

RF Exposure evaluation

FCC ID: 2AGN7-NEO-X

Exposure category: General population/uncontrolled environment

EUT Type: Production Unit

Device Type: Mobile Device

1. Reference

According to §1.1307(b)(1), 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 level in excess of the Commission’s guidelines.

According to §1.1310 and §2.1091 RF exposure is calculated.

KDB447498 D01: Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies

2. Limit

Limits for Maximum Permissible Exposure (MPE)/Controlled Exposure

Frequency Range(MHz)	Electric Field Strength(V/m)	Magnetic Field Strength(A/m)	Power Density (mW/cm ²)	Averaging Time (minute)
Limits for Occupational/Controlled Exposure				
0.3 – 3.0	614	1.63	(100) *	6
3.0 – 30	1842/f	4.89/f	(900/f ²)*	6
30 – 300	61.4	0.163	1.0	6
300 – 1500	/	/	f/300	6
1500 – 100,000	/	/	5	6

Limits for Maximum Permissible Exposure (MPE)/Uncontrolled Exposure

Frequency Range(MHz)	Electric Field Strength(V/m)	Magnetic Field Strength(A/m)	Power Density (mW/cm ²)	Averaging Time (minute)
Limits for Occupational/Controlled Exposure				
0.3 – 3.0	614	1.63	(100) *	30
3.0 – 30	824/f	2.19/f	(180/f ²)*	30
30 – 300	27.5	0.073	0.2	30
300 – 1500	/	/	f/1500	30
1500 – 100,000	/	/	1.0	30

F=frequency in MHz

*=Plane-wave equivalent power density

3. MPE Calculation Method

Predication of MPE limit at a given distance

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S=PG/4\pi R^2$$

Where: S=power density

P=power input to antenna

G=power gain of the antenna in the direction of interest relative to an isotropic radiator

R=distance to the center of radiation of the antenna

4. Antenna Information

NEO X can only use antennas certificated as follows provided by manufacturer;

Internal Identification	Antenna Identification in Internal photos	Antenna type and antenna number	Operate frequency band	Maximum antenna gain
Antenna 0	2.4G/5G Wifi Chain 0	External antenna	2.4GHz – 2.5 GHz 5.1GHz – 5.8 GHz	3.00 dBi
Antenna 1	2.4G/5G Wifi Chain 1	External antenna	2.4GHz – 2.5 GHz 5.1GHz – 5.8 GHz	3.00 dBi
Antenna 3	BT	External antenna	2.4GHz – 2.5 GHz	3.00 dBi

5. Conducted power

Bluetooth

Mode	Channel	Frequency(MHz)	Peak Conducted Output Power (dBm)
GFSK	0	2402	3.72
	39	2441	3.56
	78	2480	3.37
$\pi/4$ DQPSK	0	2402	3.69
	39	2441	3.51
	78	2480	3.32
8-DPSK	0	2402	3.81
	39	2441	3.63
	78	2480	3.45

[2.4GHz WLAN]

Mode	Channel	Frequency	Peak Conducted Output Power (dBm)	
			Antenna0	Antenna1
<i>IEEE 802.11b</i>	1	2412	18.62	17.16
	7	2437	18.10	16.65
	13	2462	18.05	16.22
<i>IEEE 802.11g</i>	1	2412	23.25	22.44
	7	2437	22.53	21.86
	13	2462	22.23	21.39
<i>IEEE 802.11n HT20</i>	1	2412	23.24	22.13
	7	2437	22.42	21.41
	13	2462	22.17	21.04
<i>IEEE 802.11n HT40</i>	3	2422	23.40	22.16
	7	2437	22.63	21.68
	11	2452	22.43	21.23

[5GHz WLAN Band 1]

Mode	Channel	Frequency	Average Conducted Output Power (dBm)	
			Antenna0	Antenna1
<i>IEEE 802.11a</i>	36	5180	11.36	10.72
	40	5200	11.95	11.42
	48	5240	12.86	12.17
<i>IEEE 802.11n HT20</i>	36	5180	11.54	10.91
	40	5200	12.04	11.34
	48	5240	13.14	12.14
<i>IEEE 802.11ac VHT20</i>	36	5180	11.48	10.90
	40	5200	12.11	11.81
	48	5240	11.38	10.75
<i>IEEE 802.11n HT40</i>	38	5190	12.04	11.37
	46	5230	12.68	12.41
<i>IEEE 802.11ac VHT40</i>	38	5190	11.46	10.73
	46	5230	12.41	11.39
<i>IEEE 802.11ac VHT80</i>	42	5210	11.59	10.76

[5GHz WLAN Band 3]

