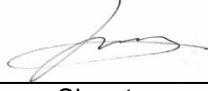


FCC & ISED MPE TEST REPORT

Project Number : EA2002C-029
Test Report Number : TR-W2006-022
Type of Equipment : WiFi/BT Combo Module
Model Name : SBW-M3
FCC ID : WF5SBWM3
ISED Canada ID : 9080A-SBWM3
Multiple Model Name : N/A
Applicant : Aroot Co., Ltd.
Address : 28-6, Gajangsaneopdong-ro, Osan-si, Gyeonggi-do, Republic of Korea
Manufacturer : Aroot Co., Ltd.
Address : 28-6, Gajangsaneopdong-ro, Osan-si, Gyeonggi-do, Republic of Korea
Regulation : FCC CFR 47 Part 2.1091, ISED RSS-102 Issue5
Total page of Report : 9 Pages
Date of Receipt : 2020-02-10
Date of Issue : 2020-06-23
Test Result : PASS

This test report only contains the result of a single test of the sample supplied for the examination.
It is not a generally valid assessment of the features of the respective products of the mass-production.

Prepared by	Song, In-young / Senior Engineer		2020-06-23
		Signature	Date
Reviewed by	Choi, Yeong-min / Technical Manager		2020-06-23
		Signature	Date

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Release Control Record

Issue Report No.	Issued Date	Details/Revisions
TR-W2006-022	2020-06-23	Initial Release
-	-	-

1. EUT (Equipment Under Test) INFORMATION

1.1 General Description

The Aroot Co., Ltd., Model SBW-M3 (referred to as the EUT in this report) is a WiFi/BT Combo Module.

The product specification described herein was obtained from product data sheet or user's manual.

Type of Equipment	☐ Fixed	☒ Mobile	☐ Portable
EUT Power Source	☐ 100-120 Vac	☒ DC Power	☐ Battery Operated
Operating Frequency	Bluetooth LE	2 402 MHz – 2 480 MHz	
	Bluetooth	2 402 MHz – 2 480 MHz	
	WLAN 2.4 GHz	2 412 MHz – 2 462 MHz (802.11b/g/n HT20)	
		2 422 MHz – 2 452 MHz (802.11n HT40)	
	UNII 1 band 5 150 MHz – 5 250 MHz	5 180 MHz – 5 240 MHz (802.11a/n HT20/ac VHT20)	
		5 190 MHz – 5 230 MHz (802.11n HT40/ac VHT40)	
		5 210 MHz (802.11ac VHT80)	
	UNII 2-A band 5 250 MHz – 5 350 MHz	5 260 MHz – 5 320 MHz (802.11a/n HT20/ac VHT20)	
		5 270 MHz – 5 310 MHz (802.11n HT40/ac VHT40)	
		5 290 MHz (802.11ac VHT80)	
	UNII 2-C band 5 470 MHz – 5 725 MHz	5 500 MHz – 5 700 MHz (802.11a/n HT20/ac VHT20)	
		5 510 MHz – 5 670 MHz (802.11n HT40/ac VHT40)	
		5 530 MHz – 5 610 MHz (802.11ac VHT80)	
	UNII 3 band 5 725 MHz – 5 850 MHz	5 745 MHz – 5 825 MHz (802.11a/n HT20/ac VHT20)	
		5 755 MHz – 5 795 MHz (802.11n HT40/ac VHT40)	
		5 775 MHz (802.11ac VHT80)	
Modulation Type	Bluetooth LE	GFSK	
		Bluetooth	
	WLAN 2.4 GHz	802.11b: DSSS (DBPSK, DQPSK, CCK)	
		802.11g/n HT20/HT40: OFDM (BPSK, QPSK, 16-QAM, 64-QAM)	
	WLAN 5 GHz	802.11g/n HT20/HT40: OFDM (BPSK, QPSK, 16-QAM, 64-QAM)	
		802.11ac VHT20/VHT40/VHT80: OFDM (BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM)	

