MAXIMUM PERMISSIBLE EXPOSURE REPORT (Measurement)

FOR THE

IRM-STAR
Model: OW3

Report No.: 108561-6

Date of issue: November 20, 2023

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The test data contained in this report documents the observed testing parameters pertaining to and are relevant for only the sample equipment tested in the agreed upon operational mode(s) and configuration(s) as identified herein. Compliance assessment remains the client's responsibility. This report may not be used to claim product endorsement by A2LA or any government agencies. This test report has been authorized for release under quality control from CKC Laboratories, Inc.

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Purpose:

To demonstrate compliance with United States, Canada, Australia and/or European Union RF Exposure requirements for Mobile Equipment (devices used >20cm from the body), where MPE measurements apply.

Device and Antenna Operating Configuration:

Device operating at maximum output power with continuous transmission of modulated data.

The ISM radio was investigated with 3 antenna configurations, the configuration tables for the particular model numbers. Configuration 1 is for a small, attached salt-shaker style antenna. Configuration 2 is for a remotely located 5.5dBi antenna. Configuration 3 is for a larger 8.15dBi remotely located antenna (with attached attenuators to simulate the minimum cable loss as documented in the configuration table). The field strength was investigated and the 25kHz modulation was found to be representative of worst case.

The cellular radio for this device always has 2 x saltshaker style antennas attached. At time of test, bands 4 and 5 were found to be representative of worst case for field strength, and separate investigations were performed along with a simultaneous transmission of the ISM radio. Band 2 was not able to operate at time of test. The other bands able to operate for an investigation were bands 12, 13, 14, 17, and 66.

The maximum field strength investigated around the unit at a 20cm distance for Configuration 1, and band 5 was found to be representative of worst case along with the 25kHz modulation enabled on the ISM radio. The measurement was repeated for Configuration 2 and 3, with the antennas moved around the main chassis find the worst-case field strength when the probe is 20cm away. The antennas were moved to all sides as well as varied in elevation relative to the main chassis. In actual use, the remote ISM antennas will not be this close to the main chassis and typically be 6 feet away per a professional installation, but it was investigated as a possible worst-case scenario.

The worst-case field strength was used to calculate the power density.

Test Procedure:

This equipment is evaluated in accordance with the guidelines set forth in KDB 447498 & ANSI C95.1 for the US, Health Canada Safety Code 6 & RSS 102 for Canada, ARPANSA RPS3 for AU and EN 62479 or EN 62311 for EU.

Other Considerations:

Report considers stand-alone configuration only. RF Exposure limits are calculated at the worst case mid-point of each operating band. Multi-transmitter devices are assumed to permit simultaneous transmission, unless indicated otherwise. Simultaneous transmissions were considered and measured.

Referenced Test Reports:

The following test reports were referenced in conjunction with this assessment:

108561-3
108561-4
58363_WP7610 (RF Exposure report for cellular module FCC ID: N7NWP7610, IC: 2417C-WP7610)

EQUIPMENT UNDER TEST (EUT)

During testing, numerous configurations may have been utilized. The configurations listed below support compliance to the standard(s) listed in the Summary of Results section.

Configuration 1

Equipment Tested:

Device	Manufacturer	Model #	S/N
IRM-STAR	Itron, Inc.	OW3	354233798

Support Equipment:

Device	Manufacturer	Model #	S/N
Integrated Multi-purpose Antenna	Cisco	ANT-5G-MP-OUT-N	NA
Integrated Multi-purpose Antenna	Cisco	ANT-5G-MP-OUT-N	NA
Laptop	Dell	Latitude E6430	NA
Integrated Multi-purpose Antenna	Cisco	ANT-5G-MP-OUT-N	NA
Router Host	Cisco	IR8140H	NA

Configuration 2

Equipment Tested:

Device	Manufacturer	Model #	S/N
IRM-STAR	Itron, Inc.	OW3	354233798

Support Equipment:

