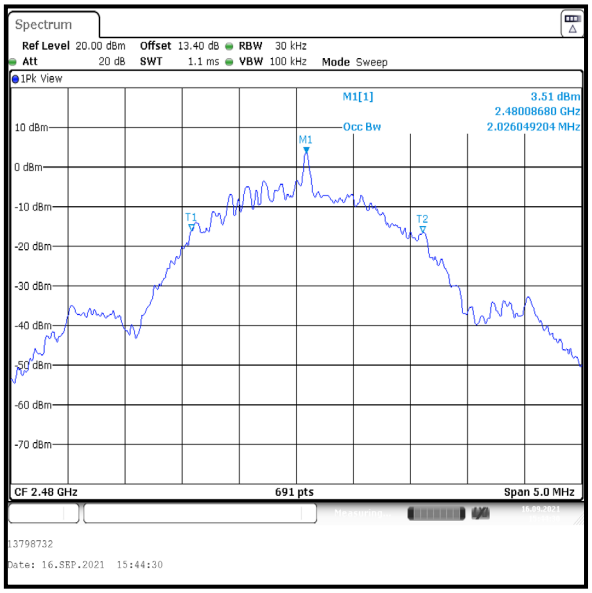
Channel	99% Occupied Bandwidth (kHz)
Bottom	2004.342
Middle	2011.577
Top	2026.049



Bottom Channel



Middle Channel



Top Channel

4.3 Transmitter Minimum 6 dB Bandwidth

Test Summary:

Test Engineer:	Chanthu Thevarajah	**Test Dates:**	16 September 2021 to 17 September 2021
Test Sample Serial Number:	0053840B		

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

Environmental Conditions:

Temperature (°C):	23 to 24
Relative Humidity (%):	56 to 59

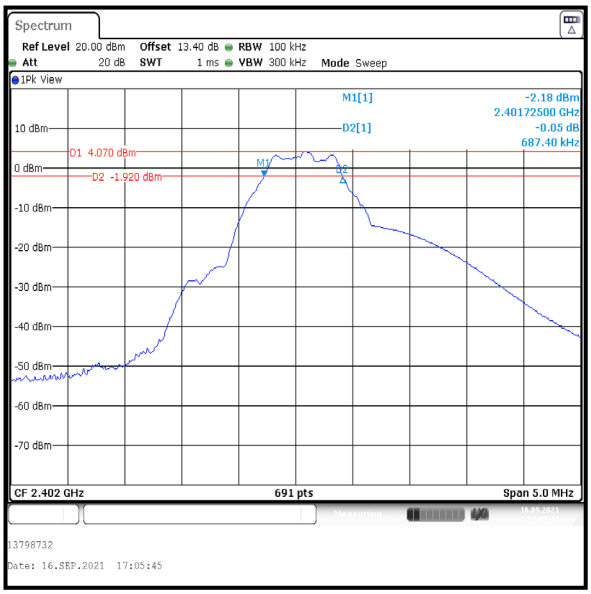
Note(s):

1. 6 dB DTS bandwidth tests were performed using a signal analyser in accordance with ANSI C63.10 Section 11.8.1 Option 1 measurement procedure. The signal 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 signal analyser was connected to the RF port on the EUT using suitable attenuation and coax cable.

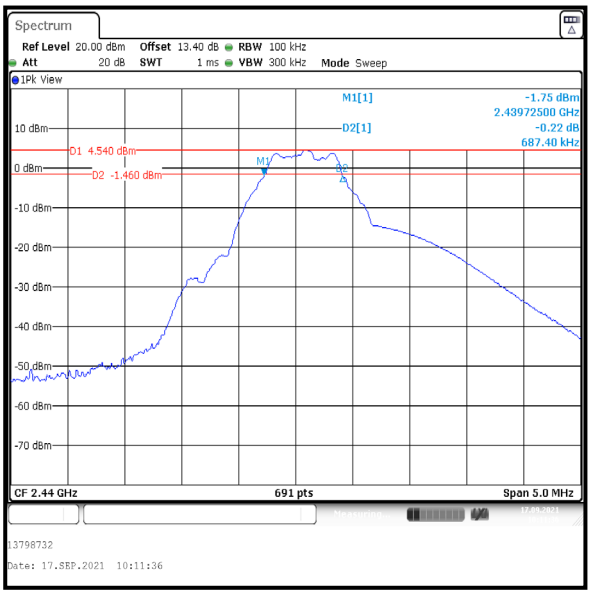
Transmitter Minimum 6 dB Bandwidth (continued)

Results: LE

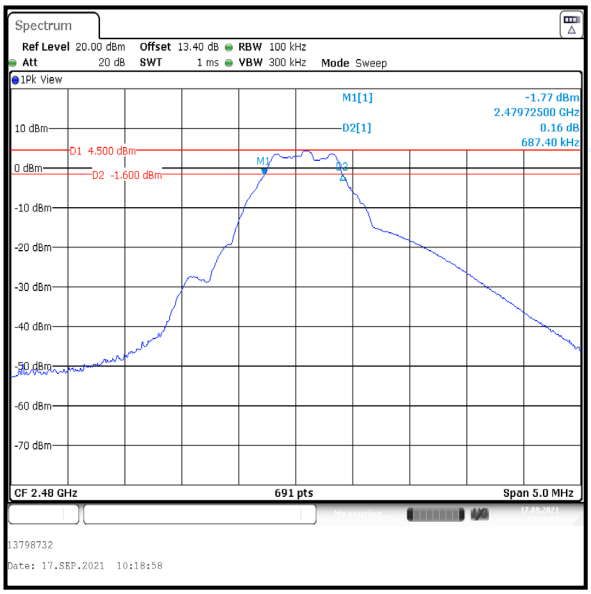
Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	687.400	≥500	187.400	Complied
Middle	687.400	≥500	187.400	Complied
Top	687.400	≥500	187.400	Complied