RF Output Power	Bluetooth LE	1 Mbps	5.06dBm
	Bluetooth	1 Mbps	6.21 dBm
		2 Mbps	5.69 dBm
		3 Mbps	5.86 dBm
	WLAN 2.4 GHz	802.11b	11.92 dBm
		802.11g	10.65 dBm
		802.11n HT20	8.97 dBm
		802.11n HT40	6.94 dBm
	UNII 1 band 5 150 MHz – 5 250 MHz	802.11a	12.53 dBm
		802.11n HT20	12.57 dBm / 12.53 dBm
		802.11n HT40	7.91 dBm / 7.82 dBm
		802.11n VHT80	7.93 dBm
	UNII 2-A band 5 250 MHz – 5 350 MHz	802.11a	12.98 dBm
		802.11n HT20	12.80 dBm / 12.81 dBm
		802.11n HT40	7.95 dBm / 8.04 dBm
		802.11n VHT80	8.72 dBm
	UNII 2-C band 5 470 MHz – 5 725 MHz	802.11a	12.87 dBm
		802.11n HT20	12.90 dBm / 12.91 dBm
		802.11n HT40	9.64 dBm / 9.59 dBm
		802.11n VHT80	5.91 dBm
	UNII 3 band 5 725 MHz – 5 850 MHz	802.11a	7.47 dBm
		802.11n HT20	7.28 dBm / 7.24 dBm
		802.11n HT40	5.28 dBm / 5.26 dBm
		802.11n VHT80	5.65 dBm
	Straddle channel UNII 2-C to 3 band	802.11a	10.80 dBm
		802.11n HT20	10.60 dBm / 10.58 dBm
		802.11n HT40	8.14 dBm / 8.08 dBm
		802.11n VHT80	5.01 dBm
Type of Antenna	■ Integrated Type(Bluetooth / Chip antenna) ■ Dedicated Type(WLAN / FPCB antenna)		
Antenna Gain	(Bluetooth) 2.07dBi (WLAN 802.11b/g/n HT20/HT40) 3.37 dBi (WLAN 802.11a/ac/HT20/HT40/VHT20/VHT40/VHT80): 4.61 dBi		

1.2 Additional Model

None

2. TEST RESULT

2.1 MPE Evaluation

The EUT will only be used with a separation of 20 centimeters or greater between the antenna and the body of the user.

The MPE sample calculation for this exposure is shown below.

$$S = \text{EIRP} / (4 \times R^2 \times \pi)$$

Note: S = Power density in mW/cm²

$$= 6.73 / (4 \times 20^2 \times \pi)$$

EIRP = Equivalent Isotropic Radiated Power in mW

$$= 0.0013 \text{ mW/cm}^2$$

R = Distance to the center of the radiation of the antenna

$$\pi \approx 3.141592$$

2.1.1 DSS- Bluetooth Classic (2.4 GHz)

Operating Mode	Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (mW)	Distance (cm)	S (mW/cm ²)	Limit (mW/cm ²)
BR (GFSK)	6.21	2.07	8.28	6.73	20	0.0013	1.00
EDR ($\pi/4$ DQPSK)	5.69	2.07	7.76	5.97	20	0.0012	1.00
EDR (8DPSK)	5.86	2.07	7.93	6.21	20	0.0012	1.00

2.1.2 DTS - Bluetooth Low Energy (2.4 GHz)

Operating Mode	Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (mW)	Distance (cm)	S (mW/cm ²)	Limit (mW/cm ²)
BLE (GFSK)	5.06	2.07	7.13	5.16	20	0.0010	1.00

2.1.3 DTS - WLAN (2.4 GHz)

Operating Mode	Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (mW)	Distance (cm)	S (mW/cm ²)	Limit (mW/cm ²)
802.11b	11.92	3.37	15.29	33.81	20	0.0067	1.00
802.11g	10.65	3.37	14.02	25.23	20	0.0050	1.00
802.11n HT20	8.97	3.37	12.34	17.14	20	0.0034	1.00
802.11n HT40	6.94	3.37	10.31	10.74	20	0.0021	1.00

Note: EIRP = Conducted Output Power + Antenna Gain

2.1.4 UNII - WLAN (5 GHz)

Operating Mode	Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (mW)	Distance (cm)	S (mW/cm ²)	Limit (mW/cm ²)
802.11a	12.98	4.61	17.59	57.41	20	0.011 4	1.00
802.11n HT20	12.90	4.61	17.51	56.36	20	0.011 2	1.00
802.11n HT40	9.64	4.61	14.25	26.61	20	0.005 3	1.00
802.11ac VHT20	12.91	4.61	17.52	56.49	20	0.011 2	1.00
802.11ac VHT40	9.59	4.61	14.20	26.30	20	0.005 2	1.00
802.11ac VHT80	8.72	4.61	13.33	21.53	20	0.004 3	1.00

