

SAR Exclusion Calculation

Project: C9618v3

Report number: C16163TR2

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Customer Details

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Equipment Under Test: ATOM 3K

FCC ID: ZERATOM3K

Operating frequency bands: RFID: 13.11 to 14.01MHz
BLE: 2400MHz to 24835MHz

RFID: 13.11 to 14.01MHz**SAR Exclusion Calculation - FCC**

The calculation is according to the FCC Knowledge Database (KDB) document KDB 447498 D01 General RF Exposure Guidance V06.

For equipment operating below 100MHz section 4.3.1 c) for <100MHz and test separation distances ≤50mm was specifically applied. According to this section the SAR test exclusion thresholds are determined by the following:

$$\text{Threshold} = 0.5 \cdot \left[\frac{P(\text{mW}) \cdot \sqrt{f(\text{GHz})}}{d(\text{mm})} + \frac{(d(\text{mm}) - 50) \cdot f(\text{MHz})}{150} \right] \cdot \left[1 + \log \left(\frac{100}{f(\text{MHz})} \right) \right]$$

Where

P is the maximum power of the channel including tune-up tolerance in mW

d is the minimum test separation distance in mm

f is the RF channel frequency in GHz

The minimum test separation distance was considered to be 3.8mm for the RFID in consultation with Section 4.2.2 *Body-worn accessory exposure conditions*.

This evaluation of the threshold is compared to the threshold limit.

- a. Limit for 1-g head or body worn devices: threshold limit ≤3
- b. Limit for 10-g extremity worn devices: threshold limit ≤7.5

Since the device can be hand held the limit b applies.

For this apparatus, the calculated threshold was evaluated using a distance of 3.8mm, and the results are tabulated in the table below.

The power level values are taken from testing report C16161TR2.

Frequency (MHz)	Power (mW)	Dist (mm)	Calculated Threshold	Threshold Limit
13.56	0.00018	3.8	-7.8	7.5

Table 1 Calculation of threshold RFID

Note: The radiated Power (ERP) of the device was calculated from the radiated field strength:

$$\text{ERP (dBm)} = \text{Radiated field strength (dB}\mu\text{V/m)} + 20\log(d) - 104.77 - 2.15$$

where d is the distance of measurement for field strength in metres.

BLE: 2400MHz to 24835MHz**SAR Exclusion Calculation - FCC**

The calculation is according to the FCC Knowledge Database (KDB) document KDB 447498 D01 General RF Exposure Guidance V06.

Section 4.3.1 General SAR Test Exclusion Bands was applied.

Section 4.3.1 b) (2) for 1500MHz to 6GHz and test separation distances >50mm, was specifically applied where applicable. According to this section the SAR test exclusion thresholds are determined by the following:

$$\text{Threshold (mW)} = \left[\left[\frac{x}{\sqrt{f(\text{GHz})}} \right] \cdot 50 \right] + [(d(\text{mm}) - 50) \cdot 10]$$

When separation distance > 50 mm and the device output power is less than the calculated result (power threshold, mW) shown in the above equation, the SAR testing exclusion is applied.

where

x is 3 for head or body worn devices and x is 7.5 for extremity worn devices.

The minimum test separation distance was considered to be 59.1mm (distance from the top surface of the Bluetooth dongle to the bottom surface of the user's hand), as declared by the customer and in consultation with Section 4.2.2 *Body-worn accessory exposure conditions*.

Bluetooth Low Energy

For this apparatus, the calculated threshold was evaluated using a distance of 59.1mm, assuming an extremity handled device, and the results are tabulated in the table below.

The worst-case output power was taken from the modules FCC listing (FCC ID: QIJ-B190).

Frequency (GHz)	Max EIRP (dBm)	Max EIRP (mW)	Dist (mm)	Threshold Limit (mW)	SAR Test required
2.480	-1.01	0.977	59.1	329.1	No

Table 2 Calculation of threshold BLE

Notes:

Power and distance were rounded to the nearest mW and mm before calculation

Determination of the SAR test exclusion for simultaneous transmission

Simultaneous transmission SAR test exclusion considerations are calculated according to KDB 447498 4.3.2 b).

