TEST REPORT

Test Report No. : UL-RPT-RP12663640-1216B V2.0

Customer	:	Raspberry Pi (Trading) Ltd
Model No.	:	Raspberry Pi 4 Model B
FCC ID	:	2ABCB-RPI4B
Technology	:	*Bluetooth* – Low Energy
Test Standard(s)	:	FCC Parts 15.207, 15.209(a) & 15.247
Test Laboratory	:	UL VS 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 2.0 supersedes all previous versions.

Date of Issue: 18 June 2019

Checked by:

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Company Signatory:

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Senior Test Engineer, Radio Laboratory
UL VS LTD

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Customer Information

Company Name:	Raspberry Pi (Trading) Ltd
Address:	Maurice Wilkes Building Cowley Road Cambridge CB4 0DS United Kingdom

Report Revision History

Version Number	Issue Date	Revision Details	Revised By
1.0	10/05/2019	Initial Version	Sarah Williams
2.0	18/06/2019	Admin update	Sarah Williams

Table of Contents

1. Attestation of Test Results

1.1. Description of EUT

The Equipment Under Test was a single board computer. It contains a *Bluetooth,* 2.4 GHz and 5 GHz WLAN module powered from an AC/DC power supply. The antenna is integral.

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
Site Registration:	621311
Location of Testing:	UL VS LTD, Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, G24 8AH, United Kingdom
Test Dates:	10 April 2019 to 23 April 2019

1.3. Summary of Test Results

FCC Reference (47CFR)	Measurement	Result
Part 15.247(a)(2)	Transmitter Minimum 6 dB Bandwidth	✓
Part 15.35(c)	Transmitter Duty Cycle	Note 1
Part 15.247(b)(3)	Transmitter Maximum Peak Output Power	✓
Part 15.247(e)	Transmitter Power Spectral Density	Note 2
Part 15.247(d)/15.209(a)	Transmitter Radiated Emissions	✓
Part 15.247(d)/15.209(a)	Transmitter Band Edge Radiated Emissions	✓
Part 15.207	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 to 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	

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 measured (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
Duty Cycle	2.4 GHz to 2.4835 GHz	95%	±1.14 %
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	30 MHz to 1 GHz	95%	±4.65 dB
Radiated Spurious Emissions	1 GHz to 25 GHz	95%	±2.94 dB
AC Conducted Spurious Emissions	0.15 MHz to 30 MHz	95%	±2.40 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)
M2039	Thermohygrometer	Testo	608-H1	45124922	06 Jan 2020	12
M1794	Spectrum Analyser	Rohde & Schwarz	FSU26	100027	18 Mar 2021	24
A2508	Attenuator	AtlanTecRF	AN18-10	821846#3	Calibrated before use	-
M199	Power Meter	Rohde & Schwarz	NRVS	827023/075	20 Apr 2020	24
M1267	Power Sensor	Rohde & Schwarz	NRV-Z52	100155	20 Apr 2020	24
G0615	Signal Generator	Rohde & Schwarz	SMBV100A	260473	08 May 2020	36

Test Equipment Used for Transmitter Radiated Emissions

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2040	Thermohygrometer	Testo	608-H1	45124934	06 Jan 2020	12
K0001	5m RSE Chamber	Rainford EMC	N/A	N/A	04 Oct 2019	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	01 Apr 2020	12
A3154	Pre-Amplifier	Com-Power	PAM-103	18020012	14 Sep 2019	12
A3155	Pre Amplifier	Com-Power	PAM-118A	18040037	14 Sep 2019	12
A3141	Pre Amplifier	Schwarzbeck	BBV 9718 B	00021	21 Nov 2019	12
A2896	Pre Amplifier	Schwarzbeck	BBV 9721	9721 – 023	08 Feb 2020	12
A553	Antenna	Chase	CBL6111A	1593	08 Oct 2019	12
A3138	Antenna	Schwarzbeck	BBHA 9120 B	00702	03 Oct 2019	12
A3139	Antenna	Schwarzbeck	HWRD750	00027	04 Oct 2019	12
A2895	Antenna	Schwarzbeck	BBHA 9170	9170-728	08 Feb 2020	12
A2523	Attenuator	AtlanTechRF	AN18W5-10	832827#1	04 Mar 2020	12
A3093	High Pass Filter	AtlanTechRF	AFH-03000	18051800077	09 Apr 2020	12
A3095	High Pass Filter	AtlanTechRF	AFH-07000	18051600012	09 Apr 2020	12
A3085	Low Pass Filter	AtlanTechRF	ALH-02000	18051600014	09 Apr 2020	12

Test and Measurement Equipment (continued)

Test Equipment Used for Transmitter Band Edge Radiated Emissions

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2040	Thermohygrometer	Testo	608-H1	45124934	06 Jan 2020	12
K0001	5m RSE Chamber	Rainford EMC	N/A	N/A	04 Oct 2019	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	17 Apr 2019	12
A3155	Pre-Amplifier	Com-Power	PAM-118A	18040037	14 Sep 2019	12
A3138	Antenna	Schwarzbeck	BBHA 9120 B	00702	03 Oct 2019	12
A2924	Attenuator	AtlanTechRF	AN18W5-20	832828#7	04 Mar 2020	12

Test Equipment Used for Transmitter AC Conducted Emissions

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2037	Thermohygrometer	Testo	608-H1	45124925	06 Jan 2020	12
A649	LISN	Rohde & Schwarz	ESH3-Z5	825562/008	23 Aug 2019	12
A1830	Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100668	10 Apr 2020	12
M1273	Test Receiver	Rohde & Schwarz	ESIB 26	100275	18 Dec 2019	12

3. Equipment Under Test (EUT)

3.1. Identification of Equipment Under Test (EUT)

Brand Name:	Raspberry Pi
Model Name or Number:	Raspberry Pi 4 Model B
Test Sample Serial Number:	0000000020d6f686 *(Conducted sample #1)*
Hardware Version:	V1.0
Software Version:	V1.0
FCC ID:	2ABCB-RPI4B

Brand Name:	Raspberry Pi
Model Name or Number:	Raspberry Pi 4 Model B
Test Sample Serial Number:	000000003f9edf4a *(Radiated sample #1)*
Hardware Version:	V1.0
Software Version:	V1.0
FCC ID:	2ABCB-RPI4B

Brand Name:	Raspberry Pi
Model Name or Number:	Raspberry Pi 4 Model B
Test Sample Serial Number:	0000000027a0c96b *(Radiated sample #2)*
Hardware Version:	V1.0
Software Version:	V1.0
FCC ID:	2ABCB-RPI4B

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:	1 Mbps		
Power Supply Requirement(s):	Nominal	5.0 VDC	
Maximum Conducted Output Power:	2.4 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:

Frequency Range (MHz)	Antenna Gain (dBi)
2400-2480	3.5

3.5. Description of Test Setup

Support Equipment

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

Description:	LCD Monitor
Brand Name:	Logik
Model Name or Number:	L22FE12A
Serial Number:	1309020661

Description:	USB Mouse
Brand Name:	Raspberry Pi
Model Name or Number:	RPI-MOUSE
Serial Number:	Not marked or stated

Description:	USB Keyboard
Brand Name:	Raspberry Pi
Model Name or Number:	RPI-KYB
Serial Number:	Not marked or stated