Note: EIRP = Conducted Output Power + Antenna Gain

2.1.5 Simultaneous Transmission Analysis: Bluetooth BR + WLAN 2.4 GHz (802.11b)

Operating Mode	Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (mW)	Distance (cm)	S (mW/cm ²)	Limit (mW/cm ²)
BR (GFSK)	6.21	2.07	8.28	6.73	20	0.001 3	1.00
802.11b	11.92	3.37	15.29	33.81	20	0.006 7	1.00
Sum S (mW/cm ²)						0.008 0	1.00

2.1.6 Simultaneous Transmission Analysis: Bluetooth BR + WLAN 5 GHz (802.11a)

Operating Mode	Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (mW)	Distance (cm)	S (mW/cm ²)	Limit (mW/cm ²)
BR (GFSK)	6.21	2.07	8.28	6.73	20	0.001 3	1.00
802.11a	12.98	4.61	17.59	57.41	20	0.011 4	1.00
Sum S (mW/cm ²)						0.012 7	1.00

Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric Field strength (V/m)	Magnetic field strength (A/m)	Power Density (mW/cm ²)	Averaging time (minutes)
0.3 – 1.34	614	1.63	*100	30
1.34 – 30	824 / f	2.19 / f	*180 / f ²	30
30 – 300	27.5	0.073	0.2	30
300 – 1 500			f / 1500	30
1 500 – 100 000			1.0	30

2.2 Safety Distance

The safe distance calculation is shown below.

$$E = \sqrt{(30 * P * G) / d} \quad \text{and} \quad S = E^2 / Z = E^2 / 377, 1 \text{ mW/cm}^2 = 10 \text{ W/m}^2$$

Where S = Power Density in mW/cm^2

Z = Impedance of free space = 377Ω

E = Electric field strength

G = Numerical antenna gain

d = distance to the center of the radiation of the antenna in meter

$$d = \sqrt{(30 * P * G) / (377 * S * 10)}$$

Changing to unit of mW and cm, using $P \text{ (mW)} = P \text{ (W)} / 1000$, $d \text{ (cm)} = d \text{ (m)} / 100$

$$d = 0.282 * \sqrt{(P * G) / S}$$

Where S = Power Density in mW/cm^2

P = Conducted power in mW

G = Numerical antenna gain

d = distance in centimeter

2.2.1 DSS - Bluetooth Classic (2.4 GHz band)

Operating Mode	Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (mW)	Safe Distance (cm) @ 1 (mW/cm ²)
BR (GFSK)	6.21	2.07	8.28	6.73	0.73
EDR ($\pi/4$ DQPSK)	5.69	2.07	7.76	5.97	0.69
EDR (8DPSK)	5.86	2.07	7.93	6.21	0.70

2.2.2 DTS - Bluetooth Low Energy (2.4 GHz band)

Operating Mode	Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (mW)	Safe Distance (cm) @ 1 (mW/cm ²)
BLE (GFSK)	5.06	2.07	7.13	5.16	0.64

According to above equation, safe distance, $d = 0.282 * \sqrt{(P * G) / S} = 0.282 * \sqrt{5.16 / 1} = 0.64 \text{ (cm)}$

2.2.3 DTS - WLAN (2.4 GHz band)

Operating Mode	Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (mW)	Safe Distance (cm) @ 1 (mW/cm ²)
802.11b	11.92	3.37	15.29	33.81	1.64
802.11g	10.65	3.37	14.02	25.23	1.42
802.11n HT20	8.97	3.37	12.34	17.14	1.17
802.11n HT40	6.94	3.37	10.31	10.74	0.92

2.2.4 WLAN (5 GHz band)

Operating Mode	Output Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP (mW)	Safe Distance (cm) @ 1 (mW/cm ²)
802.11a	12.98	4.61	17.59	57.41	2.14
802.11n HT20	12.90	4.61	17.51	56.36	2.12
802.11n HT40	9.64	4.61	14.25	26.61	1.45
802.11ac VHT20	12.91	4.61	17.52	56.49	2.12
802.11ac VHT40	9.59	4.61	14.20	26.30	1.45
802.11ac VHT80	8.72	4.61	13.33	21.53	1.31

According to above equation, safe distance, $d = 0.282 * \sqrt{(P * G) / S} = 0.282 * \sqrt{57.41 / 1} = 2.14$ (cm)