Bottom Channel



Middle Channel

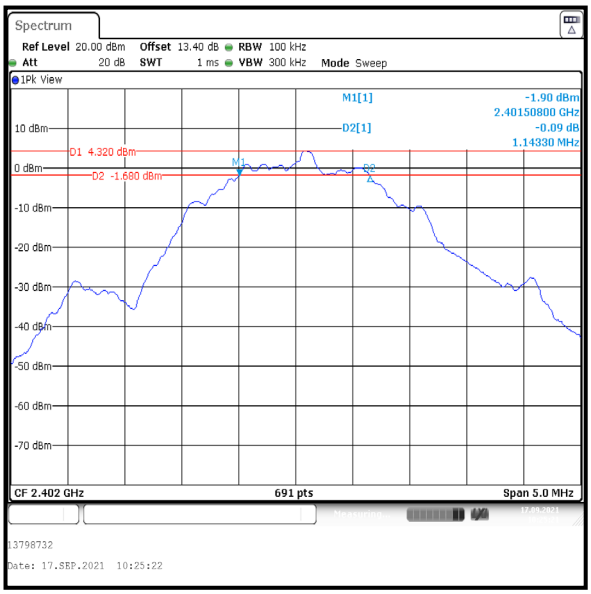


Top Channel

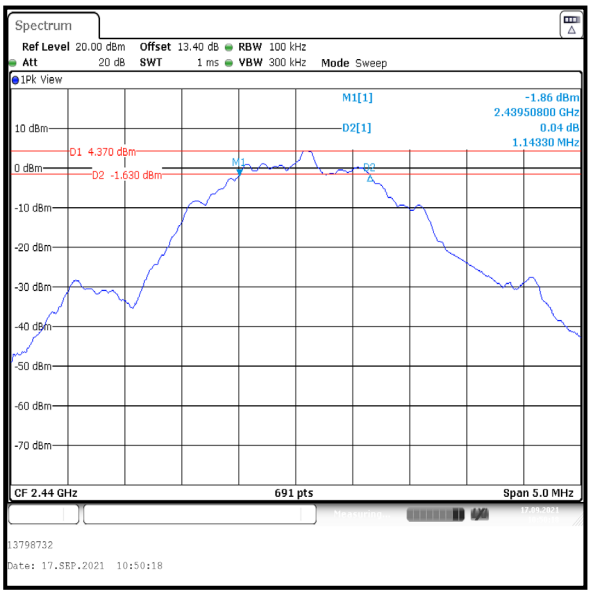
Transmitter Minimum 6 dB Bandwidth (continued)

Results: LE2M

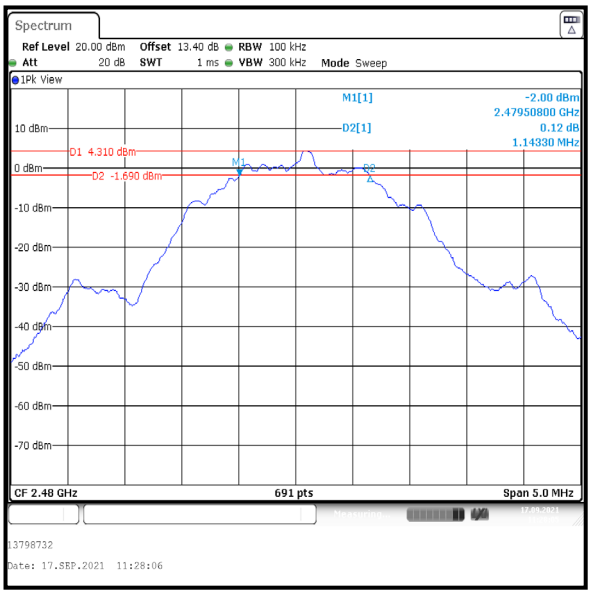
Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	1143.300	≥500	643.300	Complied
Middle	1143.300	≥500	643.300	Complied
Top	1143.300	≥500	643.300	Complied



Bottom Channel



Middle Channel



Top Channel

4.4 Transmitter Maximum Peak Output Power

Test Summary:

Test Engineer:	Chanthu Thevarajah	**Test Date:**	17 September 2021
Test Sample Serial Number:	0053840B		

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

Environmental Conditions:

Temperature (°C):	23
Relative Humidity (%):	59

Note(s):

1. Conducted power tests were performed using a signal analyser in accordance with ANSI C63.10 Section 11.9.1.1 with the RBW ≥ DTS bandwidth procedure.
2. The signal analyser resolution bandwidth was set to 1 MHz (LE) or 2 MHz (LE2M) and video bandwidth of 3 MHz (LE) or 10 MHz (LE2M). A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The span was set to 3 MHz (LE) or 6 MHz (LE2M). A marker was placed at the peak of the signal and the results recorded in the tables below.
3. The signal analyser was connected to the RF port on the EUT using suitable attenuation and coax cable. An RF level offset was entered on the signal analyser to compensate for the loss of the attenuator and RF cable.
4. The conducted power was added to the declared antenna gain to obtain the EIRP.

Transmitter Maximum Peak Output Power (continued)

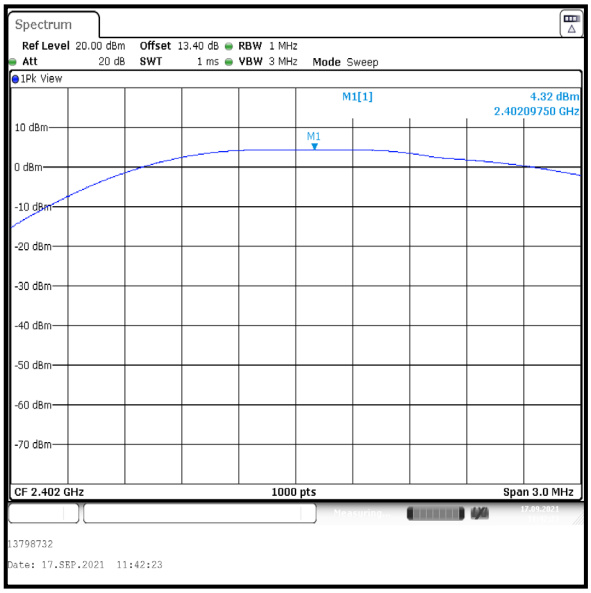
Results: LE

Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	4.3	30.0	25.7	Complied
Middle	4.4	30.0	25.6	Complied
Top	4.3	30.0	25.7	Complied

