



TEST REPORT

Test Report No. : UL-RPT-RP13041774JD10A V2.0

Customer : Apple Inc.
Model No. : A2251
FCC ID : BCGA2251
Test Standard(s) : FCC Part 15.207

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. This 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: 21 April 2020

Checked by:

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Customer Information

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Report Revision History

Version Number	Issue Date	Revision Details	Revised By
1.0	12/03/2020	Initial Version	Ian Watch
2.0	21/04/2020	Antenna gains in section 3.4 updated	Sarah Williams

Table of Contents

Customer Information.....	2
Report Revision History	2
Table of Contents.....	3
1. Attestation of Test Results.....	4
1.1. Description of EUT	4
1.2. General Information	4
1.3. Summary of Test Results	4
1.4. Deviations from the Test Specification	4
2. Summary of Testing.....	5
2.1. Facilities and Accreditation	5
2.2. Methods and Procedures	5
2.3. Calibration and Uncertainty	5
2.4. Test and Measurement Equipment	6
3. Equipment Under Test (EUT)	7
3.1. Identification of Equipment Under Test (EUT)	7
3.2. Modifications Incorporated in the EUT	7
3.3. Additional Information Related to Testing	8
3.4. Description of Available Antennas	9
3.5. Description of Test Setup	10
4. AC Power Line Conducted Emissions Test Results.....	12
4.1. Transmitter AC Conducted Spurious Emissions	12

1. Attestation of Test Results

1.1. Description of EUT

The Equipment Under Test (EUT) was a Laptop Computer with *Bluetooth*, *Bluetooth* Low Energy and 802.11 a/b/g/n/ac capabilities in the 2.4 GHz and 5.0 GHz bands.

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
Site Registration:	621311
Location of Testing:	UL VS LTD, Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom
Test Dates:	31 December 2019 to 03 January 2020

1.3. Summary of Test Results

FCC Reference (47CFR)	Measurement	Result
Part 15.207	Transmitter AC Conducted Emissions	Complied

Note(s):

1. There are two vendors of the WiFi/*Bluetooth* radio modules, Vendor 1 and Vendor 2.

The WiFi/*Bluetooth* radio modules have the same mechanical outline (i.e. the same packaging dimension and pin layout), use the same on-board antenna matching circuit, have an identical antenna structure and are built and tested to conform to the same specification and to operate within the same tolerances.

Baseline testing was performed on the two vendors to determine the worst case.

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 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 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
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 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	825563/008	08 Aug 2020	12
A1830	Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100668	10 Apr 2020	12
M1124	EMI Test Receiver	Rohde & Schwarz	ESIB 26	100046	11 Oct 2020	12

Test Measurement Software/Firmware Used:

Name	Version	Release Date
Rohde & Schwarz EMC32	6.30.0	2008

3. Equipment Under Test (EUT)

3.1. Identification of Equipment Under Test (EUT)

Brand Name:	Apple
Model Name or Number:	A2251
Test Sample Serial Number:	C02ZG00KP22J (<i>Vendor 1</i>)
Hardware Version:	REV 1.0
Software Version:	19C19
FCC ID:	BCGA2251

Brand Name:	Apple
Model Name or Number:	A2251
Test Sample Serial Number:	C02ZH002P1YX (<i>Vendor 2</i>)
Hardware Version:	REV 1.0
Software Version:	19C19
FCC ID:	BCGA2251

3.2. Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

3.3. Additional Information Related to Testing

Tested Technology:	Bluetooth		
Type of Unit:	Transceiver		
Channel Spacing:	1 MHz		
Mode:	Enhanced Data Rate		
Modulation:	8DPSK		
Packet Type: (Maximum Payload)	3DH5		
Data Rate (Mbit/s):	3 Mbit/s		
Power Supply Requirement(s):	Nominal	120 VAC 60 Hz	
Transmit Frequency Range:	2402 MHz to 2480 MHz		
Transmit Channels Tested:	Channel ID	Channel Number	Channel Frequency (MHz)
	Middle	38	2440

