

Report on the Exposure Calculation for Apple Inc. Desktop Computer, Model: A1993 In accordance with EU, FCC and Canada regional requirements

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

FCC ID: BCGA1993

IC: 579C-A1993

COMMERCIAL-IN-CONFIDENCE

Document Number: 75942779-17 | Issue: 01



Product Service

Choose certainty.
Add value.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Project Management	Steven White	16 October 2018	
Authorised Signatory	Simon Bennett	16 October 2018	

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD Product Service document control rules.

ENGINEERING STATEMENT

The calculations shown in this report were made in accordance with the procedures described in EU, FCC and Canada regional requirements.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Calculation	Pete Dorey	16 October 2018	

EXECUTIVE SUMMARY

The calculation of exposure for this product was found to be compliant at 20 cm with EU, FCC and Canada regional requirements.

DISCLAIMER AND COPYRIGHT

This non-binding report has been prepared by TÜV SÜD Product Service with all reasonable skill and care. The document is confidential to the potential Client and TÜV SÜD Product Service. No part of this document may be reproduced without the prior written approval of TÜV SÜD Product Service. © 2018 TÜV SÜD Product Service.

TÜV SÜD Product Service
is a trading name of TÜV SÜD Ltd
Registered in Scotland at East Kilbride,
Glasgow G75 0QF, United Kingdom
Registered number: SC215164

TÜV SÜD Ltd is a
TÜV SÜD Group Company

Phone: +44 (0) 1489 558100
Fax: +44 (0) 1489 558101
www.tuv-sud.co.uk

TÜV SÜD Product Service
Octagon House
Concorde Way
Fareham
Hampshire PO15 5RL
United Kingdom



Contents

1 Report Summary2

1.1 Report Modification Record.....2

1.2 Introduction.....2

1.3 Brief Summary of Results3

1.4 Product Information6

2 Assessment Details8

2.1 Assessment Method.....8

2.2 Individual Antenna Port Exposure Results.....8

2.3 Combined Antenna Port RF Exposure Results.....10

2.4 Far Field Region Boundary Results15

2.5 Uncertainty15

Annex A Regional Requirements.....16



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	16 October 2018

1.2 Introduction

Objective	To perform electromagnetic field exposure assessment to determine the equipment under test's (EUT's) compliance with the applied specifications.
Applicant	Apple Inc
Manufacturer	Apple Inc
Model Number(s)	A1993
Hardware Version(s)	EVT
Software Version(s)	18B2034
Specification/Issue/Date	• EU: EN 62311:2008 Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz to 300 GHz) • FCC: CFR 47 Pt1.1310:2016 • ISED Canada: Health Canada Safety Code 6:2015
Order Number	0540158293
Date	17 April 2018
Related Document(s)	• Directive 2013/35/EU on minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields). • European Council Recommendation 1999/519/EC of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz), Official Journal, L199, of 1999-7-30, p.59-70. • OET65:97 Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields • IEEE C95.3:2002 IEEE Recommended Practice for Measurements and Computations of Radio Frequency Electromagnetic Fields With Respect to Human Exposure to Such Fields, 100 kHz–300 GHz • RSS-102 Issue 5 Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)



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.