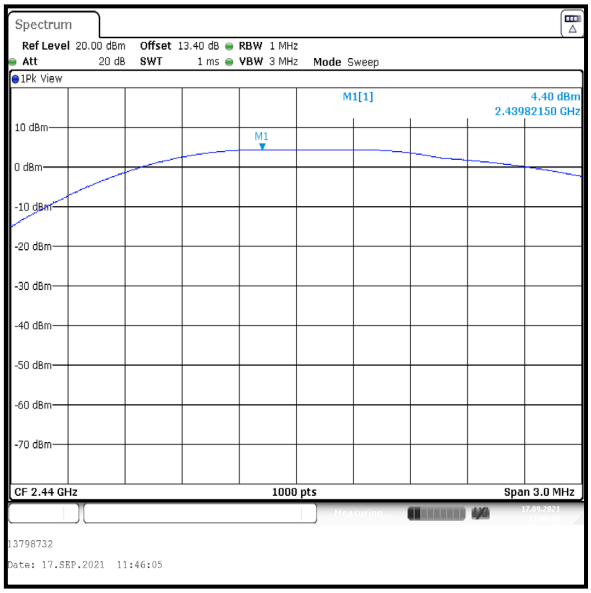
Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	4.3	0.5	4.8	36.0	31.2	Complied
Middle	4.4	0.5	4.9	36.0	31.1	Complied
Top	4.3	0.5	4.8	36.0	31.2	Complied

Transmitter Maximum Peak Output Power (continued)

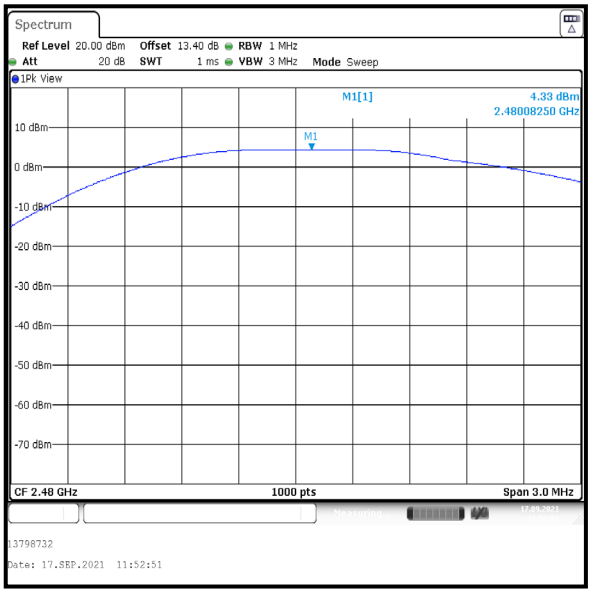
Results: LE



Bottom Channel



Middle Channel



Top Channel

Transmitter Maximum Peak Output Power (continued)

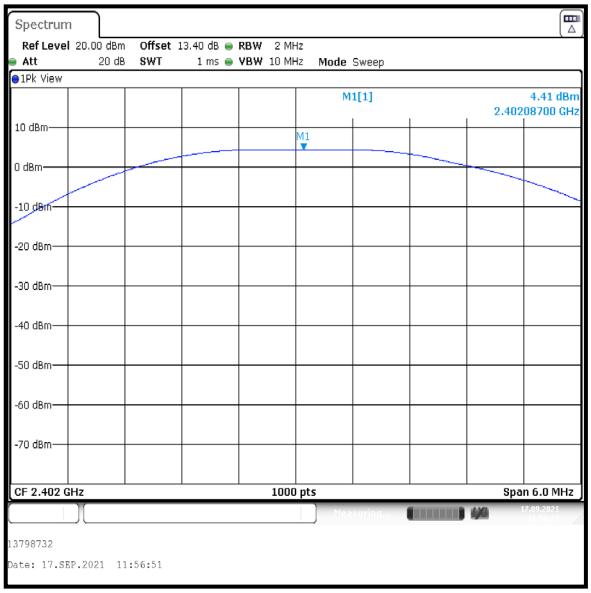
Results: LE2M

Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	4.4	30.0	25.6	Complied
Middle	4.5	30.0	25.5	Complied
Top	4.4	30.0	25.6	Complied

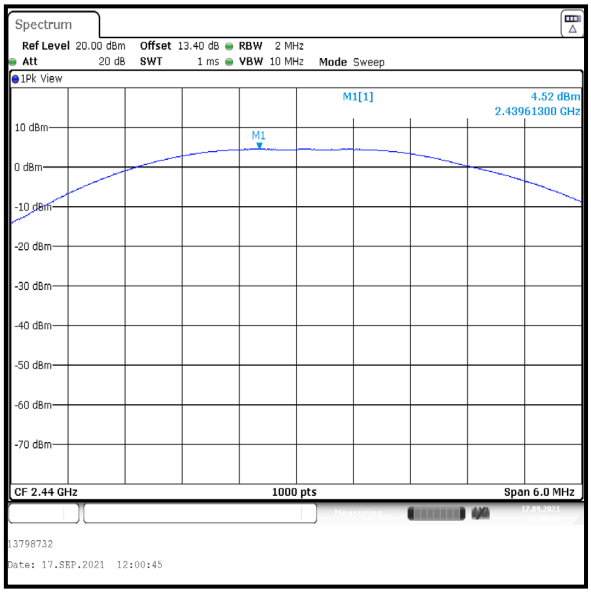
Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	4.4	0.5	4.9	36.0	31.1	Complied
Middle	4.5	0.5	5.0	36.0	31.0	Complied
Top	4.4	0.5	4.9	36.0	31.1	Complied

Transmitter Maximum Peak Output Power (continued)

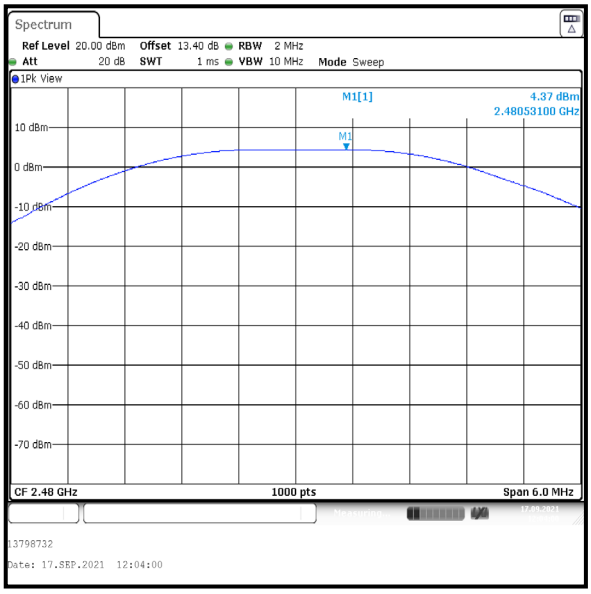
Results: LE2M



Bottom Channel



Middle Channel



Top Channel

5 Radiated Test Results

5.1 Transmitter Radiated Emissions <1 GHz

Test Summary:

Test Engineer:	Mohamed Toubella, Marco Zunarelli & Nick Raptopoulos	**Test Dates:**	26 September 2021 to 07 December 2021
Test Sample Serial Number:	0053826B		

FCC Reference:	Parts 15.247(d), 15.209(a) & Parts 15.225(d)
ISED Canada Reference:	RSS-Gen 6.13 & 8.9 / RSS-247 5.5 / RSS-210 B.6(a)(iv)
Test Method Used:	ANSI C63.10 Sections 6.3, 6.4, 6.5 and notes below
Frequency Range	9 kHz to 1000 MHz

Environmental Conditions:

Temperature (°C):	20 to 23
Relative Humidity (%):	38 to 50

Transmitter Radiated Emissions (continued)

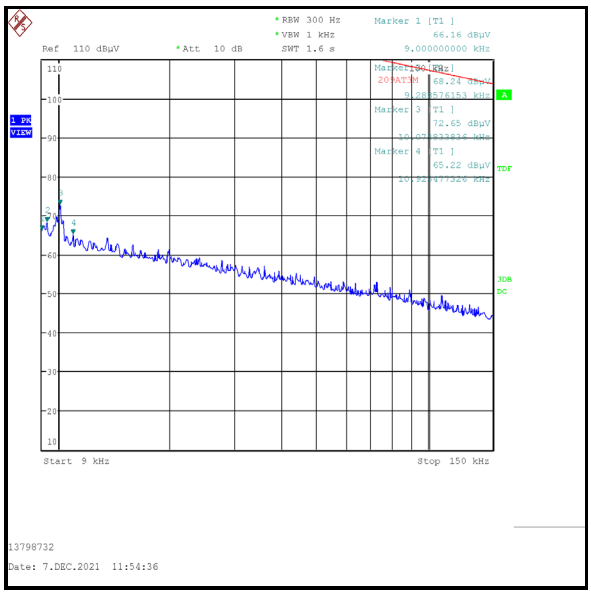
Note(s):

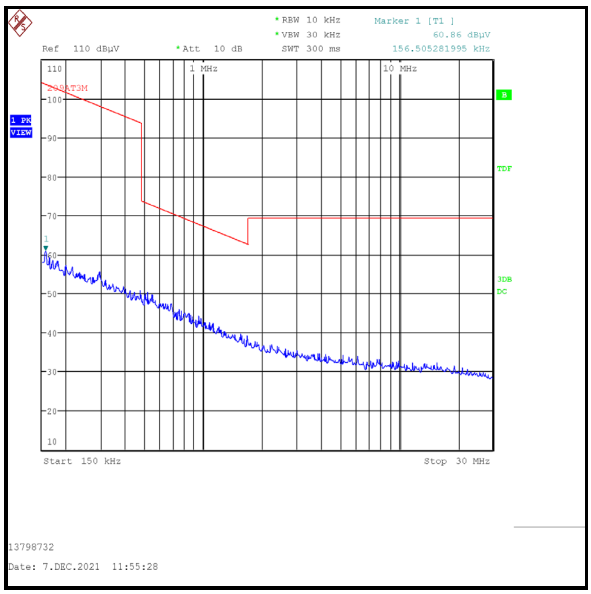
1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. All other emissions shown on the pre-scans were investigated and found to be ambient, > 20 dB below the appropriate limit or below the noise floor of the measurement system.
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 middle channel only.
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. The limits in CFR47, Part 15, Subpart C, paragraph 15.209(a), are identical to those in RSS-Gen Section 8.9, Table 6, since the measurements are performed in terms of magnetic field strength and converted to electric field strength levels (as reported in the table) using the free space impedance of 377Ω. For example, the measurement frequency X kHz resulted in a level of Y dBµV/m, which is equivalent to Y – 51.5 = Z dBµA/m, which has the same margin, W dB, to the corresponding RSS-Gen Table 6 limit as it has to the 15.209(a) limit.
6. Measurements between 30 MHz to 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.
7. Pre-scans were performed and markers placed on the highest measured levels. The test receiver was configured as follows: During 9 kHz to 150 kHz tests, 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 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. For 30 MHz to 1 GHz, the 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.
8. 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.

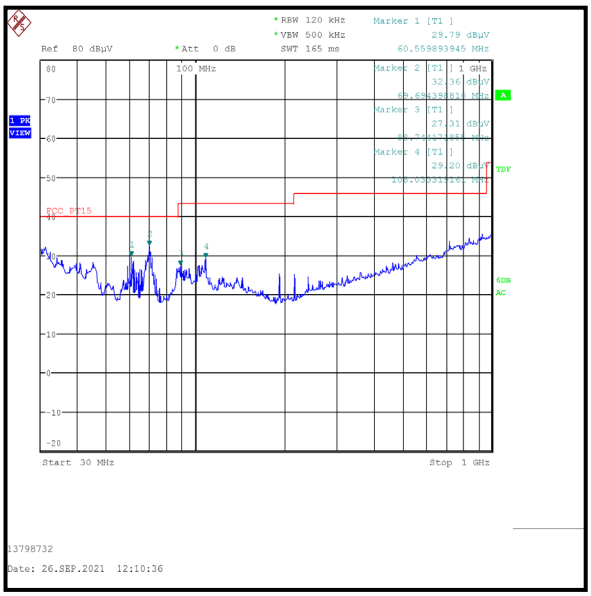
Results: Quasi-Peak / Middle Channel

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
60.656	Vertical	25.3	40.0	14.7	Complied
88.580	Vertical	24.0	43.5	19.5	Complied
108.017	Vertical	25.5	43.5	18.0	Complied
191.736	Vertical	20.9	43.5	22.6	Complied
216.035	Vertical	23.8	46.0	22.2	Complied
768.174	Vertical	26.7	54.0	27.3	Complied

Transmitter Radiated Emissions (continued)







Note: The above plots are pre-scans and for indication purposes only. For final measurements, see accompanying table.

5.2 Transmitter Radiated Emissions >1 GHz

Test Summary:

Test Engineer:	Mohamed Toubella	**Test Dates:**	19 September 2021 to 25 September 2021
Test Sample Serial Number:	0053826B		

FCC Reference:	Parts 15.247(d) & 15.209(a)
ISED Canada Reference:	RSS-Gen 6.13 & 8.9 / RSS-247 5.5
Test Method Used:	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
Frequency Range	1 GHz to 25 GHz

Environmental Conditions:

Temperature (°C):	23 to 25
Relative Humidity (%):	50

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. Measurements above 1 GHz were performed in a fully anechoic chamber (Asset Number K0017 & 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. During pre-scans, 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 at a distance of 3 metres. The EUT was placed at a height of 1.5 metres 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. Prescans 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. Peak and average measurements were performed with appropriate detectors during the prescan measurements.
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.