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

Technology Tested:	WLAN (IEEE 802.11b,g,n) / Digital Transmission System		
Type of Unit:	Transceiver		
Modulation Type:	DBPSK		
Data Rates:	802.11b	1 Mbit/s	
Power Supply Requirement(s):	Nominal	120 VAC 60 Hz	
Channel Spacing:	20 MHz		
Transmit Frequency Range:	2412 MHz to 2462 MHz		
Transmit Channels Tested:	Channel Number	Channel Frequency (MHz)	
	7	2442	

Additional Information Related to Testing (continued)

Technology Tested:	WLAN (IEEE 802.11a,n,ac) / U-NII		
Type of Unit:	Transceiver		
Modulation:	BPSK		
Data Rate:	802.11n HT20	MCS0	
Power Supply Requirement(s):	Nominal	120 VAC 60 Hz	
Channel Spacing:	20 MHz		
Transmit Frequency Band:	5150 MHz to 5250 MHz		
Transmit Channels Tested:	Channel ID	Channel Number	Channel Frequency (MHz)
	Bottom	36	5180
	Middle	40	5200
Transmit Frequency Band:	5750 MHz to 5850 MHz		
Transmit Channels Tested:	Channel ID	Channel Number	Channel Frequency (MHz)
	Top	165	5825

3.4. Description of Available Antennas

The radio utilizes 4 integrated antennas, with the following maximum gains:

Frequency Band (MHz)	G_{Antenna Core 0} (dBi)	G_{Antenna Core 1} (dBi)	G_{Antenna Core 2} (Also AUX Core) (dBi)
2400-2480 (BT)	-	1.1	-
2400-2480 (WLAN)	1.8	1.1	2.2
5150-5250	5.6	5.0	4.0
5250-5350	5.2	4.2	3.3
5470-5725	4.3	3.2	3.0
5725-5850	4.4	3.2	3.0

3.5. Description of Test Setup

Support Equipment

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

Description:	61W USB C power supply
Brand Name:	Apple
Model Name or Number:	A1947
Serial Number:	Not marked or stated

Description:	USB C cable. Length 1 metre
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Description:	USB A cable. Length 3 metres. Quantity 3
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:	Not marked or stated
Serial Number:	00078498

Description:	USB C to USB adaptor. Quantity 4
Brand Name:	Apple
Model Name or Number:	A1632
Serial Number:	Not marked or stated

Description:	PHF
Brand Name:	Apple
Model Name or Number:	Apple EarPods
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 bottom, middle and top channels as required.
- The EUT was tested in the following operating mode(s): Pre-scans were performed with the EUT transmitting in *Bluetooth* EDR, *Bluetooth* LE, 2.4 GHz WLAN and 5.0 GHz WLAN modes individually or simultaneously. The worst case mode was found to be 2.4 GHz WLAN transmitting individually. Final measurements were performed in this configuration.

