

Test No.13

Name of Test:	Radio Frequency Exposure	Test Standard:	FCC OET Bulletin 65 & RSS-GEN
Tested By:	WEI LI	Test Date:	07/10/2023-07/31/2023

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 ²)	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 ²)	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 ²)	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 ²)	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 per 2.5.2 Exemption Limits for 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;
• 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).

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.

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: $P(\text{mW}) = P(\text{W}) / 1000$ 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/cm²

Substituting the logarithmic form of power and
gain using: $P(\text{mW}) = 10^{(P(\text{dBm}) / 10)}$ and
 $G(\text{numeric}) = 10^{(G(\text{dBi}) / 10)}$

yields

$$d = 0.282 * 10^{((P + G) / 20)} / \sqrt{S}$$
$$S = 0.0795 * 10^{((P + G) / 10)} / d^2$$

Equation (1)

Equation (2)

where

d = MPE distance in cm

P = Power in dBm

G = Antenna Gain in dBi

S = Power Density Limit in mW/cm²

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 Exposure for separation \geq 20cm

FCC: From §1.1310 Table 1 (B), for Public $S = 1.0 \text{ mW/cm}^2$; for Professional, $S = 5.0 \text{ mW/cm}^2$
IC: With formula of $1.31 \times 10^{-2} f^{0.6834} \text{ W}$, more restricted EIRP limit value are 1.37W at 902MHz, 2.67W at 2400MHz.

RESULTS

No non-compliance noted.

For GPR UWB Transmitter only:

1-mW Test Exemption:

Per § 1.1307(b)(3)(i)(A), a single RF source is exempt RF device (from the requirement to show data demonstrating compliance to RF exposure limits, as previously mentioned) if the available maximum time-averaged power is no more than 1 mW, regardless of separation distance. This exemption applies to all operating configurations and exposure conditions, for the frequency range 100 kHz to 100 GHz, regardless of fixed, mobile, or portable device exposure conditions.

For this EUT, max emission level is under the 0dBm limit set in Part 15F. No RF hazard need to be concerned.

The max. power density can be obtain by using the max. $P+G=0\text{dBm}$ and $d=20\text{cm}$, and plug all three items into equation (2), yielding,

Power Density Limit (mW/cm^2)	Max. Output Power+ Antenna] Gain (dBm)	Calculated Power Density (mW/ cm^2)
1.0/5.0	0	0.0002

For UWB and WiFi Transmitters transmitting simultaneously:

The following evaluation is for combined MPE compliance: While $d=20\text{cm}$, if

$$[Pd(1) / LPd(1)] + [Pd(2) / LPd(2)] + \dots + [Pd(n) / LPd(n)] < 1$$

then, the device complies with FCC's RF radiation exposure limit for general population as a mobile device. Where;

$Pd(n)$ = Power density of n^{th} transmitter at 20cm.

$LPd(n)$ = Power density limit for the n^{th} transmitter

From WiFi module's MPE report (FCC ID: Z9W-RMB):

Frequency (MHz)	Maximum Output power (dBm)	Maximum Output power (mW)	Antenna Gain (dBi)	Antenna Gain (numeric)	Distance (cm)	Result (mW/cm ²)	Limits for General Population/ Uncontrolled Exposure (mW/cm ²)
2.4G WiFi for Antenna 1							
802.11b mode							
2462	22.64	183.65	10	10	20	0.37	1

Note:

1. Just the worst case mode was shown in report.

We can use reported 0.37mW/ cm² as the max. power density for WiFi transmission. Therefore

$$[Pd(1) / LPd(1)] + [Pd(2) / LPd(2)] = 0.0002/1 + 0.37/1 = 0.37 < 1$$

The EUT meets RF radiation exposure limit for general population as a mobile device.

For IC Application: The UWB and WiFi module meet the most restricted EIRP limit value are 0.6W at 120MHz (for UWB 120-1500MHz Band), 2.67W at 2400MHz (for WiFi) by the value of max. 1mW for UWB and 1.84W (22.64+10=32.64dBm).