Exposure Calculation Report

Apple Inc
Model: A2786

In accordance with FCC CFR 47 Pt 1.1307

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

COMMERCIAL-IN-CONFIDENCE

FCC ID: BCGA2786

Document 75955426-16 Issue: 01

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Matthew Russell	Chief Engineer (RF)	Authorised Signatory	02 March 2023

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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	02 March 2023

Table 1

1.2 Introduction

Applicant	Apple Inc
Manufacturer	Apple Inc
Model Number(s)	A2786
Hardware Version(s)	REV 1.0
Software Version(s)	Not Applicable
Specification/Issue/Date	FCC 47 CFR Part 1.1307: 2021
Order Number	0540246998
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 a tower configuration Apple computer, with Bluetooth® and IEEE 802.11 a/b/g/n/ac/ax Wi-Fi capabilities in the 2.4 GHz, 5 GHz and 6 GHz 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	12.50	100
Bluetooth (TxBF)	0 and 1	2400-2483.5	2402	16.50	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 and 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 and 1	5150 - 5850	5180	21.00	100
6 GHz WLAN (SISO)	0	5925 - 7125	5935	12.50	100
6 GHz WLAN (SISO)	1	5925 - 7125	5935	12.50	100
6 GHz WLAN (2x2 MIMO)	0 and 1	5925- 7125	5935	12.50	100
NB	0	5162 - 5844	5162	11.00	100
NB	1	5162 - 5844	5162	11.00	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 (cm)	Minimum Separation Distance (cm)
BT Core 0	Not Specified	2.99	6.860	20
BT Core 1	Not Specified	3.75	6.860	20
BT Core 2	Not Specified	5.11	6.860	20
2.4 GHz WLAN Core 0	Not Specified	2.99	6.860	20
2.4 GHz WLAN Core 1	Not Specified	5.11	6.860	20
5 GHz WLAN Core 0	Not Specified	5.90	6.860	20
5 GHz WLAN Core 1	Not Specified	6.05	6.860	20
6 GHz WLAN Core 0	Not Specified	6.93	6.860	20
6 GHz WLAN Core 1	Not Specified	6.07	6.860	20
NB Core 0	Not Specified	5.41	6.860	20
NB Core 1	Not Specified	6.07	6.860	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

Simultaneous transmission for the following configurations;

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

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

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

Notes:
MIMO operation was confirmed as worst case compared to single antenna SISO operation.
2.4 GHz WLAN (Core 1) + NB (Core 0) was confirmed as worst case compared to 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	1.991	88.92	54.22	200	3060	54.22	Yes
Bluetooth	1	2402.0	44.67	100	44.67	2.371	105.93	64.59	200	3060	64.59	Yes
Bluetooth	2	2402.0	17.78	100	17.78	3.243	57.68	35.17	200	3060	35.17	Yes
2.4 GHz WLAN	0	2412.0	177.83	100	177.83	1.991	354.00	215.85	200	3060	215.85	Yes
2.4 GHz WLAN	1	2412.0	177.83	100	177.83	3.243	576.77	351.69	200	3060	351.69	Yes
5 GHz WLAN	0	5180.0	125.89	100	125.89	3.890	489.78	298.65	200	3060	298.65	Yes
5 GHz WLAN	1	5180.0	125.89	100	125.89	4.027	506.99	309.14	200	3060	309.14	Yes
6 GHz WLAN	0	5935.0	17.78	100	17.78	4.932	87.70	53.48	200	3060	53.48	Yes
6 GHz WLAN	1	5935.0	17.78	100	17.78	4.046	71.94	43.87	200	3060	43.87	Yes
NB	0	5162.0	12.59	100	12.59	3.475	43.75	26.68	200	3060	26.68	Yes
NB	1	5162.0	12.59	100	12.59	4.046	50.93	31.06	200	3060	31.06	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

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 / ERPth
Bluetooth	0	2402.0	44.67	100	44.67	1.991	88.92	54.22	200	0.0177
Bluetooth	1	2402.0	44.67	100	44.67	2.371	105.93	64.59	200	0.0211
5 GHz WLAN	0	5180.0	125.89	100	125.89	3.890	489.78	298.65	200	0.0976
5 GHz WLAN	1	5180.0	125.89	100	125.89	4.027	506.99	309.14	200	0.1010
Calculated RF exposure level at minimum compliance boundary of 0.2 m as a fraction of the limit										0.2374

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 / ERPth
Bluetooth	0	2402.0	44.67	100	44.67	1.991	88.92	54.22	200	0.0177
Bluetooth	1	2402.0	44.67	100	44.67	2.371	105.93	64.59	200	0.0211
6 GHz WLAN	0	5935.0	17.78	100	17.78	4.932	87.70	53.48	200	0.0175
6 GHz WLAN	1	5935.0	17.78	100	17.78	4.046	71.94	43.87	200	0.0143
Calculated RF exposure level at minimum compliance boundary of 0.2 m as a fraction of the limit										0.0706

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

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 / ERPth
2.4 GHz WLAN	1	2412.0	177.83	100	177.83	3.243	576.77	351.69	200	0.1149
NB	0	5162.0	12.59	100	12.59	3.475	43.75	26.68	200	0.0087
Calculated RF exposure level at minimum compliance boundary of 0.2 m as a fraction of the limit										0.1236