TEST REPORT

Test Report No. : UL-RPT-RP14769707JD06A

Customer	:	Apple Inc.
Model No. / HVIN	:	A2991
PMN	:	MacBook Pro
FCC ID	:	BCGA2991
ISED Certification No.	:	IC: 579C-A2991
Technology	:	*Bluetooth, Bluetooth* Low Energy, *Bluetooth* HDR, *Thread*, NB-FHSS
Test Standard(s)	:	FCC Part 15.207 Innovation, Science and Economic Development Canada 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 2.0 supersedes all previous versions.

Date of Issue: 29 September 2023

Checked by:

Ben Mercer
Digitally signed by Ben Mercer
Date: 2023.09.29 16:08:33 +01'00'

Ben Mercer
Lead Project Engineer, Radio Laboratory

Company Signatory:

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Date: 2023.09.29 16:08:50 +01'00'

Sarah Williams
RF Operations Leader, Radio Laboratory

5772

Customer Information

Company Name:	Apple Inc.
Address:	One Apple Park Way Cupertino, California 95014 U.S.A.
Contact Name:	Stuart Thomas

Report Revision History

Version Number	Issue Date	Revision Details	Revised By
1.0	29/09/2023	Initial Version	Ben Mercer
2.0	29/09/2023	PMN Updated	Sarah Williams

Table of Contents

1 Attestation of Test Results

1.1 Description of EUT

The equipment under test (EUT) was a portable laptop computer.

1.2 General Information

Specification Reference:	47CFR15.207
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) – Section 15.207
Specification Reference:	RSS-Gen Issue 5 February 2021
Specification Title:	General Requirements for Compliance of Radio Apparatus
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:	01 September 2023 to 05 September 2023

1.3 Summary of Test Results

FCC Reference (47CFR)	ISED Canada Reference	Measurement	Result
Part 15.207	RSS-Gen 8.8	Transmitter AC Conducted Emissions	Complied

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.

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 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 & 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

Measurement system instrumentation shall be used with an accuracy specification meeting the accuracy specification limits according to IEC/IECEE OD-5014.

As applicable, unless specified otherwise in this report, the compliance “Decision Rule” is based on Simple Acceptance. If the measured value is on the limit, the result is defined as a pass. In this case the risk of a false positive is 50%. For further information regarding risk assessment refer to ILAC G8:09/2019.

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
AC Conducted Spurious Emissions	0.15 MHz to 30 MHz	95%	±2.42 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

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2037	Thermohygrometer	Testo	608-H1	45124925	08 Dec 2023	12
A649	LISN	Rohde & Schwarz	ESH3-Z5	825562/008	23 Aug 2024	12
A1830	Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100668	01 Jun 2024	12
M1124	Test Receiver	Rohde & Schwarz	ESIB 26	100046	06 Oct 2023	12

Test Measurement Software/Firmware Used:

Name	Version	Release Date
Rohde & Schwarz EMC32	6.30.0	2018

3 Equipment Under Test (EUT)

3.1 Identification of Equipment Under Test (EUT)

Brand Name:	Apple
Model Name or Number / HVIN:	BCGA2991
PMN:	MacBook Pro
Test Sample Serial Number:	M227XWFK4N
Hardware Version:	REV 1.0
Software Version:	23A32391v
FCC ID:	BCGA2991
ISED Canada Certification Number:	IC: 579C-A2991
Date of Receipt:	10 August 2023

3.2 Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

3.3 Additional Information Related to Testing

Category of Equipment:	*Bluetooth*		
Power Supply Requirement(s):	Nominal	12 VDC via 120 VAC 60 Hz adaptor	
Channel Spacing:	1 MHz		
Mode:	Basic Rate		
Modulation:	GFSK		
Packet Type (Maximum Payload):	DH5		
Data Rate (Mbps):	1		
Transmit Frequency Range:	2402 MHz to 2480 MHz		
Transmit Channels Tested:	**Mode**	**Hopping Frequency Range (MHz)**	
	Hopping	2402 to 2480	