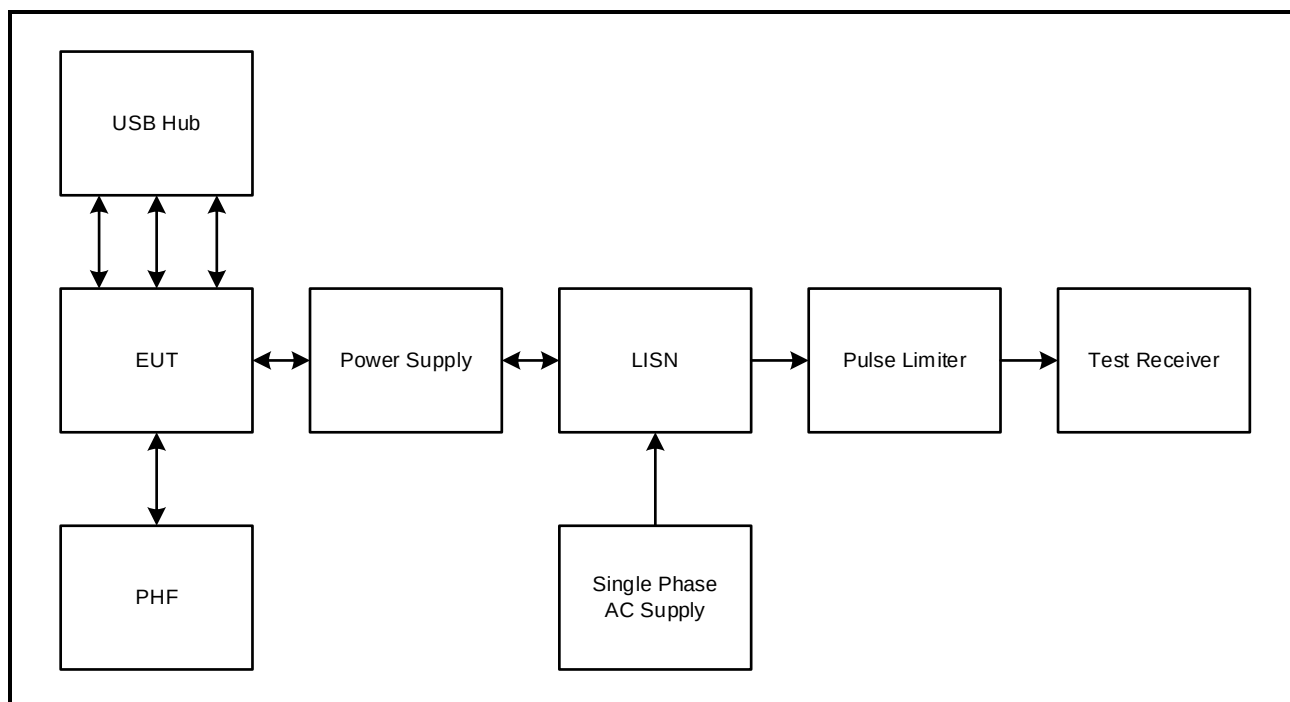
Configuration and Peripherals

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

- Final measurements were performed with the EUT configured to transmit at maximum output power using 2.4 GHz WLAN on channel 7.
- Pre-scan plots for all configurations tested are archived on the UL VS LTD IT server and available for inspection if required.
- Controlled in test mode using a software application on the EUT 'MAC_WIFI.sh' supplied by the customer. The application was used to enable a continuous transmission and to select the test channels as required, The customer also supplied a document containing the setup instructions 'MAC_WIFI_SOP.docx'.
- The EUT was powered from a 120 VAC 60 Hz single phase mains supply unless otherwise stated.
- All the unused USB C ports were terminated into a USB hub.

Test Setup Diagrams

Test Setup for Transmitter AC Conducted Emissions



4. AC Power Line Conducted Emissions Test Results

4.1. Transmitter AC Conducted Spurious Emissions

Test Summary:

Test Engineer:	Nick Tye	Test Dates:	31 December 2019 & 03 January 2020
Test Sample Serial Number:	C02ZH002P1YX		

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

Environmental Conditions:

Temperature (°C):	22 to 24
Relative Humidity (%):	36 to 42

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 power supply.
3. A pulse limiter was fitted between the LISN and the test receiver.
4. Pre-scans were performed with the EUT transmitting *Bluetooth* EDR, *Bluetooth* LE, 2.4 GHz WLAN and 5 GHz WLAN modes individually, along with *Bluetooth* technology transmitting in combination with 5 GHz WLAN and 2.4 GHz WLAN transmitting in combination with 5 GHz WLAN.
5. The worst case mode observed during pre-scans was found to be the EUT with Vendor 2 radio modules when transmitting 2.4 GHz WLAN only. The final measurements were performed in this mode only. Pre-scan result plots for Vendor 1 modules / other modes are archived on the UL VS LTD IT server and available for inspection if required.