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

1.3.1 Individual Transmitters

Regional Requirement	RAT	Frequency (MHz)	RF Exposure Level at compliance boundary of 0.2 m							
			S Power Density (W/m ²)		E Field (V/m)		H Field (A/m)		B Field (μT)	
			Result	Limit	Result	Limit	Result	Limit	Result	Limit
EU	Bluetooth	2402	0.037	N/A	3.73	140.0	0.0099	N/A	0.0124	0.4500
EU	WLAN main radio	2412	0.14	N/A	7.29	140.0	0.0193	N/A	0.0243	0.4500
EU	WLAN aux radio	2412	0.15	N/A	7.50	140.0	0.0199	N/A	0.0250	0.4500
EU	WLAN main radio	5180	0.40	N/A	12.23	140.0	0.0324	N/A	0.0408	0.4500
EU	WLAN aux radio	5180	0.42	N/A	12.59	140.0	0.0334	N/A	0.0420	0.4500
FCC	Bluetooth	2402	0.04	50.00	3.73	N/A	0.0099	N/A	0.0124	N/A
FCC	WLAN main radio	2412	1.58	50.00	24.41	N/A	0.0647	N/A	0.0814	N/A
FCC	WLAN aux radio	2412	1.58	50.00	24.41	N/A	0.0647	N/A	0.0814	N/A
FCC	WLAN main radio	5180	0.67	50.00	15.85	N/A	0.0420	N/A	0.0528	N/A
FCC	WLAN aux radio	5180	0.67	50.00	15.85	N/A	0.0420	N/A	0.0528	N/A
CANADA	Bluetooth	2402	0.04	31.64	3.73	109.21	0.0099	0.2897	0.0124	N/A
CANADA	WLAN main radio	2412	1.58	31.70	24.41	109.32	0.0647	0.2900	0.0814	N/A
CANADA	WLAN aux radio	2412	1.58	31.70	24.41	109.32	0.0647	0.2900	0.0814	N/A
CANADA	WLAN main radio	5180	0.67	46.46	15.85	132.34	0.0420	0.3511	0.0528	N/A
CANADA	WLAN aux radio	5180	0.67	46.46	15.85	132.34	0.0420	0.3511	0.0528	N/A

Table 1 – Worker/Occupational Exposure Results



The calculations show that the EUT complies with the worker/occupational exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.

Regional Requirement	RAT	Frequency (MHz)	RF Exposure Level at compliance boundary of 0.2 m							
			S Power Density (W/m ²)		E Field (V/m)		H Field (A/m)		B Field (μT)	
			Result	Limit	Result	Limit	Result	Limit	Result	Limit
EU	Bluetooth	2402	0.04	10.00	3.73	61.00	0.0099	0.1600	0.0124	0.2000
EU	WLAN main radio	2412	0.14	10.00	7.29	61.00	0.0193	0.1600	0.0243	0.2000
EU	WLAN aux radio	2412	0.15	10.00	7.50	61.00	0.0199	0.1600	0.0250	0.2000
EU	WLAN main radio	5180	0.40	10.00	12.23	61.00	0.0324	0.1600	0.0408	0.2000
EU	WLAN aux radio	5180	0.42	10.00	12.59	61.00	0.0334	0.1600	0.0420	0.2000
FCC	Bluetooth	2402	0.04	10.00	3.73	N/A	0.0099	N/A	0.0124	N/A
FCC	WLAN main radio	2412	1.58	10.00	24.41	N/A	0.0647	N/A	0.0814	N/A
FCC	WLAN aux radio	2412	1.58	10.00	24.41	N/A	0.0647	N/A	0.0814	N/A
FCC	WLAN main radio	5180	0.67	10.00	15.85	N/A	0.0420	N/A	0.0528	N/A
FCC	WLAN aux radio	5180	0.67	10.00	15.85	N/A	0.0420	N/A	0.0528	N/A
CANADA	Bluetooth	2402	0.04	5.35	3.73	44.91	0.0099	0.1191	0.0124	N/A
CANADA	WLAN main radio	2412	1.58	5.37	24.41	44.97	0.0647	0.1193	0.0814	N/A
CANADA	WLAN aux radio	2412	1.58	5.37	24.41	44.97	0.0647	0.1193	0.0814	N/A
CANADA	WLAN main radio	5180	0.67	9.05	15.85	58.40	0.0420	0.1549	0.0528	N/A
CANADA	WLAN aux radio	5180	0.67	9.05	15.85	58.40	0.0420	0.1549	0.0528	N/A

Table 2 – General Public Exposure Results

The calculations show that the EUT complies with the general public exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.



1.3.1 Configuration 1 Simultaneous Transmission - 2.4 GHz (Main Radio) + 5.0 GHz (AUX Radio) + Bluetooth

Regional Requirement	Calculated RF exposure level at compliance boundary of 0.2 m			
	S Power Density (W/m ²)	E Field (V/m)	H Field (A/m)	B Field (μT)
	Summation for simultaneous exposure; value to be <1			
EU	N/A	0.0115	N/A	0.0124
FCC	0.0457	N/A	N/A	N/A
CANADA	0.0654	0.0654	0.0654	N/A

Table 3 – Worker/Occupational Exposure Results

The calculations show that the EUT complies with the worker/occupational exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.

