

Contact person
Ermin Pasalic
Electronics
+46 10 516 55 57
ermin.pasalic@ri.se

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8P07436-F3 RF exposure

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FCC ID: 2ADEFAT-DG2, ISED ID: 12460A-ATDG2

Airtame ApS
Att: Kendra Bannister
Kuglegårdsvej 17
1434 Copenhagen K
Danmark

Equipment Authorization measurements on U-NII-3 RLAN

FCC ID: 2ADEFAT-DG2
ISED ID: 12460A-ATDG2

Test object

Product name: Airtame 2
Product model of Airtame 2: AT-DG2
HW Revision: Airtame_DG2_V7_RB
FVIN: cyw89342-dfs_IIIg.clm_blob

RISE Research Institutes of Sweden AB Electronics - EMC

Performed by

Examined by

Ermin Pasalic

Monika Fuller

RISE Research Institutes of Sweden AB

| | | |
|-----------------|-----------------|----------------------|
| Postal address | Office location | Phone / Fax / E-mail |
| Box 857 | Brinellgatan 4 | +46 10 516 50 00 |
| SE-501 15 BORÅS | SE-504 62 BORÅS | +46 33 13 55 02 |
| Sweden | | info@ri.se |

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RF exposure evaluation: 2.1091 Mobile devices / KDB 447498 / RSS-102 2.5.2

| | | |
|--------------------|-----------------------------|------------------------|
| Date 2019-04-30 | Temperature 22 °C ± 3 °C | Humidity 28 % ± 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 whereby a distance of 20 cm can be maintained between the user and the device.

According to KDB 447498 D01 General RF Exposure Guidance v06.

Results

Mobile devices:

The following formula was used to calculate the RF exposure,

$$P_d = \frac{P_{out} \cdot G}{4 \cdot \pi \cdot r^2}$$

where,

P_d = power density in mW/cm²

P_{out} = Maximum output power measured with RMS detector, in mW

G = gain of antenna in linear scale

π = 3.1416

r = distance between observation plane and the radiator in cm

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

The maximum rated power for 2400-2483.5 MHz band according the operational description is 17.0 dBm which was used for calculation of Maximum Permissible Exposure, MPE for the band 2400-2483.5 GHz. Declared tune-up tolerance in this band is 2 dB.

The maximum rated power for 5725-5850 MHz band according the operational description is 13.0 dBm per chain which was used for calculation of Maximum Permissible Exposure, MPE. Declared tune-up in the band 5725-5850 MHz is 3.9 dB.

The device can work in different modes so calculation is done for both standalone transmission and for simultaneous transmission in 2.4 GHz band and 5 GHz band.

Mobile device - Standalone transmission

| Freq. f (MHz) | Antenna Gain (dBi) | Antenna Gain (numeric) | Pout (dBm) | Tune-up (dB) | Pout (mW) | Power density, Pd [S] (mW/cm ²) | Limit of power density (mW/cm ²) |
|--------------------------|--------------------|------------------------|------------|--------------|---------------------------|---|--|
| Ch 7, 2442 MHz Note 1 | 1.5 | 1.4 | 17 | 2 | 112.2 Note 3 | 0.02 | < 1 |
| Ch149 5745 MHz Note 1 | 2.5 | 1.8 | 13 | 3.9 | 82.7 Note 2 Note 3 | 0.05 Note 4 | < 1 |
| | 6 | 4.0 | 13 | 3.9 | 185.2 Note 2 Note 3 | | |

Note 1: Only the frequencies with the highest rated power in 2.4 GHz respective 5 GHz band are noted.

Note 2: The highest declared duty cycle (worst case) in normal operating for 5 GHz band was 95%.

Duty cycle correction [dB] = 20 log duty cycle; for E-field correction

Duty cycle correction [dB] = -0.45 dB

The worst case duty cycle for 2.4 GHz band was not declared so 100 % duty cycle was used in this band.

Note 3: Tune-up correction of 2 dB is implemented for 2.4 GHz band and 3.9 dB for 5 GHz band.