Description:	Power Supply. 100-230 VAC Input / 5 VDC output
Brand Name:	Belkin
Model Name or Number:	F7U011dr
Serial Number:	Not marked or stated

Description:	16 GB Micro SD card
Brand Name:	SanDisk
Model Name or Number:	HCI
Serial Number:	Not marked or stated

Description:	HDMI Cable Type A to Type D. Quantity 1. Length 1.05 metres
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Description:	Ethernet cable. Quantity 1. Length 1.0 metres
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Support Equipment (continued)

Description:	USB cable. Quantity 3. Length 3.0 metres
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Description:	USB Hub
Brand Name:	Hama
Model Name or Number:	00078498
Serial Number:	09825891600

Description:	Ethernet Router
Brand Name:	Netgear
Model Name or Number:	GS605
Serial Number:	1YG194390218E

Description:	HDMI Hub
Brand Name:	Sumvision
Model Name or Number:	Cyclone Micro
Serial Number:	SUM091104017

Description:	Cat 5 Ethernet Cable. Quantity 1. Length 2.0 metres
Brand Name:	AWN
Model Name or Number:	2835
Serial Number:	E87647

Description:	Test Laptop
Brand Name:	Lenovo
Model Name or Number:	L440
Serial Number:	R9-019EA1 14/04

Description:	Generic Headphones (ear buds)
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Support Equipment (continued)

Description:	USB Thumb Drive
Brand Name:	Sandisk
Model Name or Number:	Ultra flair USB 3.0
Serial Number:	BM182025896Z

Description:	USB Thumb Drive
Brand Name:	Sandisk
Model Name or Number:	Ultra flair USB 3.0
Serial Number:	BM190125896Z

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.

Configuration and Peripherals

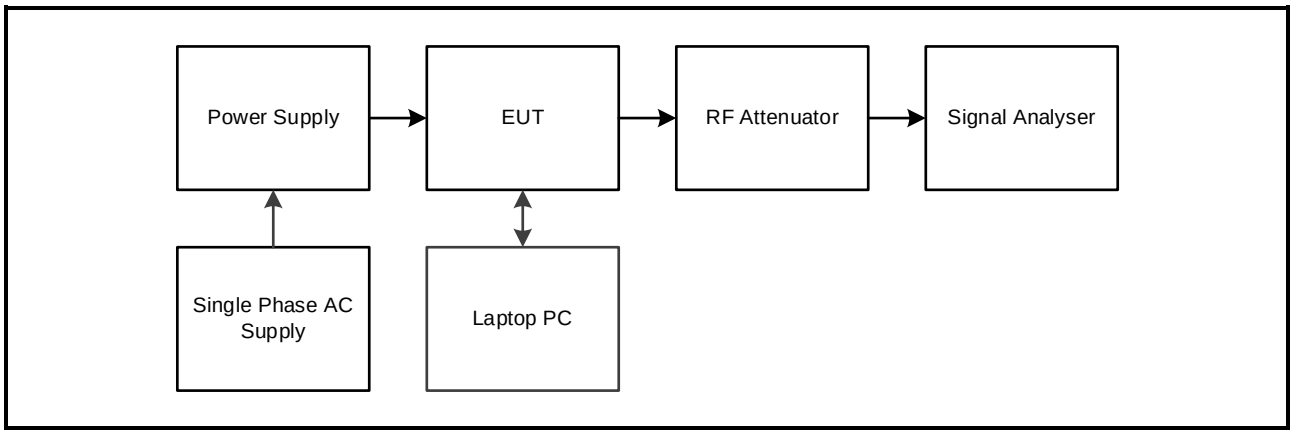
The EUT was tested in the following configuration(s):

- The customer's test application and supplied instructions were used to place the EUT into *Bluetooth* LE test mode. The supplied commands were entered into the console menu on the EUT. Test commands stated in the bt_testing.sh file located on the /home/pi drive of the EUT were used to configure the EUT to enable a continuous transmission and to select the test channels as required.
- The EUT was powered via an AC/DC switch mode power supply.
- AC conducted emissions test was tested with the EUT transmitting on the Middle channel.
- Radiated spurious emissions were performed with the EUT in the Y plane (worst case) while connected to its power supply. Tests were performed with the EUT connected to its AC adaptor and USB cable. All other ports were terminated with suitable terminations.
- The LCD monitor was connected to the EUT using a 1.05 metre long HDMI cable.
- The keyboard and mouse were connected to the USB port on the EUT.

Test Setup Diagrams

Conducted Tests:

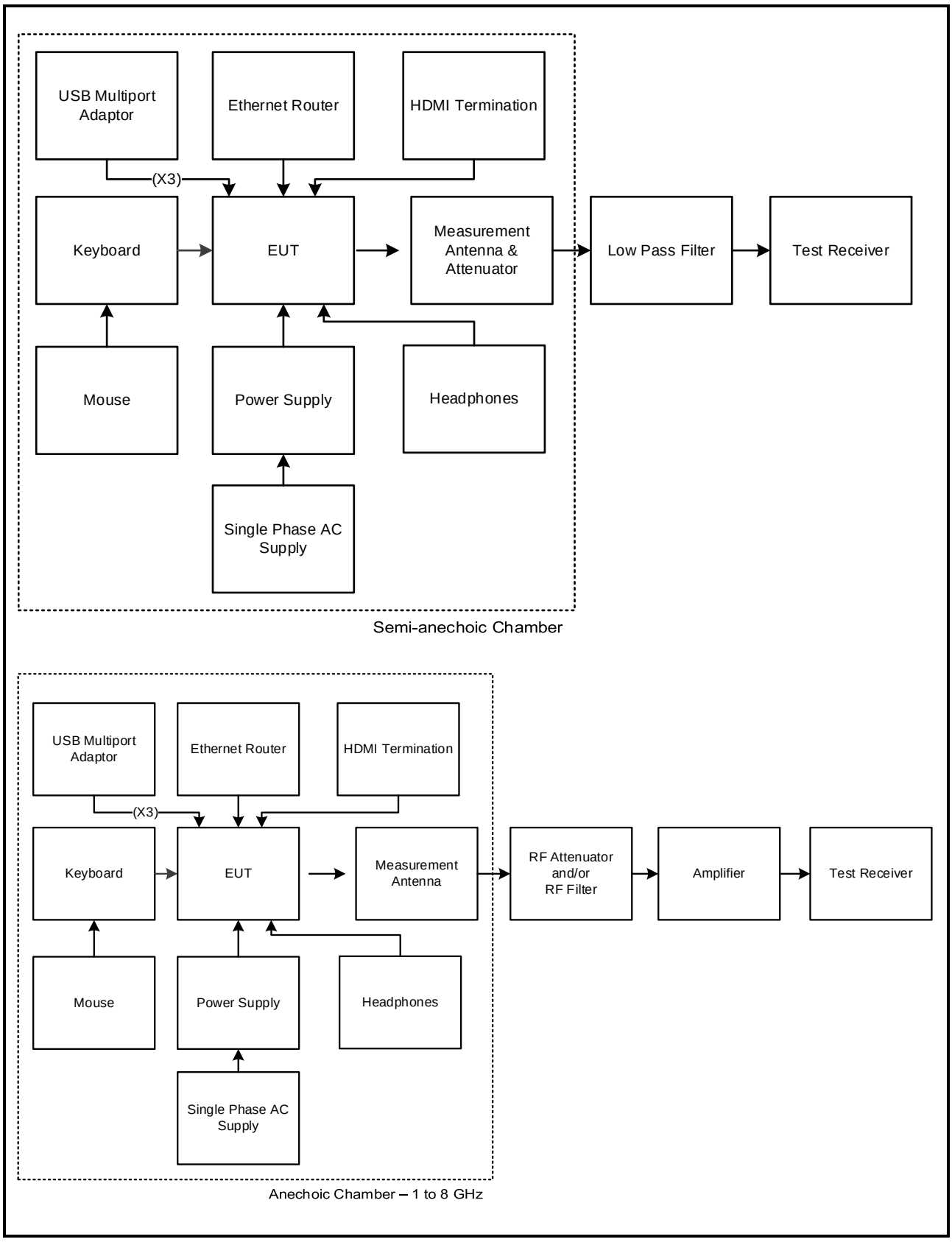
Test Setup for Transmitter Minimum 6 dB Bandwidth, Duty Cycle & Maximum Peak Output Power