Regional Requirement	Calculated RF exposure level at compliance boundary of 0.2 m			
	S Power Density (W/m ²)	E Field (V/m)	H Field (A/m)	B Field (μT)
	Summation for simultaneous exposure; value to be <1			
EU	0.0598	0.0606	0.0620	0.0626
FCC	0.2284	N/A	N/A	N/A
CANADA	0.3750	0.3751	0.3750	N/A

Table 4 – General Public Exposure Results

The calculations show that the EUT complies with the general public exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.

1.3.2 Configuration 2 Simultaneous Transmission - 5.0 GHz (Main Radio) + 2.4 GHz (AUX Radio) + Bluetooth

Regional Requirement	Calculated RF exposure level at compliance boundary of 0.2 m			
	S Power Density (W/m ²)	E Field (V/m)	H Field (A/m)	B Field (μT)
	Summation for simultaneous exposure; value to be <1			
EU	N/A	0.0112	N/A	0.0121
FCC	0.0457	N/A	N/A	N/A
CANADA	0.0654	0.0654	0.0654	0.0654

Table 5 – Worker/Occupational Exposure Results

The calculations show that the EUT complies with the worker/occupational exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.



Regional Requirement	Calculated RF exposure level at compliance boundary of 0.2 m			
	S Power Density (W/m ²)	E Field (V/m)	H Field (A/m)	B Field (μT)
	Summation for simultaneous exposure; value to be <1			
EU	0.0583	0.0591	0.0604	0.0610
FCC	0.2284	N/A	N/A	N/A
CANADA	0.3750	0.3751	0.3750	N/A

Table 6 – General Public Exposure Results

The calculations show that the EUT complies with the general public exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.

1.4 Product Information

1.4.1 Technical Description

The Equipment Under Test (EUT) was a desktop computer with Bluetooth, Bluetooth Low Energy and 802.11 b/g/n/ac capabilities in the 2.4GHz and 5GHz bands.

Refer to the manufacturer's details for further information.

1.4.2 Transmitter Description

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

Radio Access Technology	Antenna Port	Frequency Band	Minimum Frequency	Output Power	Duty Cycle
		MHz	MHz	dBm	%
Bluetooth	Internal	2400 – 2483.5 MHz	2402	12.68	100
WLAN main radio (EU)	Internal	2400 – 2483.5 MHz	2412	13.5	100
WLAN main radio (FCC, Canada)	Internal	2400 – 2483.5 MHz	2412	24	100
WLAN aux radio (EU)	Internal	2400 – 2483.5 MHz	2412	18.5	100
WLAN aux radio (FCC, Canada)	Internal	2400 – 2483.5 MHz	2412	24	100
WLAN main radio (EU)	Internal	5150 MHz – 5850 MHz	5180	19	100
WLAN main radio (FCC, Canada)	Internal	5150 MHz – 5850 MHz	5180	22.5	100
WLAN aux radio (EU)	Internal	5150 MHz – 5850 MHz	5180	20.5	100
WLAN aux radio (FCC, Canada)	Internal	5150 MHz – 5850 MHz	5180	22.5	100

Table 7 – Transmitter Description



1.4.3 Antenna Description

The following antennas are supported by the equipment under test.

Antenna No	Radio Access Technology	Antenna Model	Gain	Antenna length	Minimum Separation Distance
			dBi	cm	cm
1	Bluetooth	Internal	0	2	20
2	WLAN (main radio) 2.4 GHz	Internal	5	2	20
3	WLAN (aux radio) 2.4 GHz	Internal	0.25	2	20
4	WLAN (main radio) 5 GHz	Internal	4	2	20
5	WLAN (aux radio) 5 GHz	Internal	2.75	2	20

Table 8 – Antenna description

1.4.4 Equipment Configuration

Configuration 1:

2.4 GHz (Main Radio any core except the BT shared core where WLAN 2.4GHz and BT cannot work together) + 5.0 GHz (AUX Radio) + Bluetooth

Configuration 2:

5.0 GHz (Main Radio) + 2.4 GHz (AUX Radio) + Bluetooth

2 Assessment Details

2.1 Assessment Method

The assessment method is by calculation of the power density S, electric field strength E, magnetic field strength H or magnetic flux density B.

