



TEST REPORT

Test Report No. : UL-RPT-RP12718494JD11A

Customer : Apple Inc.

Model No. : A1991

FCC ID : BCGA1991

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: 15 July 2019

Checked by:

Ian Watch
Senior Test Engineer, Radio Laboratory

Company Signatory:

Ben Mercer
Senior Test Engineer, Radio Laboratory
UL VS LTD



UL VS LTD

Unit 1-3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, UK
Telephone: +44 (0)1256 312000
Facsimile: +44 (0)1256 312001

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	15/07/2019	Initial Version	Ian Watch

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1. Attestation of Test Results

1.1. Description of EUT

The Equipment Under Test (EUT) was a Desktop 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
Location of Testing:	UL VS Ltd, Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom
Test Dates:	30 May 2019 to 07 June 2019

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	825562/008	23 Aug 2019	12
A067	LISN	Rohde & Schwarz	ESH3-Z5	890603/002	08 Nov 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

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:	A1991
Test Sample Serial Number:	C02YD006MFLQ
Hardware Version:	REV 1.0
Software Version:	18F98
FCC ID:	BCGA1991

Brand Name:	Apple
Model Name or Number:	A1991
Test Sample Serial Number:	C02YF00CMFLF
Hardware Version:	REV 1.0
Software Version:	18F98
FCC ID:	BCGA1991

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:	Basic Rate		
Modulation:	GFSK		
Packet Type: (Maximum Payload)	DH5		
Data Rate:	1 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 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	17	2440

Technology Tested:	WLAN (IEEE 802.11b,g,n) / Digital Transmission System		
Type of Unit:	Transceiver		
Modulation Type:	DBPSK		
Data Rate:	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) / 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:	5470 MHz to 5725 MHz		
Transmit Channels Tested:	Channel ID	Channel Number	Channel Frequency (MHz)
	Middle	116	5580

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)	4.5	-	-
2400-2480 (WLAN)	4.6	4.3	4.5
5150-5250	5.0	4.5	4.5
5250-5350	5.3	3.8	4.2
5470-5725	5.8	5.3	4.9
5725-5850	6.1	5.7	4.6

3.5. Description of Test Setup

Support Equipment

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

Description:	USB Mouse
Brand Name:	Apple
Model Name or Number:	A1152
Serial Number:	CC2446203TADMYPAS

Description:	USB Keyboard
Brand Name:	Apple
Model Name or Number:	A1243
Serial Number:	CC02T300BHX0X

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

Description:	PC Monitor
Brand Name:	Lenovo
Model Name or Number:	LT223PWC
Serial Number:	VN385259

Description:	HDMI Cable. Length 1.5 metres
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Description:	HDMI Cable. Length 2.0 metres
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Description:	Ethernet Cable. Length 1.5 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 Memory Stick. Quantity 4
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Description:	USB-C to USB Adapter. Quantity 4
Brand Name:	Apple
Model Name or Number:	A1632
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 as required.
- The EUT was tested in the following operating mode(s): Pre-scans were performed with the EUT transmitting in *Bluetooth BR*, *Bluetooth LE*, 2.4 GHz WLAN and 5.0 GHz WLAN modes individually or simultaneously. The worst case mode was found to be with *Bluetooth BR* transmitting. Final measurements were performed in this configuration.

