

RF exposure evaluation: 2.1091 Mobile devices / KDB 447498/ RSS-102 2.5.2 and 2.1093 Portable devices / KDB 447498/ RSS-102 2.5.1

Date	Temperature	Humidity
2017-12-18	22 °C ± 3 °C	25 % ± 5 %
2017-12-21	22 °C ± 3 °C	31 % ± 5 %

Procedure

Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess limit for maximum permissible exposure.

In accordance with 47 CFR FCC Part 2 Subpart J, section 2.1091 and RSS-102 2.5.2 this device has been defined as a mobile device (EUT 1) whereby a distance of 20 cm can be maintained between the user and the device.

In accordance with 47 CFR FCC Part 2 Subpart J, section 2.1093 and RSS-102 2.5.1 this devices (EUT 2) have been defined as a portable device to be used within 20 centimetres of the body of the user.

According to KDB 447498 D01 General RF Exposure Guidance v06.

Results

Mobile devices: EUT 1:

The following formula was used to calculate the RF exposure,

$$Pd = Pout \times G / (4 \times \pi \times r^2_{cm})$$

where,

Pd = power density in mW/cm²

Pout = Maximum output power measured with RMS detector, in mW

G = gain of antenna in linear scale

$\pi = 3.1416$

r = distance between observation and center of the radiator in cm

From the peak EUT RF output power, the minimum mobile separation distance, r=20 cm, as well as the gain of the used antenna, the RF power density can be obtained.

The maximum radiated RMS output power from page 64 was used for calculation of Maximum Permissible Exposure, MPE.

EUT 1:

Frequency f, (MHz)	Antenna Gain (dBi)	Antenna Gain (numeric)	EIRP RMS output power (dBm)	Pout (dBm) acc. to soured -based time averaging	Pout (mW)	Power density, Pd [S] (mW/cm ²)	Limit of power density (mW/cm ²)
2405 Note 1	Note 2	Note 2	-14.4 Note 3	-64.9 Note 4	6.45x10 ⁻⁷ Note 5	1.28x10⁻¹⁰ Note 2, 6	1.0

- Note 1: Only the frequency with the highest RMS value, 80.8 dBμV/m, is noted.
- Note 2: The antenna gain is not used in the MPE calculation as the EIRP value (including the antenna) is used.
- Note 3: The measurements were performed in field strength in dBμV/m. The EIRP level was then calculated by the formula $P = (Exd)^2/30 \times G$, with G as unity gain of 1.
- Note 4: The highest measured duty cycle (worst case) in normal operating according duty cycle section was 0.003%, thus the duty cycle correction was calculated (dB=20 log duty cycle) to -50.5 dB).
- Note 5: According to RSS-102 cl. 2.5.1 the RMS value shall be adjusted for tune-up tolerance. According to the client the tune-up tolerance was declared to ±3 dB, thus the values at Note 4 were increased with 3 dB to -61.9 dBm.
- Note 6: As the Power density value was very low, a complementary calculation as a Portable/SAR exclusion was presented, see below.

Portable devices: EUT 1:

Standalone SAR exclusion:

The maximum radiated RMS output power from page 64 was used for calculation.

Frequency f, (GHz) Note 1	EIRP RMS output power (dBm) Note 2	Pout (dBm) acc. to soured-based time averaging Note 3	Peak output power (mW) Note 4
2.405	-14.4	-64.9	6.45×10^{-7}

- Note 1: Only the frequency with the highest RMS value, 80.8 dBμV/m, is noted.
- Note 2: The measurements were performed in field strength in dBμV/m. The EIRP level was then calculated by the formula $P = (Exd)^2/30 \times G$, with G as unity gain of 1.
- Note 3: The highest measured duty cycle (worst case) in normal operating according duty cycle section was 0.003%, thus the duty cycle correction was calculated (dB=20 log duty cycle) to -50.5 dB).
- Note 4: According to RSS-102 cl. 2.5.1 the RMS value shall be adjusted for tune-up tolerance. According to the client the tune-up tolerance was declared to ±3 dB, thus the value at Note 3 were increased with 3 dB to -61.9 dBm.

Step a):

The following formula was used to calculate the RF exposure SAR exclusion threshold,
 $Thld = [P_{out} / r] \times [\sqrt{f}]$

where,

Thld= SAR exclusion threshold

Pout = Maximum output power measured with RMS detector, in mW

r = minimum test separation distance, in mm

f=frequency, in GHz

Frequency f, (GHz)	Pout, (mW)	Distance r, (mm)	Exclusion threshold Thld	Limit Threshold 1-g SAR	Limit Threshold 10-g SAR
2.405	6.45×10^{-7}	5	2.00×10^{-7}	< 3	< 7.5

Portable devices: EUT 2:

Standalone SAR exclusion:

The maximum radiated RMS output power from page 64 was used for calculation.

Frequency f, (GHz) Note 1	EIRP RMS output power (dBm) Note 2	Pout (dBm) acc. to soured-based time averaging Note 3	Peak output power (mW) Note 4
2.405	-12.9	-46.4	4.57×10^{-5}

Note 1: Only the frequency with the highest RMS value, 82.3 dB μ V/m, is noted.

Note 2: The measurements were performed in field strength in dB μ V/m. The EIRP level was then calculated by the formula $P = (Exd)^2 / 30 \times G$, with G as unity gain of 1.

Note 3: The highest measured duty cycle (worst case) in normal operating according duty cycle section was 0.021%, thus the duty cycle correction was calculated (dB=20 log duty cycle) to -33.5 dB).

Note 4: According to RSS-102 cl. 2.5.1 the RMS value shall be adjusted for tune-up tolerance. According to the client the tune-up tolerance was declared to ± 3 dB, thus the value at Note 3 were increased with 3 dB to -43.4 dBm.