Test Setup Diagrams (continued)

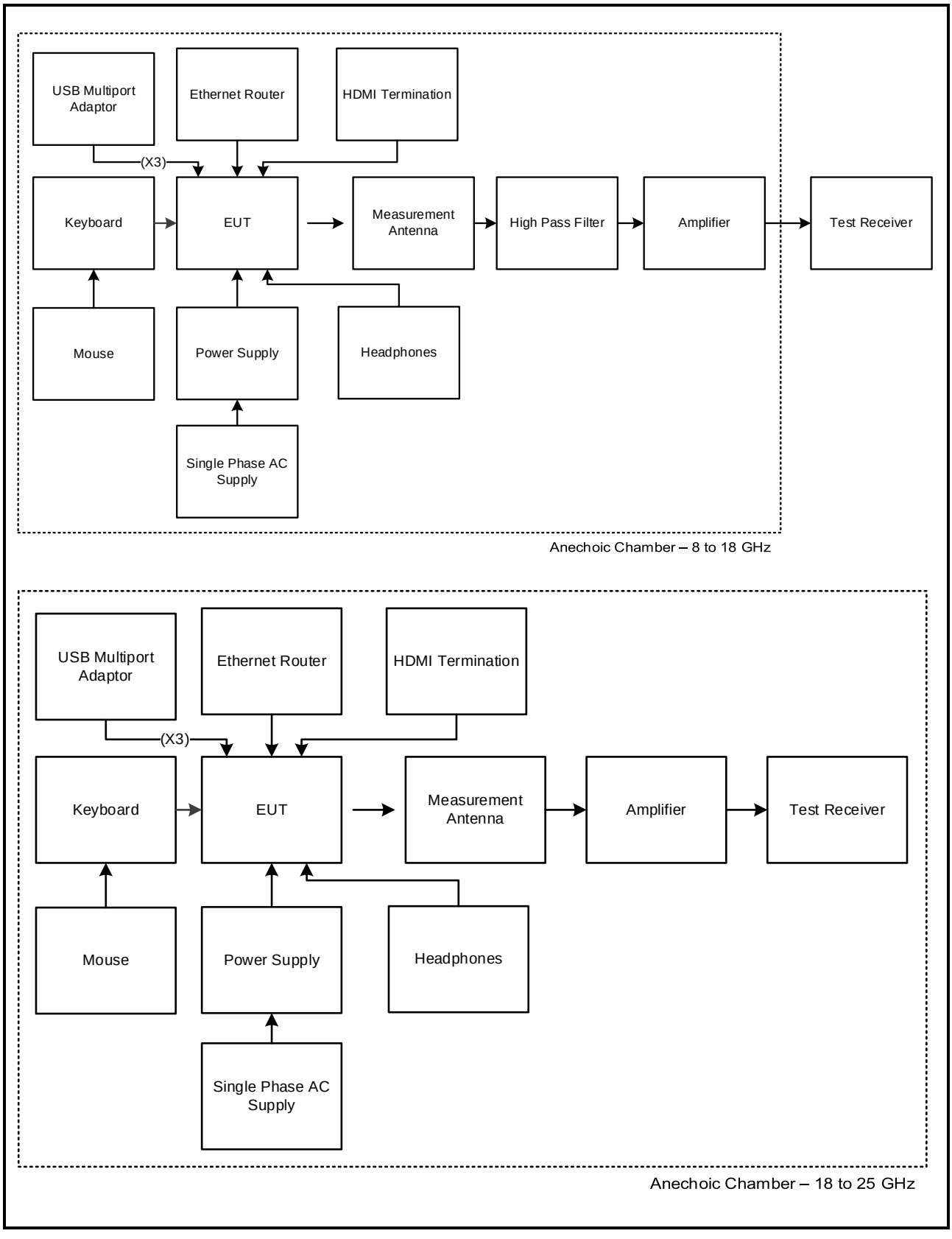
Radiated Tests:

Test Setup for Transmitter Radiated Emissions



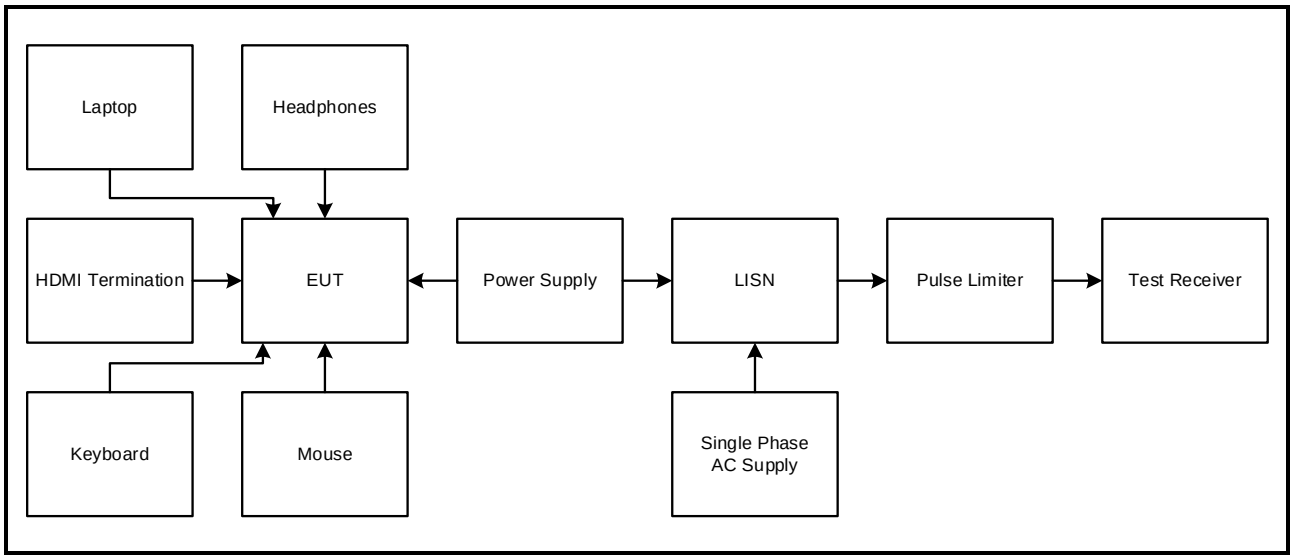
Test Setup Diagrams (continued)

Test setup for radiated measurements (continued):



