

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 KE3-30034451
 2721A-30034451
 23-0105 and 23-0107
 July 11, 2023
 Radio Systems Corporation
 STD00-17812 and STD00-17811

MPE/SAR exclusion/RF Exposure Evaluation

Maximum Permissible Exposure to RF (MPE) CFR 15.247 (i), CFR 1.1310 (e)

The maximum exposure level to the public from the RF power of the EUT shall not exceed a power density, **S** as per the respective limits in Table 1 below, at a distance, **d**, of 5 mm for 900 MHz and 10 mm for 2.4 GHz (portable condition) from the EUT.

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)
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
30-300	27.5	0.073	0.2	30
300-1,500			f/1500	30
1,500-100,000			1.0	30

Note 1: f = frequency in MHz * = Plane-wave equivalent power density

Note 2: multiplication factor of 2.5 applied to the limits to convert to extremity limits.

As required by §§ 2.1091(d)(2) and 2.1093(d)(5), RF exposure compliance must be determined at the maximum average power level according to source-based time-averaging requirements to determine compliance for general population exposure conditions. Unless it is specified differently in the *published RF exposure KDB procedures*, these requirements also apply to test reduction and test exclusion considerations. Time-averaged maximum conducted output power applies to SAR and, as required by § 2.1091(c), time-averaged effective radiated power applies to MPE.

Therefore, for:

MPE for 902 MHz – 928 MHz Extremity Limit:

$$f/1500 \text{ mW/cm}^2 = 915/1500 = 0.61 \text{ mW/cm}^2 \times 2.5 = \underline{1.525 \text{ mW/cm}^2 \text{ Extremity limit}}$$

$$\text{Peak Power (dBm)} = +27.35 \text{ dBm} \times 8.65\% \text{ (DC from below)} = 2.37 \text{ dBm}$$

$$\text{Peak Power (Watts)} = 0.0017 \text{ W}$$

$$\text{Gain of Transmit Antenna} = +1.0 \text{ dBi} = 1.259 \text{ numeric}$$

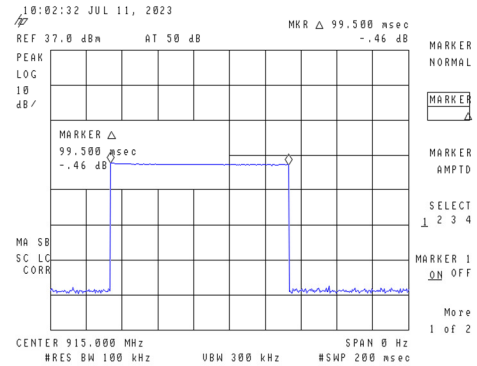
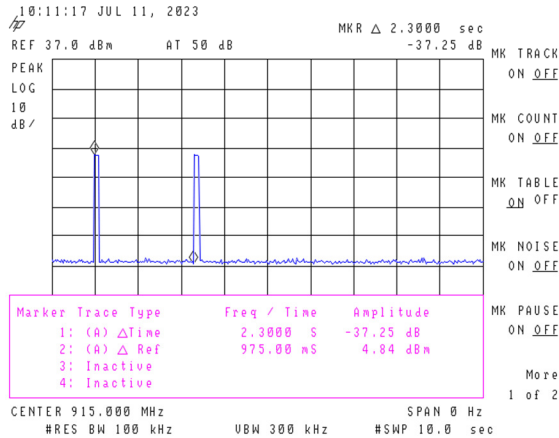
$$\underline{d = \text{Distance} = 5 \text{ mm} = 0.005 \text{ m}}$$

$$\begin{aligned} \mathbf{S} &= (\mathbf{PG}/4\pi d^2) = \text{EIRP}/4A = 0.002(1.259)/4\pi \cdot 0.005 \cdot 0.005 \\ &= 0.0021/0.0003 = 8.333 \text{ W/m}^2 \\ &= (8.333 \text{ W/m}^2) (1\text{m}^2/\text{W}) (0.1 \text{ mW/cm}^2) \\ &= \underline{0.8333 \text{ mW/cm}^2} \ll 1.525 \text{ mW/cm}^2 \end{aligned}$$

