



TEST REPORT

Test Report No. : UL-RPT-RP12185759JD11A V2.0

Customer : Apple Inc.
Model No. : A1990
FCC ID : BCGA1990
Test Standard(s) : FCC Part 15.207(a)

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 2.0 supersedes all previous versions.

Date of Issue: 30 June 2018

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Customer Information

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Report Revision History

Version Number	Issue Date	Revision Details	Revised By
1.0	27/06/2018	Initial Version	Ben Mercer
2.0	30/06/2018	Admin update	Sarah Williams

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1. Attestation of Test Results

1.1. Description of EUT

The equipment under test was a Laptop Computer with WLAN and *Bluetooth*.

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:	16 May 2018 to 17 May 2018

1.3. Summary of Test Results

FCC Reference (47CFR)	Measurement	Result
Part 15.207(a)	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%	±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 AC Conducted Emissions**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2013	Thermohygrometer	Testo	608-H1	45046419	20 Jun 2018	12
M1263	Test Receiver	Rohde & Schwarz	ESIB7	100265	13 Nov 2018	12
A649	LISN	Rohde & Schwarz	ESH3-Z5	825562/008	31 May 2018	12
A1830	Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100668	06 Apr 2019	12
M1269	Multimeter	Fluke	179	90250210	02 May 2019	12

3. Equipment Under Test (EUT)

3.1. Identification of Equipment Under Test (EUT)

Brand Name:	Apple
Model Name or Number:	A1990
Test Sample Serial Number:	C02WC004JMF5M
Hardware Version:	EVT
Software Version:	17G2057
FCC ID:	BCGA1990

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:	<i>Bluetooth</i>		
Type of Unit:	Transceiver		
Channel Spacing:	1 MHz		
Mode:	Basic Rate	Enhanced Data Rate	
Modulation:	GFSK	$\pi/4$ -DQPSK	8DPSK
Packet Type: (Maximum Payload)	DH5	2DH5	3DH5
Data Rate (Mbit/s):	1	2	3
Power Supply Requirement(s):	Nominal	3.8 VDC via 120 VAC 60 Hz AC/DC Adapter	
Transmit Frequency Range:	2402 MHz to 2480 MHz		
Transmit Channels Tested:	Channel ID	Channel Number	Channel Frequency (MHz)
	Middle	39	2441
	Top	78	2480

Technology Tested:	<i>Bluetooth</i> 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	3.8 VDC via 120 VAC 60 Hz AC/DC Adapter	
Transmit Frequency Range:	2402 MHz to 2480 MHz		
Transmit Channels Tested:	Channel ID	Channel Number	Channel Frequency (MHz)
	Middle	17	2440

Additional Information Related to Testing (continued)

Technology Tested:	WLAN (IEEE 802.11b,g,n) / Digital Transmission System	
Type of Unit:	Transceiver	
Modulation Type:	DBPSK	
Data Rates:	802.11b	1 Mbps
Power Supply Requirement(s):	Nominal	3.8 VDC via 120 VAC 60 Hz AC/DC Adapter
Channel Spacing:	20 MHz	
Transmit Frequency Range:	2412 MHz to 2472 MHz	
Transmit Channels Tested:	Channel Number	Channel Frequency (MHz)
	1	2412
	6	2437

Technology Tested:	WLAN (IEEE 802.11a,n) / U-NII		
Type of Unit:	Transceiver		
Modulation:	BPSK		
Data rates:	802.11a	6 Mbps	
Power Supply Requirement(s):	Nominal	3.8 VDC via 120 VAC 60 Hz AC/DC Adapter	
Channel Spacing:	20 MHz		
Transmit Frequency Band:	5725 MHz to 5850 MHz		
Transmit Channels Tested:	Channel ID	Channel Number	Channel Frequency (MHz)
	Middle	157	5785
	Top	165	5825

3.4. Description of Available Antennas

The radio utilizes three integrated antennas of 50 Ω impedance. Maximum gains are shown below:

Frequency Band (MHz)	G_{Antenna Core 1} (dBi)	G_{Antenna Core 0} (dBi)	G_{Antenna Core 2} (dBi)
2400-2480	2.1	3.3	2.1
5150-5250	4.9	6.7	3.8
5250-5350	6.0	7.6	4.9
5470-5725	5.2	7.4	4.9
5725-5850	4.7	6.3	4.0

3.5. Description of Test Setup

Support Equipment

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

Description:	USB-C Power Adapter
Brand Name:	Apple
Model Name or Number:	A1718
Serial Number:	Not marked or stated

Description:	USB Cable
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:	Apple
Model Name or Number:	Apple EarPods
Serial Number:	Not marked or stated

Description:	USB-C Adapter
Brand Name:	Belkin
Model Name or Number:	F2CU040
Serial Number:	Not marked or stated

Description:	Type C USB Cable. 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:	Belkin
Model Name or Number:	F5U404-BLK
Serial Number:	Not marked or stated

Operating Modes

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

- Continuously transmitting at maximum power on bottom, middle or top channels as required.
- Pre-scans were performed with the EUT transmitting in the following modes:
 - *Bluetooth* BR
 - *Bluetooth* LE
 - 2.4 GHz WLAN
 - 5.0 GHz WLAN
 - 2.4 GHz WLAN and 5 GHz WLAN simultaneously
 - *Bluetooth* BR, 2.4 GHz WLAN and 5 GHz WLAN simultaneously
- The worst case mode was found to be 2.4 GHz WLAN . Final measurements were performed in this configuration.
- The EUT was charging during all measurements.

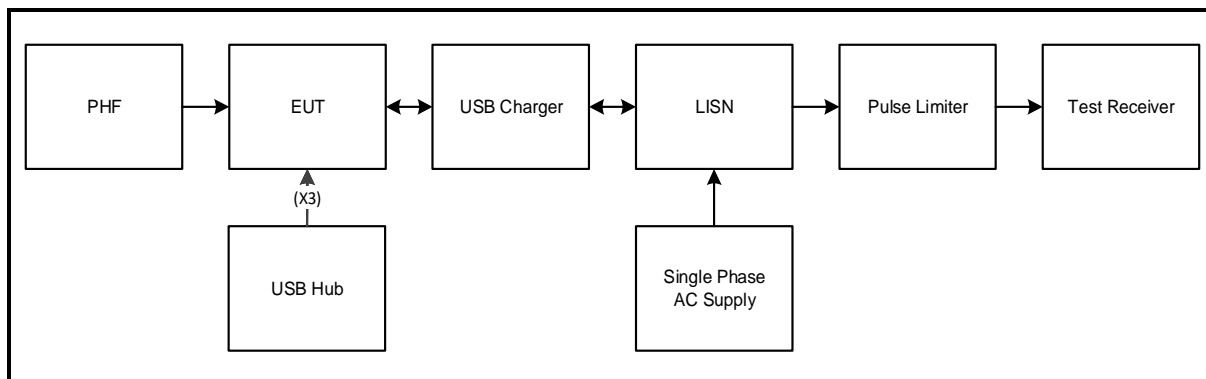
Configuration and Peripherals

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

- The EUT was powered from a 120 VAC 60 Hz single phase mains supply unless otherwise stated.
- Controlled using a bespoke application on the laptop PC supplied by the customer. The application was used to enable continuous transmission and to select the test channels as required. *Bluetooth* was configured using customer supplied setup instructions 'EUT_BT_BTLE_CPM_SOP v1.0'. WLAN was configured using customer provided scripts loaded on the EUT.
- Final measurements were performed with the EUT configured to transmit 2.4 GHz WLAN: 802.11b / 20 MHz / MIMO / 3Tx CDD / DBPSK / 1 Mbps / Channel 6 / 2437 MHz. Pre-scan plots for all other configurations are archived on UL VS LTD IT server and available for inspection if required.