Mode	Channel	Frequency	Average Conducted Output Power (dBm)	
			Antenna0	Antenna1
IEEE 802.11a	149	5745	13.34	12.51
	157	5785	12.09	11.53
	165	5825	11.35	10.35
IEEE 802.11n HT20	149	5745	13.03	12.51
	157	5785	12.10	11.42
	165	5825	11.13	10.52
IEEE 802.11ac VHT20	149	5745	12.87	12.54
	157	5785	11.77	11.06
	165	5825	13.00	12.66
IEEE 802.11n HT40	151	5755	12.08	11.60
	159	5795	11.30	10.43
IEEE 802.11ac VHT40	151	5755	12.98	12.23
	159	5795	11.35	11.19
IEEE 802.11ac VHT80	155	5775	12.46	11.84

6. Manufacturing Tolerance

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GFSK (Peak)			
Channel	Channel 0	Channel 39	Channel 78
Target (dBm)	3.0	3.0	3.0
Tolerance \pm (dB)	1.0	1.0	1.0
$\pi/4$ DQPSK (Peak)			
Channel	Channel 0	Channel 39	Channel 78
Target (dBm)	3.0	3.0	3.0
Tolerance \pm (dB)	1.0	1.0	1.0
8-DPSK (Peak)			
Channel	Channel 0	Channel 39	Channel 78
Target (dBm)	3.0	3.0	3.0
Tolerance \pm (dB)	1.0	1.0	1.0

2.4GHz WLAN

IEEE 802.11b (Peak)						
Frequency (MHz)	Antenna 0			Antenna 1		
	2412	2437	2462	2412	2437	2462
Target (dBm)	18.0	18.0	18.0	17.0	17.0	17.0
Tolerance \pm (dB)	1.0	1.0	1.0	1.0	1.0	1.0

IEEE 802.11g (Peak)						
Frequency (MHz)	Antenna 0			Antenna 1		
		2412	2437	2462	2412	2437
Target (dBm)	23.0	22.0	22.0	22.0	21.0	21.0
Tolerance \pm (dB)	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11n HT20 (Peak)						
Frequency (MHz)	Antenna 0			Antenna 1		
		2412	2437	2462	2412	2437
Target (dBm)	23.0	22.0	22.0	22.0	21.0	21.0
Tolerance \pm (dB)	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11n HT40 (Peak)						
Frequency (MHz)	Antenna 0			Antenna 1		
		2422	2437	2452	2422	2437
Target (dBm)	23.0	22.0	22.0	22.0	21.0	21.0
Tolerance \pm (dB)	1.0	1.0	1.0	1.0	1.0	1.0

5GHz WLAN Band 1

IEEE 802.11a (Average)						
Frequency (MHz)	Antenna 0			Antenna 1		
		5180	5200	5240	5180	5200
Target (dBm)	11.0	11.0	12.0	11.0	11.0	12.0
Tolerance \pm (dB)	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11n HT20 (Average)						
Frequency (MHz)	Antenna 0			Antenna 1		
		5180	5200	5240	5180	5200
Target (dBm)	11.0	12.0	13.0	11.0	12.0	13.0
Tolerance \pm (dB)	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11ac VHT20 (Average)						
Frequency (MHz)	Antenna 0			Antenna 1		
		5180	5200	5240	5180	5200
Target (dBm)	11.0	12.0	13.0	11.0	12.0	13.0
Tolerance \pm (dB)	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11n HT40 (Average)						
Frequency (MHz)	Antenna 0			Antenna 1		
		5190	5230	5190	5230	
Target (dBm)	11.0	12.0	11.0	12.0		
Tolerance \pm (dB)	1.0	1.0	1.0	1.0	1.0	

IEEE 802.11ac VHT40 (Average)				
Frequency (MHz)	Antenna 0		Antenna 1	
		5190	5230	5190
Target (dBm)	11.0	12.0	11.0	12.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0
IEEE 802.11ac VHT80 (Average)				
Frequency (MHz)	Antenna 0		Antenna 1	
		5210		5210
Target (dBm)	11.0		11.0	
Tolerance ±(dB)	1.0		1.0	

5GHz WLAN Band 3

IEEE 802.11a (Average)						
Frequency (MHz)	Antenna 0			Antenna 1		
		5745	5785	5825	5745	5785
Target (dBm)	13.0	12.0	11.0	13.0	12.0	11.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11n HT20 (Average)						
Frequency (MHz)	Antenna 0			Antenna 1		
		5745	5785	5825	5745	5785
Target (dBm)	13.0	12.0	11.0	13.0	12.0	11.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11ac VHT20 (Average)						
Frequency (MHz)	Antenna 0			Antenna 1		
		5745	5785	5825	5745	5785
Target (dBm)	13.0	12.0	11.0	13.0	12.0	11.0
Tolerance ±(dB)	1.0	1.0	1.0	1.0	1.0	1.0
IEEE 802.11n HT40 (Average)						
Frequency (MHz)	Antenna 0		Antenna 1			
		5755	5795	5755	5795	
Target (dBm)	12.0	11.0	12.0	11.0		
Tolerance ±(dB)	1.0	1.0	1.0	1.0		
IEEE 802.11ac VHT40 (Average)						
Frequency (MHz)	Antenna 0		Antenna 1			
		5755	5795	5755	5795	
Target (dBm)	12.0	11.0	12.0	11.0		
Tolerance ±(dB)	1.0	1.0	1.0	1.0		