Device	Manufacturer	Model #	S/N
Integrated Multi-purpose Antenna	Cisco	ANT-5G-MP-OUT-N	NA
Integrated Multi-purpose Antenna	Cisco	ANT-5G-MP-OUT-N	NA
Laptop	Dell	Latitude E6430	NA
Antenna (5.5 dBi remote ISM)	PCTEL	BOA9025NM-ITR	NA
Router Host	Cisco	IR8140H	NA

Configuration 3

Equipment Tested:

Device	Manufacturer	Model #	S/N
IRM-STAR	Itron, Inc.	OW3	354233798

Support Equipment:

Device	Manufacturer	Model #	S/N
Integrated Multi-purpose Antenna	Cisco	ANT-5G-MP-OUT-N	NA
Integrated Multi-purpose Antenna	Cisco	ANT-5G-MP-OUT-N	NA
Laptop	Dell	Latitude E6430	NA
Antenna (8.15 dBi remote ISM)	PCTEL	BOA9028	NA
1dB Attenuator (Qty: 2)	Mini-Circuits	15542 UNAT-1+	NA
Surge Protector	Times Microwave Systems	LP-BTRW-NMP	NA
Router Host	Cisco	IR8140H	NA

MPE Measurements

Operational Details					
Power Reported is:	☒ Peak ☐ Average				
Limit Used is:	☒ General Population ☐ Occupational Exposure				
Operating Band MHz	**Power dBm**	**Ant Type/Max Gain dBi**	**EIRP dBm**	**TX Simultaneous**	**Antenna Configuration**
699-1910MHz (LTE Bands 2, 4, 5, 12, 13, 14, 17, 66)	24.5	5.5	30.0	Yes	2 x identical attached external antennas 617-960MHz Gain = 2.0dBi 1710-5924MHz Gain = 5.5dBi
902-928MHz (ISM)	26.0	5.5	31.5	Yes	3 options: 1 x external attached 2.0dBi 1 x external remote 5.5dBi 1 x external remote 8.15dBi (requires 3dB of cable loss/attenuators to be attached)

Test Equipment					
Asset	**Description**	**Manufacturer**	**Model**	**Cal Date**	**Cal Due**
P07824	USB to Fiber Optic Interface	ETS-Lindgren	HI-4413USB	11/24/2021	11/24/2023
03620	Field Probe	ETS	HI-6053	3/20/2023	3/20/2025

MPE Measurements for Static Fields (Free Space Configuration) - US

For equipment where the fields are invariant in time, measurements are performed at a fixed height between 1.0m to 1.8mrepresenting worst case measurements as determined by preliminary assessment.

Configuration	Distance (m)	Height (m)	Measured Exposure mW/cm^2	Limit mW/cm^2 (selected from worst case LTE mid band of 707.5MHz)	Result
1	0.2	1m (bottom of unit)	0.11	0.47	Pass
2	0.2	1.45m (ISM antenna was moved to put the area with the maximum field strength in line with cell antennas)	0.11	0.47	Pass
3	0.2	1.45m (ISM antenna was moved to put the area with the maximum field strength in line with cell antennas)	0.05	0.47	Pass

MPE Measurements for Static Fields (Free Space Configuration) - Canada

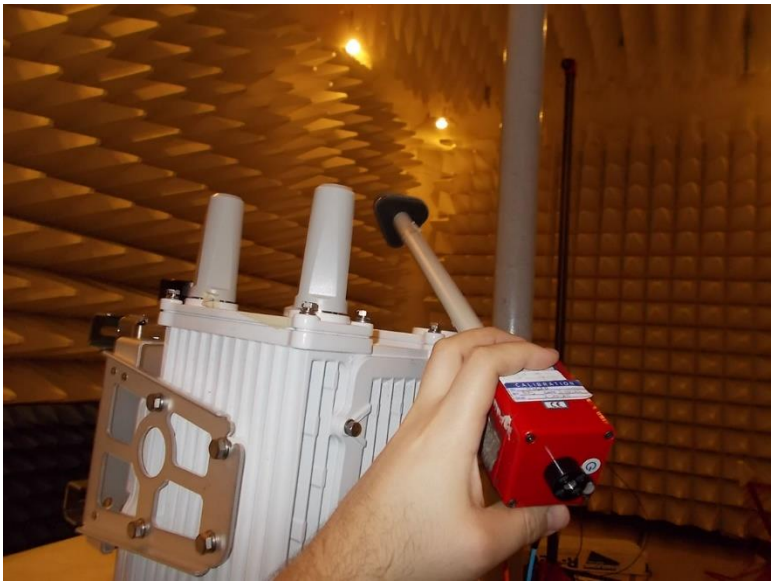
For equipment where the fields are invariant in time, measurements are performed at a fixed height between 1.0m to 1.8mrepresenting worst case measurements as determined by preliminary assessment.