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

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.208500	Live	49.4	63.3	13.9	Complied
0.271500	Live	32.3	61.1	28.8	Complied
0.366000	Live	30.4	58.6	28.2	Complied
0.438000	Live	27.6	57.1	29.5	Complied
0.573000	Live	36.1	56.0	19.9	Complied
2.112000	Live	38.4	56.0	17.6	Complied

Results: Live / Average / 120 VAC 60 Hz

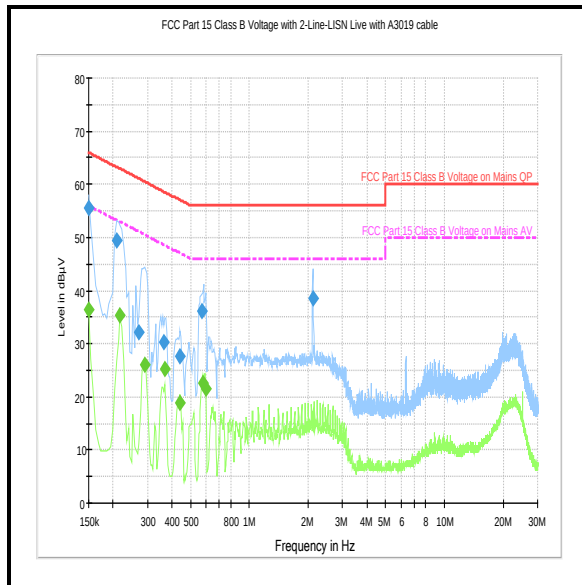
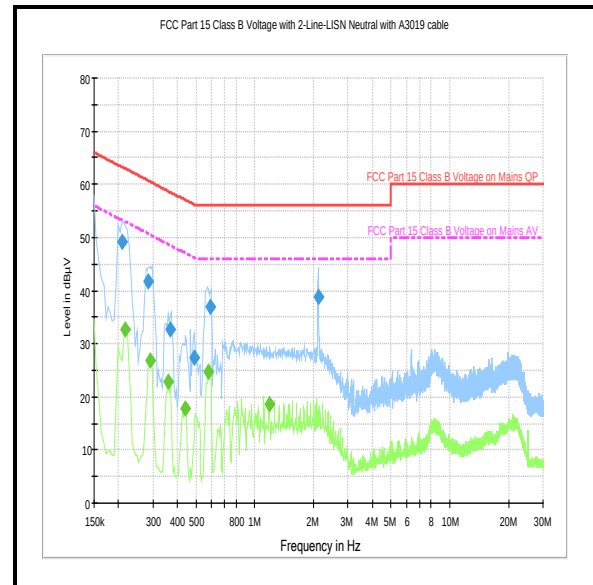
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.217500	Live	35.3	52.9	17.6	Complied
0.289500	Live	26.1	50.5	24.4	Complied
0.370500	Live	25.3	48.5	23.2	Complied
0.442500	Live	18.9	47.0	28.1	Complied
0.577500	Live	22.5	46.0	23.5	Complied
0.595500	Live	21.6	46.0	24.4	Complied

Results: Neutral / Quasi Peak / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.208500	Neutral	49.1	63.3	14.2	Complied
0.285000	Neutral	41.7	60.7	19.0	Complied
0.370500	Neutral	32.8	58.5	25.7	Complied
0.487500	Neutral	27.3	56.2	28.9	Complied
0.591000	Neutral	37.0	56.0	19.0	Complied
2.112000	Neutral	38.7	56.0	17.3	Complied

Results: Neutral / Average / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.217500	Neutral	32.8	52.9	20.1	Complied
0.289500	Neutral	26.9	50.5	23.6	Complied
0.361500	Neutral	23.0	48.7	25.7	Complied
0.442500	Neutral	17.7	47.0	29.3	Complied
0.577500	Neutral	24.6	46.0	21.4	Complied
1.189500	Neutral	18.6	46.0	27.4	Complied

