



SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch

SZEMC-TRF-01 Rev. A/0 Aug01,2022

Report No.: SZCR230700244607

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RF EXPOSURE EVALUATION REPORT

Application No.: SZCR2307002446AT
Applicant: Shenzhen Hua Xin Information Technology Co.,Ltd.
Address of Applicant: B101-B801, building 4,No.7 Industrial Area,Heshuikou Community, Matian Street,Guangming District, Shenzhen,China
Manufacturer: Shenzhen Hua Xin Information Technology Co.,Ltd.
Address of Manufacturer: B101-B801, building 4,No.7 Industrial Area,Heshuikou Community, Matian Street,Guangming District, Shenzhen,China
Equipment Under Test (EUT):
EUT Name: Robotic vacuum cleaner
Model No.: X2000, X2000-1, X2000-2, X2000-3, X2000S, X2000S-1, X2000S-2, X2000PRO, X2000PRO-1, X2000PRO-2, G20, R20 ♣
♣ Please refer to section 3 of this report which indicates which model was actually tested and which were electrically identical.
FCC ID: 2AMYQ-2023X2000
Standard(s) : FCC Rules 47 CFR §2.1091
KDB 447498 D04 interim General RF Exposure Guidance v01
Date of Receipt: 2023-07-30
Date of Evaluation: 2023-09-24 to 2023-10-12
Date of Issue: 2023-10-24

Evaluation Result:	Pass*
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* In the configuration evaluated, the EUT complied with the standards specified above.

Keny Xu

Keny Xu
EMC Laboratory Manager



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Shenzhen Branch EMC Laboratory

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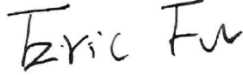
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Revision Record				
Version	Chapter	Date	Modifier	Remark
01		2023-10-24		Original

Authorized for issue by:				
				
		Winkey Wang/Project Engineer		
				
		Eric Fu/Reviewer		



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3 General Information

3.1 General Description of E.U.T.

Product Type:	<input type="checkbox"/> Portable device
	<input checked="" type="checkbox"/> Mobile device
	<input type="checkbox"/> Fixed device

3.2 Details of E.U.T.

Power supply:	Input 19Vdc, 1A, Li-ion battery inside:14.4Vdc, 5200mAh, Rated power: 60W
For 2.4G BT&WIFI Module: AW-NM372SM Note: the 2.4GWIFI Module: AW-NM372SM has been tested and certified before it is applied in the EUT, only changed the ANT. please refer test report No.: FR0O0601AC, FR0O0601AD and FR0O0601AE, FCC ID: 2AMYQ-2023X2000	
For BT:	
Operation Frequency:	2402MHz to 2480MHz;
Modulation Type:	GFSK, $\pi/4$ -DQPSK, 8DPSK
Number of Channels:	79
Channel Spacing:	1MHz
Antenna Type:	Internal Antenna
Antenna Gain:	-2.40dBi
For BLE	
Operation Frequency:	2402MHz to 2480MHz;
Modulation Type:	GFSK
Number of Channels:	40
Channel Spacing:	2MHz
Data Rate:	1Mbps
Antenna Type:	Internal Antenna
Antenna Gain:	-2.40dBi
For 2.4G WIFI	
Operation Frequency:	802.11b/g/n(HT20): 2412MHz to 2462MHz;
Modulation Type:	802.11b: DSSS (CCK, DQPSK, DBPSK); 802.11g/n:OFDM (64QAM, 16QAM, QPSK, BPSK)
Number of Channels:	802.11b/g/n(HT20):11;
Channel Spacing:	5MHz
Antenna Type:	Internal Antenna
Antenna Gain:	-2.40dBi



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For 2.4GWIFI Module: ESP-WROOM-02D Note: the 2.4GWIFI Module: ESP-WROOM-02D has been tested and certified before it is applied in the EUT, please refer test report No.: RXA1709-0323RF02R3, FCC ID: 2AC7Z-ESPWROOM02D	
Operation Frequency:	802.11b/g/n(HT20): 2412MHz to 2462MHz;
Modulation Type:	802.11b: DSSS (CCK, DQPSK, DBPSK); 802.11g/n:OFDM (64QAM, 16QAM, QPSK, BPSK)
Number of Channels:	802.11b/g/n(HT20):11
Channel Spacing:	5MHz
Antenna Type:	Internal Antenna
Antenna Gain:	3.77dBi for 2412MHz, 3.74dBi for 2437MHz, 3.42dBi for 2462MHz,

Remark: The information in this section is provided by the applicant or manufacturer, CCS is not liable to the accuracy, suitability, reliability or/and integrity of the information.