Configuration	Distance (m)	Height (m)	Measured Exposure W/m^2	Limit W/m^2 (selected from worst case LTE mid band of 707.5MHz)	Result
1	0.2	1m (bottom of unit)	1.1	2.32	Pass
2	0.2	1.45m (ISM antenna was moved to put the area with the maximum field strength in line with cell antennas)	1.1	2.32	Pass
3	0.2	1.45m (ISM antenna was moved to put the area with the maximum field strength in line with cell antennas)	0.5	2.32	Pass

Approximate Probe Positions

Configuration 1

Configuration 2



Configuration 3

Summary:

MPE Measurement Results:

Equipment demonstrating compliance with MPE measurement have been evaluated for use under mobile RF exposure configurations as identified herein. Additional configurations including collocation or simultaneous transmission with other transmitters (including necessary separation distances) are subject to further assessment. It is assumed that the manufacturer shall design the equipment such that the minimum separation distance of 20cm (or greater, as listed above) is met or that the manufacturer provides a protection guide (e.g. installation instructions) to the end user such that the antenna(s) may be installed in accordance with the manufacturer's instructions in such a manor to maintain the minimum separation distance.

General Comments:

The absorption and distribution of Electromagnetic energy in the body is a very complex phenomena that depends on the mass, shape, and physiological condition of the body; the orientation of the body with respect to the fields; and the electrical properties of the body and the environment. Variables that may play a substantial role in possible biological effects are those that characterize the environment (including but not limited to: ambient temperature, air velocity, relative humidity, and body insulation); and those that characterize the individual (including but not limited to: age, gender, activity level and existing debilitation or disease). Because innumerable factors may interact to determine specific biological effects of exposure to electromagnetic fields, any protection guide should consider both intended and unintended operational environments and provide guidance for installation and use of the product such that proper separation distances can be maintained. (ANSI C95.1).

APPENDIX A - Assessment Procedure

Test Configuration

The EUT antenna is placed in a configuration typical of normal installation. Where antenna mounting is required, non-conductive materials are used for support structures. In the special case of magnetically mounted vehicle antennas, a reference ground plane is used to simulate actual installation. In order to limit external interference effects, the test is performed in a semi-anechoic chamber. The EUT equipment is setup in a configuration representative of normal use. Support equipment for the measurement instruments are located outside of the testing area.

Test Procedure

Measurements are performed using a broadband detector with three orthogonal measurement axes. Values recorded are RMS based on the maximum measurements. To determine the direction of the maximum measurement, the detector is moved throughout the RF field generated by the transmit antenna. The detector is positioned at a minimum of 12 radials and at varying distances from the antenna along each radial. The area of maximum RF energy determined during preliminary investigation shall be used for the remainder of the tests. In the case where a transmitter may have multiple frequency bands, the preliminary investigation shall be repeated for each band.

For time varying fields, the appropriate averaging time is used. For spatially uniform fields, the measurement height is selected based on maximum preliminary measurements.

For spatially non-uniform fields (e.g., distances close to a magnetically mounted vehicle antenna), spatial averaging may be performed. The method for performing spatially averaged measurements is as follows:

1. Determine the direction of the maximum measurement.
2. At a specific distance measure vertically from the floor 5 points comprising a linear cross section of an adult human body, beginning at 0.2m and at each 40cm up to 1.8m.
3. Calculate the average of the measurements and compare with the established limit.

Since the applicable limits exist in several different measurement units, the following outlines the most common calculations used for determining the spatially averaged field.

