Maximum Permissible Exposure Report

1. Product Information

FCC ID:	2A2QB-FP16
Product name	Firewalla Purple
Test Model	Firewalla Purple
Power supply	Adapter Input: 100-240V~, 50/60Hz, 0.45A Adapter Output: 5V⎓3A
Operation frequency	2402MHz-2480MHz 2412MHz-2462MHz 5180MHz-5240MHz
Antenna Type	ANT0: PIFA Antenna ANT1: PIFA Antenna
Antenna Gain	Bluetooth: 0.8dBi(Max.) 2.4G WIFI: 0.8dBi(Max.) 5.2G WIFI: 1.0dBi(Max)
Hardware version	/
Software version	/
Channel Number	79 channels for Bluetooth V4.1 (BDR/EDR) 40 channels for Bluetooth V4.1 (BT LE / BT 2LE) 11 Channels for 20MHz bandwidth (2412~2462MHz) 7 Channels for 40MHz bandwidth (2422~2452MHz) 4 channels for 20MHz bandwidth (5180-5240MHz) 2 channels for 40MHz bandwidth (5190~5230MHz) 1 channels for 80MHz bandwidth (5210MHz)
Channel Spacing	5MHz
Exposure category	General population/uncontrolled environment
EUT Type	Production Unit
Device Type	Mobile Devices

2. Evaluation Method

Systems operating under the provisions of FCC 47 CFR 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.
In accordance with 47 CFR FCC Part 2 Subpart J, section 2.1091 this device has been defined as mobile device whereby a distance of 0.2m normally can be maintained between the user and the device, and below RF Permissible Exposure limit shall comply with.

In accordance with KDB447498D01 for Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneous transmitting antennas incorporated in a host device, based on the calculated/estimated, numerically modelled or measured field strengths or power density, is ≤ 1.0. The MPE ratio of each antenna is determined at the minimum test separation distance required by the operating configurations and exposure conditions of the host device, according to the ratio of field strengths or power density to MPE limit, at the test frequency. Either the maximum peak or spatially averaged results from measurements or numerical simulations may be used to determine the MPE ratios. Spatial averaging does not apply when MPE is estimated using simple calculations based on far-field plane-wave equivalent conditions. The antenna installation and operating requirements for the host device must meet the minimum test separation distances required by all antennas, in both standalone and simultaneous transmission operations, to satisfy compliance.

3. Limit

3. 1 Refer Evaluation Method

ANSI C95.1–1999: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.
FCC KDB publication 447498 D01 General 1 RF Exposure Guidance v06: Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies.
FCC CFR 47 part1 1.1310: Radiofrequency radiation exposure limits.
FCC CFR 47 part2 2.1091: Radiofrequency radiation exposure evaluation: Mobile Devices

3. 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

4. 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

5. Antenna Information

ES-D4 can only use antennas certificated as follows provided by manufacturer;

Antenna type and antenna number	Operate frequency band	Maximum antenna gain	Notes
PIFA Antenna 0	2400MHz-2500MHz 5150MHz-5250MHz	0.8 dBi @ 2.4G 1 dBi @ 5.2G	BT/WiFi Antenna
PIFA Antenna 1	2400MHz-2500MHz 5150MHz-5250MHz	0.8 dBi @ 2.4G 1 dBi @ 5.2G	WiFi Antenna

6. Conducted Power

[BT Max Conducted Power]

Mode	Channel	Frequency (MHz)	Peak Conducted Output Power (dBm)
GFSK	0	2402	-1.647
	39	2441	-1.650
	78	2480	-1.250
π/4DQPSK	0	2402	0.923
	39	2441	0.626
	78	2480	1.276
8DPSK	0	2402	1.011
	19	2441	1.257
	39	2480	1.931

[BLE Max Conducted Power]

Mode	Channel	Frequency (MHz)	Peak Conducted Output Power (dBm)
BT LE	0	2402	-0.841
	19	2440	-0.776
	39	2480	-0.364

[2BLE Max Conducted Power]

Mode	Channel	Frequency (MHz)	Peak Conducted Output Power (dBm)
BT 2LE	0	2402	-1.235
	19	2440	-1.227
	39	2480	-0.916