The calculation uses the spherical model applicable under far field conditions.

$$S = E \times H = \frac{E^2}{\eta} = H^2 \times \eta = \frac{P \times G_i}{4 \times \pi \times r^2}$$

Where:

η - Impedance of free space (377 ohm in far field)

P – Transmitter power W

G_i – Antenna gain ratio relative to isotropic

R – Separation distance m

The magnetic flux density is related to the magnetic field strength by a constant:

$$B = \mu_o \times H$$

Where:

μ_o – Permeability of free space $4\pi \times 10^{-7}$ H/m

Where additional calculations are required by the regional specifications these are detailed below.

The far field region boundary depends on the frequency and wavelength and also on the antenna dimension. The boundary of the far field region is calculated below to demonstrate the validity of using the spherical model.

2.2 Individual Antenna Port Exposure Results

2.2.1 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.



Regional Requirement	Antenna Port	RAT	Frequency (MHz)	RF Exposure Level at compliance boundary of 0.2 m							
				S Power Density (W/m ²)		E Field (V/m)		H Field (A/m)		B Field (μT)	
				Result	Limit	Result	Limit	Result	Limit	Result	Limit
EU	Internal	Bluetooth	2402	0.04	N/A	3.73	140.0	0.0099	N/A	0.0124	0.4500
EU	Internal	WLAN main radio	2412	0.14	N/A	7.29	140.0	0.0193	N/A	0.0243	0.4500
EU	Internal	WLAN aux radio	2412	0.15	N/A	7.50	140.0	0.0199	N/A	0.0250	0.4500
EU	Internal	WLAN main radio	5180	0.40	N/A	12.23	140.0	0.0324	N/A	0.0408	0.4500
EU	Internal	WLAN aux radio	5180	0.42	N/A	12.59	140.0	0.0334	N/A	0.0420	0.4500
FCC	Internal	Bluetooth	2402	0.04	50.00	3.73	N/A	0.0099	N/A	0.0124	N/A
FCC	Internal	WLAN main radio	2412	1.58	50.00	24.41	N/A	0.0647	N/A	0.0814	N/A
FCC	Internal	WLAN aux radio	2412	1.58	50.00	24.41	N/A	0.0647	N/A	0.0814	N/A
FCC	Internal	WLAN main radio	5180	0.67	50.00	15.85	N/A	0.0420	N/A	0.0528	N/A
FCC	Internal	WLAN aux radio	5180	0.67	50.00	15.85	N/A	0.0420	N/A	0.0528	N/A
CANADA	Internal	Bluetooth	2402	0.04	31.64	3.73	109.21	0.0099	0.2897	0.0124	N/A
CANADA	Internal	WLAN main radio	2412	1.58	31.70	24.41	109.32	0.0647	0.2900	0.0814	N/A
CANADA	Internal	WLAN aux radio	2412	1.58	31.70	24.41	109.32	0.0647	0.2900	0.0814	N/A
CANADA	Internal	WLAN main radio	5180	0.67	46.46	15.85	132.34	0.0420	0.3511	0.0528	N/A
CANADA	Internal	WLAN aux radio	5180	0.67	46.46	15.85	132.34	0.0420	0.3511	0.0528	N/A

Table 9 – Worker/Occupational Transmitter Summary

The calculations show that the EUT complies with the worker/occupational exposure levels described in in the listed specifications in Annex A at the point of investigation, 0.2 m.