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EUT duty cycle measurement:



$$\text{TX on} = 99.5 \text{ mSec} \times 2 = 199.0 \text{ mSec}$$

$$\text{TX on} + \text{TX off} = 2.3 \text{ sec}$$

$$\text{DC} = 0.199 / 2.3 = 0.0865 = \underline{8.65\%}$$

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MPE for 2400 – 2483.5 MHz Extremity Limit::

Limit = $1.0 \text{ mW/cm}^2 \times 2.5 = \underline{2.5 \text{ mW/cm}^2}$ Extremity limit

Peak Power (dBm) = +10.33 dBm (FCC ID: QOQ-GM240S)

Peak Power (Watts) = 0.0107 W

Gain of Transmit Antenna = +2.8 dBi = 1.905 numeric

d = Distance = 10 mm = 0.01 m

$$\begin{aligned} S &= (PG / 4\pi d^2) = \text{EIRP} / 4A = 0.0107(1.905) / (4\pi * 0.01^2) \\ &= 0.0204 / 0.0013 = 15.69 \text{ W/m}^2 \\ &= (15.69 \text{ W/m}^2) (1\text{m}^2/\text{W}) (0.1 \text{ mW/cm}^2) \\ &= \underline{1.569 \text{ mW/cm}^2} \ll 2.5 \text{ mW/cm}^2 \end{aligned}$$

Simultaneous MPE (900 MHz band +2.4 GHz band) Calculation:

Total MPE (%) = [(900 MHz MPE result*100%) + [(2.4 GHz MPE result*100%) << 100%

= [0.80 %] + [6.49%] = 7.29 % << 100%

Calculation above shows device complies with the simultaneous MPE requirement

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SAR Exclusion:

General SAR test exclusion per KDB 447498 D01 V06 section 4.3

Test exclusion conditions are based on source-based time averaged maximum conducted output power of the RF channel, adjusted for tune-up tolerance, and the minimum test separation distance required for the 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:

$$[(\text{max. power of channel mW}) / (\text{min. test separation distance, mm})] * [(\sqrt{f_{\text{GHz}}})]$$

Where the result must be ≤ 3.0 for 1-g SAR and ≤ 7.0 for 10-g SAR

For 900 MHz ISM radio:

$$\text{Max. power of channel} = +27.35 \text{ dBm} * 8.65\% \text{ (DC)} = +2.36 \text{ dBm} = 1.72 \text{ mW}$$

Min. test separation distance = 5mm

F= 925 MHz

$$\text{Therefore: } 1.72 \text{ mW} / \underline{5\text{mm}} * (\sqrt{0.925\text{GHz}}) = 0.33 \underline{\leq 7.0 \text{ for 10-g SAR}}$$

For 2.4 GHz ISM radio:

$$\text{Max. power of channel} = +10.33 \text{ dBm} = 10.8 \text{ mW}$$

Min. test separation distance = 5mm

F= 2440 MHz

$$\text{Therefore: } 10.8 \text{ mW} / 5\text{mm} * (\sqrt{2.44\text{GHz}}) = 3.4 \underline{\leq 7.0 \text{ for 10-g SAR}}$$

The Device meets the SAR Threshold exempt for limb and extremity.

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RSS-102, 2.5.1 Exemption Limits for Routine Evaluation 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 levels presented in Table 1 below.

Table 1: SAR evaluation – Exemption limits for routine evaluation based on frequency and separation distance^{4,5}

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	345 mW
450	141 mW	159 mW	177 mW	195 mW	213 mW
835	80 mW	92 mW	105 mW	117 mW	130 mW
1900	99 mW	153 mW	225 mW	316 mW	431 mW
2450	83 mW	123 mW	173 mW	235 mW	309 mW
3500	86 mW	124 mW	170 mW	225 mW	290 mW
5800	56 mW	71 mW	85 mW	97 mW	106 mW

Output power level shall be the higher of the maximum conducted or equivalent isotopically radiated power (e.i.r.p) source-based time averaged (SBTA) output power.