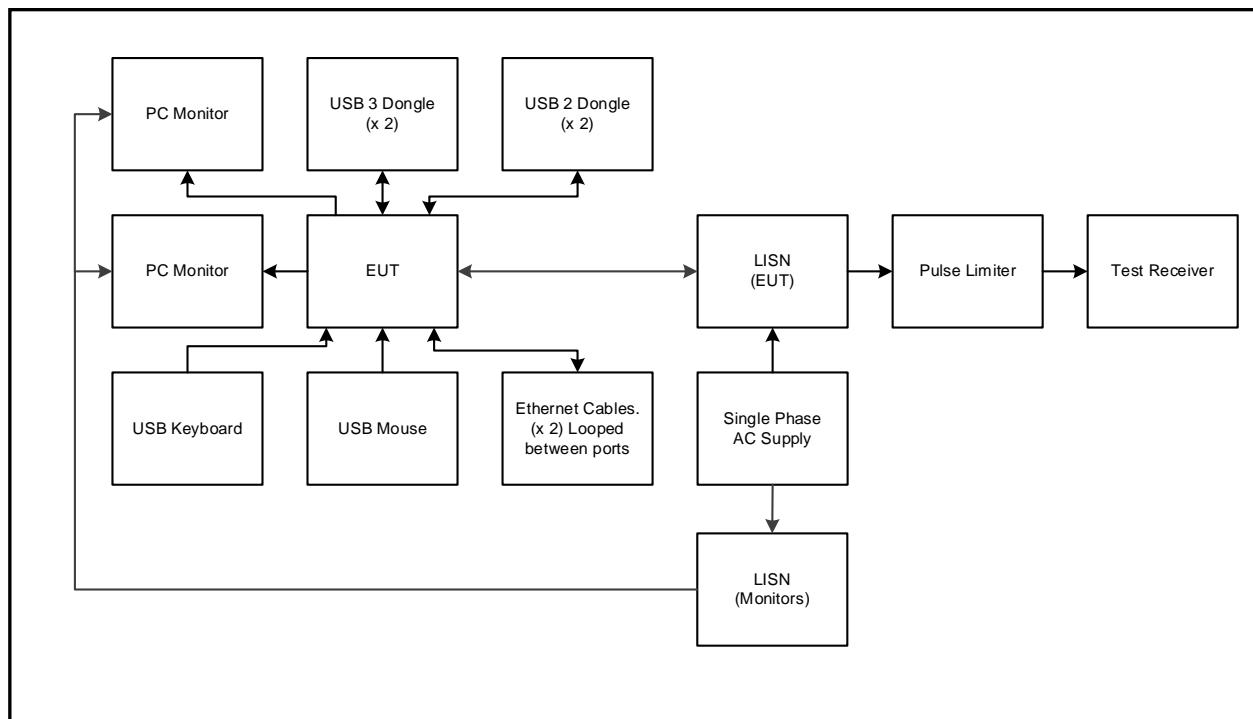
Configuration and Peripherals

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

- Final measurements were performed with the EUT configured to transmit at maximum output power using *Bluetooth BR* on channel 38.
- Pre-scan plots for all other configurations 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 supplied by the customer. 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 'MAC_scripts_310119.zip'.
- The EUT was powered from a 120 VAC 60 Hz single phase mains supply unless otherwise stated.
- Both HDMI ports were terminated into powered monitors. The Ethernet ports and all USB ports were also terminated.

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 Engineers:	Nick Tye & Alison Johnston	Test Dates:	30 May 2019 to 07 June 2019
Test Sample Serial Numbers:	C02YF00CMFLF		

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 23
Relative Humidity (%):	52 to 53

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 also performed with a 240 VAC 60 Hz single phase supply as this was within the voltage range marked on the EUT 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.
5. Pre-scans were performed with the EUT transmitting on the middle channels of *Bluetooth* BR, *Bluetooth* LE, 2.4 GHz WLAN and 5 GHz WLAN modes individually, along with each *Bluetooth* technology transmitting in combination with WLAN transmitting in both bands.
6. The worst case mode observed during prescans was found to be the EUT with Vendor 2 radio modules when transmitting *Bluetooth* BR 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
3.521	Live	35.1	56.0	20.9	Complied
4.268	Live	38.2	56.0	17.8	Complied
9.254	Live	48.3	60.0	11.7	Complied
12.773	Live	53.7	60.0	6.3	Complied
15.617	Live	51.4	60.0	8.6	Complied
24.792	Live	38.0	60.0	22.0	Complied