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:	Victor Carmon	Test Dates:	16 May 2018 & 17 May 2018
Test Sample Serial Number:	C02WC004JMFM		

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

Environmental Conditions:

Temperature (°C):	23 to 24
Relative Humidity (%):	35 to 49

Note(s):

1. The EUT was connected to the power supply input which 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.
3. A pulse limiter was fitted between the LISN and the test receiver.
4. Pre-scans were performed as detailed in section 3.5 of this report. The worst case mode was found to be 2.4 GHz WLAN and final measurements were performed in this mode only. Pre-scan result plots for all 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
0.186	Live	47.9	64.2	16.3	Complied
0.258	Live	42.9	61.5	18.6	Complied
0.312	Live	42.5	59.9	17.4	Complied
1.982	Live	35.3	56.0	20.7	Complied
8.750	Live	31.4	60.0	28.6	Complied
14.325	Live	17.6	60.0	42.4	Complied

Results: Live / Average / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.191	Live	38.3	54.0	15.7	Complied
0.254	Live	34.0	51.6	17.6	Complied
0.317	Live	33.2	49.8	16.6	Complied
8.538	Live	23.2	50.0	26.8	Complied
14.334	Live	13.6	50.0	36.4	Complied
25.058	Live	24.5	50.0	25.5	Complied

Results: Neutral / Quasi Peak / 120 VAC 60 Hz

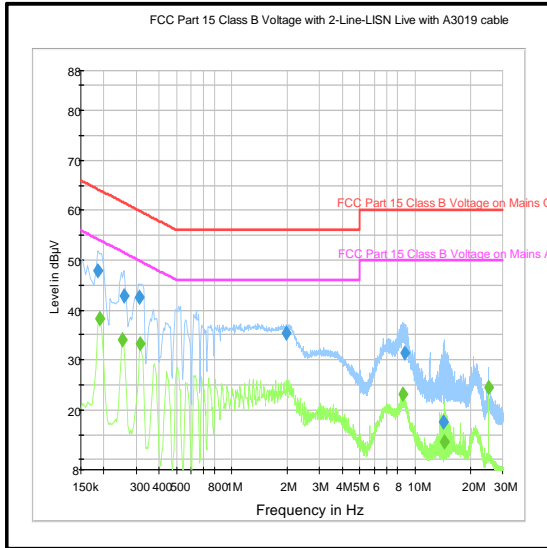
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.191	Neutral	47.5	64.0	16.5	Complied
0.254	Neutral	43.5	61.6	18.1	Complied
0.312	Neutral	42.4	59.9	17.5	Complied
6.900	Neutral	30.1	60.0	29.9	Complied
8.628	Neutral	29.4	60.0	30.6	Complied
14.244	Neutral	23.8	60.0	36.2	Complied

Results: Neutral / Average / 120 VAC 60 Hz

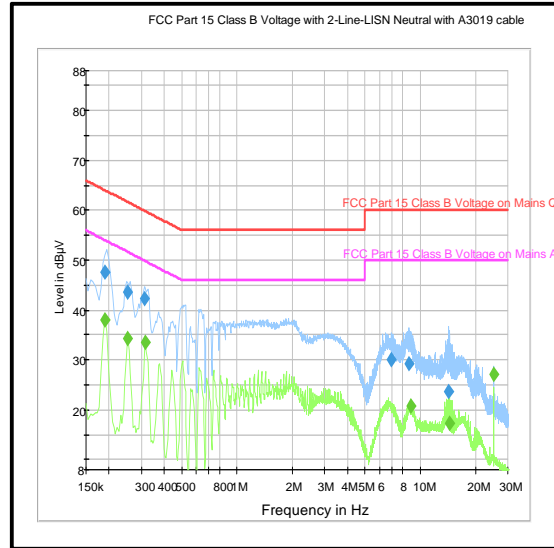
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.191	Neutral	38.0	54.0	16.0	Complied
0.254	Neutral	34.4	51.6	17.2	Complied
0.317	Neutral	33.4	49.8	16.4	Complied
8.889	Neutral	20.8	50.0	29.2	Complied
14.334	Neutral	17.4	50.0	32.6	Complied
25.058	Neutral	27.1	50.0	22.9	Complied