Technology Tested:	*Bluetooth* Low Energy (Digital Transmission System)		
Type of Unit:	Transceiver		
Channel Spacing:	2 MHz		
Modulation:	GFSK		
Data Rate: LE1M	1 Mbps		
Power Supply Requirement(s):	Nominal	12 VDC via 120 VAC 60 Hz adaptor	
Transmit Frequency Range:	2402 MHz to 2480 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Middle	17	2440

Technology Tested:	*Bluetooth* (Digital Transmission System)		
Type of Unit:	Transceiver		
Channel Spacing:	1 MHz		
Mode	High Data Rate		
Modulation:	π/4-DQPSK		
Packet Type (Maximum Payload):	4DH5		
Data Rate (Mbps):	4		
Power Supply Requirement(s):	Nominal	12 VDC via 120 VAC 60 Hz adaptor	
Transmit Frequency Range:	2404 MHz to 2476 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Middle	39	2441

Additional Information Related to Testing (continued)

Technology Tested:	*Thread* (Digital Transmission System)		
Type of Unit:	Transceiver		
Channel Spacing:	5 MHz		
Modulation:	OQPSK		
Data Rate (kbps):	250		
Power Supply Requirement(s):	Nominal	12 VDC via 120 VAC 60 Hz adaptor	
Transmit Frequency Range:	2404 MHz to 2478 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Middle	18	2440

Technology Tested:	NarrowBand FHSS	
Type of Unit:	Transceiver	
Mode:	Basic Rate	
Modulation:	GFSK	
Packet Type (Maximum Payload):	DH5	
Data Rate (Mbps):	1	
Power Supply Requirement:	Nominal	12 VDC via 120 VAC 60 Hz adaptor
Channel Bandwidth(s):	1 MHz	
Transmit Frequency Range:	5150 MHz to 5250 MHz	
Transmit Channels Tested:	**Mode**	**Hopping Frequency Range (MHz)**
	Hopping	5152 to 5230
Transmit Frequency Range:	5725 MHz to 5850 MHz	
Transmit Channels Tested:	**Mode**	**Hopping Frequency Range (MHz)**
	Hopping	5727 to 5805
Transmit Frequency Range:	5925 MHz to 6015 MHz	
Transmit Channels Tested:	**Mode**	**Hopping Frequency Range (MHz)**
	Hopping	5927 to 6005
Transmit Frequency Range:	6300 MHz to 6385 MHz	
Transmit Channels Tested:	**Mode**	**Hopping Frequency Range (MHz)**
	Hopping	6301 to 6379

3.4 Description of Available Antennas

The radio utilises three integrated antennas, with the following maximum gain:

Antenna Port	Frequency Range (MHz)	Antenna Gain (dBi)
Core 0	2400 to 2483.5	3.1
	5150 to 5250	6.0
	5725 to 5850	6.2
	5925 to 6015	6.2
	6300 to 6385	5.5
Core 1	2400 to 2483.5	5.3
	5150 to 5250	4.5
	5725 to 5850	4.7
	5925 to 6015	3.7
	6300 to 6385	2.6
Dedicated Core	2400 to 2480	5.8

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:	Apple
Model Name or Number:	MacBook Pro
Serial Number:	C02CF02XP3XY

Description:	USB Diagnostic Cable
Brand Name:	Apple
Model Name or Number:	Chimp
Serial Number:	427A65

Description:	USB Flash Drive. Quantity 2
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Numbers:	Not marked or stated

Description:	USB-A to USB-C Adapter. Quantity 2.
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Description:	HDMI Cable. Length 2 m.
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Description:	USB/HDMI Termination Hub
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Description:	Personal Hands Free (PHF)
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Operating Modes

