Technical Memorandum

SAR test exclusion and antenna gain assessment of AF100 according to FCC specifications

Performed for Glowforge Inc.

Project no.: 122-31550-12 Rev.B

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Title	SAR test exclusion and antenna gain assessment of AF100 according to FCC specifications
Assessment object	AF100
Report no.	122-31550-12 Rev.B
Client	Glowforge Inc. 1938 Occidental Avenue S, Suite C WA 98134 Seattle Washington United States
Manufacturer	Glowforge Inc.
Specifications	KDB 447498 D01 General RF Exposure Guidance v06
Results	The test object was found to be in compliance with the specifications
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Date	03 April 2023

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1. Conclusion

Portable:

The AF100 with FCC ID 2A83C-1JM2D is assessment as portable device.

The assessment object mentioned in this report meets the requirements of the FCC rule parts for a user separation distances > 190 mm for portable device in a general population/uncontrolled exposure environment stated below.

- KDB 447498 D01 General RF Exposure Guidance v06

The results relate only to the object assessed.

1.1 Assessment objects

Assessment object 1.1.1

Name of test object	AF100
Model / type	AF100
Part no.	-
Serial no.	GFAF100-JVR-0087
Manufacturer	Glowforge Inc.
Supply voltage	100 - 240 VAC, 50 – 60 Hz, 2 A
Software version	"dtm_with_peripherials_sweep_4resistance.hex" - (20221205)
Hardware version	DVT Build_RD20221115_00295 - (20221205)

2. General test conditions

2.1 Description and intended use of test object

The AF100 is an air filter unit used with a 3D laser printer. The laser printer cuts, engraves, and scores different materials and the AF100 filters the air coming out from the 3D laser printer.

2.2 Test modes during emission tests

Simultaneous transmission - BLE is active transmitting and is hopping between low, mid and high frequencies within a duty cycle of 25 ms and NFC active within a duty cycle of 1s.

3. Characteristics and parameters of the assessed object

3.1 Exposed parts of the body

Any significant exposure will be to the head (worst case).

3.2 Pulsed / transient fields

The emissions from the assessed object are not pulse modulated.

There are no occasional or periodic transients in the emitted field.

4. Assessment of compliance with FCC requirements

Assessment method:

- KDB 447498 D01 General RF Exposure Guidance v06 clause 4.3.1
    - General population/uncontrolled exposure environment

4.1 Parameters for assessment

The requirements for determination of compliance and the preparation of an Environmental Assessment regarding human exposure to levels of radiofrequency radiation.

The exposure is assessed according to KDB 447498 D01 General RF Exposure Guidance v06 clause 4.3.1 according to the mail from the TCBC on behalf of FCC - Friday the 01/20-2023 – CET 17:43.

4.1.1 BTL radio:

This calculation is based on the highest e.i.r.p. or Pcon possible from the system, considering maximum power and antenna gain.

The maximum conduced output power is the worst-case power due to the low antenna gain.

The conducted power is the worst-case scenario for the RF power, and it is constant transmitting – e.g. 100 % duty cycle.

- Duty Cycle 100 %
- G(antenna) = -10.3 dBi
- User separation distances > 190 mm
- P(BLE_RF pwr conducted_measured) = 1.45 mW [1]
- P(BLE_Limit@190 mm) = 1496 mW
    - in a general population/uncontrolled exposure environment.
    - According to KDB 447498 D01 General RF Exposure Guidance v06 Clause 4.3.1

1 See the technical memorandum: "Conducted power measurement - 15.249_11b_AF100 GFD AF Operational description.pdf" page 2, 3 and 4.

4.1.2 NFC/RFID radio:

The NFC/RFID radio radiated power is determent from a worst-case scenario with at constant NFC/RFID radio transmission, average current consumption input power for the RF chip when transmitting and at fixed voltage supply at 5 VDC. The antenna gain is very low due to antenna coil design – a very short antenna, the length of the coil wire is very short compared to a λ/4.

- Duty cycle 100 %
- G(antenna) = N/A (Very short antenna – PCB coil with a very low antenna gain)
- User separation distances > 190 mm
- I(NFC/RFID_Tx) = 57.7 mA [2]
- V(CC_ NFC/RFID) = 5 VDC

- P(NFC/RFID_input power to RF radio chip) = V(CC_NFC/RFID)*I(NFC/RFID_Tx)
- P(NFC/RFID_input power to RF radio chip) = 285.5 mW
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- P(NFC/RFID_Limit@190 mm) = 1060 mW
    - in a general population/uncontrolled exposure environment.
    - According to KDB 447498 D01 General RF Exposure Guidance v06 Clause 4.3.1

4.2 Limit

When the sum of 1-g or 10-g SAR of all simultaneously transmitting antennas in an operating mode and exposure condition combination is within the SAR limit, it is complient.

- P(total_measured) = P(NFC/RFID_input power to RF radio chip)+P(BLE_RF pwr conducted_measured)
- P(total_measured = 285.5 mW + 1.45 mW = 286.95 mW

- P(total_limit) = 1060 mW (worst-case from the NFC/RFID radio)

According to KDB 447498 D01 General RF Exposure Guidance v06, clause 4.3.2

4.3 Result

The P(total_measured) < P(total_limit)

Therefore, the product is considered compliant with the FCC rule parts for a user separation distances > 190 mm for portable device in a general population/uncontrolled exposure environment.

[2] See the technical memorandum "NFC Current consumption_11b_AF100 GFD AF Operational description.pdf" page 3, only the transmitting current.

5. Antenna gain calculation for BLE radio

BLE Radio	fLow	fMidt	fHigh	Unit	Note
Frq	2402	2440	2480	MHz	1
Efield	86.4	86.4	86.5	dBuV/m	2
e.i.r.p.	-8.8	-8.8	-8.7	dBm	3
Pcon	1.4	1.5	1.6	dBm	4
Pcon	1.38	1,41	1,45	mW	5
Gant	**-10.2**	**-10.3**	**-10.3**	dBi	6

BLE radio: The Bluetooth Low Energy radio

Frq: The frequency in MHz

Efield: The electromagnetic field in dBuV/m in 3 meters distance to the antenna.

e.i.r.p: The equivalent isotropically radiated power in dBm

Pcon: The RF conducted power in dBm.

Gant: The antenna gain for an isotropically antenna in dBm

Note 1:
The low frequency, the mid frequency, and the high frequency for the Bluetooth Low Energy radio (BLE radio)

Note 2:
The electromagnetic field strengths in dBuV/m at 3 meters distance to the antenna, data is coming from the Report - "122-31550-6 Rev.A" page 24

Note 3:
The electromagnetic field strengths are converted to e.i.r.p. – at 3 meters distance to test object

Note: 4
From the technical memorandum - "Conducted power measurement - 15.249_11b_AF100 GFD AF Operational description.pdf" page 2, 3 and 4.

Note. 5
RF conducted power in [dBm] converted to [mW], P[mW] = 10(Pcon/10)

Note 6:
The antenna gain is Gant [dBi] = e.i.r.p.[dBm] – Pcon [dBm] and determined from: (e.i.r.p. [dBm] = Pcon [dBm] + Gant [dBi]).