Test Setup Diagrams (continued)

Test Setup for Transmitter AC Conducted Emissions



4. Antenna Port Test Results

4.1. Transmitter Minimum 6 dB Bandwidth

Test Summary:

Test Engineers:	Victor Carmon & Matthew Botfield	**Test Date:**	17 April 2019
Test Sample Serial Number:	0000000020d6f686		

FCC Reference:	Part 15.247(a)(2)
Test Method Used:	FCC KDB 558074 Section 8.2 referencing ANSI C63.10 Section 11.8.1

Environmental Conditions:

Temperature (°C):	21
Relative Humidity (%):	41

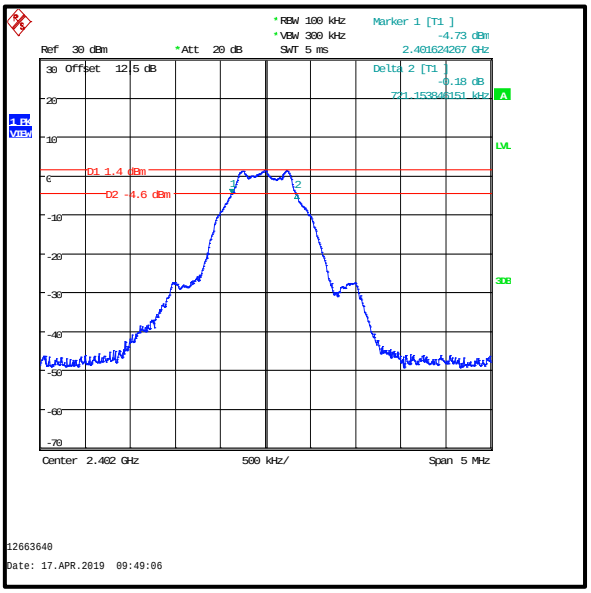
Note(s):

1. 6 dB DTS bandwidth tests were performed using a spectrum analyser in accordance with ANSI C63.10 Section 11.8.1 Option 1 measurement procedure. The spectrum analyser resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and the trace mode was Max Hold. The DTS bandwidth was measured at 6 dB down from the peak of the signal.
2. The spectrum analyser was connected to the RF port on the EUT using suitable attenuation and RF cable.

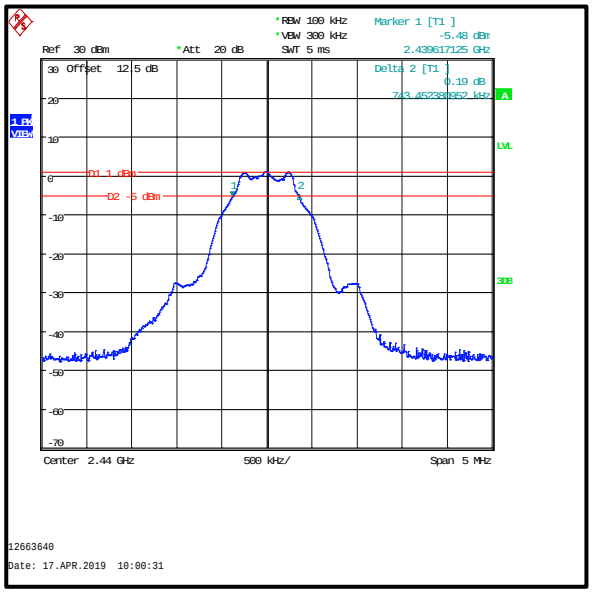
Transmitter Minimum 6 dB Bandwidth (continued)

Results:

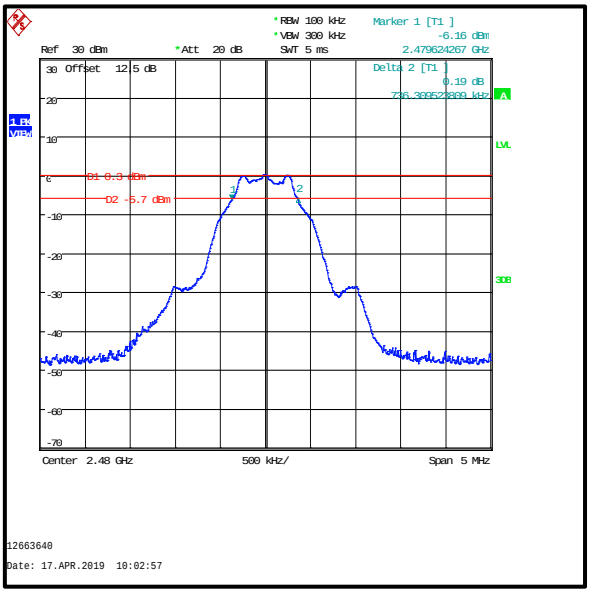
Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	721.154	≥500	221.154	Complied
Middle	743.452	≥500	243.452	Complied
Top	736.310	≥500	236.310	Complied



Bottom Channel



Middle Channel



Top Channel

4.2.Transmitter Duty Cycle

Test Summary:

Test Engineers:	Victor Carmon & Matthew Botfield	**Test Date:**	17 April 2019
Test Sample Serial Number:	0000000020d6f686		

FCC Reference:	Part 15.35(c)
Test Method Used:	FCC KDB 558074 Section 6 referencing ANSI C63.10 Section 11.6

Environmental Conditions:

Temperature (°C):	21
Relative Humidity (%):	41

Note(s):

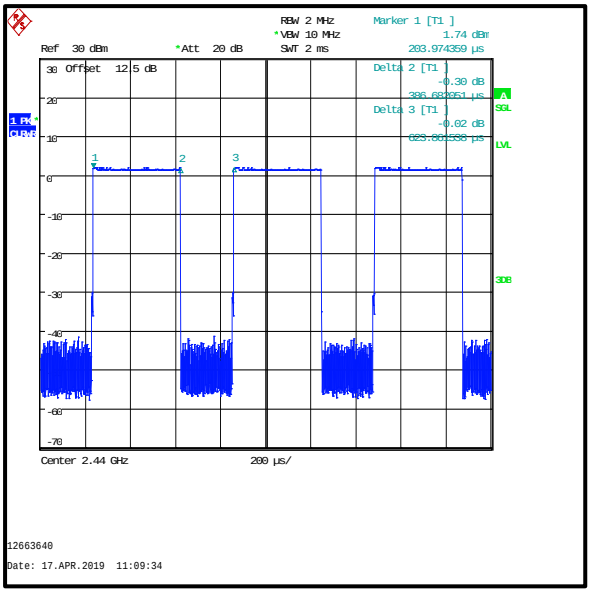
1. In order to assist with the determination of the average level of spurious emissions field strength in LE mode, measurements were made of duty cycle to determine the transmission duration and the silent period time of the transmitter. The transmitter duty cycle was measured using a spectrum analyser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

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

Duty cycle: 10 log (1 / (386.682 µs / 623.862 µs)) = 2.1 dB

Results:

Pulse Duration (µs)	Period (µs)	Duty Cycle (dB)
386.682	623.862	2.1



4.3. Transmitter Maximum Peak Output Power

Test Summary:

Test Engineers:	Victor Carmon & Matthew Botfield	**Test Date:**	17 April 2019
Test Sample Serial Number:	0000000020d6f686		

FCC Reference:	Part 15.247(b)(3)
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):	21
Relative Humidity (%):	41

