

## 7.3 MAXIMUM PERMISSIBLE EXPOSURE

### LIMITS for FCC RF Exposure Evaluation

§1.1310 The criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

| Frequency range (MHz)                                   | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density (mW/cm <sup>2</sup> ) | Averaging time (minutes) |
|---------------------------------------------------------|-------------------------------|-------------------------------|-------------------------------------|--------------------------|
| (A) Limits for Occupational/Controlled Exposures        |                               |                               |                                     |                          |
| 0.3–3.0 .....                                           | 614                           | 1.63                          | *(100)                              | 6                        |
| 3.0–30 .....                                            | 1842/f                        | 4.89/f                        | *(900/f <sup>2</sup> )              | 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 |                               |                               |                                     |                          |
| 0.3–1.34 .....                                          | 614                           | 1.63                          | *(100)                              | 30                       |
| 1.34–30 .....                                           | 824/f                         | 2.19/f                        | *(180/f <sup>2</sup> )              | 30                       |

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

| Frequency range (MHz) | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density (mW/cm <sup>2</sup> ) | Averaging time (minutes) |
|-----------------------|-------------------------------|-------------------------------|-------------------------------------|--------------------------|
| 30–300 .....          | 27.5                          | 0.073                         | 0.2                                 | 30                       |
| 300–1500 .....        | .....                         | .....                         | f/1500                              | 30                       |
| 1500–100,000 .....    | .....                         | .....                         | 1.0                                 | 30                       |

f = frequency in MHz

\* = Plane-wave equivalent power density

NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

### LIMITS for FCC SAR Evaluation

#### KDB 447498 D04 Interim General RF Exposure Guidance v01, section 2.1.3 SAR-Based Exemption:

“A more comprehensive exemption, considering a variable power threshold that depends on both the *separation distance* and power, is provided in § 1.1307(b)(3)(i)(B). This exemption is applicable to the frequency range between 300 MHz and 6 GHz, with *test separation distances* between 0.5 cm and 40 cm, and for all RF sources in fixed, mobile, and portable device exposure conditions.”

For 100 MHz to 6 GHz and test separation distances ≤ 50 mm, the 1-g and 10-g SAR test exclusion thresholds are determined by the following:

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

FCC KDB 447498 D01 General RF Exposure Guidance v06, section 4.3.1 & Appendix A provides the SAR Test Exclusion Thresholds (ERP/Conducted) to verify that the device is exempt from 1-g extremity SAR at different separation distances. As example, for 900MHz Tx: 16mW (12dBm); For 2450MHz Tx: 10mW (10dBm) at ≤5 mm.

Details in calculation formula for reference, given in § 1.1307(b)(3)(i)(B) to calculate the exemption:

$$P_{th} \text{ (mW)} = \begin{cases} ERP_{20 \text{ cm}} (d/20 \text{ cm})^x & d \leq 20 \text{ cm} \\ ERP_{20 \text{ cm}} & 20 \text{ cm} < d \leq 40 \text{ cm} \end{cases}$$

Where

$$x = -\log_{10} \left( \frac{60}{ERP_{20 \text{ cm}} \sqrt{f}} \right) \text{ and } f \text{ is in GHz;}$$

and

$$ERP_{20 \text{ cm}} \text{ (mW)} = \begin{cases} 2040f & 0.3 \text{ GHz} \leq f < 1.5 \text{ GHz} \\ 3060 & 1.5 \text{ GHz} \leq f \leq 6 \text{ GHz} \end{cases}$$

$d$  = the separation distance (cm);