Regional Requirement	Antenna Port	RAT	Frequency (MHz)	RF Exposure Level at compliance boundary of 0.2 m							
				S Power Density (W/m ²)		E Field (V/m)		H Field (A/m)		B Field (μT)	
				Result	Limit	Result	Limit	Result	Limit	Result	Limit
EU	Internal	Bluetooth	2402	0.04	10.00	3.728	61.00	0.0099	0.1600	0.0124	0.2000
EU	Internal	WLAN main radio	2412	0.14	10.00	7.29	61.00	0.0193	0.1600	0.0243	0.2000
EU	Internal	WLAN aux radio	2412	0.15	10.00	7.50	61.00	0.0199	0.1600	0.0250	0.2000
EU	Internal	WLAN main radio	5180	0.40	10.00	12.23	61.00	0.0324	0.1600	0.0408	0.2000
EU	Internal	WLAN aux radio	5180	0.42	10.00	12.59	61.00	0.0334	0.1600	0.0420	0.2000
FCC	Internal	Bluetooth	2402	0.04	10.00	3.73	N/A	0.0099	N/A	0.0124	N/A
FCC	Internal	WLAN main radio	2412	1.58	10.00	24.41	N/A	0.0647	N/A	0.0814	N/A
FCC	Internal	WLAN aux radio	2412	1.58	10.00	24.41	N/A	0.0647	N/A	0.0814	N/A
FCC	Internal	WLAN main radio	5180	0.67	10.00	15.85	N/A	0.0420	N/A	0.0528	N/A
FCC	Internal	WLAN aux radio	5180	0.67	10.00	15.85	N/A	0.0420	N/A	0.0528	N/A
CANADA	Internal	Bluetooth	2402	0.04	5.35	3.73	44.91	0.0099	0.1191	0.0124	N/A
CANADA	Internal	WLAN main radio	2412	1.58	5.37	24.41	44.97	0.0647	0.1193	0.0814	N/A
CANADA	Internal	WLAN aux radio	2412	1.58	5.37	24.41	44.97	0.0647	0.1193	0.0814	N/A
CANADA	Internal	WLAN main radio	5180	0.67	9.05	15.85	58.40	0.0420	0.1549	0.0528	N/A
CANADA	Internal	WLAN aux radio	5180	0.67	9.05	15.85	58.40	0.0420	0.1549	0.0528	N/A

Table 10 – General Public Transmitter Summary

The calculations show that the EUT complies with the general public exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.

2.3 Combined Antenna Port RF Exposure Results

As the frequency of operation for each transmitter is not the same, in order to evaluate compliance with the limit which is dependent on frequency, the fractional exposure value is calculated: The calculated S power density is divided by the limit to get a fractional exposure value. The calculated E and H fields are divided by the limit and squared to get a fractional exposure value. The summation of the fractional RF exposure results for each transmitter provides the combined result. Any values less than one are compliant with the limit. <The compliance boundary distance has been calculated to ensure the summation is ≤1.>



2.3.1 Configuration 1 - Simultaneous Transmission - 2.4 GHz (Main Radio) + 5.0 GHz (AUX Radio) + Bluetooth

EU EN 62311 specifies the method of summation in clause 8.3 with results as follows:

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at compliance boundary of 0.2 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
1	Bluetooth	2402	N/A	0.0007	N/A	0.0008
2	WLAN main radio	2412	N/A	0.0027	N/A	0.0029
3	WLAN aux radio	5180	N/A	0.0081	N/A	0.0087
Summation			N/A	0.0115	N/A	0.0124

Table 11 – EU Worker/Occupational Combined Exposure

The calculations show that the EUT complies with the worker/occupational exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at compliance boundary of 0.2 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
1	Bluetooth	2402	0.0037	0.0037	0.0038	0.0039
2	WLAN main radio	2412	0.0141	0.0143	0.0146	0.0147
3	WLAN aux radio	5180	0.0420	0.0426	0.0436	0.0440
Summation			0.0598	0.0606	0.0620	0.0626

Table 12 – EU General Public Combined Exposure

The calculations show that the EUT complies with the general public exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.

FCC OET 65 specifies the method of summation in clause; Multiple-Transmitter Sites and Complex Environments; with results as follows:

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at compliance boundary of 0.2 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
1	Bluetooth	2402	0.0007	N/A	N/A	N/A
2	WLAN main radio	2412	0.0316	N/A	N/A	N/A
3	WLAN aux radio	5180	0.0133	N/A	N/A	N/A
Summation			0.0457	N/A	N/A	N/A

Table 13 – FCC Worker/Occupational Combined Exposure



The calculations show that the EUT complies with the worker/occupational exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at compliance boundary of 0.2 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
1	Bluetooth	2402	0.0037	N/A	N/A	N/A
2	WLAN main radio	2412	0.1580	N/A	N/A	N/A
3	WLAN aux radio	5180	0.0666	N/A	N/A	N/A
Summation			0.2284	N/A	N/A	N/A

Table 14 – FCC General Public Combined Exposure

The calculations show that the EUT complies with the general public exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.