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

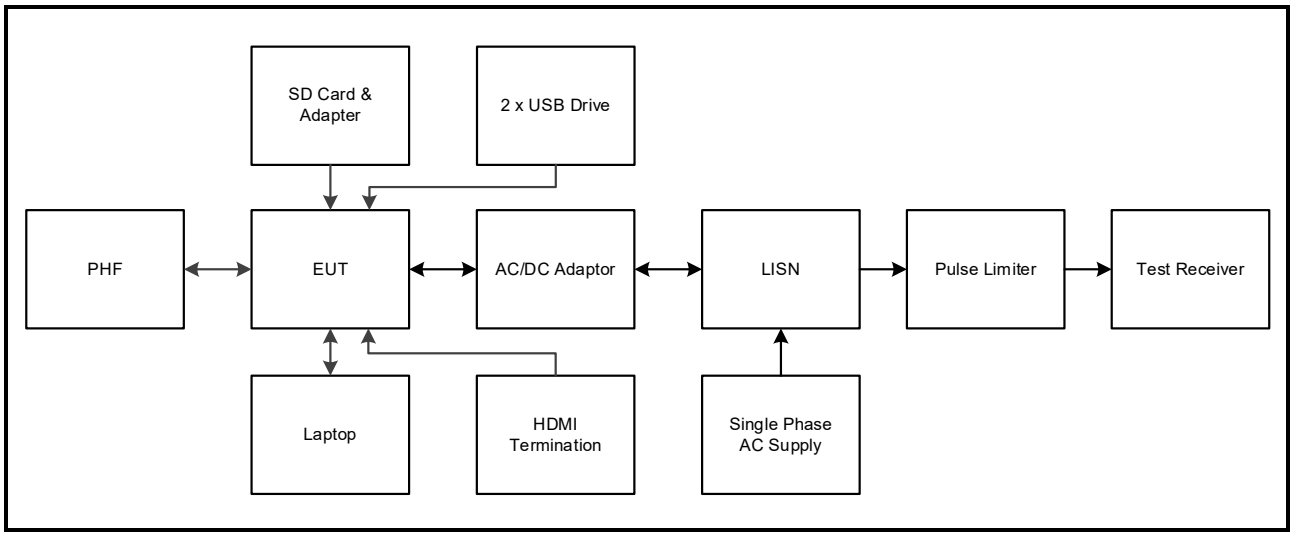
- Continuously transmitting at maximum power on the middle channels / hopping as required.
- The EUT was tested in the following operating mode(s): Pre-scans were performed with the EUT transmitting in *Bluetooth* BDR, *Bluetooth* LE, *Thread* and NB-FHSS UNII-1, UNII-3 & UNII-5 modes individually. The worst-case mode was found to be *Bluetooth* BDR using DH5 packets. Final measurements were performed in this configuration.

Configuration and Peripherals

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

- Controlled in test mode using a desktop application on the test laptop supplied by the customer. The commands were used to enable a continuous transmission and to select the test channels as required on the EUT.
- Pre-scan plots for all configurations are archived on the UL IT server and available for inspection if required.
- The EUT was powered from a 120 VAC 60 Hz single phase mains supply unless otherwise stated.
- All ports were populated with suitable terminations.

Test Setup Diagrams



4 AC Power Line Conducted Emissions Test Results

4.1 Transmitter AC Conducted Spurious Emissions

Test Summary:

Test Engineer:	Alison Johnston	**Test Dates:**	01 September 2023 to 05 September 2023
Test Sample Serial Number:	M227XWFK4N		

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 (%):	60

Note(s):

1. The EUT was connected to a 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 140W USB-C power supply.
3. A pulse limiter was fitted between the LISN and the test receiver.