Results: LE / Peak / Bottom Channel

Frequency (MHz)	Antenna Polarity	Peak Level (dBµV/m)	Average Limit (dBµV/m)	Margin (dB)	Result
4804.058	Horizontal	51.5	54.0*	2.5	Complied
7205.462	Vertical	52.9	54.0*	1.1	Complied

Results: LE2M / Peak / Bottom Channel

Frequency (MHz)	Antenna Polarity	Peak Level (dBµV/m)	Average Limit (dBµV/m)	Margin (dB)	Result
4803.364	Vertical	51.0	54.0*	3.0	Complied
7206.206	Horizontal	52.1	54.0*	1.9	Complied

Results: LE / Peak / Middle Channel

Frequency (MHz)	Antenna Polarity	Peak Level (dBµV/m)	Average Limit (dBµV/m)	Margin (dB)	Result
4887.278	Horizontal	53.5	54.0*	0.5	Complied
7332.822	Horizontal	53.0	54.0*	1.0	Complied
12221.380	Vertical	53.4	54.0*	0.6	Complied
14662.860	Horizontal	52.7	54.0*	1.3	Complied

Results: LE2M / Peak / Middle Channel

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
4888.234	Horizontal	53.0	54.0*	1.0	Complied
7332.174	Vertical	52.3	54.0*	1.7	Complied
12221.720	Vertical	52.6	54.0*	1.4	Complied
14662.860	Horizontal	52.7	54.0*	1.3	Complied

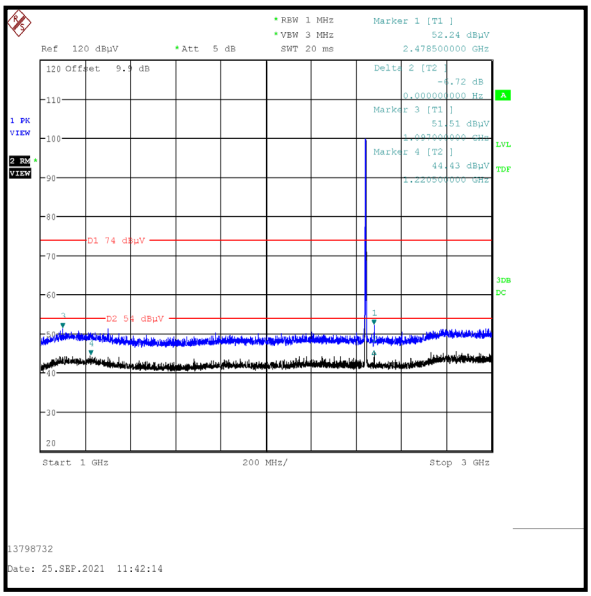
Results: LE / Peak / Top Channel

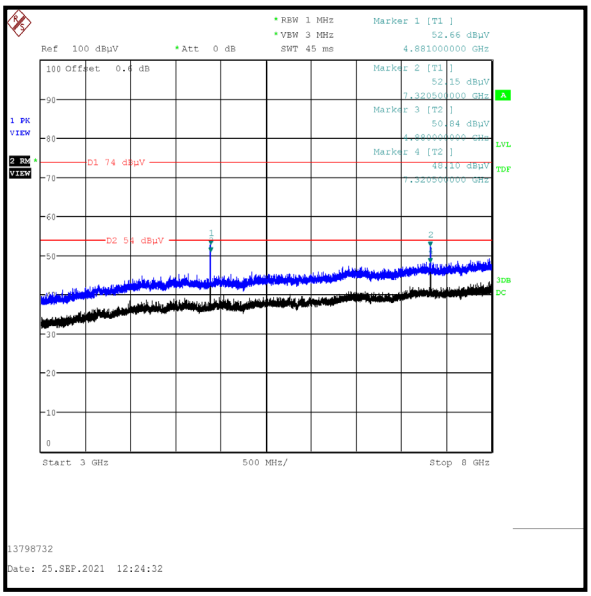
Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
4960.520	Vertical	52.8	54.0*	1.2	Complied
7440.538	Horizontal	53.9	54.0*	0.1	Complied

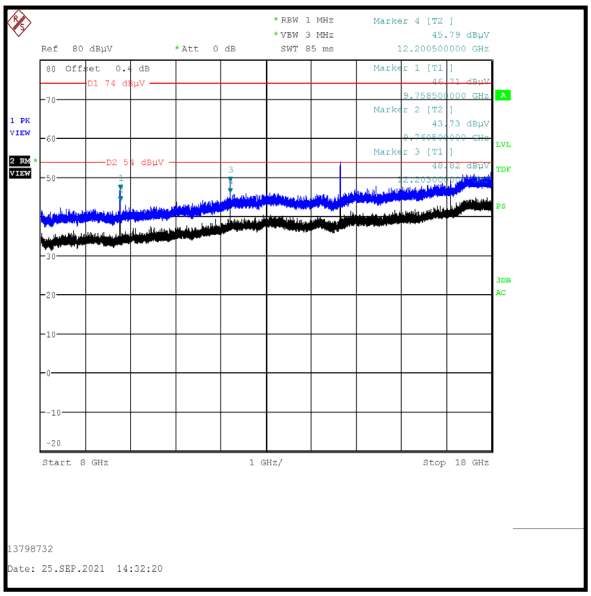
Results: LE2M / Peak / Top Channel

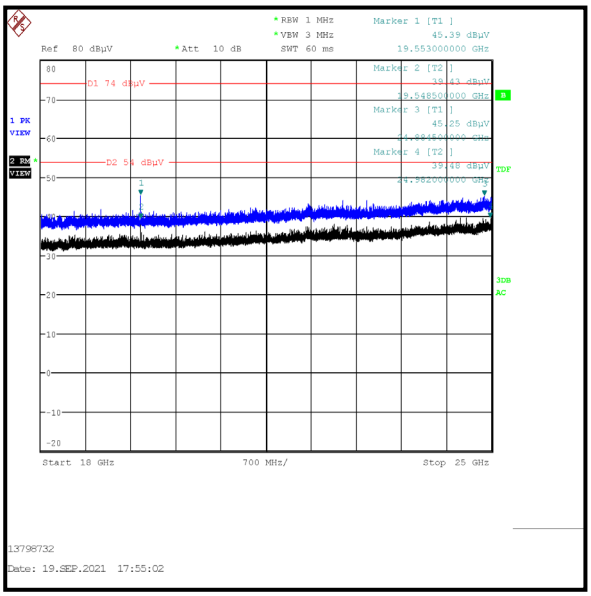
Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
4960.054	Vertical	52.8	54.0*	1.2	Complied
7440.108	Horizontal	53.3	54.0*	0.7	Complied