Step a):

The following formula was used to calculate the RF exposure SAR exclusion threshold,
 $Thld = [P_{out} / r] \times [\sqrt{f}]$

where,

Thld= SAR exclusion threshold

Pout = Maximum output power measured with RMS detector, in mW

r = minimum test separation distance, in mm

f=frequency, in GHz

Frequency f, (GHz)	Pout, (mW)	Distance r, (mm)	Exclusion threshold Thld	Limit Threshold 1-g SAR	Limit Threshold 10-g SAR
2.405	4.57×10^{-5}	5	1.42×10^{-4}	< 3	< 7.5

Limits

Mobile devices: EUT 1:

Limits for Maximum Permissible Exposure (MPE)

(A) Limits for Occupational/Controlled Exposure

Frequency range (MHz)	Electric field strength [E] (V/m)	Magnetic field strength [H] (A/m)	Power density [S] (mW/cm ²)	Averaging time E ² , H ² or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	(900/f)*	6
30-300	61.4	0.163	1.0	6
300-1500			F/300	6
1500-100,000			5	6

(B) Limits for General Population/Uncontrolled Exposure

Frequency range (MHz)	Electric field strength [E] (V/m)	Magnetic field strength [H] (A/m)	Power density [S] (mW/cm ²)	Averaging time E ² , H ² or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	(180/f)*	30
30-300	27.5	0.073	0.2	30
300-1500			F/1500	30
1500-100,000			1.0	30

Note: f=frequency in MHz, *Plane-wave equivalent power density

IC RSS-102 Issue 5 cl. 2.5.2 Exemption from Routine Evaluation – RF Exposure Evaluation

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device’s radiating element is greater than 20 cm, except when the device operates as follows:

- below 20 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $4.49/f^{0.5}$ W (adjusted for tune-up tolerance), where *f* is in MHz;
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
- **at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834}$ W (adjusted for tune-up tolerance), where *f* is in MHz (2.73 W);**
- at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

Rev 1: 2018-06-26

In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the e.i.r.p. was derived.

Portable devices: EUT 1 and EUT 2:

FCC 2.1093 / KDB 447498 D01 General RF Exposure Guidance v06

4.3.1 Standalone SAR exclusion:

a) The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

$[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] \times [\sqrt{f(\text{GHz})}] \leq 3.0$ for 1-g SAR and ≤ 7.5 for 10-g extremity SAR, where

- $f(\text{GHz})$ is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

b) At 100 MHz to 6 GHz and for test separation distances > 50 mm, the SAR test exclusion threshold is determined according to the following, and as illustrated in Appendix B.

a) [Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50 mm) \cdot x ($f(\text{MHz})/150$)] mW, at 100 MHz to 1500 MHz

b) [Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50 mm) \cdot x 10] mW at > 1500 MHz and ≤ 6 GHz

c) At frequencies below 100 MHz, the following may be considered for SAR test exclusion, and as illustrated in Appendix C:

a) The power threshold at the corresponding test separation distance at 100 MHz in step 2) is multiplied by $[1 + \log(100/f(\text{MHz}))]$ for *test separation distances* > 50 mm and < 200 mm

b) The power threshold determined by the equation in a) for 50 mm and 100 MHz is multiplied by $\frac{1}{2}$ for *test separation distances* ≤ 50 mm

c) SAR measurement procedures are not established below 100 MHz. When SAR test exclusion cannot be applied, a KDB inquiry is required to determine SAR evaluation requirements for any test results to be acceptable.

IC RSS-102 Issue 5 cl. 2.5.1 Exemption from Routine Evaluation Limits – SAR Evaluation

SAR evaluation is required if the separation distance between the user and/or bystander and the antenna and/or radiating element of the device is less than or equal to 20 cm, except when the device operates at or below the applicable output power level (adjusted for tune-up tolerance) for the specified separation distance defined in Table 1.

Table 1: SAR evaluation – Exemption limits for routine evaluation based on frequency and separation distance

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of 30 mm	At separation distance of 35 mm	At separation distance of 40 mm	At separation distance of 45 mm	At separation distance of ≥50 mm
≤300	223 mW	254 mW	284 mW	315 mW	193 mW
450	141 mW	159 mW	177 mW	195 mW	123 mW
835	80 mW	92 mW	105 mW	117 mW	67 mW
1900	99 mW	153 mW	225 mW	316 mW	60 mW
2450	83 mW	123 mW	173 mW	235 mW	52 mW
3500	86 mW	124 mW	170 mW	225 mW	55 mW
5800	56 mW	71 mW	85 mW	27 mW	41 mW

Output power level shall be the higher of the maximum conducted or equivalent isotropically radiated power (e.i.r.p.) source-based, time-averaged output power. For controlled use devices where the 8 W/kg for 1 gram of tissue applies, the exemption limits for routine evaluation in Table 1 are multiplied by a factor of 5. For limb-worn devices where the 10 gram value applies, the exemption limits for routine evaluation in Table 1 are multiplied by a factor of 2.5. If the operating frequency of the device is between two frequencies located in Table 1, linear interpolation shall be applied for the applicable separation distance. For test separation distance less than 5 mm, the exemption limits for a separation distance of 5 mm can be applied to determine if a routine evaluation is required.

For medical implants devices, the exemption limit for routine evaluation is set at 1 mW. The output power of a medical implants device is defined as the higher of the conducted or e.i.r.p to determine whether the device is exempt from the SAR evaluation.

For medical implants devices, the exemption limit for routine evaluation is set at 1 mW. The output power of a medical implants device is defined as the higher of the conducted or e.i.r.p to determine whether the device is exempt from the SAR evaluation.

Test engineers: Fredrik Isaksson and Markel Bertilsson

Complies?	Yes
-----------	-----