Transmitter AC Conducted Spurious Emissions (continued)

Results: Live / Quasi Peak / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.172500	Live	47.3	64.8	17.5	Complied
0.262500	Live	37.5	61.4	23.9	Complied
0.429000	Live	34.0	57.3	23.3	Complied
2.080500	Live	31.3	56.0	24.7	Complied
4.164000	Live	35.2	56.0	20.8	Complied
21.777000	Live	34.5	60.0	25.5	Complied

Results: Live / Average / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.469500	Live	23.6	46.5	22.9	Complied
0.793500	Live	19.1	46.0	26.9	Complied
1.108500	Live	18.8	46.0	27.2	Complied
4.128000	Live	23.7	46.0	22.3	Complied
8.092500	Live	26.0	50.0	24.0	Complied
16.030500	Live	26.8	50.0	23.2	Complied

Results: Neutral / Quasi Peak / 120 VAC 60 Hz

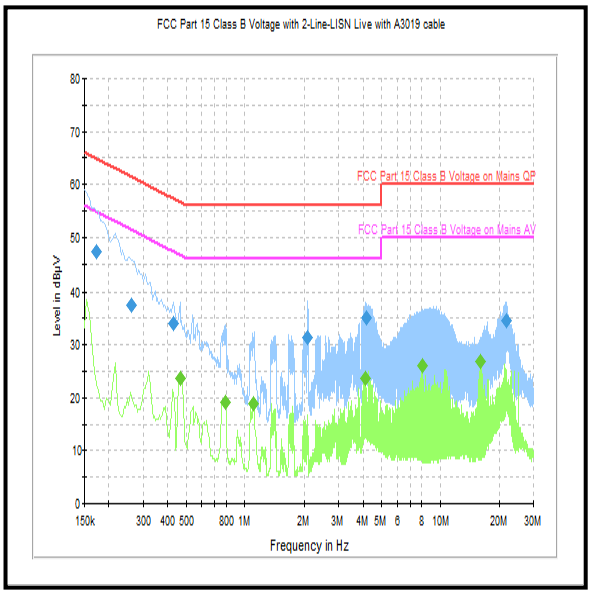
Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.181500	Neutral	45.9	64.4	18.5	Complied
0.276000	Neutral	36.3	60.9	24.6	Complied
0.433500	Neutral	33.0	57.2	24.2	Complied
0.771000	Neutral	33.5	56.0	22.5	Complied
2.080500	Neutral	31.3	56.0	24.7	Complied
4.164000	Neutral	35.7	56.0	20.3	Complied

Results: Neutral / Average / 120 VAC 60 Hz

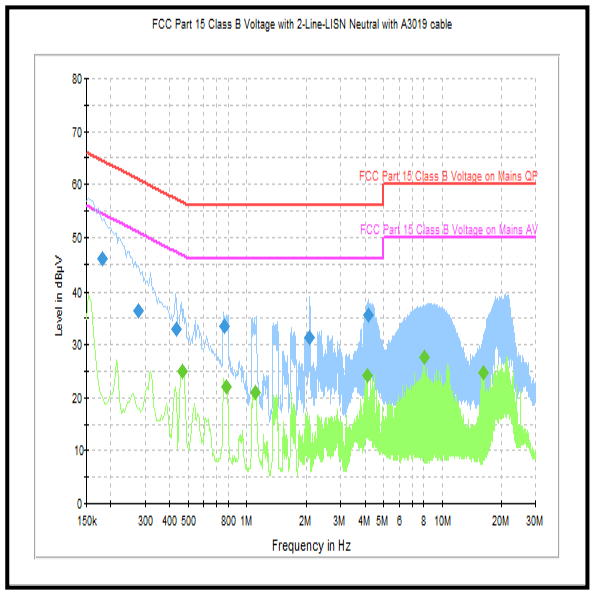
Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.469500	Neutral	24.9	46.5	21.6	Complied
0.784500	Neutral	22.1	46.0	23.9	Complied
1.108500	Neutral	21.1	46.0	24.9	Complied
4.123500	Neutral	24.1	46.0	21.9	Complied
8.092500	Neutral	27.5	50.0	22.5	Complied
16.183500	Neutral	24.8	50.0	25.2	Complied

Transmitter AC Conducted Spurious Emissions (continued)

Results: 120 VAC 60 Hz



Live



Neutral

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

Transmitter AC Conducted Spurious Emissions (continued)