CANADA Health Canada Safety Code 6 specifies the method of summation in clause 2.2.1 Note 6 with results as follows:

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at compliance boundary of 0.2 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
1	Bluetooth	2402	0.0012	0.0012	0.0012	N/A
2	WLAN main radio	2412	0.0498	0.0498	0.0498	N/A
3	WLAN aux radio	5180	0.0143	0.0143	0.0143	N/A
Summation			0.0654	0.0654	0.0654	N/A

Table 15 – CANADA Worker/Occupational Combined Exposure

The calculations show that the EUT complies with the worker/occupational exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at compliance boundary of 0.2 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
1	Bluetooth	2402	0.0069	0.0069	0.0069	N/A
2	WLAN main radio	2412	0.2945	0.2945	0.2945	N/A
3	WLAN aux radio	5180	0.0737	0.0737	0.0737	N/A
Summation			0.3750	0.3751	0.3750	N/A

Table 16 – CANADA General Public Combined Exposure

The calculations show that the EUT complies with the general public exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.



2.3.2 Configuration 2 - Simultaneous Transmission - 5.0 GHz (Main Radio) + 2.4 GHz (AUX Radio) + Bluetooth

EU EN 62311 specifies the method of summation in clause 8.3 with results as follows:

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at compliance boundary of 0.2 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
1	Bluetooth	2402	N/A	0.0007	N/A	0.0008
2	WLAN main radio	2412	N/A	0.0029	N/A	0.0031
3	WLAN aux radio	5180	N/A	0.0076	N/A	0.0082
Summation			N/A	0.0112	N/A	0.0121

Table 17 – EU Worker/Occupational Combined Exposure

The calculations show that the EUT complies with the worker/occupational exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at compliance boundary of 0.2 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
1	Bluetooth	2402	0.0037	0.0037	0.0038	0.0039
2	WLAN main radio	2412	0.0149	0.0151	0.0155	0.0156
3	WLAN aux radio	5180	0.0397	0.0402	0.0411	0.0416
Summation			0.0583	0.0591	0.0604	0.0610

Table 18 – EU General Public Combined Exposure

The calculations show that the EUT complies with the general public exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.

FCC OET 65 specifies the method of summation in clause; Multiple-Transmitter Sites and Complex Environments; with results as follows:

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at compliance boundary of 0.2 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
1	Bluetooth	2402	0.0007	N/A	N/A	N/A
2	WLAN main radio	2412	0.0316	N/A	N/A	N/A
3	WLAN aux radio	5180	0.0133	N/A	N/A	N/A
Summation			0.0457	N/A	N/A	N/A

Table 19 – FCC Worker/Occupational Combined Exposure

The calculations show that the EUT complies with the worker/occupational exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.



Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at compliance boundary of 0.2 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
1	Bluetooth	2402	0.0037	N/A	N/A	N/A
2	WLAN main radio	2412	0.1580	N/A	N/A	N/A
3	WLAN aux radio	5180	0.0666	N/A	N/A	N/A
Summation			0.2284	N/A	N/A	N/A

Table 20 – FCC General Public Combined Exposure

The calculations show that the EUT complies with the general public exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.

CANADA Health Canada Safety Code 6 specifies the method of summation in clause 2.2.1 Note 6 with results as follows:

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at compliance boundary of 0.2 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
1	Bluetooth	2402	0.0012	0.0012	0.0012	N/A
2	WLAN main radio	2412	0.0498	0.0498	0.0498	N/A
3	WLAN aux radio	5180	0.0143	0.0143	0.0143	N/A
Summation			0.0654	0.0654	0.0654	0.0654

Table 21 – CANADA Worker/Occupational Combined Exposure

The calculations show that the EUT complies with the worker/occupational exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.

Antenna Port	RAT	Frequency (MHz)	Calculated RF exposure level at compliance boundary of 0.2 m as a fraction of the limit			
			S Power Density	E Field	H Field	B Field
1	Bluetooth	2402	0.0069	0.0069	0.0069	N/A
2	WLAN main radio	2412	0.2945	0.2945	0.2945	N/A
3	WLAN aux radio	5180	0.0737	0.0737	0.0737	N/A
Summation			0.3750	0.3751	0.3750	N/A

Table 22 – CANADA General Public Combined Exposure

The calculations show that the EUT complies with the general public exposure levels described in the listed specifications in Annex A at the point of investigation, 0.2 m.