Case 1: Where limits are applied in electric field strength (V/m), the spatially averaged electric field strength along a grid of *n* points is calculated using:

$$E = \left[\frac{1}{n} \sum_{i=1}^{n} E_i^2 \right]^{\frac{1}{2}}$$

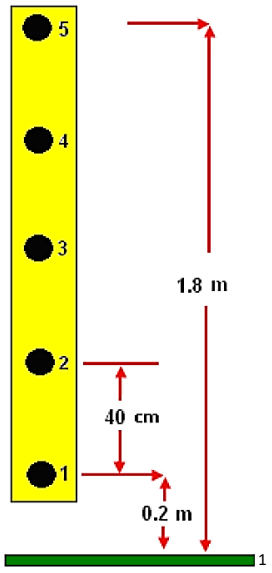
Case 2: Where limits are applied in units of power density (mW/cm^2), assuming measurements are made in the far field, where the E and H vectors are mutually orthogonal, power density is first calculated using:

$$S = \frac{E^2}{3770}$$

And the spatially averaged power density along a grid of n points is calculated using:

$$S = \frac{1}{n}\sum_{i=1}^{n} S_i$$

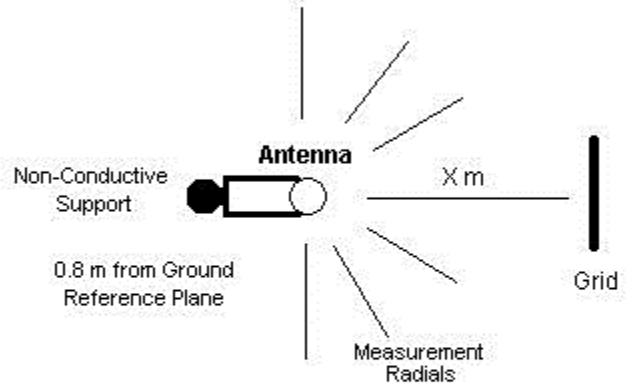
The following diagram is an example of the grid used to perform local measurements for RF exposure evaluation over a whole-body spatial average.



The following diagram is an example of the setup used for most tests, excluding magnetically mounted vehicle antennas.

Setup Used for RF Evaluation Measurements

(excluding magnetically mounted vehicle antennas)

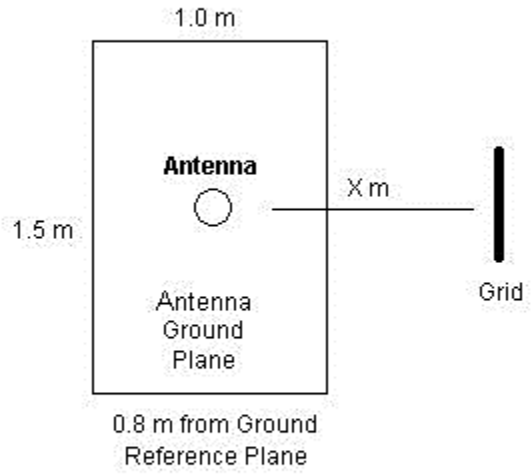


Top View

[1] Source: IC GL-01

The following diagram is an example of the setup used for vehicle-mounted antennas. In the case where vehicle glass mounted antennas are used, this setup shall not apply. The letter X represents the test distance used for RF exposure measurements. The distance X is measured from the phase center of the transmitting antenna to the volumetric center of the measurement instrument. In order to more accurately simulate normal installation, the antenna ground plane is not bonded to the ground reference plane. The transmitting antenna is placed in the center of the antenna ground plane.

Setup Used for Vehicle-Mounted Antennas



Top View

APPENDIX B - RF Exposure Limits

United States Compliance Requirements (1.1310):

RF Exposure Evaluation Limits
Occupational / Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Averaging Time (minutes)
0.3-3.0	614	1.63	*(100)	6
3.0-30	1842/f	4.89/f	*($900/f^2$)	6
30-300	61.4	0.163	1	6
300-1500	---	---	f/300	6
1500-100,000	---	---	5.0	6

RF Exposure Evaluation Limits
General Population / Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Averaging Time (minutes)
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*($180/f^2$)	30
30-300	27.5	0.073	0.2	30
300-1500	---	---	f/1500	30
1500-100,000	---	---	1.0	30

** Plane wave equivalent power density*
Limit is calculated based on the mid-band frequency used in the operating frequency range.

