REPORT-ANNEX, AT-DG2 RF exposure

issued by an Accredited Testing Laboratory

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Date
2018-12-04
Rev.1:2018-12-11

Reference
8P07436-F1

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Testing

Airtame ApS
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Equipment Authorization measurements on 5150-5250 MHz RLAN
FCC ID: 2ADEFAT-DG2

Rev.1:2018-12-11: The following pages have been revised; 3, 4, 5, 6 and 7

Page 3: Maximum reported conducted power is replaced with Maximum rated power. Respective values for power are updated.

Page 3: Added text: '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.'

Page 4: Updated table Mobile device – Standalone transmission with new values.

Page 4: Added Note 4. The highest RMS value in Note 1 is replaced by the highest rated power.

Page 4: Tune-up is changed for 5 GHz. Added Note 4

Page 4: Updated table Mobile device – Simultaneous transmission with new values. Updated MPE results.

Page 5: Updated MPE result to 0.03. Updated values in table. Added column Rated power (dBm)

Page 6 Updated values in table Portable device - Standalone transmission. Distance of 31 mm is replaced by 42 mm in Note 3.

Page 6: Updated values in table Portable device - Simultaneous transmission.

Page 7: Added table Portable device - Simultaneous transmission 5 GHz RLAN MIMO.

Page 7: Table Max SAR in simulated mode (W/kg) changed name to Max SAR in simultaneous mode (W/kg). The values in the table are updated. Column have got name '2.4 GHz and 5 GHz'. New column with name '5 GHz MIMO' added.

Page 7: Added text 'The worst case is 2.4 GHz WiFi and 5 GHz RLAN. 31 mm is replaced by 42 mm in conclusion.

Page 9: The max SAR positions' labels are changed

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Test object

Product name: Airtame 2
Product model of Airtame 2: AT-DG2
Product number: 18
HW Revision: Airtame_DG2_V7_RB
FW Revision: 3.3.0

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Electronics - EMC

Performed by   Examined by

Ermin Pasalic   Monika Fuller

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RF exposure evaluation: 2.1091 Mobile devices / KDB 447498

Date	Temperature	Humidity
2018-11-14	22 °C ± 3 °C	29 % ± 5 %
2018-11-15	21 °C ± 3 °C	35 % ± 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 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/cm^2
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 5150-5250 MHz band according the operational description is 9.0 dBm per chain which was used for calculation of Maximum Permissible Exposure, MPE for the band 5150-5250 MHz. Declared tune-up in the band 5150-5250 MHz is 3.8 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.

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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	82.2 Note 3	**0.02**	< 1
Ch48 5240 MHz Note 1	2,5	1.8	9	3.8	32.2 Note 2 Note 3	**0.02** Note 4	< 1
	6	4.0	9	3.8	72.1 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 3.8 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

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
Ch48 5240 MHz	6	4.0	9	3.8	72.1	**0.01**	< 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 GHz = 0.02 mW/cm^2
MPE2 = MPE_5 GHz = 0.01 mW/cm^2
MPE1_Limit = 1 mW/cm^2
MPE2_Limit = 1 mW/cm^2

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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:

$$\text{Requirement: } \sum \frac{MPE1}{MPE1\ LIMIT1} + \frac{MPE2}{MPE\ LIMIT2} + \cdots \leq 1$$

∑(MPE1/MPE1_LIMIT + MPE2/MPE2_LIMIT) = ∑0.02 + 0.01 =0.03 < 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)
2442	17	17	2	79.4
5.240	9 Note 3	8.55	3.8	18.1

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: 9 dBm per chain

Step a):
The following formula was used to calculate the RF exposure SAR exclusion threshold,

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

where,
Thld = SAR exclusion threshold
Pout = Maximum rated power, in mW
r = minimum test separation distance, in mm
f = frequency, in GHz

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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
5.240	7.5 Note 1 Note 2	3.8	13.9	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:

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

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

for separation distances ≤ 50 mm.

Where:
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

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	0.23	≤ 0.4
5.240	7.5 Note 1 Note 2	3.8	13.9	0.40	0.16	≤ 0.4

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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)
5.240 Chain 1	7.5 Note 1 Note 2	3.8	13.9	0.40	0.16	≤ 0.4
5.240 Chain 2	7.5 Note 1 Note 2	3.8	13.9	0.40	0.16	≤ 0.4

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

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

SAR_1 – highest estimated 1g-SAR of 2.4 GHz WiFi in simultaneous transmission
SAR_2 – highest estimated 1g-SAR of 5 GHz RLAN in simultaneous transmission
SAR_3 – highest estimated 10g-SAR of 2.4 GHz WiFi in simultaneous transmission
SAR_4 – 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	0.23	0.16
SAR_4	0.16	0.16

The worst case is 2.4 GHz WiFi and 5 GHz RLAN
Calculation result:
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.

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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 filed 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 filed 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

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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:
[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] x [√f(GHz)] ≤ 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
• 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) [Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50 mm)· x (f(MHz)/150)] mW, at 100 MHz to 1500 MHz
b) [Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50 mm)· 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(MHz))] for *test separation distances* > 50 mm and < 200 mm
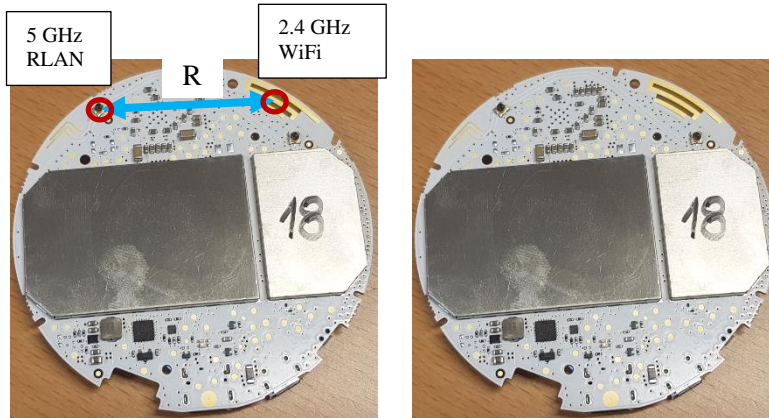b) The power threshold determined by the equation in a) for 50 mm and 100 MHz is multiplied by ½ for *test separation distances* ≤ 50 mm
c) SAR measurement procedures are not established below 100 MHz. When SAR test exclusion cannot be applied, a KDB inquiry is required to determine SAR evaluation requirements for any test results to be acceptable.

Test engineer: Ermin Pasalic

Complies?	Yes

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Photos

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

R = 35 mm

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