RF Exposure Exemption Report

Apple Inc
Model: A2901

In accordance with FCC CFR 47 Pt 1.1307

Prepared for: Apple Inc
One Apple Park Way
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95014, USA

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FCC ID: BCGA2901

Document 75958006-16 Issue: 01

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Matthew Russell	Chief Engineer (RF)	Authorised Signatory	28 April 2023

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FCC Accreditation
90987 Octagon House, Fareham Test Laboratory

EXECUTIVE SUMMARY

The wireless devices described within this report are compliant with the exemption criteria related to human exposure to electromagnetic fields laid out in FCC CFR 47 Part 1.1307.

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1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	28 April 2023

Table 1

1.2 Introduction

Applicant	Apple Inc
Manufacturer	Apple Inc
Model Number(s)	A2901
Hardware Version(s)	REV1.0
Software Version(s)	Not Applicable
Specification/Issue/Date	FCC 47 CFR Part 1.1307: 2021
Order Number	0540251848
Related Document(s)	• KDB 447498 D04 v01

1.3 Brief Summary of Results

The wireless device described within this report was compliant with the restrictions related to human exposure to electromagnetic fields for both general public and worker/occupational exposures for a separation distance of 20 cm.

The calculations shown in this report were made in accordance with the procedures specified in the applied test specification(s).

1.4 Product Information

1.4.1 Technical Description

The equipment under test (EUT) was an Apple desktop computer with Bluetooth®, Bluetooth® Low Energy, Thread and IEEE 802.11 a/b/g/n/ac/ax Wi-Fi capabilities in the 2.4 GHz, 5GHz and 6GHz bands.

1.4.2 Transmitter Description

The following radio access technologies and frequency bands are supported by the equipment under test.

Radio Access Technology	Core	Frequency Band (MHz)	Minimum Frequency (MHz)	Output Power (dBm)	Duty Cycle (%)
Bluetooth (SISO)	0	2400-2483.5	2402	16.50	100
Bluetooth (SISO)	1	2400-2483.5	2402	16.50	100
Bluetooth (SISO)	2	2400-2483.5	2402	13.00	100
Bluetooth (TxBF)	0	2400-2483.5	2402	15.00	100
	1	2400-2483.5	2402	15.00	100
2.4 GHz WLAN (SISO)	0	2400-2483.5	2412	22.50	100
2.4 GHz WLAN (SISO)	1	2400-2483.5	2412	22.50	100
2.4 GHz WLAN (2x2 MIMO)	0	2400-2483.5	2412	22.50	100
	1	2400-2483.5	2412	22.50	100
5 GHz WLAN (SISO)	0	5150 - 5850	5180	21.00	100
5 GHz WLAN (SISO)	1	5150 - 5850	5180	21.00	100
5 GHz WLAN (2x2 MIMO)	0	5150 - 5850	5180	21.00	100
	1	5150 - 5850	5180	21.00	100
6 GHz WLAN (SISO)	0	5925 - 7125	5935	15.50	100
6 GHz WLAN (SISO)	1	5925 - 7125	5935	15.50	100
6 GHz WLAN (2x2 MIMO)	0	5925- 7125	5935	13.50	100
	1	5925- 7125	5935	13.50	100
NB	0	5162 - 5844	5162	15.00	100
NB	1	5162 - 5844	5162	15.00	100

Table 2 – Transmitter Description- FCC

Note: Transmitter power includes upper bounds of uncertainty therefore maximum values are used.

1.4.3 Antenna Description

The following antennas are supported by the equipment under test.

Radio Access Technology	Antenna Model	Gain (dBi)	Antenna length (mm)	Minimum Separation Distance (cm)
BT Core 0	Not Specified	3.11	68.2	20
BT Core 1	Not Specified	0.93	68.2	20
BT Core 2	Not Specified	0.71	68.2	20
2.4 GHz WLAN Core 0	Not Specified	3.11	68.2	20
2.4 GHz WLAN Core 1	Not Specified	0.93	68.2	20
5 GHz WLAN Core 0	Not Specified	4.26	68.2	20
5 GHz WLAN Core 1	Not Specified	1.83	68.2	20
6 GHz WLAN Core 0	Not Specified	4.67	68.2	20
6 GHz WLAN Core 1	Not Specified	2.25	68.2	20
NB Core 0	Not Specified	4.26	68.2	20
NB Core 1	Not Specified	1.83	68.2	20

Table 3 – Antenna Description

In the case of more than one type of antenna being supported by the equipment, the calculation is based on the maximum of the antenna gains. If other antennas can be used that have greater gains, the minimum separation distances will need to be recalculated.

Note: Antenna gain includes upper bounds of uncertainty therefore maximum values are used.