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3.3 Separation Distance

Minimum test separation distance:	20cm
Remark: This minimum test separation distance is determined by the smallest distance from the antenna and radiating structures or outer surface of the device, according to the host form factor, exposure conditions and platform requirements, to any part of the body or extremity of a user or bystander.	

3.4 Test Location

All tests were performed at:

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen Branch

No. 1 Workshop, M-10, Middle Section, Science & Technology Park, Nanshan District, Shenzhen, Guangdong, China. 518057.

Tel: +86 755 2601 2053 Fax: +86 755 2671 0594

No tests were sub-contracted.

3.5 Test Facility

• A2LA (Certificate No. 3816.01)

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen EMC Laboratory is accredited by the American Association for Laboratory Accreditation(A2LA). Certificate No. 3816.01.

• VCCI (Member No. 1937)

The 3m Fully-anechoic chamber for above 1GHz, 10m Semi-anechoic chamber for below 1GHz, Shielded Room for Mains Port Conducted Interference Measurement and Telecommunication Port Conducted Interference Measurement of SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen EMC laboratory have been registered in accordance with the Regulations for Voluntary Control Measures with Registration No.: G-20026, R-14188, C-12383 and T-11153 respectively.

• FCC –Designation Number: CN1336

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen EMC Laboratory has been recognized as an accredited testing laboratory.

Designation Number: CN1336. Test Firm Registration Number: 787754.

• Innovation, Science and Economic Development Canada

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen EMC Laboratory has been recognized by ISED as an accredited testing laboratory.

CAB identifier: CN0006.

IC#: 4620C.

3.6 Deviation from Standards

None

3.7 Abnormalities from Standard Conditions

None



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FCC Radiofrequency radiation exposure limits

Test exemptions apply for devices used in general population/uncontrolled exposure environments, according to the SAR-based, or MPE-based exemption thresholds.

3.8 Blanket 1 mW Blanket Exemption

The 1 mW Blanket Exemption of §1.1307(b)(3)(i)(A) applies for single fixed, mobile, and portable RF sources with available maximum time-averaged power of no more than 1 mW, regardless of separation distance.

The 1-mW blanket exemption applies at separation distances less than 0.5 cm, including where there is no separation. This exemption shall not be used in conjunction with other exemption criteria other than those for multiple RF sources in paragraph §1.1307(b)(3)(ii)(A).

The 1-mW exemption is independent of service type and covers the full range of 100 kHz to 100 GHz, but it shall not be used in conjunction with other exemption criteria or in devices with higher-power transmitters operating in the same time-averaging period. Exposure from such higher-power transmitters would invalidate the underlying assumption that exposure from the lower-power transmitter is the only contributor to SAR in the relevant volume of tissue.

3.9 MPE-based Exemption

General frequency and separation-distance dependent MPE-based effective radiated power (ERP) thresholds are in Table B.1 [Table 1 of §1.1307(b)(1)(i)(C)] to support an exemption from further evaluation from 300 kHz through 100 GHz.

Table B.1—Thresholds For Single RF Sources Subject to Routine Environmental Evaluation

RF Source Frequency			Minimum Distance			Threshold ERP
f_L MHz		f_H MHz	$\lambda_L / 2\pi$		$\lambda_H / 2\pi$	W
0.3	—	1.34	159 m	—	35.6 m	1,920 R ²
1.34	—	30	35.6 m	—	1.6 m	3,450 R ² /f ²
30	—	300	1.6 m	—	159 mm	3.83 R ²
300	—	1,500	159 mm	—	31.8 mm	0.0128 R ² f
1,500	—	100,000	31.8 mm	—	0.5 mm	19.2R ²
Subscripts L and H are low and high; λ is wavelength.						
From §1.1307(b)(3)(i)(C), modified by adding Minimum Distance columns.						

