Technical Memorandum

MPE and Gant Assessment of AF100 according to FCC specifications

Performed for Glowforge Inc.

Project no.: 122-31550-8 Rev.B

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Title	MPE and Gant Assessment of AF100 according to FCC specifications
Assessment object	AF100
Report no.	122-31550-8 Rev.B
Client	Glowforge Inc. 1938 Occidental Avenue S, Suite C WA 98134 Seattle Washington United States
Manufacturer	Glowforge Inc.
Specifications	7 CFR Part 2.1091, 47 CFR 1.1310 and 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 Aspril 2023

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Table of contents

1. Conclusion

Maximum Permissible Exposure (MPE) assessment for a mobile device with product name AF100 and FCC ID 2A83C-1JM2D.

The assessment object mentioned in this report meets the requirements of the rule parts stated below

- 7 CFR Part 2.1091
- 47 CFR 1.1310
- 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.he test object AF100 air filter.

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 EU requirements

Assessment method:

- KDB 447498 D01 General RF Exposure Guidance v06 clause 7.2
    - Maximum Permissible Exposure (MPE)
    - 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, regulated in 47 CFR Part 2.1091 and 47 CFR 1.1310 for mobile RF devices.

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

The following information provides the minimum separation distance for the highest gain antenna provided with the AF100 as calculated from (B) Limits for General Population / Uncontrolled Exposure of: TABLE 1- LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE) of §1.1310 Radiofrequency radiation exposure limits.

4.1.1 BLE radio:

This calculation is based on the highest EIRP or Pcon possible from the system, considering maximum power and antenna gain, and considering the Power density:

- S_{limit_BLE} = 1.0 [mW/cm^2] in a general population/uncontrolled exposure environment.

The maximum conduced output power is the worst-case power, see the technical memorandum - "Conducted power measurement - 15.249_11b_AF100 GFD AF Operational description.pdf" page 2, 3 and 4. This is due to the low antenna gain.

The formula used for power density:	S = (e.i.r.p. or Pcon) / (4* π *r^2) where
Maximum conduced output power:	Pcon = 1.45 [mW] (WC)
Distance to user:	≥ 20 [cm]
Frequency range:	2400 to 2480 [MHz] (far-field)
Power density:	$S_{measured\_BLE}$ = 0.0003 [mW/cm^2]

$Factor_{BLE} = S_{measured\_BLE} / S_{limit\_BLE}$

$Factor_{BLE}$ = 0.0003 [mW/cm^2] /1.0 [mW/cm^2] = 0.0003 (No unit)

4.1.2 NFC/RFID radio

The following information provides the minimum separation distance for the highest gain antenna provided with the AF100 as calculated from (B) Limits for General Population / Uncontrolled Exposure of: TABLE 1- LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE) of §1.1310 Radiofrequency radiation exposure limits.

This calculation is based on the highest electric field strength possible from the system.

- $E_{limit\ NFC/RFID} = 824/f = 824/13.56 = 60.8$[V/m] ~ 155.67 [dBµV/m]
  in a general population/uncontrolled exposure environment.

The method used for electric field strength correction:

The electric field strength is measured at 3 [m] distance at 66.56 [dBuV/m], see test report "122-31550-5 - Test Report FCC part 15.225 - ISED RSS 210 - Glowforge Inc. - AF100.pdf"
and the worst-case extrapolation factor is 60 [dB]/decade of distance for near field measurements for MPE.)

Measurement distance: 3 [m]
Assessment distance: x = 0.20 [m]

Extrapolation factor (x) = 60 x $\log_{10}$ (measurement distance / assessment distance) [dB]
Extrapolation factor (0.2 [m]) = 60 x $\log_{10}$ (3 [m]/0.2 [m]) [dB] = 70.57 [dB]

The electric field strength is to be increased by 70.57 [dB] to give electric field strength value at 0.2 [m] distance in a worst-case scenario.

Electric field strength measured:	E = 66.56+70.57=137.14 [dBµV/m] (7.19 [V/m]) corrected to 0.2 [m]
Distance to user:	≥0.2 [m]
Frequency range:	13.56 [MHz] (near-field)

Electric field strength measured:	$E_{measured\ NFC/RFID}$ = 137.13 [dBuV/m] (7.19 [V/m]) corrected to 0.2 [m]

$Factor_{NFC/RFID} = E_{measured\ NFC/RFID} / E_{limit\ NFC/RFID}$

$Factor_{NFC/RFID}$ = 7.19 [V/m] / 60.8 [V/m] = 0.1183 (-18.54 [dB])

(Check: $Factor_{NFC/RFID}$ = 137.13 [dBuV/m] - 155.67 [dBµV/m] = -18.54 [dB])

4.2 Limit

General population/uncontrolled exposure environment.

$Factor_{total} \leq 1$

According to KDB 447498 D01 General RF Exposure Guidance v06 clause 7.2

4.3 Result

$Factor_{BLE} = 0.0003$

$Factor_{NFC/RFID} = 0.1183$

$Factor_{total} = Factor_{BLE} + Factor_{NFC/RFID} = 0.0003 + 0.1183 = 0.1186$ and this is ≤ 1.

Therefore, the product is considered compliant with the FCC rule parts for Maximum Permissible Exposure (MPE) in a general population/uncontrolled exposure environment without further test or analysis at an assessment distance: x = 0.20 [m].

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

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]).