Results: Live / Quasi Peak / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.172500	Live	47.9	64.8	16.9	Complied
0.280500	Live	37.1	60.8	23.7	Complied
0.442500	Live	26.1	57.0	30.9	Complied
2.080500	Live	31.4	56.0	24.6	Complied
4.168500	Live	36.0	56.0	20.0	Complied
21.781500	Live	33.4	60.0	26.6	Complied

Results: Live / Average / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.474000	Live	23.1	46.4	23.3	Complied
0.771000	Live	19.1	46.0	26.9	Complied
1.077000	Live	18.8	46.0	27.2	Complied
4.123500	Live	23.7	46.0	22.3	Complied
8.092500	Live	26.0	50.0	24.0	Complied
16.021500	Live	26.8	50.0	23.2	Complied

Results: Neutral / Quasi Peak / 240 VAC 60 Hz

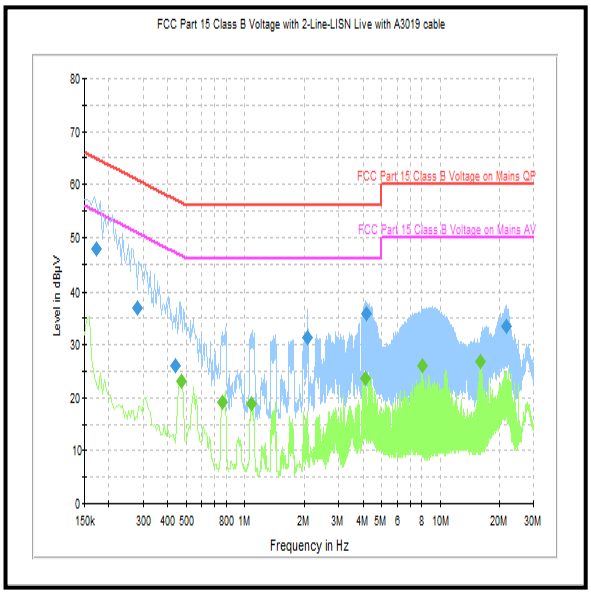
Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.181500	Neutral	46.3	64.4	18.1	Complied
0.271500	Neutral	37.8	61.1	23.3	Complied
0.451500	Neutral	31.4	56.8	25.4	Complied
2.080500	Neutral	31.7	56.0	24.3	Complied
4.272000	Neutral	36.8	56.0	19.2	Complied
21.061500	Neutral	36.8	60.0	23.2	Complied

Results: Neutral / Average / 240 VAC 60 Hz

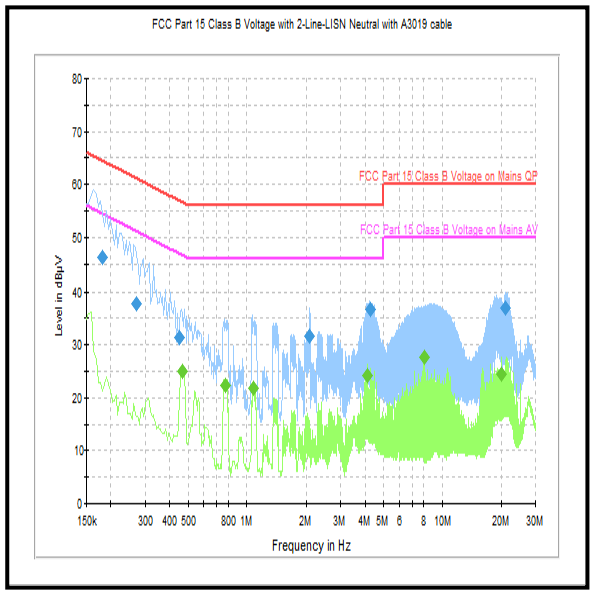
Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.469500	Neutral	24.9	46.5	21.6	Complied
0.775500	Neutral	22.3	46.0	23.7	Complied
1.077000	Neutral	21.7	46.0	24.3	Complied
4.123500	Neutral	24.1	46.0	21.9	Complied
8.088000	Neutral	27.5	50.0	22.5	Complied
19.995000	Neutral	24.4	50.0	25.6	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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