[2.4GWIFI Max Conducted Power]

Mode	Channel	Frequency (MHz)	ANT 0 Max Conducted Power(dBm)	ANT 1 Max Conducted Power(dBm)
11B	1	2412	11.61	11.51
	6	2437	12.40	12.43
	11	2462	12.91	12.91
11G	1	2412	9.52	9.94
	6	2437	11.49	10.95
	11	2462	12.72	12.88
11N20SISO	1	2412	9.23	9.00
	6	2437	11.05	11.01
	11	2462	12.26	12.24
11N40SISO	3	2422	10.44	10.46
	6	2437	11.29	11.41
	9	2452	12.32	12.17

[5.2GWIFI Max Conducted Power]

Mode	Channel	Frequency (MHz)	ANT 0 Max Conducted Power(dBm)	ANT 1 Max Conducted Power(dBm)
11A	36	5180	13.02	13.54
	40	5200	13.94	13.56
	48	5240	13.20	13.35
11N20 SISO	36	5180	11.72	11.73
	40	5200	12.08	12.06
	48	5240	11.74	11.64
11N40 SISO	38	5190	13.75	11.92
	46	5230	10.53	11.90
11AC20 SISO	36	5180	11.82	11.46
	40	5200	12.08	11.76
	48	5240	11.65	11.42
11AC40 SISO	38	5190	11.30	11.37
	46	5230	11.08	11.37
11AC80 SISO	42	5210	10.56	10.42

7. Measurement Results

BT

GFSK (Peak)			
Channel	Channel 0	Channel 39	Channel 78
Target (dBm)	-1.0	-1.0	-1.0
Tolerance ±(dB)	1.0	1.0	1.0
π/4DQPSK (Peak)			
Channel	Channel 0	Channel 39	Channel 78
Target (dBm)	0	0	1.0
Tolerance ±(dB)	1.0	1.0	1.0
8DPSK (Peak)			
Channel	Channel 0	Channel 19	Channel 39
Target (dBm)	1.0	1.0	1.0
Tolerance ±(dB)	1.0	1.0	1.0

BLE

BT LE (Peak)			
Channel	Channel 0	Channel 19	Channel 39
Target (dBm)	0	0	0
Tolerance ±(dB)	1.0	1.0	1.0

2BLE

BT LE (Peak)			
Channel	Channel 0	Channel 19	Channel 39
Target (dBm)	-1.0	-1.0	0
Tolerance ±(dB)	1.0	1.0	1.0

2.4GWIFI (ANT0)

11B (Peak)			
Channel	Channel 1	Channel 6	Channel 11
Target (dBm)	11.0	12.0	12.0
Tolerance ±(dB)	1.0	1.0	1.0
11G (Peak)			
Channel	Channel 1	Channel 6	Channel 11
Target (dBm)	9.0	11.0	12.0
Tolerance ±(dB)	1.0	1.0	1.0
11N20SISO (Peak)			
Channel	Channel 1	Channel 6	Channel 11
Target (dBm)	9.0	11.0	12.0
Tolerance ±(dB)	1.0	1.0	1.0
11N40SISO (Peak)			
Channel	Channel 3	Channel 6	Channel 9
Target (dBm)	10.0	11.0	12.0
Tolerance ±(dB)	1.0	1.0	1.0

2.4GWIFI (ANT1)

11B (Peak)			
Channel	Channel 1	Channel 6	Channel 11
Target (dBm)	11.0	12.0	12.0
Tolerance ±(dB)	1.0	1.0	1.0
11G (Peak)			
Channel	Channel 1	Channel 6	Channel 11
Target (dBm)	9.0	11.0	12.0
Tolerance ±(dB)	1.0	1.0	1.0
11N20SISO (Peak)			
Channel	Channel 1	Channel 6	Channel 11
Target (dBm)	9.0	11.0	12.0
Tolerance ±(dB)	1.0	1.0	1.0
11N40SISO (Peak)			
Channel	Channel 3	Channel 6	Channel 9
Target (dBm)	10.0	11.0	12.0
Tolerance ±(dB)	1.0	1.0	1.0

5.2GWIFI (ANT0)