Transmitter Radiated Emissions (continued)









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

5.3 Transmitter Band Edge Radiated Emissions

Test Summary:

Test Engineer:	Mohamed Toubella	**Test Date:**	25 September 2021
Test Sample Serial Number:	0053826B		

FCC Reference:	Parts 15.247(d) & 15.209(a)
ISED Canada Reference:	RSS-Gen 6.13 / RSS-247 5.5
Test Method Used:	KDB 558074 Section 8.7 referencing ANSI C63.10 Sections 11.11, 11.12 & 11.13

Environmental Conditions:

Temperature (°C):	23
Relative Humidity (%):	53

Note(s):

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. 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.
3. 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 Max Hold. 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.
4. 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 peak and RMS detectors respectively. Markers were placed on the highest point on each trace.
5. * -20 dBc limit.
6. As the EUT had a duty cycle < 98% the duty cycle correction factor has been applied to the upper band edge average result. The corrected level is shown in the tables below.

Upper Band Average result + duty cycle = Corrected band edge level

Transmitter Band Edge Radiated Emissions (continued)

Results: LE / Peak

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2399.519	Vertical	44.9	80.9*	36.0	Complied
2400.000	Vertical	43.8	80.9*	37.1	Complied
2483.500	Vertical	49.4	74.0	24.6	Complied

Results: LE / Average

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Duty cycle correction (dB)	Corrected Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	Vertical	44.6	1.8	46.4	54.0	7.6	Complied

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

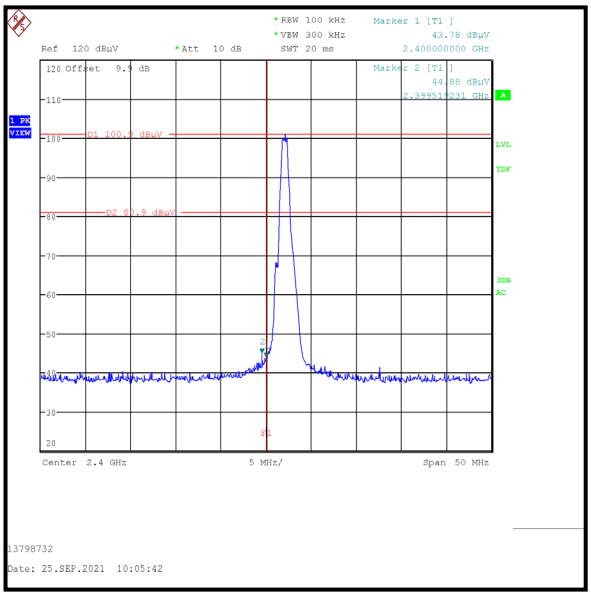
Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2363.590	Vertical	54.3	74.0	19.7	Complied

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

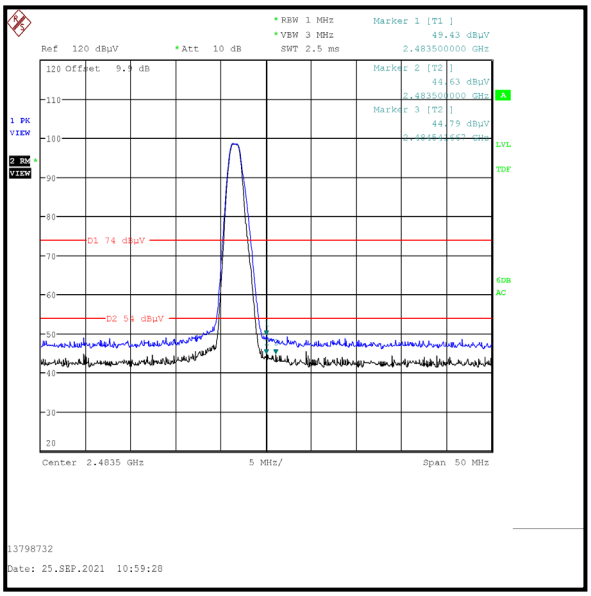
Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Duty cycle correction (dB)	Corrected Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2363.590	Vertical	48.5	1.8	50.3	54.0	3.7	Complied

Transmitter Band Edge Radiated Emissions (continued)

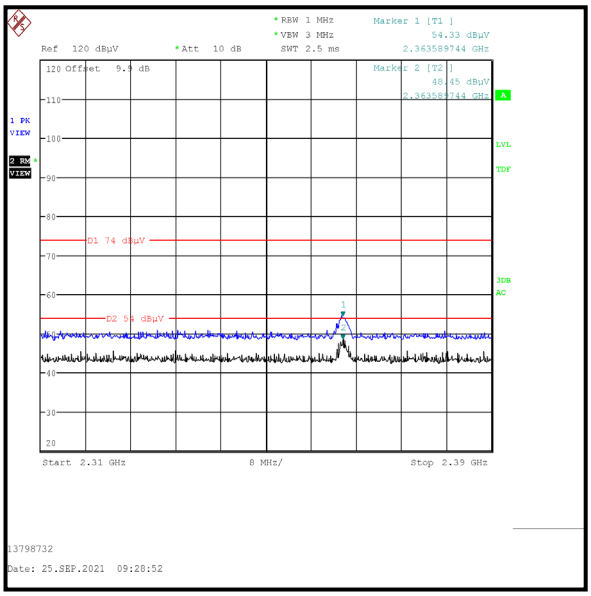
Results: LE



Lower Band Edge



Upper Band Edge



2310 MHz to 2390 MHz Restricted Band

Transmitter Band Edge Radiated Emissions (continued)

Results: LE2M / Peak

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2400.000	Vertical	67.3	80.8*	13.5	Complied
2483.500	Vertical	49.6	74.0	24.4	Complied

Results: LE2M / Average

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Duty cycle correction (dB)	Corrected Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	Vertical	45.3	4.4	49.7	54.0	4.3	Complied