Note(s):

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

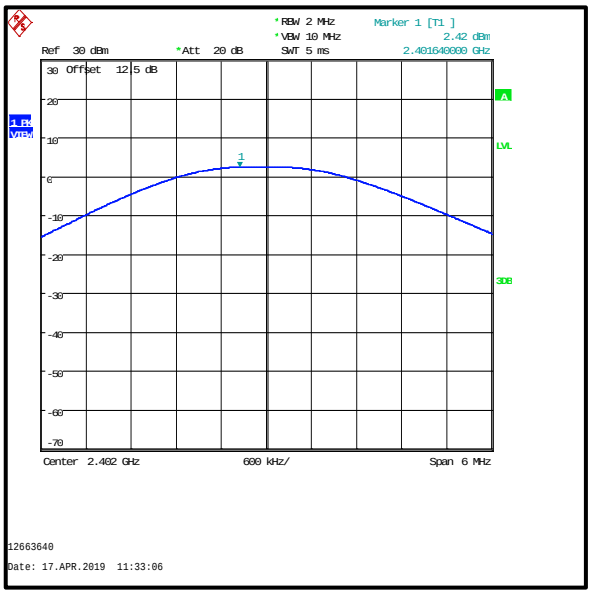
Results:

Channel	Conducted Peak Power (dBm)	Conducted Peak Power Limit (dBm)	Margin (dB)	Result
Bottom	2.4	30.0	27.6	Complied
Middle	2.0	30.0	28.0	Complied
Top	1.1	30.0	28.9	Complied

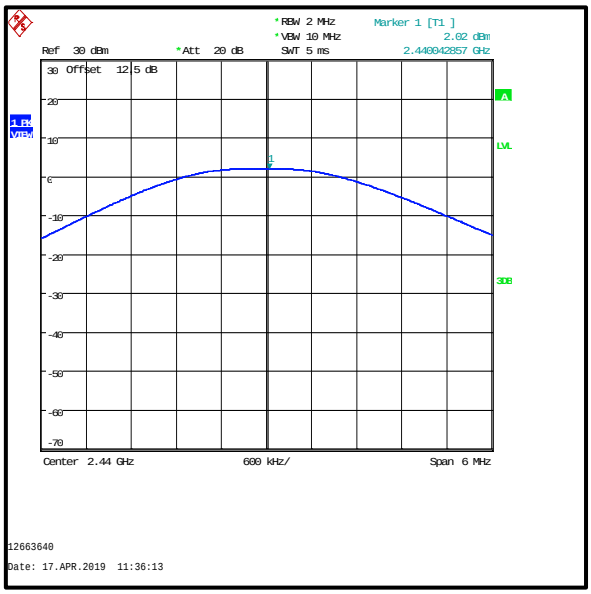
Channel	Conducted Peak Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	2.4	3.5	5.9	36.0	30.1	Complied
Middle	2.0	3.5	5.5	36.0	30.5	Complied
Top	1.1	3.5	4.6	36.0	31.4	Complied

Transmitter Maximum Peak Output Power (continued)

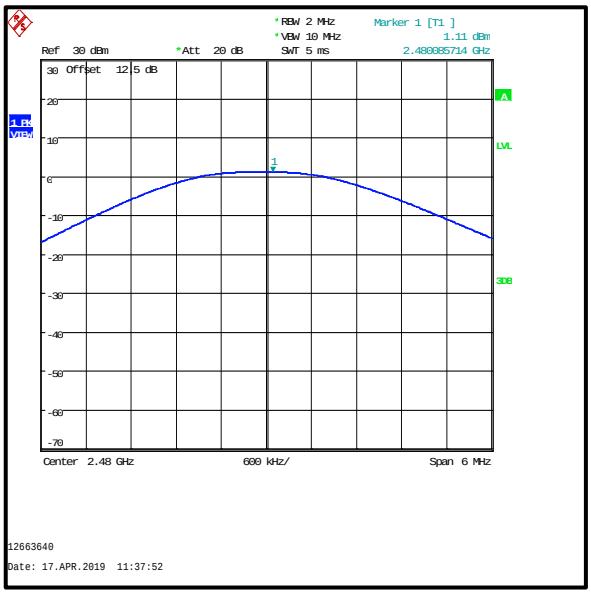
Results:



Bottom Channel



Middle Channel



Top Channel

5. Radiated Test Results

5.1. Transmitter Radiated Emissions <1 GHz

Test Summary:

Test Engineer:	David Doyle	**Test Date:**	12 April 2019
Test Sample Serial Number:	000000003f9edf4a		

FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	ANSI C63.10 Sections 6.3 and 6.5
Frequency Range	30 MHz to 1000 MHz

Environmental Conditions:

Temperature (°C):	19
Relative Humidity (%):	38

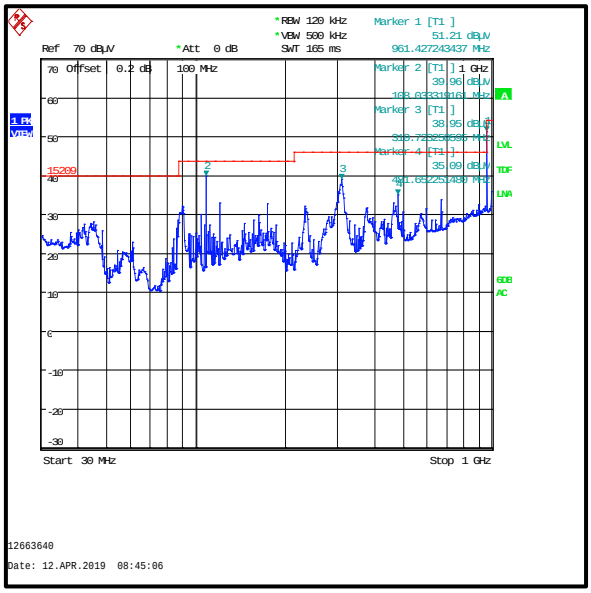
Note(s):

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, or > 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 1 GHz were performed in a semi-anechoic chamber (Asset Number K0001) at a distance of 3 metres. The EUT was placed at a height of 80 cm above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 metre to 4 metres.
5. Pre-scans were performed and markers placed on the highest measured levels. The test receiver resolution bandwidth was set to 120 kHz and video bandwidth 500 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold.
6. 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 (continued)

Results: Quasi-Peak

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
108.327	Horizontal	34.6	43.5	8.9	Complied
120.352	Horizontal	31.2	43.5	12.3	Complied
162.498	Vertical	30.8	43.5	12.7	Complied
960.277	Horizontal	50.5	54.0	3.5	Complied



Note: This plot is a pre-scan and for indication purposes only. For final measurements, see accompanying table.

5.2. Transmitter Radiated Emissions >1 GHz

Test Summary:

Test Engineer:	David Doyle	**Test Dates:**	10 April 2019 to 12 April 2019
Test Sample Serial Number:	000000003f9edf4a		

FCC Reference:	Parts 15.247(d) & 15.209(a)
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):	19 to 20
Relative Humidity (%):	38 to 41

Note(s):

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. The emission shown on the 1 GHz to 3 GHz plot is the EUT fundamental.
3. 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.
4. All other emissions shown on the pre-scans were investigated and found to be ambient, or > 20 dB below the appropriate limit or below the noise floor of the measurement system.
5. Pre-scans above 1 GHz were performed in a fully anechoic chamber (Asset Number K0001) at a distance of 3 metres. The EUT was placed at a height of 1.5 metres above the test chamber floor in the centre of the chamber turntable. All measurement antennas were placed at a fixed height of 1.5 metres above the test chamber floor, in line with the EUT. Final measurements were performed 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.
6. Pre-scans were performed and a marker placed on the highest measured level of the appropriate plot. 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 their own appropriate detectors during the pre-scan measurements.