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

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

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

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.186000	Live	49.8	64.2	14.4	Complied
0.244500	Live	46.4	61.9	15.5	Complied
0.307500	Live	43.4	60.0	16.6	Complied
0.568500	Live	38.2	56.0	17.8	Complied
2.112000	Live	38.8	56.0	17.2	Complied
10.414500	Live	28.2	60.0	31.8	Complied

Results: Live / Average / 240 VAC 60 Hz

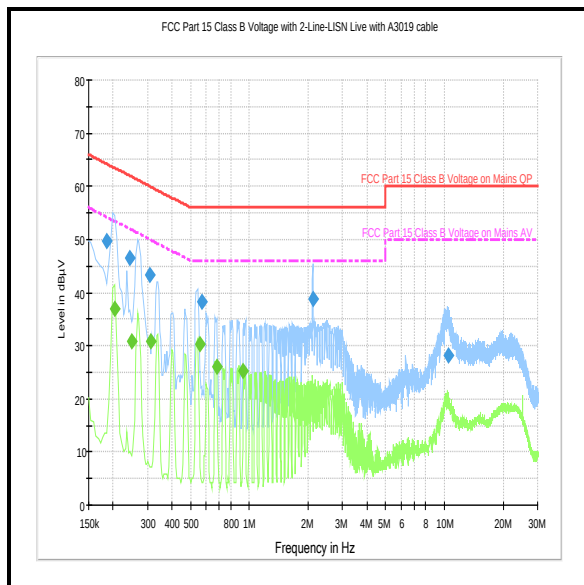
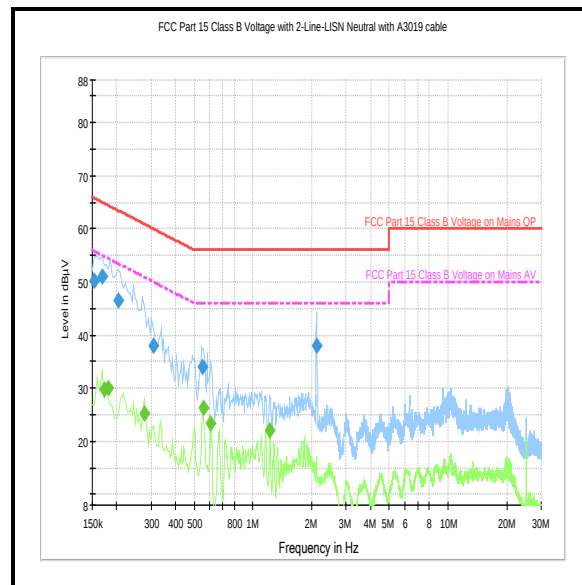
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.204000	Live	37.0	53.4	16.4	Complied
0.249000	Live	30.8	51.8	21.0	Complied
0.312000	Live	30.8	49.9	19.1	Complied
0.559500	Live	30.3	46.0	15.7	Complied
0.681000	Live	26.1	46.0	19.9	Complied
0.928500	Live	25.2	46.0	20.8	Complied

Results: Neutral / Quasi Peak / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.154500	Neutral	50.2	65.8	15.6	Complied
0.168000	Neutral	51.0	65.1	14.1	Complied
0.204000	Neutral	46.4	63.4	17.0	Complied
0.307500	Neutral	38.2	60.0	21.8	Complied
0.550500	Neutral	34.0	56.0	22.0	Complied
2.112000	Neutral	37.9	56.0	18.1	Complied

Results: Neutral / Average / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.172500	Neutral	29.7	54.8	25.1	Complied
0.181500	Neutral	29.9	54.4	24.5	Complied
0.276000	Neutral	25.4	50.9	25.5	Complied
0.555000	Neutral	26.3	46.0	19.7	Complied
0.609000	Neutral	23.4	46.0	22.6	Complied
1.221000	Neutral	22.2	46.0	23.8	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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