Note 4: As worst case in 5 GHz band, power density is calculated for MIMO mode

Mobile device - Simultaneous transmission, 2.4 GHz WiFi and 5 GHz RLAN, the worst case

| Freq. f (MHz) | Antenna Gain (dBi) | Antenna Gain (numeric) | Pout (dBm) | Tune-up (dB) | Pout (mW) | Power density, Pd [S] (mW/cm ²) | Limit of power density (mW/cm ²) |
|----------------|--------------------|------------------------|------------|--------------|-----------|---|--|
| Ch 7, 2442 MHz | 1.5 | 1.4 | 17 | 2 | 112.2 | 0.02 | < 1 |
| Ch149 5745 MHz | 6 | 4.0 | 13 | 3.9 | 185.2 | 0.04 | < 1 |

Note: In simultaneous transmission mode, chain 1 with 1.5 dBi antenna is used by 2.4 GHz WiFi and chain 2 with 6 dBi antenna is used by 5 GHz RLAN.

$$MPE1 = MPE_{2.4\text{ GHz}} = 0.02\text{ mW/cm}^2$$

$$MPE2 = MPE_{5\text{ GHz}} = 0.04\text{ mW/cm}^2$$

$$MPE1_Limit = 1\text{ mW/cm}^2$$

$$MPE2_Limit = 1\text{ mW/cm}^2$$

According KDB 447498 D01, clause 7.2, simultaneous transmission MPE test exclusion applies when the sum of the all MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0 :

$$\text{Requirement: } \sum \frac{MPE1}{MPE1 \text{ LIMIT}1} + \frac{MPE2}{MPE \text{ LIMIT}2} + \dots \leq 1$$

$$\sum(MPE1/MPE1_LIMIT + MPE2/MPE2_LIMIT) = \sum 0.02 + 0.04 = 0.06 < 1$$

Device comply to the mobile RF exposure requirement in simultaneous transmission operation.

Note : As the Power density values were very low, a complementary calculation as a Portable/SAR exclusion was presented, see below.

This calculation needs in case of the lack of the control over device usage and where is a risk that user comes close to the device. The result of the calculation is minimum distance between device and the body without risk for RF exposure and without need for SAR measurement.

Portable devices:

Standalone SAR exclusion:

The maximum radiated RMS output power was used for calculation.

| Frequency f, (GHz) Note 1 | Rated power (dBm) | Pout (dBm) acc. to source-based time averaging Note 2 | Tune-up (dB) | Peak output power (mW) |
|------------------------------|-------------------|--|--------------|------------------------|
| 2.442 | 17 | 17 | 2 | 79.4 |
| 5.745 | 13 Note 3 | 12.55 | 3.9 | 46.5 |

Note 1: Only the frequencies with the highest rated power are noted.

Note 2: The highest declared duty cycle (worst case) in normal operation is 95%, thus the duty cycle correction was calculated to -0.45 dB in the 5 GHz band.

Note 3: per chain

Step a):

The following formula was used to calculate the RF exposure SAR exclusion threshold,

$$\text{Thld} = \frac{P_{out}}{r} \cdot \sqrt{f}$$

Thld = SAR exclusion threshold

Pout = Maximum rated power, in mW

r = minimum test separation distance, in mm

f = frequency, in GHz

Portable device - Standalone transmission

| Frequency f (GHz) | Pout (mW) | Tune- up (dB) | Distance r (mm) Note 3 | Exclusion threshold Thld | Limit Threshold 1-g SAR | Limit Threshold 10-g SAR |
|-------------------------|--------------------------|---------------------|---------------------------------|--------------------------------|-------------------------------|--------------------------------|
| 2.442 | 50.1 Note 1 | 2 | 41.4 | 3.0 | ≤ 3 | ≤ 7.5 |
| 5.745 | 19.0 Note 1 Note 2 | 3.9 | 37.4 | 3.0 | ≤ 3 | ≤ 7.5 |

Note 1: Rated power without tune-up tolerance.

Note 2: Reduced output power for time averaging of signal with 95 % duty cycle.

Note 3: Distance r of 42 mm is minimum distance between device and body when no SAR measurements are required.

Portable device - Simultaneous transmission

According to 447498 D01 General RF exposure Guidance v06, clause 4.3.2.b) standalone SAR values estimates according following to determine simultaneous transmission SAR test exclusion:

$$1g\ SAR = \frac{P_{out}}{R} \cdot \frac{\sqrt{f}}{7.5}$$

$$10g\ SAR = \frac{P_{out}}{R} \cdot \frac{\sqrt{f}}{18.75}$$

for separation distances ≤ 50 mm.

Pout = Maximum power of channel including tune-up tolerance, in mW

r = minimum test separation distance, in mm

f = frequency, in GHz

Portable device - Simultaneous transmission 2.4 GHz WiFi and 5 GHz RLAN, worst case

| Frequency f (GHz) | Pout (mW) | Tune-up (dB) | Distance r (mm) | 1g-SAR 4.3.2.b (W/kg) | 10g-SAR 4.3.2.b (W/kg) | Limit (W/kg) |
|-------------------|--------------------------|--------------|-----------------|-----------------------|------------------------|--------------|
| 2.442 | 50.1 Note 1 | 2 | 41.4 | 0.40 | 0.16 | ≤ 0.4 |
| 5.745 | 19.0 Note 1 Note 2 | 3.9 | 37.4 | 0.40 | 0.16 | ≤ 0.4 |

Note 1: Rated power without tune-up tolerance.