The table applies to any RF source (i.e. single fixed, mobile, and portable transmitters) and specifies power and distance criteria for each of the five frequency ranges used for the MPE limits. These criteria apply at separation distances from any part of the radiating structure of at least $\lambda/2\pi$. The thresholds are

based on the general population MPE limits with a single perfect reflection, outside of the reactive near-field, and in the main beam of the radiator.

For mobile devices that are not exempt per Table B.1 [Table 1 of §1.1307(b)(1)(i)(C)] at distances from 20 cm to 40 cm and in 0.3 GHz to 6 GHz, evaluation of compliance with the exposure limits in §1.1310 is necessary if the ERP of the device is greater than ERP_{20cm} in Formula (B.1) [repeated from §2.1091(c)(1); also in §1.1307(b)(1)(i)(B)].

$$P_{th} \text{ (mW)} = ERP_{20 \text{ cm}} \text{ (mW)} = \begin{cases} 2040f & 0.3 \text{ GHz} \leq f < 1.5 \text{ GHz} \\ 3060 & 1.5 \text{ GHz} \leq f \leq 6 \text{ GHz} \end{cases} \quad (B.1)$$

If the ERP is not easily obtained, then the available maximum time-averaged power may be used (i.e., without consideration of ERP only if the physical dimensions of the radiating structure(s) do not exceed the electrical length of $\lambda/4$ or if the antenna gain is less than that of a half-wave dipole.

SAR-based exemptions are constant at separation distances between 20 cm and 40 cm to avoid discontinuities in the threshold when transitioning between SAR-based and MPE-based exemption criteria at 40 cm, considering the importance of reflections.

Limit calculation			
Frequency range	Frequency(MHz)	$R(\lambda/2\pi)(m)$	Threshold ERP(W)
300~1500MHz	915	0.0522	0.032
1500~100000MHz	2480	0.0193	0.007

3.10 SAR-based Exemption

SAR-based thresholds are derived based on frequency, power, and separation distance of the RF source. The formula defines the thresholds in general for either available maximum time-averaged power or maximum time-averaged ERP, whichever is greater.

If the ERP of a device is not easily determined, such as for a portable device with a small form factor, the applicant may use the available maximum time-averaged power exclusively if the device antenna or radiating structure does not exceed an electrical length of $\lambda/4$.

As for devices with antennas of length greater than $\lambda/4$ where the gain is not well defined, but always less than that of a half-wave dipole (length $\lambda/2$), the available maximum time-averaged power generated by the device may be used in place of the maximum time-averaged ERP, where that value is not known.

The separation distance is the smallest distance from any part of the antenna or radiating structure for all persons, during operation at the applicable ERP. In the case of mobile or portable devices, the separation distance is from the outer housing of the device where it is closest to the antenna.



The SAR-based exemption formula of §1.1307(b)(3)(i)(B), repeated here as Formula (B.2), applies for single fixed, mobile, and portable RF sources with available maximum time-averaged power or effective radiated power (ERP), whichever is greater, of less than or equal to the threshold P_{th} (mW).

This method shall only be used at separation distances from 0.5 cm to 40 cm and at frequencies from 0.3 GHz to 6 GHz (inclusive). P_{th} is given by Formula (B.2).

$$P_{th} \text{ (mW)} = \begin{cases} ERP_{20 \text{ cm}}(d/20 \text{ cm})^x & d \leq 20 \text{ cm} \\ ERP_{20 \text{ cm}} & 20 \text{ cm} < d \leq 40 \text{ cm} \end{cases} \quad (\text{B.2})$$

where

$$x = -\log_{10} \left(\frac{60}{ERP_{20 \text{ cm}} \sqrt{f}} \right)$$

and f is in GHz, d is the separation distance (cm), and $ERP_{20 \text{ cm}}$ is per Formula (B.1).

Example values shown in Table B.2 are for illustration only.