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
0.204	Live	53.4	63.4	10.0	Complied
0.272	Live	48.3	61.1	12.8	Complied
0.551	Live	40.4	56.0	15.6	Complied
1.361	Live	35.8	56.0	20.2	Complied
11.040	Live	28.6	60.0	31.4	Complied
25.058	Live	27.6	60.0	32.4	Complied

Results: Live / Average / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.204	Live	39.3	53.4	14.1	Complied
0.272	Live	38.6	51.1	12.5	Complied
0.339	Live	35.0	49.2	14.2	Complied
0.551	Live	33.7	46.0	12.3	Complied
14.330	Live	16.8	50.0	33.2	Complied
25.058	Live	26.4	50.0	23.6	Complied

Results: Neutral / Quasi Peak / 240 VAC 60 Hz

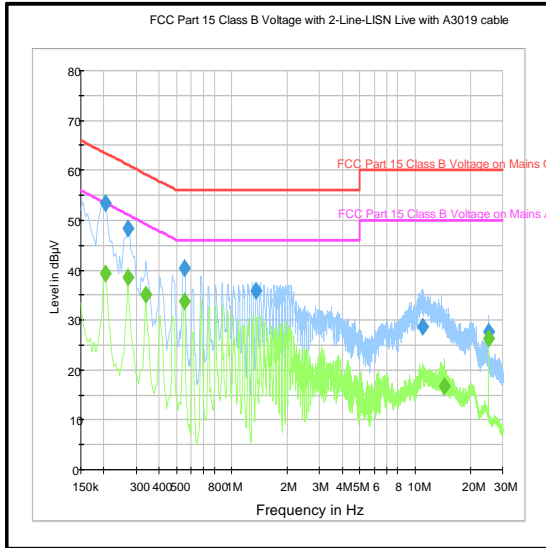
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.191	Neutral	48.4	64.0	15.6	Complied
0.204	Neutral	53.1	63.4	10.3	Complied
0.267	Neutral	45.3	61.2	15.9	Complied
6.311	Neutral	28.6	60.0	31.4	Complied
10.964	Neutral	28.4	60.0	31.6	Complied
25.058	Neutral	26.8	60.0	33.2	Complied

Results: Neutral / Average / 240 VAC 60 Hz

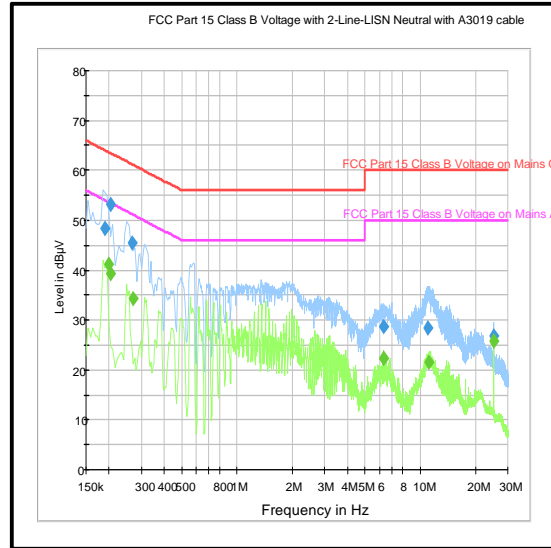
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.200	Neutral	41.1	53.6	12.5	Complied
0.204	Neutral	39.4	53.4	14.0	Complied
0.272	Neutral	34.2	51.1	16.9	Complied
6.311	Neutral	22.4	50.0	27.6	Complied
11.063	Neutral	21.6	50.0	28.4	Complied
25.058	Neutral	25.8	50.0	24.2	Complied

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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