#### LIMITS per ISSED RSS-102 (issue 6)

##### Section 6.3 & Table 11 for Exemption Limits for Routine Evaluation — SAR Evaluation

**Table 11: Power limits for exemption from routine SAR evaluation based on the separation distance**

| Frequency (MHz) | ≤ 5 mm (mW) | 10 mm (mW) | 15 mm (mW) | 20 mm (mW) | 25 mm (mW) | 30 mm (mW) | 35 mm (mW) | 40 mm (mW) | 45 mm (mW) | > 50 mm (mW) |
|-----------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|--------------|
| ≤ 300           | 45          | 116        | 139        | 163        | 189        | 216        | 246        | 280        | 319        | 362          |
| 450             | 32          | 71         | 87         | 104        | 124        | 147        | 175        | 208        | 248        | 296          |
| 835             | 21          | 32         | 41         | 54         | 72         | 96         | 129        | 172        | 228        | 298          |
| 1900            | 6           | 10         | 18         | 33         | 57         | 92         | 138        | 194        | 257        | 323          |
| 2450            | 3           | 7          | 16         | 32         | 56         | 89         | 128        | 170        | 209        | 245          |
| 3500            | 2           | 6          | 15         | 29         | 50         | 72         | 94         | 114        | 134        | 158          |
| 5800            | 1           | 5          | 13         | 23         | 32         | 41         | 54         | 74         | 102        | 128          |

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.

*Example: Exclusion Thresholds to verify that the 2450MHz Tx is exempt from 1-g SAR at separation distance of ≤5 mm: 3mW (4.77dBm) & 10-g SAR at separation distance of ≤5 mm: 7.5mW (8.75dBm).*

### Section 5.3.2 Table 7&8 for Exemption Limits for Routine Evaluation – RF Exposure Evaluation (10MHz ro300GHz)

**Table 7: RF field strength and power density limits for devices used by the general public (uncontrolled environment)**

| Frequency range (MHz) | Electric field (V <sub>RMS</sub> /m) | Magnetic field (A <sub>RMS</sub> /m) | Power density (W/m <sup>2</sup> ) | Reference period (minutes) |
|-----------------------|--------------------------------------|--------------------------------------|-----------------------------------|----------------------------|
| 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                          |
| 15000-150000          | 61.4                                 | 0.163                                | 10                                | $616000 / f^{1.2}$         |
| 150000-300000         | $0.158 f^{0.5}$                      | $4.21 \times 10^{-4} f^{0.5}$        | $6.67 \times 10^{-5} f$           | $616000 / f^{1.2}$         |

Note:  $f$  is frequency in MHz.

**Table 8: RF field strength and power density limits for controlled-use devices (controlled environment)**

| Frequency range (MHz) | Electric field (V <sub>RMS</sub> /m) | Magnetic field (A <sub>RMS</sub> /m) | Power density (W/m <sup>2</sup> ) | Reference period (minutes) |
|-----------------------|--------------------------------------|--------------------------------------|-----------------------------------|----------------------------|
| 10-20                 | 61.4                                 | 0.163                                | 10                                | 6                          |
| 20-48                 | $129.8 / f^{0.25}$                   | $0.3444 / f^{0.25}$                  | $44.72 / f^{0.5}$                 | 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                          |
| 15000-150000          | 137                                  | 0.364                                | 50                                | $616000 / f^{1.2}$         |
| 150000-300000         | $0.354 f^{0.5}$                      | $9.40 \times 10^{-4} f^{0.5}$        | $3.33 \times 10^{-4} f$           | $616000 / f^{1.2}$         |

Note:  $f$  is frequency in MHz.

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.

## Summary

For FCC and IC, that max. declared power level can be modified by any duty cycle over the time averaging period. Time-averaging period is a time period not to exceed 30 minutes for fixed RF sources or a time period inherent from device transmission characteristics not to exceed 30 minutes for mobile and portable RF sources.

For rf exposure, the averaging period is 6 minutes for ISED Canada and for FCC it varies by frequency but 1~60 second for RF exposure or the period specified by product design spec. for RF exposure can be used.

So the power value for RF exposure= Declared power x Duty Cycle factor

### **CALCULATIONS for MPE distance and Power Density**

Given

$$E = \sqrt{(30 * P * G) / d}$$

and

$$S = E^2 / 3770$$

where

E = Field Strength in Volts/meter

P = Power in Watts

G = Numeric antenna gain

d = Distance in meters

S = Power Density in milliwatts/square centimeter

Combining equations and rearranging the terms to express the distance as a function of the remaining variables yields:

$$d = \sqrt{((30 * P * G) / (3770 * S))}$$

Changing to units of Power to mW and Distance to cm, using:

$$P(\text{mW}) = P(\text{W}) / 1000 \text{ and}$$

$$d(\text{cm}) = 100 * d(\text{m})$$

yields

$$d = 100 * \sqrt{((30 * (P / 1000) * G) / (3770 * S))}$$

$$d = 0.282 * \sqrt{(P * G / S)}$$

where

d = distance in cm

P = Power in mW

G = Numeric antenna gain

S = Power Density in mW/cm<sup>2</sup>

Substituting the logarithmic form of power and gain using: P

$$(\text{mW}) = 10^{(P(\text{dBm}) / 10)} \text{ and}$$

$$G(\text{numeric}) = 10^{(G(\text{dBi}) / 10)}$$

yields

$$d = 0.282 * 10^{((P + G) / 20)} / \sqrt{S}$$

Equation (1)

$$S = 0.0795 * 10^{((P + G) / 10)} / d^2$$

Equation (2)

where

d = MPE distance in cm

P = Power in dBm

G = Antenna Gain in dBi

S = Power Density Limit in mW/cm<sup>2</sup>

Equation (1) and the measured Output power is used to calculate the MPE distance.

Equation (2) and the measured Output power is used to calculate the Power density.

## APPLICABLE LIMITS

**RF MPE** for separation  $\geq 20\text{cm}$

FCC: From §1.1310 Table 1 (B), for Public  $S = 1.0 \text{ mW/cm}^2$  (for Professional,  $S = 5.0 \text{ mW/cm}^2$ )

Limits For Maximum Permissible Exposure (MPE)

| Frequency Range (MHz)                                 | Electric Field Strength (V/m) | Magnetic Field Strength (A/m) | Power Density ( $\text{mW/cm}^2$ ) | Average Time (minutes) |
|-------------------------------------------------------|-------------------------------|-------------------------------|------------------------------------|------------------------|
| Limits For General Population / Uncontrolled Exposure |                               |                               |                                    |                        |
| 300-1,500                                             | -                             | -                             | F/1500                             | 30                     |
| 1,500-100,000                                         | -                             | -                             | 1.0                                | 30                     |

IC: Per RSS-102, Sec. 5.3.2 Table 7,

Limits For Maximum Permissible Exposure (MPE)

| Frequency Range (MHz)                                 | Electric Field Strength (V/m) | Magnetic Field Strength (A/m) | Power Density ( $\text{W/m}^2$ ) | Average Time (minutes) |
|-------------------------------------------------------|-------------------------------|-------------------------------|----------------------------------|------------------------|
| Limits For General Population / Uncontrolled Exposure |                               |                               |                                  |                        |
| 48-300                                                | 22.06                         | 0.05852                       | 1.291                            | 6                      |
| 30-6000                                               | $3.142 \cdot f^{0.3417}$      | $0.008335 \cdot f^{0.3417}$   | $0.02619 \cdot f^{0.6834}$       | 6                      |

With formula of  $2.619 \times 10^{-2} f^{0.6834} \text{ W/m}^2$ , most restricted power density limit values are  $2.74 \text{ W/m}^2$  at 902MHz,  $5.34 \text{ W/m}^2$  at 2400MHz.

**SAR Exclusion Thresholds** for separation  $\leq 5\sim 40\text{cm}$ :

FCC : Use Formular in FCC § 1.1307(b)(3)(i)(B) & KDB 447498 D04

IC: Use RSS-102 Table11

Apply duty cycle factor & 2.5 factor for extremity or limb-worn devices

## RESULTS

No non-compliance noted.

For Hand-held /limb-worn usage: **SAR Exemption Evaluation Limit** (2.5 factor with 10-g extremity SAR) is ***10mW for separation distance of  $\leq 5$  mm, 17.5mW for 10mm separation distance for EUT frequency band: 2.405-2.480GHz.***

Duty Cycle: Based on EUT design document, total duty cycle factor (DCF) is 21.63%.

---For FCC, Conducted power=17mW. With DCF, it is 3.7mW.

--- For IC, EIRP=66mW. With DCF, it is 14.3mW.

According to the product design, minimum 10mm distance from antenna to user's hand/wrist is also well kept. See the attachment.

**Therefore, EUT design & power meets this minimum separation requirement for SAR test exclusion.**