Transmitter Radiated Emissions (continued)

Results: Bottom Channel

Frequency (MHz)	Antenna Polarity	Peak Level (dBµV/m)	Average Limit (dBµV/m)	Margin (dB)	Result
3843.421	Horizontal	47.8	54.0	6.2	Complied
4725.288	Vertical	51.4	54.0	2.6	Complied

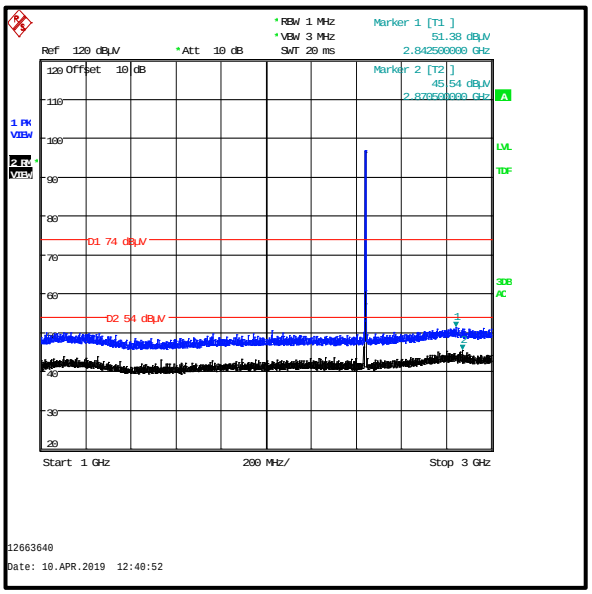
Results: Middle Channel

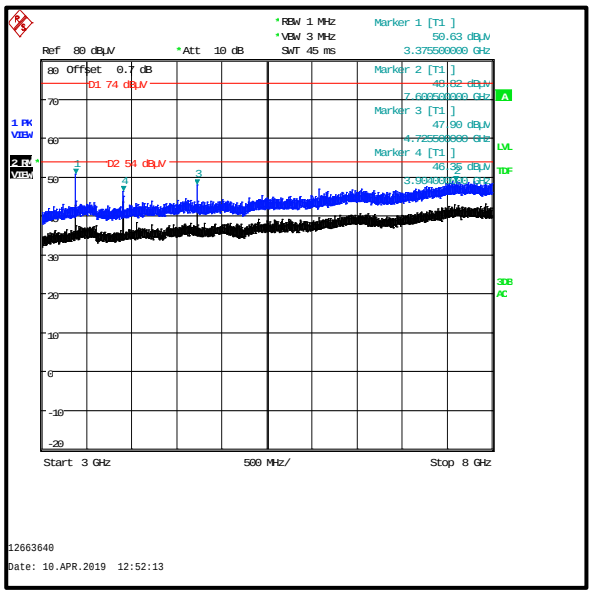
Frequency (MHz)	Antenna Polarity	Peak Level (dBµV/m)	Average Limit (dBµV/m)	Margin (dB)	Result
3903.821	Horizontal	47.9	54.0	6.1	Complied
4725.159	Vertical	51.2	54.0	2.8	Complied

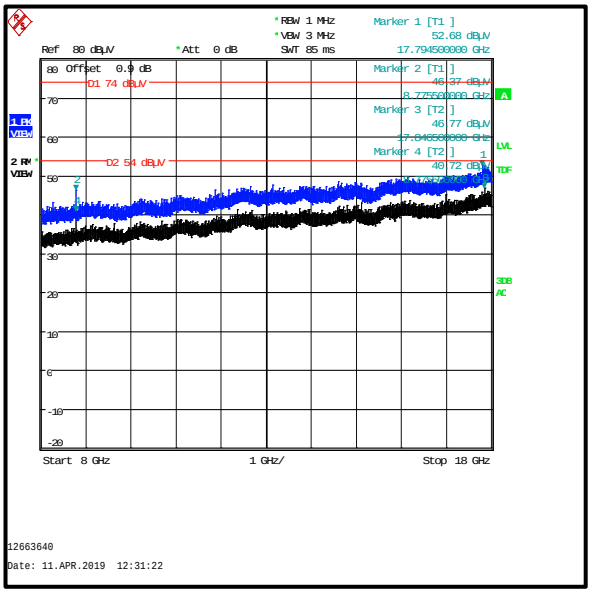
Results: Top Channel

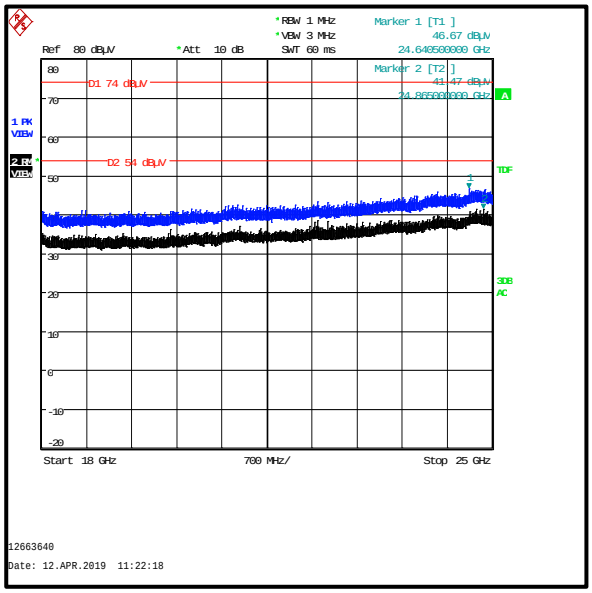
Frequency (MHz)	Antenna Polarity	Peak Level (dBµV/m)	Average Limit (dBµV/m)	Margin (dB)	Result
3968.098	Horizontal	47.9	54.0	6.1	Complied
4725.009	Vertical	51.2	54.0	2.8	Complied

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:	David Doyle	**Test Date:**	10 April 2019
Test Sample Serial Number:	000000003f9edf4a		

FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	KDB 558074 Section 8.7 referencing ANSI C63.10 Sections 11.11, 11.12 & 11.13

Environmental Conditions:

Temperature (°C):	20
Relative Humidity (%):	41

Note(s):