Stand-Alone Evaluation Exemption Levels:
In accordance with KDB 447498 D01 v05r02

	Max Output Power at Exemption Limit (mW)	
Frequency (MHz)	*d ≤ 50mm*	*50mm < d ≤ 20cm*
<100	$\frac{1}{2}\cdot\left(\frac{R\cdot 50}{\sqrt{0.1}}\right)\cdot\left(1+LOG\left(\frac{100}{f_{MHz}}\right)\right)$	$\left(\frac{R\cdot 50}{\sqrt{0.1}}+(d-50)\frac{100}{150}\right)\cdot\left(1+LOG\left(\frac{100}{f_{MHz}}\right)\right)$
100-1500	$\left(\frac{R\cdot d}{\sqrt{f_{GHz}}}\right)$	$\left(\frac{R\cdot 50}{\sqrt{f_{GHz}}}+(d-50)\frac{f_{MHz}}{150}\right)$
1500-6000		$\left(\frac{R\cdot 50}{\sqrt{f_{GHz}}}+(d-50)\cdot 10\right)$

R is the allowed ratio: 3 for 1-g SAR and 7.5 for 10-g extremity SAR.
d is distance in mm, rounded to the nearest mm.

Canadian Compliance Requirements (RSS-102):

RF Exposure Evaluation Limits
Occupational / Controlled Exposure:

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (W/m^2)	Averaging Time (minutes)
0.003-10	170	180	--	Instantaneous
0.1-10	--	1.6 / f	--	6
1.29-10	$193 / f^{0.5}$	--	--	6
10-20	61.4	0.163	10	6
20-48	$129.8 / f^{0.5}$	$0.3444 / f^{0.25}$	$44.72 / f^{0.5}$	6
48-100	49.33	0.1309	6.455	6
100-6000	$15.60\ f^{0.25}$	$0.04138\ f^{0.25}$	$0.6455\ f^{0.5}$	6
6000-15000	137	0.364	50	6
15000-150,000	137	0.364	50	$616000 / f^{1.2}$
150,000-300,000	$0.354\ f^{0.5}$	$9.40x10^{-4}\ f^{0.5}$	$3.33x10^{-4}\ f$	$616000 / f^{1.2}$

RF Exposure Evaluation Limits
General Population / Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (W/m^2)	Averaging Time (minutes)
0.003-10	83	90	--	Instantaneous
0.1-10	--	0.73 / f	--	6
1.1-10	$87 / f^{0.5}$	--	--	6
10-20	27.46	0.0728	2	6
20-48	$58.07 / f^{0.25}$	$0.1540 / f^{0.25}$	$8.944 / f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142\ f^{0.3417}$	$0.008335\ f^{0.3417}$	$0.02619\ f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150,000	61.4	0.163	10	$616000 / f^{1.2}$
150,000-300,000	$0.158\ f^{0.5}$	$4.21x10^{-4}\ f^{0.5}$	$6.67x10^{-5}\ f$	$616000 / f^{1.2}$