For 900 MHz ISM radio:

In this case the maximum SBTA value is used:

EUT source based time averaged (SBTA) = (output power + antenna gain * duty cycle)

$$SBTA = \underline{27.35 \text{ dBm}} + \underline{1.0 \text{ dBm}} = \underline{28.35 \text{ dBm}} * (8.65\% \text{ (DC)}) = 2.45 \text{ dBm} = 1.75 \text{ mW}$$

The limit at a separation distance of 5 mm @ 925 MHz = (16.15 mW * 2.5) = 40.38 mW for limb exposure. The EUT meets the Exemption Limits.

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For the 2402-2480 MHz radio with integral trace antenna
pre-approved under FCC ID: QOQ-GM240S and IC: 5123A-GM240S

EUT source based time averaged (SBTA) = (output power + antenna gain * duty cycle)

$$\text{SBTA} = 10.33 \text{ dBm} + 1.48 \text{ dBi} = 11.81 \text{ dBm} * (90.6\% \text{ (from test report)}) = 10.7 \text{ dBm} = \underline{11.74 \text{ mW}}$$

The limit at a separation distance of 10 mm @ 2450 MHz = $(7 \text{ mW} * 2.5) = 17.5 \text{ mW}$ for limb exposure. The EUT meets the Exemption Limits therefore, it is considered to be exempt from routine evaluations.

Simultaneous transmission SAR test exclusion considerations

900 MHz = 1.75 mW

2.4 GHz = 11.74 mW

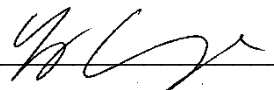
Sum of the total = 13.49 mW << 17.5 mW (worst case limit for limb exposure from above at 2450 MHz)

The EUT meets the exclusion considerations.

All calculations performed by:

Test Engineer: George Yang

Date: July 27, 2023

Signature: 

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Antenna Separation Photographs

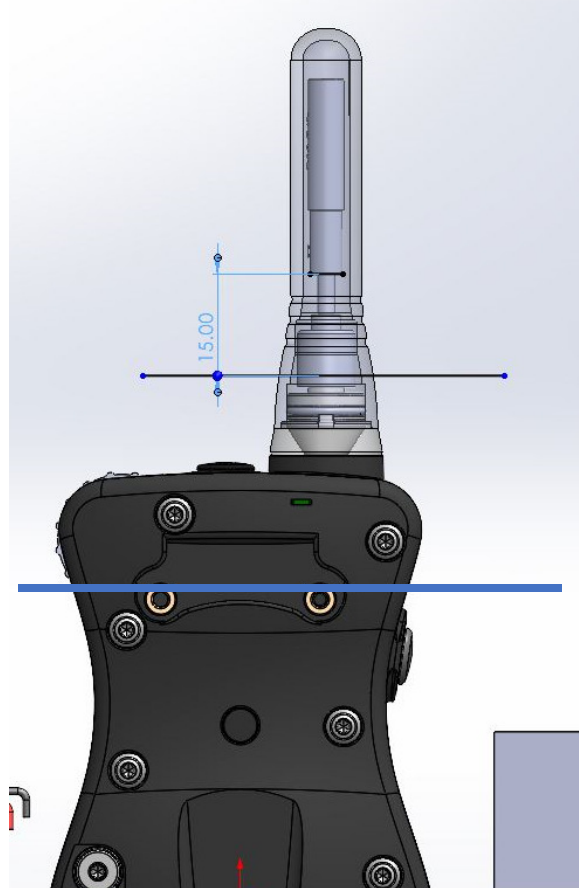


Figure 1. 1 Mile Version. Antenna distance to palm rest point

More than 15mm. The EUT is designed so that the hand is below the main body of the plastic during normal operation.