Note 2: Reduced output power for time averaging of signal with 95 % duty cycle.

Portable device - Simultaneous transmission 5 GHz RLAN MIMO

| Frequency f (GHz) | Pout (mW) | Tune-up (dB) | Distance r (mm) | 1g-SAR 4.3.2.b (W/kg) | 10g-SAR 4.3.2.b (W/kg) | Limit (W/kg) |
|-------------------|--------------------------|--------------|-----------------|-----------------------|------------------------|--------------|
| 5.745 Chain 1 | 19.0 Note 1 Note 2 | 3.9 | 37.4 | 0.40 | 0.16 | ≤ 0.4 |
| 5.745 Chain 2 | 19.0 Note 1 Note 2 | 3.9 | 37.4 | 0.40 | 0.16 | ≤ 0.4 |

Note 1: Rated power without tune-up tolerance.

Note 2: Reduced output power for time averaging of signal with 95 % duty cycle.

$$1g - SAR_{simult} = \frac{\sqrt{(SAR_1 + SAR_2)^3}}{R} \leq 0.04 \text{ for 1-g SAR exclusion and}$$

$$10g - SAR_{simult} = \frac{\sqrt{(SAR_3 + SAR_4)^3}}{R} \leq 0.1 \text{ for 10-g SAR exclusion.}$$

SAR₁ – highest estimated 1g-SAR of 2.4 GHz WiFi in simultaneous transmission

SAR₂ – highest estimated 1g-SAR of 5 GHz RLAN in simultaneous transmission

SAR₃ – highest estimated 10g-SAR of 2.4 GHz WiFi in simultaneous transmission

SAR₄ – highest estimated 10g-SAR of 5 GHz RLAN in simultaneous transmission

R – separation distance between peak max SAR locations

R = 35 mm

For max SAR location see [Photos](#)

| Max SAR in simultaneous mode (W/kg) | | |
|-------------------------------------|-------------------|------------|
| | 2.4 GHz and 5 GHz | 5 GHz MIMO |
| SAR ₁ | 0.40 | 0.40 |
| SAR ₂ | 0.40 | 0.40 |
| SAR ₃ | 0.16 | 0.16 |
| SAR ₄ | 0.16 | 0.16 |

Calculation result for simultaneous mode:

1g SAR = 0.02W/kg < 0.04

10g SAR = 0.01W/kg < 0.1

Conclusion: If the device is kept more than 42 mm from the body, no risk for RF exposure and not need for SAR test.

Limits

Mobile devices:

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

ISED 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).

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

b) $[\text{Power allowed at numeric threshold for 50 mm in step 1}) + (\text{test separation distance} - 50 \text{ mm}) \cdot x 10]$ 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.

ISED 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 | 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 |

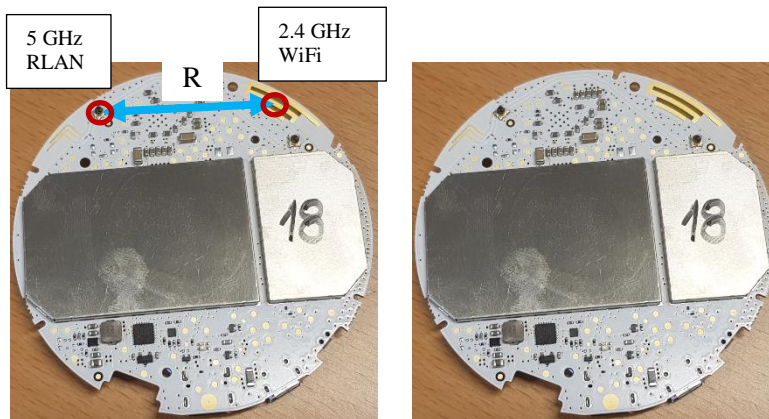
Output power level shall be the higher of the maximum conducted or equivalent isotropically radiated power (e.i.r.p.) source-based, time-averaged output power. For controlled use devices where the 8 W/kg for 1 gram of tissue applies, the exemption limits for routine evaluation in Table 1 are multiplied 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 engineer: Ermin Pasalic

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

Photos

DUT, Marked max SAR values for
2.4 GHz WiFi and 5 GHz RLAN

R = 35 mm