Table B.2—Example Power Thresholds (mW)

Frequency (MHz)	Distance(mm)									
	5	10	15	20	25	30	35	40	45	50
300	39	65	88	110	129	148	166	184	201	217
450	22	44	67	89	112	135	158	180	203	226
835	9	25	44	66	90	116	145	175	207	240
1900	3	12	26	44	66	92	122	157	195	236
2450	3	10	22	38	59	83	111	143	179	219
3600	2	8	18	32	49	71	96	125	158	195
5800	1	6	14	25	40	58	80	106	136	169

Limit calculation				
Frequency range(GHz)	Frequency(GHz)	X	Distance(cm)	Pth (mW)
0.3~1.5	0.915	1.474	0.5	8.133
1.5~6	2.48	1.905	0.5	2.717

4 Measurement and Calculation

4.1 Maximum transmit power

For 2.4G BT&WIFI Module 1: AW-NM372SM

For BT

The Power Data is based on the RF Test Report No.:FR0O0601AD

Antenna Gain: -2.40dBi

Output Power Into Antenna & RF Exposure Evaluation Distance:

Frequency	Maximum Conducted Power [dBm]	Maximum Conducted Power [mW]	Maximum EIRP (mW)
2441	9.20	8.32	6.79

Note: Refer to report No.: FR0O0601AD for EUT test Max Power Value.

The distance r (4th column) calculated from the Fries transmission formula is far greater than 20cm separation requirement.

For BLE

The Power Data is based on the RF Test Report No.:FR0O0601AE

Antenna Gain: -2.40dBi

Output Power Into Antenna & RF Exposure Evaluation Distance:

Frequency	Maximum Conducted Power [dBm]	Maximum Conducted Power [mW]	Maximum EIRP (mW)
2440	8.97	7.89	4.54

Note: Refer to report No.: FR0O0601AE for EUT test Max Power Value.

The distance r (4th column) calculated from the Fries transmission formula is far greater than 20cm separation requirement.

For 2.4G WIFI

The Power Data is based on the RF Test Report No.:FR0O0601AC

Antenna Gain: -2.40dBi

Output Power Into Antenna & RF Exposure Evaluation Distance:

Frequency	Maximum Conducted Power [dBm]	Maximum Conducted Power [mW]	Maximum EIRP (mW)
2462	21.15	130.32	74.99



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Note: Refer to report No.: FR000601AC for EUT test Max Power Value.

The distance r (4th column) calculated from the Fries transmission formula is far greater than 20cm separation requirement.

For 2.4GWIFI Module 2: ESP-WROOM-02D

The Power Data is based on the RF Test Report No.:RXA1709-0323RF02R3, FCC ID:2AC7Z-ESPWROOM02D

Antenna Gain: 3.74dBi

Output Power Into Antenna & RF Exposure Evaluation Distance:

Frequency	Maximum Conducted Power [dBm]	Maximum EIRP [dBm]	Maximum EIRP (mW)
2437	15.53	19.27	84.53

Note: Refer to report No. RF Test Report No.:RXA1709-0323RF02R3 (FCC ID:2AC7Z-ESPWROOM02D) for EUT test Max Power Value.

The distance r (4th column) calculated from the Fries transmission formula is far greater than 20cm separation requirement.



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4.2 RF Exposure Calculation

Remark: we used the maximum power between the conducted power and ERP/EIRP to perform RF exposure exemption evaluation.

For 2.4G BT&WIFI Module 1: AW-NM372SM

The Max Conducted power is 130.32mW.

	Evaluation method	Exempt Limit(mW)	Verdict
<input type="checkbox"/>	Blanket 1 mW Blanket Exemption	1mW	N/A
<input type="checkbox"/>	MPE-based Exemption(ERP)	7mW(ERP)	N/A
<input checked="" type="checkbox"/>	SAR-based Exemption(P_{th})	3060	Yes

For 2.4GWIFI Module 2: ESP-WROOM-02D

The Max EIRP is 84.53mW.

	Evaluation method	Exempt Limit(mW)	Verdict
<input type="checkbox"/>	Blanket 1 mW Blanket Exemption	1mW	N/A
<input type="checkbox"/>	MPE-based Exemption(ERP)	7mW(ERP)	N/A
<input checked="" type="checkbox"/>	SAR-based Exemption(P_{th})	3060	Yes

Simultaneous transmitting

Σ ratios of simultaneous transmitting: 2.4G BT&WIFI Module: AW-NM372SM + 2.4G WIFI Module:ESP-WROOM-02D as the following table:

Ratio of EIRP power of 2.4G WIFI 1	Ratio of EIRP power of 2.4G WIFI 2	Total ratios of simultaneous transmitting	Limit	Result
0.043	0.026	0.069	1.0	PASS

So, the device is to qualify for SAR test exemption, the exemption report is in lieu of the SAR report.

--End of the Report--