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. The maximum peak conducted output power was previously measured. In accordance with ANSI C63.10 Section 11.11.1(a), the lower band edge measurement was performed with a peak detector and the -20 dBc limit applied.
3. As the lower band edge is adjacent to a non-restricted band, only peak measurements are required. In accordance with ANSI C63.10 Section 11.11.1, the test method in Section 11.11.3 was followed: the test receiver resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The test receiver was left to sweep for a sufficient length of time in order to maximise the carrier level and out-of-band emissions. A marker and corresponding reference level line were placed on the peak of the carrier. As the maximum peak conducted output power was measured using an peak detector in accordance with ANSI C63.10 Section 11.9.1.1 an out-of-band limit line was placed 20 dB (ANSI C63.10 Section 11.11.1(a)) below the peak level. A marker was placed on the band edge spot frequencies. Marker frequency and levels were recorded.
4. As the upper band edge is adjacent to a restricted band, both peak and average measurements were recorded by placing a marker at the edge of the band. For peak measurements the test receiver resolution bandwidth was set to 1 MHz and the video bandwidth 3 MHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. For average measurements the test receiver resolution bandwidth was set to 1 MHz and the video bandwidth 3 MHz. An RMS detector was used, sweep time was set to auto and trace mode was trace averaging over 300 sweeps. A marker was placed on the band edge spot frequencies and a second marker placed on the highest emission level in the adjacent restricted band of operation (where a higher level emission was present). Marker frequencies and levels were recorded.
5. There is a restricted band 10 MHz below the lower band edge. The test receiver was set up as follows: the RBW set to 1 MHz, the VBW set to 3 MHz, with the sweep time set to auto couple. Peak and average measurements were performed with peak and RMS detectors respectively. Markers were placed on the highest point on each trace.
6. * -20 dBc limit.
7. For the upper band average result, the EUT had a duty cycle <98%. The duty cycle correction factor has been applied and the corrected level is shown below:

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

Corrected band edge level at 2483.5 MHz: 40.4 + 2.1 = 42.5 dBμV/m

Transmitter Band Edge Radiated Emissions (continued)

Results: Peak

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2393.990	Horizontal	50.2	76.1*	25.9	Complied
2400.0	Horizontal	46.9	76.1*	29.2	Complied
2483.5	Horizontal	51.1	74.0	22.9	Complied

Results: Average

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Duty Cycle Correction Factor (dB)	Corrected Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.5	Horizontal	40.4	2.1	42.5	54.0	11.5	Complied
2483.901	Horizontal	41.6	2.1	43.7	54.0	10.3	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

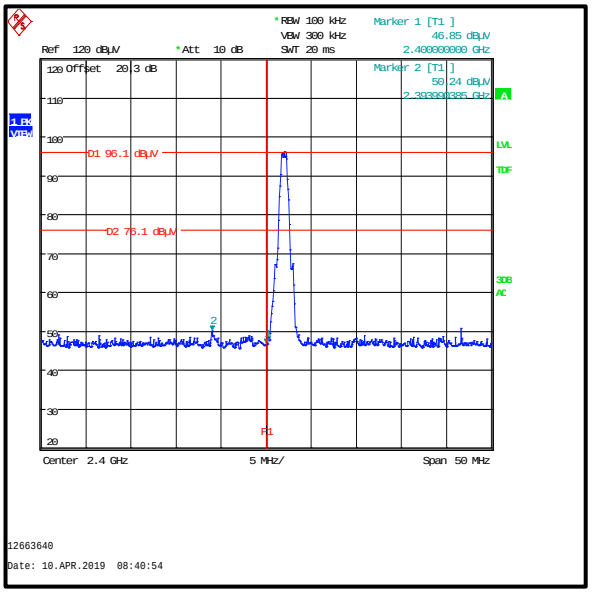
Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2386.795	Horizontal	51.8	74.0	22.2	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

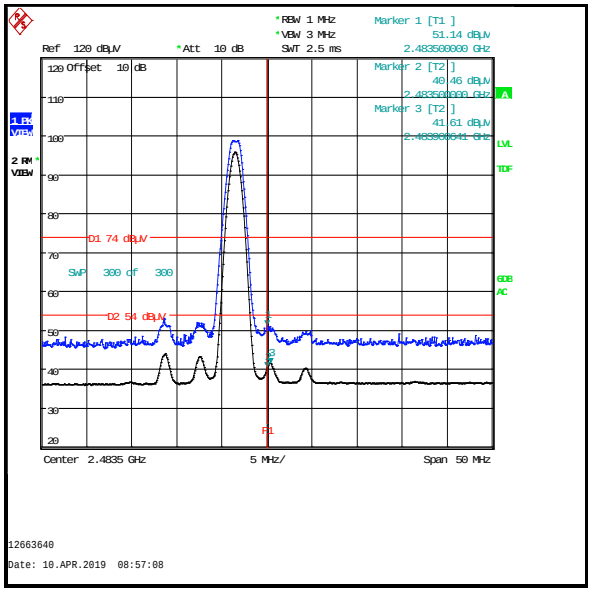
Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2316.538	Horizontal	37.7	54.0	16.3	Complied

Transmitter Band Edge Radiated Emissions (continued)

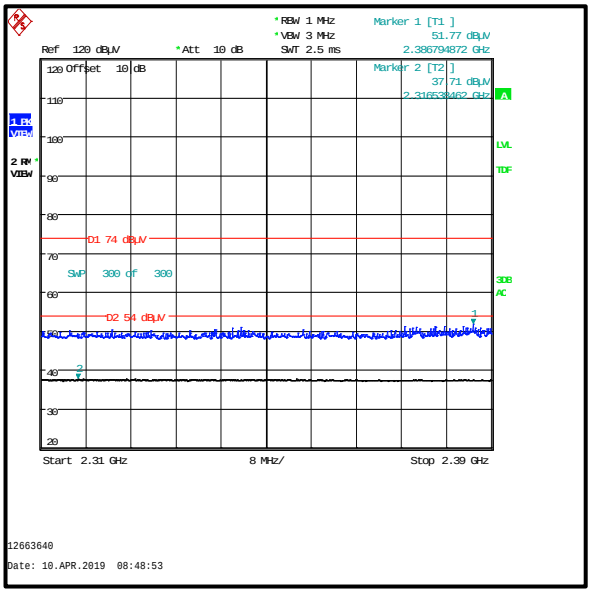
Results:



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 Engineer:	Victor Carmon	**Test Date:**	23 April 2019
Test Sample Serial Number:	0000000027a0c96b		

FCC Reference:	Part 15.207
Test Method Used:	ANSI C63.10 Section 6.2 / FCC KDB 174176 and notes below

Environmental Conditions:

Temperature (°C):	21
Relative Humidity (%):	45

Note(s):

1. The EUT was connected to the AC to DC switch mode power supply which 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 EUT's power supply.
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
0.150	Live	43.4	66.0	22.6	Complied
0.195	Live	38.7	63.8	25.1	Complied
0.447	Live	36.6	56.9	20.3	Complied
11.576	Live	27.8	60.0	32.2	Complied
24.054	Live	11.5	60.0	48.5	Complied

Results: Live / Average / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dBµV)	Limit (dBµV)	Margin (dB)	Result
0.155	Live	27.2	55.8	28.6	Complied
0.155	Live	26.8	55.8	29.0	Complied
0.443	Live	26.2	47.0	20.8	Complied
0.519	Live	24.3	46.0	21.7	Complied
11.531	Live	21.1	50.0	28.9	Complied
24.158	Live	7.8	50.0	42.2	Complied