Results: LE2M / 2310 MHz to 2390 MHz Restricted Band / Peak

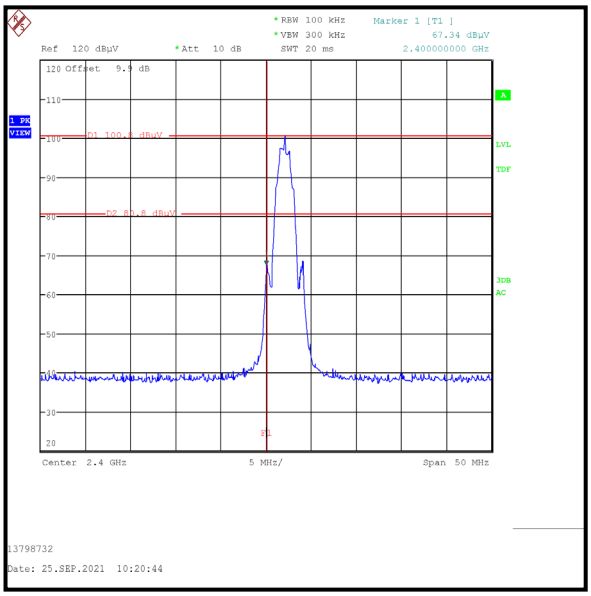
Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2363.590	Vertical	53.3	74.0	20.7	Complied

Results: LE2M / 2310 MHz to 2390 MHz Restricted Band / Average

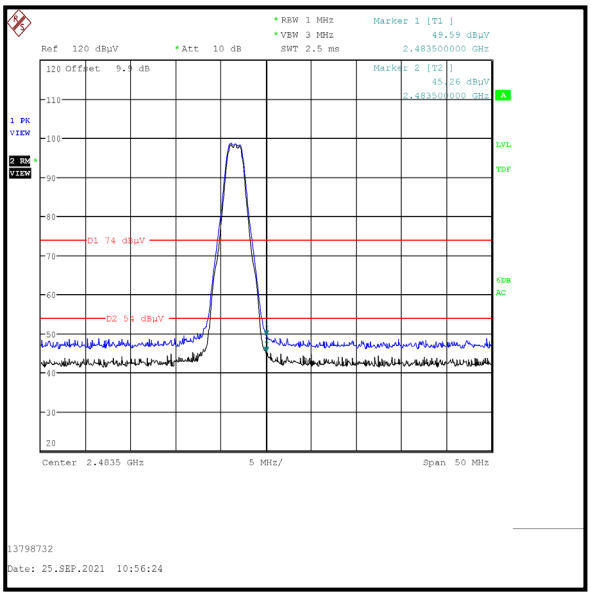
Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Duty cycle correction (dB)	Corrected Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2363.718	Vertical	47.9	4.4	52.3	54.0	1.7	Complied

Transmitter Band Edge Radiated Emissions (continued)

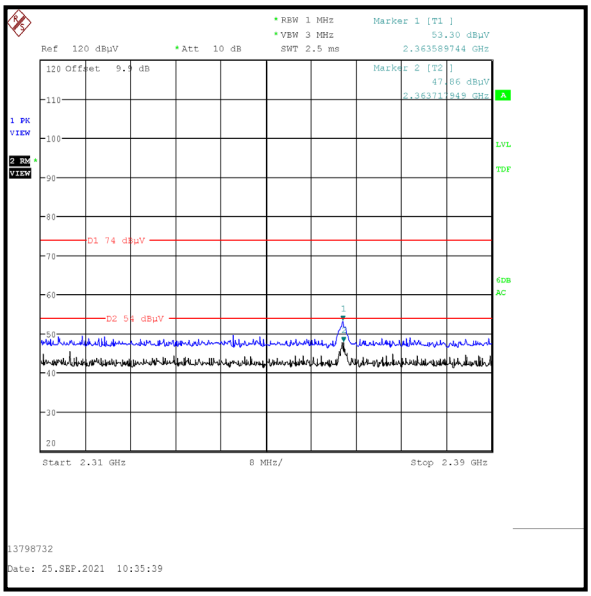
Results: LE2M



Lower Band Edge



Upper Band Edge



2310 MHz to 2390 MHz Restricted Band

6 AC Power Line Conducted Emissions Test Results

6.1 Transmitter AC Conducted Spurious Emissions

Test Summary:

Test Engineers:	Alison Johnston and Nick Raptopoulos	**Test Date:**	15 September 2021
Test Sample Serial Number:	0053826B		

FCC Reference:	Part 15.207
ISED Canada Reference:	RSS-Gen 8.8
Test Method Used:	ANSI C63.10 Section 6.2 / FCC KDB 174176 and notes below

Environmental Conditions:

Temperature (°C):	23
Relative Humidity (%):	65

Note(s):

1. The EUT was connected to a test laptop via the USB to UART cable. The test laptop AC to DC adapter 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 test laptop AC to DC adapter.
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.

Transmitter AC Conducted Spurious Emissions (continued)

Results: Live / Quasi Peak / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.163500	Live	53.3	65.3	12.0	Complied
0.177000	Live	54.8	64.6	9.8	Complied
0.280500	Live	35.5	60.8	25.3	Complied
2.661000	Live	32.3	56.0	23.7	Complied
3.894000	Live	35.9	56.0	20.1	Complied
17.263500	Live	28.9	60.0	31.1	Complied

Results: Live / Average / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.150000	Live	37.1	56.0	18.9	Complied
0.501000	Live	24.0	46.0	22.0	Complied
2.652000	Live	19.4	46.0	26.6	Complied
3.862500	Live	27.1	46.0	18.9	Complied
6.472500	Live	18.8	50.0	31.2	Complied
17.290500	Live	19.6	50.0	30.4	Complied

Results: Neutral / Quasi Peak / 120 VAC 60 Hz

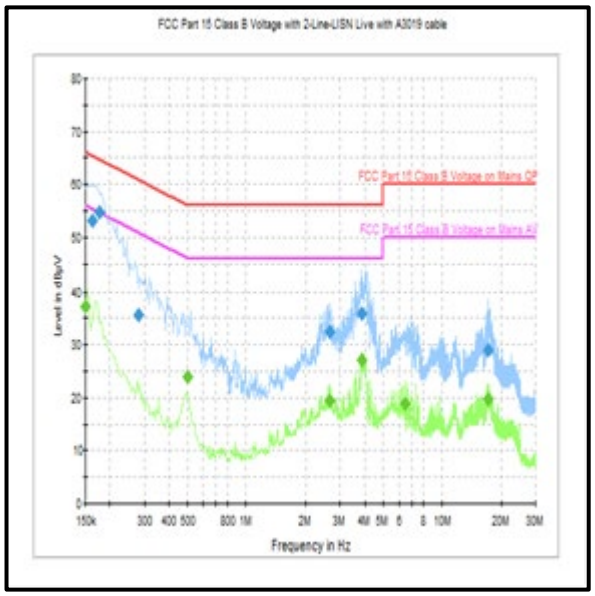
Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.154500	Neutral	54.4	65.8	11.4	Complied
0.204000	Neutral	45.1	63.4	18.3	Complied
0.285000	Neutral	36.2	60.7	24.5	Complied
2.499000	Neutral	31.0	56.0	25.0	Complied
3.970500	Neutral	35.6	56.0	20.4	Complied
17.272500	Neutral	30.9	60.0	29.1	Complied