IEEE 802.11ac VHT80 (Average)		
Frequency (MHz)	Antenna 0	Antenna 1
	5775	5775
Target (dBm)	12.0	11.0
Tolerance \pm (dB)	1.0	1.0

7. Standalone MPE Result

As declared by the Applicant, the EUT is a wireless device used in a fix application, at least 20 cm from any body part of the user or nearby persons; from the maximum EUT RF output power, the minimum separation distance, $r=20\text{cm}$, as well as the gain of the used antenna is 3dBi, the RF power density can be obtained.

Bluetooth

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
GFSK	4.00	2.5119	3.00	1.9953	100%	0.0010	1.0000
$\pi/4$ DQPSK	4.00	2.5119	3.00	1.9953	100%	0.0010	1.0000
8-DPSK	4.00	2.5119	3.00	1.9953	100%	0.0010	1.0000

2.4GHz WLAN

Antenna 0

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11b	19.00	79.4328	3.00	1.9953	100%	0.0315	1.0000
IEEE 802.11g	24.00	251.1886	3.00	1.9953	100%	0.0997	1.0000
IEEE 802.11n HT20	24.00	251.1886	3.00	1.9953	100%	0.0997	1.0000
IEEE 802.11n HT40	24.00	251.1886	3.00	1.9953	100%	0.0997	1.0000

Antenna 1

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11b	18.00	63.0957	3.00	1.9953	100%	0.0250	1.0000
IEEE 802.11g	23.00	199.5262	3.00	1.9953	100%	0.0792	1.0000
IEEE 802.11n HT20	23.00	199.5262	3.00	1.9953	100%	0.0792	1.0000
IEEE 802.11n HT40	23.00	199.5262	3.00	1.9953	100%	0.0792	1.0000

5GHz WLAN Band 1

Antenna 0

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11a	13.00	19.9526	3.00	1.9953	100%	0.0079	1.0000
IEEE 802.11n HT20	14.00	25.1189	3.00	1.9953	100%	0.0100	1.0000
IEEE 802.11ac VHT20	14.00	25.1189	3.00	1.9953	100%	0.0100	1.0000
IEEE 802.11n HT40	13.00	19.9526	3.00	1.9953	100%	0.0079	1.0000
IEEE 802.11ac VHT40	13.00	19.9526	3.00	1.9953	100%	0.0079	1.0000
IEEE 802.11ac VHT80	12.00	15.8489	3.00	1.9953	100%	0.0063	1.0000

Antenna 1

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11a	13.00	19.9526	3.00	1.9953	100%	0.0079	1.0000
IEEE 802.11n HT20	14.00	25.1189	3.00	1.9953	100%	0.0100	1.0000
IEEE 802.11ac VHT20	14.00	25.1189	3.00	1.9953	100%	0.0100	1.0000
IEEE 802.11n HT40	13.00	19.9526	3.00	1.9953	100%	0.0079	1.0000
IEEE 802.11ac VHT40	13.00	19.9526	3.00	1.9953	100%	0.0079	1.0000
IEEE 802.11ac VHT80	12.00	15.8489	3.00	1.9953	100%	0.0063	1.0000

5GHz WLAN Band 3

Antenna 0

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11a	14.00	25.1189	3.00	1.9953	100%	0.0100	1.0000
IEEE 802.11n HT20	14.00	25.1189	3.00	1.9953	100%	0.0100	1.0000
IEEE 802.11ac VHT20	14.00	25.1189	3.00	1.9953	100%	0.0100	1.0000
IEEE 802.11n HT40	13.00	19.9526	3.00	1.9953	100%	0.0079	1.0000
IEEE 802.11ac VHT40	13.00	19.9526	3.00	1.9953	100%	0.0079	1.0000
IEEE 802.11ac VHT80	13.00	19.9526	3.00	1.9953	100%	0.0079	1.0000

Antenna 1

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW					
IEEE 802.11a	14.00	25.1189	3.00	1.9953	100%	0.0100	1.0000
IEEE 802.11n HT20	14.00	25.1189	3.00	1.9953	100%	0.0100	1.0000
IEEE 802.11ac VHT20	14.00	25.1189	3.00	1.9953	100%	0.0100	1.0000