11A (Peak)			
Channel	Channel 36	Channel 40	Channel 48
Target (dBm)	13.0	13.0	13.0
Tolerance ±(dB)	1.0	1.0	1.0
11N20 SISO (Peak)			
Channel	Channel 36	Channel 40	Channel 48
Target (dBm)	12.0	12.0	12.0
Tolerance ±(dB)	1.0	1.0	1.0
11N40 SISO (Peak)			
Channel	Channel 38		Channel 46
Target (dBm)	13.0		11.0
Tolerance ±(dB)	1.0		1.0
11AC20 SISO (Peak)			
Channel	Channel 36	Channel 40	Channel 48
Target (dBm)	12.0	12.0	12.0
Tolerance ±(dB)	1.0	1.0	1.0
11AC40 SISO (Peak)			
Channel	Channe38		Channel 46
Target (dBm)	11.0		11.0
Tolerance ±(dB)	1.0		1.0
11AC80 SISO (Peak)			
Channel	Channel 42		
Target (dBm)	10.0		
Tolerance ±(dB)	1.0		

5.2GWIFI (ANT1)

11A (Peak)			
Channel	Channel 36	Channel 40	Channel 48
Target (dBm)	13.0	13.0	13.0
Tolerance ±(dB)	1.0	1.0	1.0
11N20 SISO (Peak)			
Channel	Channel 36	Channel 40	Channel 48
Target (dBm)	12.0	12.0	12.0
Tolerance ±(dB)	1.0	1.0	1.0
11N40 SISO (Peak)			
Channel	Channel 38		Channel 46
Target (dBm)	12.0		12.0
Tolerance ±(dB)	1.0		1.0
11AC20 SISO (Peak)			
Channel	Channel 36	Channel 40	Channel 48
Target (dBm)	11.0	11.0	11.0
Tolerance ±(dB)	1.0	1.0	1.0
11AC40 SISO (Peak)			
Channel	Channe38		Channel 46
Target (dBm)	11.0		11.0
Tolerance ±(dB)	1.0		1.0
11AC80 SISO (Peak)			
Channel	Channel 42		
Target (dBm)	10.0		
Tolerance ±(dB)	1.0		

8. Evaluation Results

8.1 Standalone MPE Evaluation

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 =20cm, as well as the gain of the used antenna refer to antenna information, the RF power density can be obtained.

Mode	RF output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm2)	MPE Limits (mW/cm2)
	dBm	mW				
BT	2	1.59	0.8	1.20	0.0004	1.0
BLE	1	1.26	0.8	1.20	0.0003	1.0
2.4G WIFI (ANT0)	13	19.95	0.8	1.20	0.0095	1.0
2.4G WIFI (ANT1)	13	19.95	0.8	1.20	0.0095	1.0
5.2G WIFI (ANT0)	14	25.12	1.0	1.26	0.0079	1.0
5.2G WIFI (ANT1)	14	25.12	1.0	1.26	0.0079	1.0

Remark:
1. Output power including turn-up tolerance;
2. MPE evaluate distance is 20cm from user manual provide by manufacturer;
3. MPE values = $PG/4\pi R^2$

8.2 Simultaneous Transmission MPE

The sample support two antennas, so need consider simultaneous transmission;
Simultaneous transmission MPE
According to KDB447498 for Transmitters used in mobile exposure conditions for simultaneous transmission operations;
$\sum$ of MPE ratios ≤ 1.0

Mode	MPE1 (mW/cm^2)	MPE2 (mW/cm^2)	∑MPE ratios	Limit	Results
BT+2.4G WIFI	0.0004	0.0095	0.0099	1.0000	PASS
BT+5.2G WIFI	0.0004	0.0079	0.0083	1.0000	PASS
BLE+2.4G WIFI	0.0003	0.0095	0.0098	1.0000	PASS
BLE +5.2G WIFI	0.0003	0.0079	0.0082	1.0000	PASS
2.4G WIFI+2.4G WIFI	0.0095	0.0095	0.0190	1.0000	PASS
5.2G WIFI +5.2G WIFI	0.0079	0.0079	0.0158	1.0000	PASS

Remark:
The worst case results were recorded.
The 2.4G WIFI and 5.2G WIFI can't transmit at the same time.

9. 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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