$[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})/x}] = \text{W/kg}$ for test separation distances ≤ 50 mm; where $x = 7.5$ for 1-g SAR and $x = 18.75$ for 10-g SAR.

Alternatively, 0.4 W/kg for 1-g SAR and 1.0 W/kg for 10-g SAR, when the test separation distance is > 50 mm.

RFID

$[(0.000180 \text{ mW}) / 5.0 \cdot \text{mm}] \cdot [\sqrt{f(0.01356 \text{ GHz})/18.75}] = 0.0000002 \text{ W/kg}$

BLE

$= 1.0 \text{ W/kg}$

RFID+BLE = 1.0000002 W/kg

1.0000002 W/kg is under the limit of 4.0 W/kg for 10-g SAR.

*Minimum distance allowable.

Conclusion

For the required stated distance the apparatus met the exclusion requirements for SAR testing (FCC).

SAR Exclusion Calculation - ISED**Standard:****RSS-102 Radio Frequency (RF) –Exposure Compliance of Radio communication Apparatus (All Frequency Bands)**

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From RSS-102: 6.3 SAR exemption limits

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 11.

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 of tissue applies, the exemption limits for routine evaluation in table 11 are multiplied by a factor of 2.5.

For controlled-use devices where the 8 W/kg for 1 gram of tissue applies, the exemption limits for routine evaluation in table 11 Table 11 are multiplied by a factor of 5.

When the operating frequency of the device is between two frequencies located in table 11, linear interpolation shall be applied for the applicable separation distance. If the separation distance of the device is between two distances located in table 11, linear interpolation may be applied for the applicable frequency. Alternatively, the limit corresponding to the smaller distance may be employed.

RFID

The power level values are taken from the testing report C16161TR2.

Frequency (GHz)	Max ERP (dBm)	Max ERP (mW)	Dist (mm)	Exemption Limit (mW)*	SAR Test required
0.01356	-37.44	0.000180	3.8	112.50	No

*Values are multiplied by 2.5 for limb-exposure devices.

BLE

The power level values are taken from the modules FCC listing (FCC ID: QIJ-B190).

Frequency (GHz)	Max EIRP (dBm)	Max EIRP (mW)	Dist (mm)	Exemption Limit (mW)*	SAR Test required
2.480	-1.01	0.977	59.1	606.25	No

*245mW at 2450MHz, 158mW at 3500MHz, values are interpolated and multiplied by 2.5 for limb-exposure devices.

Simultaneous transmission of RFID and BLE

The SAR exemption limits outlined in clause 5.2.2 of RSS-102 have been derived based on an approximate SAR value of 0.4 W/kg using half-wave dipole antennas. As such, when simultaneous transmitter SAR evaluations include transmitters that have been exempt from routine SAR evaluation, the SAR must be estimated based on the ratio between the maximum tune-up tolerance limit of the transmitter that has been exempt and the exemption limit at the specific distance and frequency for that transmitter. This ratio must be multiplied by 0.4 W/kg (2.0 W/kg for controlled use and 1.0 W/kg for limb worn devices) in order to calculate the estimated SAR level.

The estimate SAR value is calculated based the following equation:
(maximum power level including tune-up tolerance for transmitter A / maximum power level of exemption at the same frequency and distance) * (0.4W/kg* 2.5)

The SAR limit for Localized Limbs is 4 W/kg.

Maximum ratio RFID (W/kg)	Maximum ratio BLE (W/kg)	Sum of exposure ratios (W/kg)	Limit of exposure ratios (W/kg)	Requirement
0.000004	0.004	0.004004	4	Pass

Conclusion

For the required stated distances, the apparatus met the exclusion requirements for SAR testing (ISED).

Prepared by:



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