1.4.4 Equipment Configuration

The device supports the following modes:-
- Bluetooth can operate in SISO modes on Core 0, 1, 2 & MIMO Mode on Core 0 – 1
- WLAN can operate in SISO modes on Core 0, 1 & MIMO Mode on Core 0 – 1
- Simultaneous operation - Bluetooth and 5 GHz WLAN
- Simultaneous operation - Bluetooth and 6 GHz WLAN
- Simultaneous operation - Narrowband (Core 0) and 2.4 GHz WLAN (Core 1)
- Simultaneous operation - Narrowband (Core 1) and 2.4 GHz WLAN (Core 0)

Worst case configurations for simultaneous transmission were identified as;

Combination 1 - 5 GHz WLAN MIMO (Core 0 & 1) + Bluetooth MIMO (Core 0 & 1)

Combination 2 - 6 GHz WLAN (Core 0) + Bluetooth MIMO (Core 0 & 1)

Combination 3 –2.4 GHz WLAN (Core 0) + NB (Core 1)

2 Assessment Details

2.1 Single RF Source options for determination of exemption.

<table>
<tr><th>Option</th><th>Reference</th><th>RF Exposure Test Exemptions for Single Source</th></tr>
<tr><td>A
(1-mW Test Exemption)</td><td>FCC
1.1307(b)(3)(i)(A)</td><td>The available maximum time averaged power is no more than 1 mW, regardless of separation distance.</td></tr>
<tr><td>B
(SAR-Based Exemption)</td><td>FCC
1.1307(b)(3)(i)(B)</td><td>The available maximum timeaveraged power or effective radiated power (ERP), whichever is greater, is less than or equal to the threshold Pth (mW) described in the following formula. This method shall only be used at separation distances (cm) from 0.5 centimeters to 40 centimeters and at frequencies from 0.3 GHz to 6 GHz (inclusive). Pth is given by:
$$P_{th}\ (\text{mW}) = \begin{cases} ERP_{20\ cm}(d/20\ \text{cm})^{x} & d \le 20\ \text{cm} \\ ERP_{20\ cm} & 20\ \text{cm} < d \le 40\ \text{cm} \end{cases}$$
Where
$$x = -\log_{10}\left(\frac{60}{ERP_{20\ cm}\sqrt{f}}\right)$$ and f is in GHz;
and
$$ERP_{20\ cm}\ (\text{mW}) = \begin{cases} 2040f & 0.3\ \text{GHz} \le f < 1.5\ \text{GHz} \\ 3060 & 1.5\ \text{GHz} \le f \le 6\ \text{GHz} \end{cases}$$
d = the separation distance (cm);</td></tr>
<tr><td>C
(MPE-Based Exemption)</td><td>FCC
1.1307(b)(3)(i)(C)</td><td>Or using Table 1 and the minimum separation distance (R in meters) from the body of a nearby person for the frequency (f in MHz) at which the source operates, the ERP (watts) is no more than the calculated value prescribed for that frequency. For the exemption in Table 1 to apply, R must be at least λ/2π, where λ is the free-space operating wavelength in meters. If the ERP of a single RF source is not easily obtained, then the available maximum time-averaged power may be used in lieu of ERP if the physical dimensions of the radiating structure(s) do not exceed the electrical length of λ/4 or if the antenna gain is less than that of a half-wave dipole (1.64 linear value).
TABLE 1 TO § 1.1307(b)(3)(i)(C)—SINGLE RF SOURCES SUBJECT TO ROUTINE ENVIRONMENTAL EVALUATION
<table>
<tr><th>RF Source frequency (MHz)</th><th>Threshold ERP (watts)</th></tr>
<tr><td>0.3–1.34</td><td>1,920 R².</td></tr>
<tr><td>1.34–30</td><td>3,450 R²/f².</td></tr>
<tr><td>30–300</td><td>3.83 R².</td></tr>
<tr><td>300–1,500</td><td>0.0128 R²f.</td></tr>
<tr><td>1,500–100,000</td><td>19.2R².</td></tr>
</table></td></tr>
</table>

2.2 Multiple RF Sources options for determination of exemption.

Option	Reference	
A 1-mW Test Exemption for Multiple Sources	FCC 1.1307(b)(3)(ii)(A)	The available maximum time averaged power of each source is no more than 1 mW and there is a separation distance of two centimeters between any portion of a radiating structure operating and the nearest portion of any other radiating structure in the same device, except if the sum of multiple sources is less than 1 mW during the time-averaging period, in which case they may be treated as a single source (separation is not required). This exemption may not be used in conjunction with other exemption criteria other than those is paragraph (b)(3)(i)(A) of this section. Medical implant devices may only use this exemption and that in paragraph (b)(3)(i)(A).
B Simultaneous Transmission with both SAR-based and MPE-Based Test Exemptions	FCC 1.1307(b)(3)(ii)(B)	in the case of fixed RF sources operating in the same time-averaging period, or of multiple mobile or portable RF sources within a device operating in the same time averaging period, if the sum of the fractional contributions to the applicable thresholds is less than or equal to 1 as indicated in the following equation. $\sum_{i=1}^{a} \frac{P_i}{P_{th,i}} + \sum_{j=1}^{b} \frac{ERP_j}{ERP_{th,j}} + \sum_{k=1}^{c} \frac{Evaluated_k}{Exposure\ Limit_k} \leq 1$

2.3 Individual Antenna Port Exposure Results

2.3.1 Calculation of Exposure at Specified Separation Distance

The frequencies shown in the tables below have been chosen based on the lowest possible frequency that the EUT can transmit. A full list of the regional requirements is shown in Annex A.