Results: Live / Average / 120 VAC 60 Hz

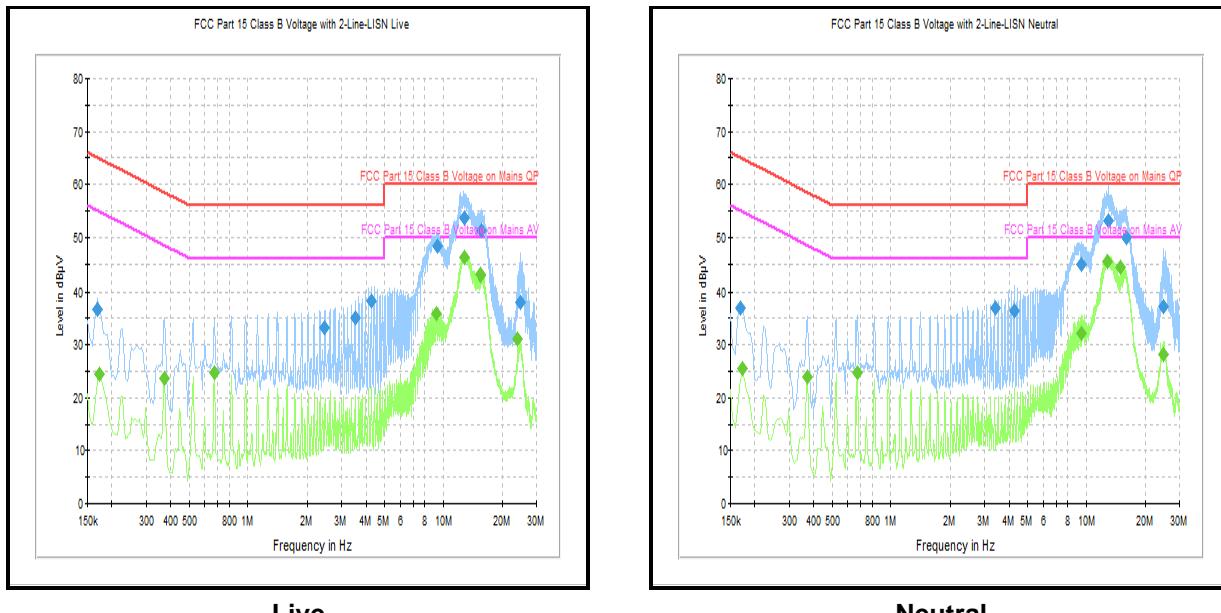
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.375	Live	23.6	48.4	24.8	Complied
0.672	Live	24.8	46.0	21.2	Complied
9.159	Live	35.8	50.0	14.2	Complied
12.867	Live	46.3	50.0	3.7	Complied
15.549	Live	43.1	50.0	6.9	Complied
24.000	Live	31.1	50.0	18.9	Complied

Results: Neutral / Quasi Peak / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
3.390	Neutral	36.9	56.0	19.1	Complied
4.263	Neutral	36.5	56.0	19.5	Complied
9.389	Neutral	44.9	60.0	15.1	Complied
12.961500	Neutral	53.2	60.0	6.8	Complied
15.959	Neutral	50.0	60.0	10.0	Complied
24.792	Neutral	37.2	60.0	22.8	Complied

Results: Neutral / Average / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.375	Neutral	24.0	48.4	24.4	Complied
0.672	Neutral	24.8	46.0	21.2	Complied
9.371	Neutral	32.2	50.0	17.8	Complied
12.737	Neutral	45.5	50.0	4.5	Complied
14.946	Neutral	44.4	50.0	5.6	Complied
24.747	Neutral	28.1	50.0	21.9	Complied

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

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
0.825	Live	34.7	56.0	21.3	Complied
4.281	Live	38.8	56.0	17.2	Complied
9.254	Live	47.9	60.0	12.1	Complied
12.728	Live	53.1	60.0	6.9	Complied
15.424	Live	49.0	60.0	11.0	Complied
25.193	Live	39.2	60.0	20.8	Complied