Results: Neutral / Quasi Peak / 120 VAC 60 Hz

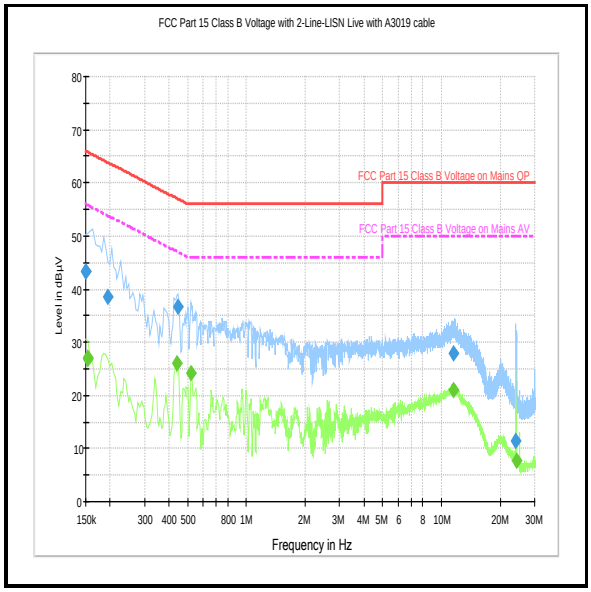
Frequency (MHz)	Line	Level (dBµV)	Limit (dBµV)	Margin (dB)	Result
0.150	Neutral	42.1	66.0	23.9	Complied
0.155	Neutral	42.0	65.8	23.8	Complied
0.447	Neutral	36.8	56.9	20.1	Complied
0.515	Neutral	38.0	56.0	18.0	Complied
11.252	Neutral	29.5	60.0	30.5	Complied
12.723	Neutral	29.2	60.0	30.8	Complied

Results: Neutral / Average / 120 VAC 60 Hz

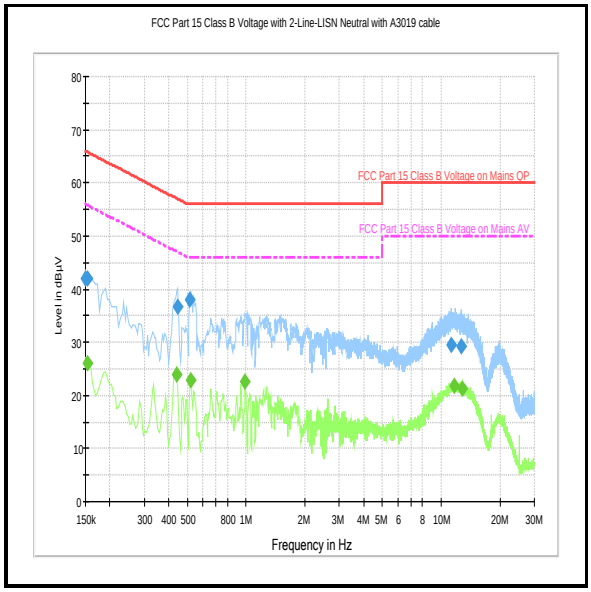
Frequency (MHz)	Line	Level (dBµV)	Limit (dBµV)	Margin (dB)	Result
0.155	Neutral	26.0	55.8	29.8	Complied
0.443	Neutral	24.0	47.0	23.0	Complied
0.519	Neutral	22.9	46.0	23.1	Complied
0.987	Neutral	22.6	46.0	23.4	Complied
11.594	Neutral	21.9	50.0	28.1	Complied
12.764	Neutral	21.2	50.0	28.8	Complied

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
0.159	Live	37.4	65.5	28.1	Complied
0.213	Live	34.6	63.1	28.5	Complied
0.501	Live	36.7	56.0	19.3	Complied
1.176	Live	31.4	56.0	24.6	Complied
1.640	Live	31.6	56.0	24.4	Complied
11.427	Live	28.6	60.0	31.4	Complied

Results: Live / Average / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dBµV)	Limit (dBµV)	Margin (dB)	Result
0.164	Live	24.8	55.3	30.5	Complied
0.353	Live	25.8	48.9	23.1	Complied
0.515	Live	25.0	46.0	21.0	Complied
0.740	Live	24.5	46.0	21.5	Complied
2.531	Live	22.6	46.0	23.4	Complied
11.558	Live	22.3	50.0	27.7	Complied

Results: Neutral / Quasi Peak / 240 VAC 60 Hz

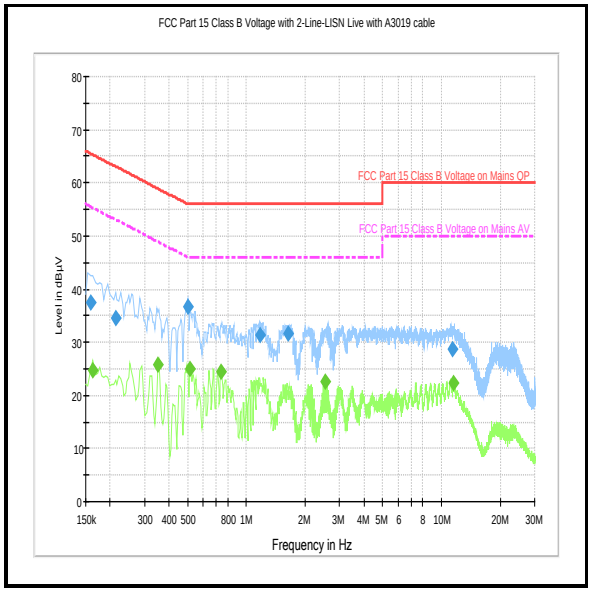
Frequency (MHz)	Line	Level (dBµV)	Limit (dBµV)	Margin (dB)	Result
0.150	Neutral	31.3	66.0	34.7	Complied
0.501	Neutral	37.8	56.0	18.2	Complied
0.785	Neutral	34.0	56.0	22.0	Complied
1.158	Neutral	35.1	56.0	20.9	Complied
1.541	Neutral	34.6	56.0	21.4	Complied
10.766	Neutral	28.5	60.0	31.5	Complied

Results: Neutral / Average / 240 VAC 60 Hz

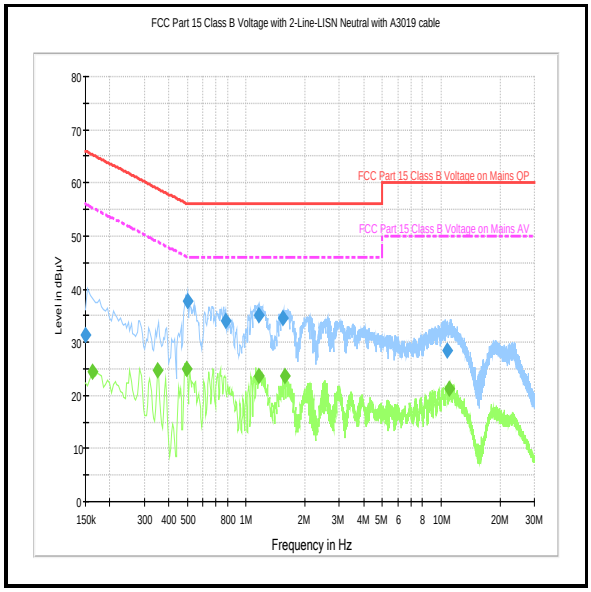
Frequency (MHz)	Line	Level (dBµV)	Limit (dBµV)	Margin (dB)	Result
0.164	Neutral	24.6	55.3	30.7	Complied
0.353	Neutral	24.7	48.9	24.2	Complied
0.497	Neutral	25.0	46.1	21.1	Complied
1.158	Neutral	23.8	46.0	22.2	Complied
1.572	Neutral	23.6	46.0	22.4	Complied
11.031	Neutral	21.2	50.0	28.8	Complied

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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