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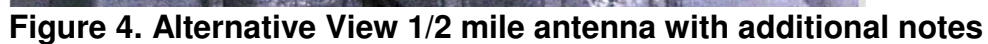
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Figure 2. Hand holding EUT

As presented in Figure 1 above. The hand rest below the radiating element during normal use of the handheld device.

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Figure 5. Hand holding EUT

Figure 3 & 4 above show the closest point where the ½ mile 900 MHz radiating element can come into contact with the hand. It's on the left side of the handheld. Figure 3 & 4 show the separation distance. As long as the hand resting on the outside of the enclosure it will maintain this separation distance or more.

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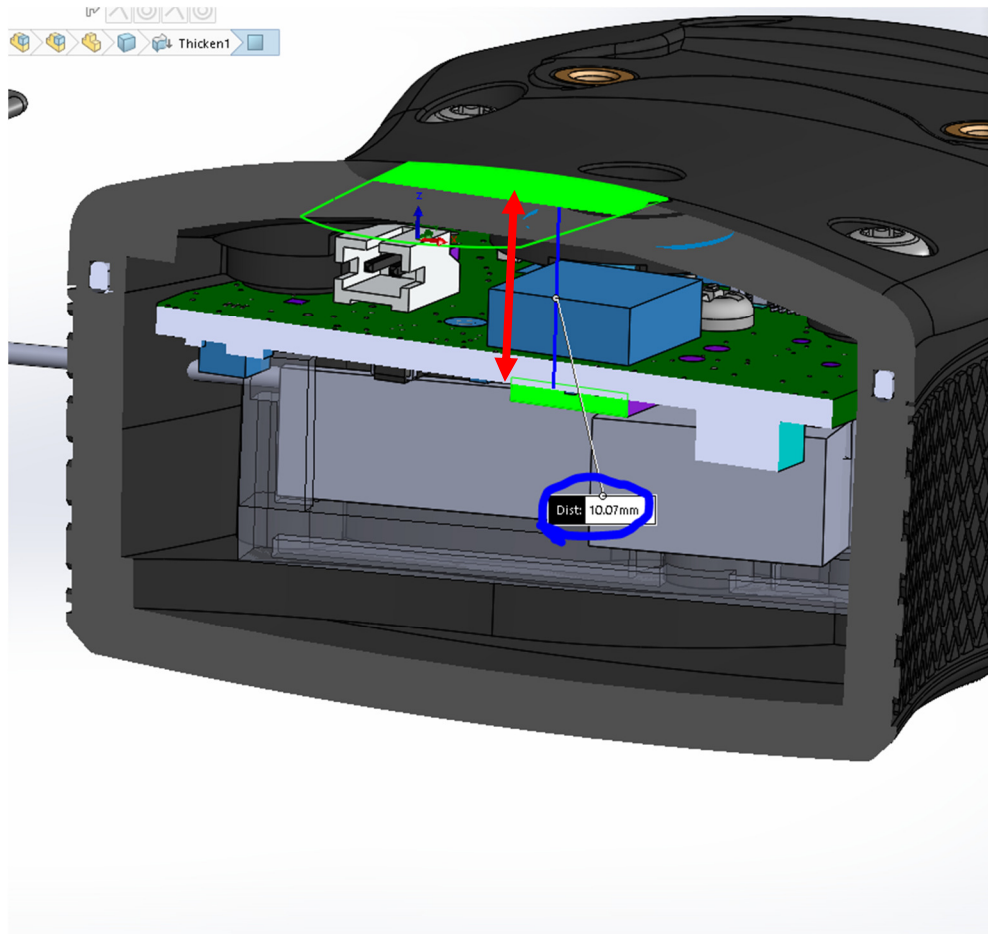


Figure 6. BLE antenna separation

From the trace antenna on the PCBA to the back of the handheld, the separation distance is 10.07mm.

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Figure 7. Hand holding EUT

When held by the hand, the closest skin contact remains on the outer part of the enclosure which provides 10 mm separation as presented in the diagram above.