RAT	Core	Frequency (MHz)	Conducted Power Output mW	Duty Cycle %	Time Average Conducted Power Output mW	Antenna Gain Ratio	Maximum Power (EIRP) mW	Maximum Power (ERP) mW	Minimum Antenna to User Separation Distance (mm)	Pth (mW) 1.1307 (b)(3)(i)(B)	Greater of Max time averaged conducted power or ERP?	1.1307(b)(3)(i)(B) Exemption (Yes/No) (300 MHz to 6 GHz, 0.5 cm to 20 cm)
Bluetooth	0	2402.0	44.67	100	44.67	2.046	91.41	55.74	200	3060	55.74	Yes
Bluetooth	1	2402.0	44.67	100	44.67	1.239	55.34	33.74	200	3060	44.67	Yes
Bluetooth	2	2402.0	19.95	100	19.95	1.178	23.50	14.33	200	3060	19.95	Yes
2.4 GHz WLAN	0	2412.0	177.83	100	177.83	2.046	363.92	221.90	200	3060	221.90	Yes
2.4 GHz WLAN	1	2412.0	177.83	100	177.83	1.239	220.29	134.32	200	3060	177.83	Yes
5 GHz WLAN	0	5180.0	125.89	100	125.89	2.667	335.74	204.72	200	3060	204.72	Yes
5 GHz WLAN	1	5180.0	125.89	100	125.89	1.524	191.87	116.99	200	3060	125.89	Yes
6 GHz WLAN	0	5935.0	35.48	100	35.48	2.931	103.99	63.41	200	3060	63.41	Yes
6 GHz WLAN	1	5935.0	35.48	100	35.48	1.679	59.57	36.32	200	3060	36.32	Yes
NB	0	5162.0	31.62	100	31.62	2.667	84.33	51.42	200	3060	51.42	Yes
NB	1	5162.0	31.62	100	31.62	1.524	48.19	29.39	200	3060	31.62	Yes

Table 4 –Transmitter Result

The calculations show that the individual transmitters comply with FCC 1.1307(b)(3)(i)(B) SAR-based exemption at a minimum distance of 0.2 m.

2.4 Combined Antenna Port RF Exposure Results using "1.1307(b)(3)(i)(B) SAR Exemption"

2.4.1 Combination 1 - 5 GHz WLAN (2x2 MIMO on Core 0 & 1) + Bluetooth (2x2 MIMO on Core 0 & 1)

RAT	Core	Frequency (MHz)	Conducted Power Output mW	Duty Cycle %	Time Average Conducted Power Output mW	Antenna Gain Ratio	Maximum Power (EIRP) mW	Maximum Power (ERP) mW	Test Separation Distance (mm)	ERPj / Max of time averaged conducted power or ERPth
Bluetooth	0	2402.0	31.62	100	31.62	2.046	64.71	39.46	200	0.0129
Bluetooth	1	2402.0	31.62	100	31.62	1.239	39.17	23.89	200	0.0078
5 GHz WLAN	0	5180.0	125.89	100	125.89	2.667	335.74	204.72	200	0.0669
5 GHz WLAN	1	5180.0	125.89	100	125.89	1.524	191.87	116.99	200	0.0382
Calculated RF exposure level at minimum compliance boundary of 0.2 m as a fraction of the limit										0.1258

2.4.2 Combination 2 - 6 GHz WLAN (2x2 MIMO on Core 0 & 1) + Bluetooth (2x2 MIMO on Core 0 & 1)

RAT	Core	Frequency (MHz)	Conducted Power Output mW	Duty Cycle %	Time Average Conducted Power Output mW	Antenna Gain Ratio	Maximum Power (EIRP) mW	Maximum Power (ERP) mW	Test Separation Distance (mm)	ERPj / Max of time averaged conducted power or ERPth
Bluetooth	0	2402.0	31.62	100	31.62	2.046	64.71	39.46	200	0.0129
Bluetooth	1	2402.0	31.62	100	31.62	1.239	39.17	23.89	200	0.0078
6 GHz WLAN	0	5935.0	35.48	100	35.48	2.931	103.99	63.41	200	0.0207
Calculated RF exposure level at minimum compliance boundary of 0.2 m as a fraction of the limit										0.0414

2.4.3 Combination 3 – 2.4 GHz WLAN (Core 0) + NB (Core 1)

RAT	Core	Frequency (MHz)	Conducted Power Output mW	Duty Cycle %	Time Average Conducted Power Output mW	Antenna Gain Ratio	Maximum Power (EIRP) mW	Maximum Power (ERP) mW	Test Separation Distance (mm)	ERPj / Max of time averaged conducted power or ERPth
2.4 GHz WLAN	0	2412.0	177.83	100	177.83	2.046	363.92	221.90	200	0.0725
NB	1	5162.0	31.62	100	31.62	1.524	48.19	29.39	200	0.0103
Calculated RF exposure level at minimum compliance boundary of 0.2 m as a fraction of the limit										0.0829