2.4 Far Field Region Boundary Results

The far field region boundary calculation is specified in the standards referenced:

Near Field / Far Field Boundary	
RAT Name	Antennas - on axis Far Field Region (Ref: IEEE C95.3 Annex B.2) (Ref: EN 62311 Annex A.3)
	$2D^2/\lambda$ (m)
Bluetooth	0.0064
WLAN main radio 2.4 GHz	0.0064
WLAN aux radio 2.4 GHz	0.0064
WLAN main radio 5 GHz	0.0138
WLAN aux radio 5 GHz	0.0138

Table 23 – Far Field Boundary

The far field boundary is 1.4 cm. The 0.2 m compliance boundary is beyond this distance and in the far field and therefore the approach described in section 2.1 is valid.

2.5 Uncertainty

The basic computation formulas presented in section 2.1 are conservative formulas for the estimation of RF field strength or power density. No uncertainty estimations are required when using these formulas but there is clear guidance on where and when these formulas are applicable.

For the estimate of S, E or H to be conservative, the transmitter power P and antenna gain G_i values shall be the upper bounds of uncertainty therefore maximum values are used.

The spherical formula is valid under far field conditions which are established in section 2.4.



Product Service

ANNEX A

REGIONAL REQUIREMENTS



Frequency Range (MHz)	Power Density (W/m ²)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m) (Converted from μ T)	Magnetic Flux Density (μ T)
0.1 - 1	-	610	N/A	2/f
1 - 10	-	610/f	N/A	2/f
10 - 400		61	N/A	0.2
400 - 2000		$3 \cdot f^{0.5}$	N/A	$1E-2 \cdot f^{0.5}$
2000 - 6000		140	N/A	0.45
6000 - 300000	50	140	N/A	0.45

Table A.1 – <standard> Action levels in Directive 2013/35/EU Annex III Table B1 Worker/Occupational Limits

Frequency Range (MHz)	Power Density (W/m ²)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Magnetic Flux Density (μ T)
0.003 - 0.15	-	87	5	6.25
0.15 - 1	-	87	0.73/f	0.92/f
1 - 10	-	$87/f^{0.5}$	0.73/f	0.92/f
10 - 400	2	28	0.073	0.092
400 - 2000	f/200	$1.375 \cdot f^{0.5}$	$0.0037 \cdot f^{0.5}$	$0.0046 \cdot f^{0.5}$
2000 - 300000	10	61	0.16	0.2

Table A.2 – <standard>: Council Recommendation 1999/519/EC Annex II Table 1 General Public Limits

Frequency Range (MHz)	Power Density (mW/cm ²)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)
0 - 0.3	-	-	-
0.3 - 3	100	614	1.63
3 - 30	$900/f^2$	$1842/f$	$4.89/f$
30 - 300	1	61.4	0.163
300 - 1500	f/300	-	-
1500 - 100000	5	-	-

Table A.3 – CFR 47 Pt1.1310 (2016) Worker/Occupational Limits

Frequency Range (MHz)	Power Density (mW/cm ²)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)
0 - 0.3	-	-	-
0.3 - 3	100	614	1.63
3 - 30	$180/f^2$	$824/f$	$2.19/f$
30 - 300	0.2	27.5	0.073
300 - 1500	f/1500	-	-
1500 - 100000	1	-	-

Table A.4 – CFR 47 Pt1.1310 (2016) General Public Limits



Frequency Range (MHz)	Power Density (W/m ²)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)
10 - 20	10	61.4	0.163
20 - 48	$44.72/f^{0.5}$	$129.8/f^{0.25}$	$0.3444/f^{0.25}$
48 - 100	6.455	49.33	0.1309
100 - 6000	$0.6455*f^{0.5}$	$15.60*f^{0.25}$	$0.04138*f^{0.25}$
6000 - 150000	50	137	0.364

Table A.5 – Health Canada Safety Code 6 Worker/Occupational Limits

Frequency Range (MHz)	Power Density (W/m ²)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)
10 - 20	2	27.46	0.0728
20 - 48	$8.944/f^{0.5}$	$58.07/f^{0.25}$	$0.1540/f^{0.25}$
48 - 300	1.291	22.06	0.05852
300 - 6000	$0.02619*f^{0.6834}$	$3.142*f^{0.3417}$	$0.008335*f^{0.3417}$
6000 - 15000	10	61.4	0.163

Table A.6 – Health Canada Safety Code 6 General Public Limits