Results: Live / Average / 240 VAC 60 Hz

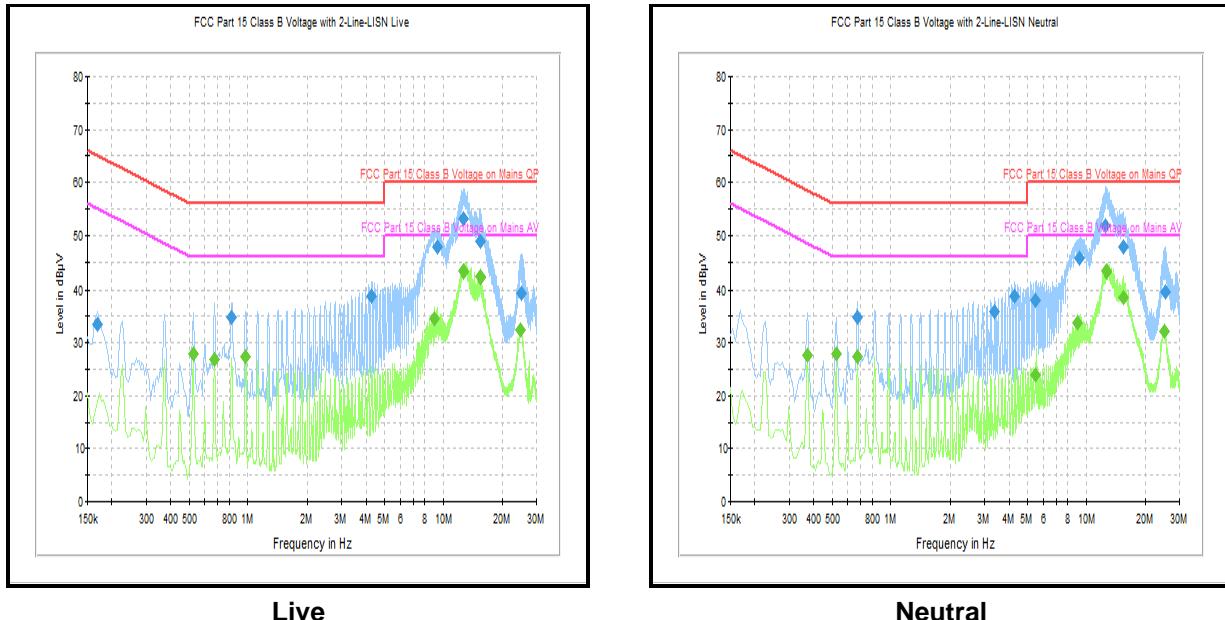
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.524	Live	27.9	46.0	18.1	Complied
0.974	Live	27.3	46.0	18.7	Complied
9.011	Live	34.5	50.0	15.5	Complied
12.593	Live	43.4	50.0	6.6	Complied
15.455	Live	42.3	50.0	7.7	Complied
24.770	Live	32.5	50.0	17.5	Complied

Results: Neutral / Quasi Peak / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
3.377	Neutral	35.8	56.0	20.2	Complied
4.277	Neutral	38.8	56.0	17.2	Complied
9.218	Neutral	45.6	60.0	14.4	Complied
12.494	Neutral	51.8	60.0	8.2	Complied
15.401	Neutral	47.8	60.0	12.2	Complied
25.350	Neutral	39.7	60.0	20.3	Complied

Results: Neutral / Average / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.524	Neutral	27.8	46.0	18.2	Complied
0.672	Neutral	27.3	46.0	18.7	Complied
9.029	Neutral	33.8	50.0	16.2	Complied
12.579	Neutral	43.3	50.0	6.7	Complied
15.424	Neutral	38.5	50.0	11.5	Complied
25.085	Neutral	32.1	50.0	17.9	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.

--- END OF REPORT ---