IEEE 802.11n HT40	13.00	19.9526	3.00	1.9953	100%	0.0079	1.0000
IEEE 802.11ac VHT40	13.00	19.9526	3.00	1.9953	100%	0.0079	1.0000
IEEE 802.11ac VHT80	13.00	19.9526	3.00	1.9953	100%	0.0079	1.0000

Remark:

1. Output power (Average) including turn-up tolerance;
2. Output power was adjust to duty cycle at 100% if measured duty cycle less than 98%;
3. MPE evaluate distance is 20cm from user manual provide by manufacturer.

8. Summary simultaneous transmission information

Synchronization transmit between WIFI Ant0 and Ant1

Modulation Type	Work Frequency Band	Transmit Antenna		Antenna 0 Antenna 1 Synchronization transmit
		Antenna 0	Antenna 1	
IEEE 802.11a	5.8G/5.2GHz	Yes	Yes	No
IEEE 802.11b	2.4GHz	Yes	Yes	No
IEEE 802.11g	2.4GHz	Yes	Yes	No
IEEE 802.11n HT20	2.4GHz	Yes	Yes	Yes
IEEE 802.11n HT20	5.8G/5.2GHz	Yes	Yes	Yes
IEEE 802.11n HT40	2.4GHz	Yes	Yes	Yes
IEEE 802.11n HT40	5.8G/5.2GHz	Yes	Yes	Yes
IEEE 802.11ac VHT20	5.8G/5.2GHz	Yes	Yes	Yes
IEEE 802.11ac VHT40	5.8G/5.2GHz	Yes	Yes	Yes
IEEE 802.11ac VHT80	5.8G/5.2GHz	Yes	Yes	Yes

Synchronization transmit between WIFI and BT

Modulation Type	Modulation Type	Synchronization transmit
IEEE 802.11a	BT	Yes
IEEE 802.11b	BT	Yes
IEEE 802.11g	BT	Yes
IEEE 802.11n HT20	BT	Yes
IEEE 802.11n HT20	BT	Yes
IEEE 802.11n HT40	BT	Yes
IEEE 802.11n HT40	BT	Yes
IEEE 802.11ac VHT20	BT	Yes
IEEE 802.11ac VHT40	BT	Yes
IEEE 802.11ac VHT80	BT	Yes

9. Summary simultaneous transmission results

Antenna 0 and Antenna 1 for 2.4G WLAN

Modulation Type	MPE _{Antenna0} (mW/cm ²)	MPE _{Antenna1} (mW/cm ²)	ΣMPE ratios	Limit	Results
IEEE 802.11n HT20	0.0997	0.0792	0.1789	1.0	PASS
IEEE 802.11n HT40	0.0997	0.0792	0.1789	1.0	PASS

Antenna 0 and Antenna 1 for 5G WLAN Band 1

Modulation Type	MPE _{Antenna0} (mW/cm ²)	MPE _{Antenna1} (mW/cm ²)	ΣMPE ratios	Limit	Results
IEEE 802.11n HT20	0.0079	0.0079	0.0158	1.0	PASS
IEEE 802.11ac VHT20	0.0100	0.0100	0.0200	1.0	PASS
IEEE 802.11n HT40	0.0100	0.0100	0.0200	1.0	PASS
IEEE 802.11ac VHT40	0.0079	0.0079	0.0158	1.0	PASS
IEEE 802.11ac VHT80	0.0079	0.0079	0.0158	1.0	PASS

Antenna 0 and Antenna 1 for 5G WLAN Band 3

Modulation Type	MPE _{Antenna0} (mW/cm ²)	MPE _{Antenna1} (mW/cm ²)	ΣMPE ratios	Limit	Results
IEEE 802.11n HT20	0.0100	0.0100	0.0200	1.0	PASS
IEEE 802.11ac VHT20	0.0100	0.0100	0.0200	1.0	PASS
IEEE 802.11n HT40	0.0100	0.0100	0.0200	1.0	PASS
IEEE 802.11ac VHT40	0.0079	0.0079	0.0158	1.0	PASS
IEEE 802.11ac VHT80	0.0079	0.0079	0.0158	1.0	PASS

Synchronization transmit between WIFI and BT

Max. ΣMPE _(wifi) (mW/cm ²)	MPE _(BT) (mW/cm ²)	ΣMPE _(WIFI+BT) ratios	Limit	Results
0.1789	0.0010	0.1799	1.0	PASS

10. Conclusion

The measurement results comply with the FCC Limit per 47 CFR 2.1091 for the uncontrolled RF Exposure of mobile device.

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