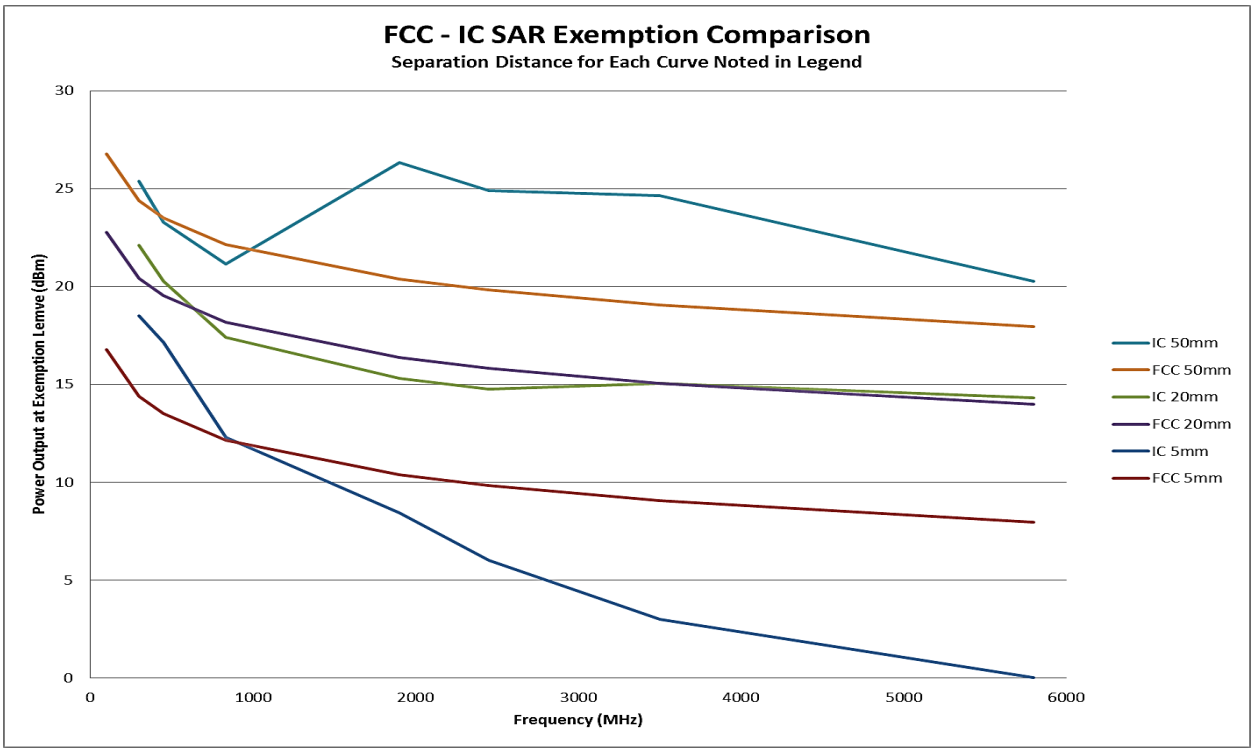
Stand-Alone Evaluation Exemption Levels:

Exemption Limits (mW) at Separation Distance (mm)										
Freq(MHz)	**≤5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**≥50**
≤300	71	101	132	162	193	223	254	284	315	345
450	52	70	88	106	123	141	159	177	195	213
835	17	30	42	55	67	80	92	105	117	130
1900	7	10	18	34	60	99	153	225	316	431
2450	4	7	15	30	52	83	123	173	235	309
3500	2	6	16	32	55	86	124	170	225	290
5800	1	6	15	27	41	56	71	85	97	106

Stand-Alone Evaluation Exemption Levels:

Frequency (MHz)	RF Exposure Exemption Limit (mW)
<20	1000
20-48	$22480 / f^{0.5}$
48-300	600
300-6000	$1310\ f^{0.6834}$
≥6000	5000

General[2] Comparison of FCC and IC Exemption Limits



[2] Non-Exhaustive

Australian Radiation Protection and Nuclear Safety Agency Requirements (ARPANSA):

RF Exposure Evaluation Limits
Occupational / Controlled Exposure:

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (W/m^2)	Averaging Time (minutes)
0.1 – 1.0	614	1.63/f	---	6
1.0-10	614/f	1.63/f	$1000/f^2$	6
10-400	61.4	0.163	10	6
400-2000	$3.07 * f^{0.5}$	$0.00814 * f^{0.5}$	f/40	6
2000-10,000	137	0.36	50	6
10,000 – 300,000	137	0.36	50	$9.6x10^4 / f^{1.05}$

RF Exposure Evaluation Limits
General Population / Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (W/m^2)	Averaging Time (minutes)
0.10-0.15	86.8	4.86	---	6
0.150-1.0	86.8	0.729/f	--	6
1.0-10	$86.8/f^{0.5}$	0.729/f	---	6
10-400	27.4	0.0729	2	6
400-2000	$1.37 f^{0.5}$	$0.00364*f^{0.5}$	f/200	6
2000-10,000	61.4	0.163	10	6
10,000 – 300,000	61.4	0.163	10	$9.6x10^4 / f^{1.05}$