Results: Neutral / Average / 120 VAC 60 Hz

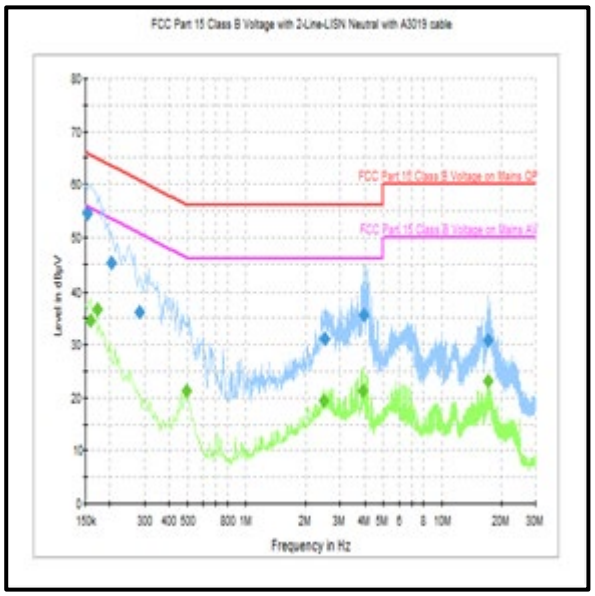
Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.159000	Neutral	34.6	55.5	20.9	Complied
0.172500	Neutral	36.8	54.8	18.0	Complied
0.496500	Neutral	21.3	46.1	24.8	Complied
2.481000	Neutral	19.4	46.0	26.6	Complied
3.912000	Neutral	21.3	46.0	24.7	Complied
17.128500	Neutral	23.0	50.0	27.0	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 (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.150000	Live	55.5	66.0	10.5	Complied
0.181500	Live	50.0	64.4	14.4	Complied
0.280500	Live	39.3	60.8	21.5	Complied
2.805000	Live	30.7	56.0	25.3	Complied
3.925500	Live	35.1	56.0	20.9	Complied
21.439500	Live	32.2	60.0	27.8	Complied

Results: Live / Average / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.195000	Live	30.2	53.8	23.6	Complied
0.541500	Live	18.0	46.0	28.0	Complied
2.454000	Live	20.6	46.0	25.4	Complied
3.993000	Live	25.2	46.0	20.8	Complied
7.008000	Live	15.5	50.0	34.5	Complied
21.633000	Live	23.2	50.0	26.8	Complied

Results: Neutral / Quasi Peak / 240 VAC 60 Hz

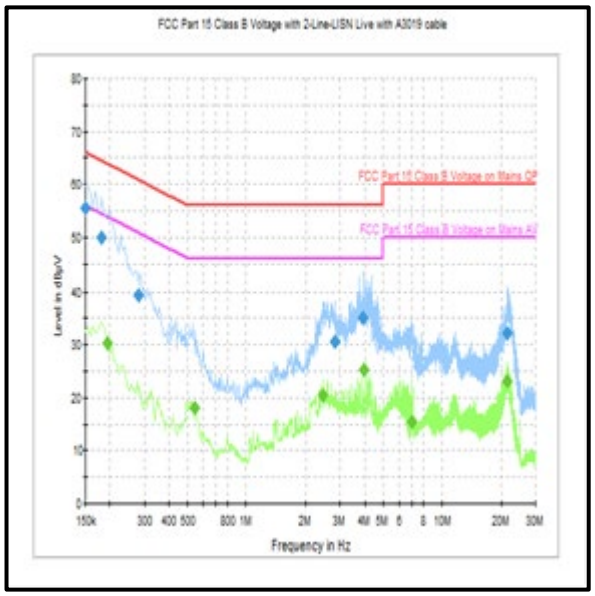
Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.150000	Neutral	54.5	66.0	11.5	Complied
0.172500	Neutral	52.5	64.8	12.3	Complied
0.271500	Neutral	39.2	61.1	21.9	Complied
2.571000	Neutral	33.5	56.0	22.5	Complied
3.538500	Neutral	30.5	56.0	25.5	Complied
21.169500	Neutral	30.7	60.0	29.3	Complied

Results: Neutral / Average / 240 VAC 60 Hz

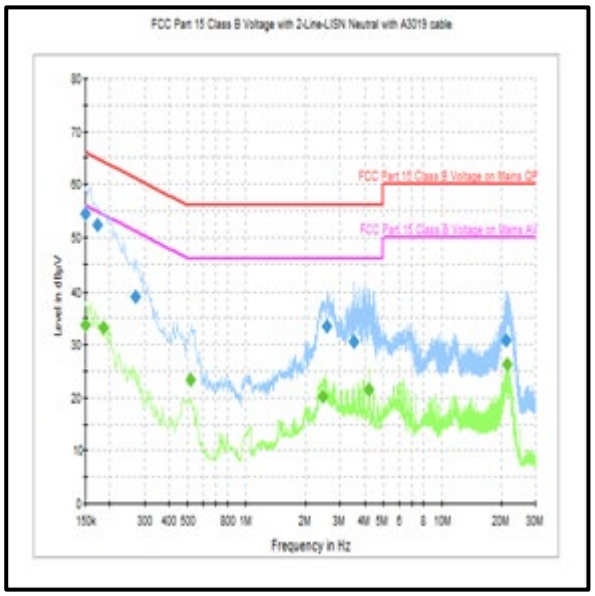
Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.150000	Neutral	33.7	56.0	22.3	Complied
0.186000	Neutral	33.1	54.2	21.1	Complied
0.519000	Neutral	23.3	46.0	22.7	Complied
2.449500	Neutral	20.2	46.0	25.8	Complied
4.218000	Neutral	21.6	46.0	24.4	Complied
21.610500	Neutral	26.4	50.0	23.6	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.

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