**Power density limit applicable >100MHz*

Stand-Alone Evaluation Exemption Levels:

Occupational Exposure: 100mW
Portable - General Public: 20mW
Mobile – General Public: Separation distance >20cm and power < ARPANSA RPS3 Table S2
Or according to ARPANSA RPS3 Table S1

Table S2

Operating Frequency (MHz)	Nominal Mean Power Output (W)
0.1-450	7
450-2500	3150 / f

European Union Compliance Requirements (ICNIRP):

RF Exposure Evaluation Limits
Occupational / Controlled Exposure:

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (W/m^2)	Averaging Time (minutes)
0.00082-0.065	610	24.4	---	6
0.065-1.0	610	1.6/f	---	6
1.0-10	610/f	1.6/f	---	6
10-400	61	0.16	10	6
400-2000	$3.0 * f^{0.5}$	$0.008 * f^{0.5}$	f/40	6
2000-300,000	137	0.36	50	6

RF Exposure Evaluation Limits
General Population / Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (W/m^2)	Averaging Time (minutes)
0.003-0.150	87	5.0	---	6
0.150-1.0	87	0.73/f	--	6
1.0-10	$87/f^{0.5}$	0.73/f	---	6
10-400	28	0.073	2	6
400-2000	$1.375\ f^{0.5}$	$0.0037*f^{0.5}$	f/200	6
2000-300,000	61	0.16	10	6

**Power density limit applicable >100MHz*

Stand-Alone Evaluation Exemption[3] Levels:
Head / Body: 20mW
Extremity: 40mW

[3] EN 62479 Annex A, General Public

APPENDIX C - References

1. ACMA Radiocommunications (Electromagnetic Radio – Human Exposure) Standard, 2014.
2. AS/NZS 2772.2, Radiofrequency fields – Principles and method of measurement and computation – 3 kHz to 300 GHz, 2011.
3. Australian Radiation Protection and Nuclear Safety Agency, ARPANSA RPS 3, Maximum Exposure Levels to Radiofrequency Fields 3 kHz to 300 GHz, 2002 (&Errata, 2003).
4. New Zealand Standard, NZS 2772.1, Radiofrequency Fields Part 1: Maximum Exposure Levels 3 kHz to 300 GHz, 2009.
5. Federal Communications Commission Knowledge Database (KDB) Publication 447498, "What are the RF exposure requirements and procedures for mobile and portable devices?" As in effect on the issue date of this report.
6. Title 47 Code of Federal Regulations, Part 1.1310, "Radiofrequency radiation exposure limits." As in effect on the issue date of this report.
7. Title 47 Code of Federal Regulations, Part 2.1091, "Radiofrequency radiation exposure evaluation: mobile devices." As in effect on the issue date of this report.
8. ANSI C95.1 (2005) IEEE Standard for Safety Level with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300 GHz, 2005.
9. Health Canada Safety Code 6 Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz, 2015.
10. Industry Canada GL-01 Guidelines for the Measurement of Radio Frequency Fields at Frequencies From 3 kHz to 300 GHz, Issue 3, March 2015.
11. Industry Canada RSS-102 Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands), Issue 5, March 2015.
12. EC Council Recommendation 1999/519/EC "On the limitation of exposure of the general public to electromagnetic fields (0Hz to 300GHz)," (1999).
13. European Committee for Electrotechnical Standardization. European Normative, EN 62311 Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz to 300 GHz), 2008.
14. European Committee for Electrotechnical Standardization. European Normative, EN 62479 Assessment of the compliance of low power electronic and electrical equipment with the basic restrictions related to human exposure to electromagnetic fields (10 MHz to 300 GHz), 2010.
15. International Commission on Non-Ionizing Radiation Protection. Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz). Health Physics 74 (4): 494-522; 1998.
16. International Commission on Non-Ionizing Radiation Protection Statement on the "Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz). Health Physics 97(3):257-259, 2009.