

Maximum Permissible Exposure Report

Product Information

EUT	: NucBox2
Model Number	: KB2
Model Declaration	: N/A
Test Model	: KB2
Power Supply	: DC 19V by adapter
Hardware version	: IP3_CB1D_MB_V13 2020_11_30A
Software version	: Windows 10
Sample ID	: TZ210302066-1#

Bluetooth

Bluetooth Version	: V4.2
Channel Number	: 79 Channels for Bluetooth BR/EDR(DSS) 40 Channels for BLE (DTS)
Modulation Technology	: GFSK, $\pi/4$ -DQPSK, 8-DPSK for Bluetooth BR/EDR (DSS) GFSK for BLE (DTS)
Data Rates	: Bluetooth BR/EDR (DSS): 1/2/3Mbps BLE (DTS): 1Mbps
Antenna Type And Gain	Internal Antenna /2.39 dBi(Max.)

WiFi

WLAN	: Supported IEEE 802.11a/b/g/n
WLAN FCC Operation Frequency	: IEEE 802.11b:2412-2462MHz IEEE 802.11g:2412-2462MHz IEEE 802.11n HT20:2412-2462MHz / 5180-5240MHz IEEE 802.11n HT40:2422-2452MHz / 5190-5230MHz IEEE 802.11a: 5180-5240MHz
WLAN Channel Number	: 11 Channels for 2412-2462MHz(IEEE 802.11b/g/n HT20) 7 Channels for 2422-2452MHz(IEEE 802.11n HT40) 4 Channels for 5180-5240MHz (IEEE 802.11a/n HT20) 2 Channels for 5190-5230MHz (IEEE 802.11n HT40)
WLAN Modulation Technology	: IEEE 802.11b: DSSS(CCK,DQPSK,DBPSK) IEEE 802.11g: OFDM (64QAM, 16QAM, QPSK, BPSK) IEEE 802.11n: OFDM (64QAM, 16QAM, QPSK, BPSK) IEEE 802.11a: OFDM (64QAM, 16QAM, QPSK, BPSK)
Antenna Type And Gain	: Internal Antenna Wlan2.4G: 2.39 dBi(Max.) Wlan5G:1.99 dBi(Max.)

Note: Antenna position refer to EUT Photos.

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

This Product can only use antennas certificated as follows provided by manufacturer;

Antenna Gain and type refer to Product information

6. Conducted Power

2.4G Band:

Bluetooth(BDR+EDR)

Test Mode	Channel	Frequency (MHz)	Measured Peak Output Power (dBm)
GFSK	00	2402	2.99
	39	2441	3.96
	78	2480	5.09
$\pi/4$ -DQPSK	00	2402	4.39
	39	2441	5.15
	78	2480	6.05
8-DPSK	00	2402	4.75
	39	2441	5.63
	78	2480	6.56

Bluetooth(BLE)

Test Mode	Channel	Frequency (MHz)	Measured Peak Output Power (dBm)
GFSK	00	2402	3.10
	19	2440	3.92
	39	2480	5.07

WiFi 2.4GHz Band

Test Mode	Channel	Frequency (MHz)	Measured Peak Output Power (dBm)
IEEE 802.11b	1	2412	16.28
	6	2437	15.28
	11	2462	16.40
IEEE 802.11g	1	2412	19.87
	6	2437	19.19
	11	2462	20.28
IEEE 802.11n HT20	1	2412	20.30
	6	2437	19.65
	11	2462	20.56
IEEE 802.11n HT40	1	2412	18.80
	6	2437	17.51
	11	2462	17.87

5G Band

UNII-1 Band

Test Mode	Channel	Frequency (MHz)	Measured Conducted Average Power (dBm)
IEEE 802.11a	36	5180	11.97
	40	5200	12.06
	48	5240	13.22
IEEE 802.11n HT20	36	5180	10.92
	40	5200	10.96
	48	5240	12.20
IEEE 802.11ac VHT20	36	5190	11.13
	40	5230	12.17
	48	5180	11.00
IEEE 802.11n HT40	38	5200	10.84
	46	5240	12.28
IEEE 802.11ac VHT40	38	5190	10.96
	46	5230	12.00
IEEE 802.11ac VHT80	42	5210	10.83

7. Manufacturing Tolerance

Bluetooth(BDR+EDR)

GFSK (Peak)			
Channel	Channel 0	Channel 39	Channel 78
Target (dBm)	3.5	3.5	4.5
Tolerance $\pm$ (dB)	1.0	1.0	1.0
$\pi/4$ -DQPSK (Peak)			
Channel	Channel 0	Channel 39	Channel 78
Target (dBm)	4.5	4.5	5.5
Tolerance $\pm$ (dB)	1.0	1.0	1.0
8-DPSK (Peak)			
Channel	Channel 0	Channel 39	Channel 78
Target (dBm)	5.0	5.0	6.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0

Bluetooth(BLE)

GFSK (Peak)			
Channel	Channel 0	Channel 19	Channel 39
Target (dBm)	3.5	3.5	5.5
Tolerance $\pm$ (dB)	1.0	1.0	1.0

WiFi 2.4GHz Band

IEEE 802.11b (Peak)			
Channel	Channel 1	Channel 6	Channel 11
Target (dBm)	16.0	16.0	16.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0
IEEE 802.11g (Peak)			
Channel	Channel 1	Channel 6	Channel 11
Target (dBm)	20.0	20.0	20.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0
IEEE 802.11n HT20 (Peak)			
Channel	Channel 1	Channel 6	Channel 11
Target (dBm)	20.0	20.0	20.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0
IEEE 802.11n HT20 (Peak)			
Channel	Channel 3	Channel 6	Channel 9
Target (dBm)	18.0	18.0	18.0
Tolerance $\pm$ (dB)	1.0	1.0	1.0

UNII-1 Band – Antenna 0

IEEE 802.11a (Maximum)			
Channel	Channel 36	Channel 40	Channel 48
Target (dBm)	12.5	12.5	12.5
Tolerance $\pm$ (dB)	1.0	1.0	1.0
IEEE 802.11n HT20 (Maximum)			
Channel	Channel 36	Channel 40	Channel 48
Target (dBm)	11.5	11.5	11.5
Tolerance $\pm$ (dB)	1.0	1.0	1.0
IEEE 802.11ac VHT20 (Maximum)			
Channel	Channel 36	Channel 40	Channel 48
Target (dBm)	11.5	11.5	11.5
Tolerance $\pm$ (dB)	1.0	1.0	1.0
IEEE 802.11n HT40 (Maximum)			
Channel	Channel 38	Channel 46	--
Target (dBm)	11.5	11.5	--
Tolerance $\pm$ (dB)	1.0	1.0	--
IEEE 802.11ac VHT40 (Maximum)			
Channel	Channel 38	Channel 46	--
Target (dBm)	11.5	11.5	--
Tolerance $\pm$ (dB)	1.0	1.0	--

IEEE 802.11ac VHT80 (Maximum)			
Channel	Channel 42	--	--
Target (dBm)	10.0	--	--
Tolerance $\pm$ (dB)	1.0	--	--

8. Measurement Results

8.1 Standalone MPE

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 refer to antenna information, the RF power density can be obtained.

Bluetooth(BDR+EDR)

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm^2)	MPE Limits (mW/cm^2)
	dBm	mW					
GFSK	5.5	3.5481	2.39	1.7338	100%	0.0012	1.0000
$\pi/4$ -DQPSK	6.5	4.4668	2.39	1.7338	100%	0.0015	1.0000
8-DPSK	7.0	5.0119	2.39	1.7338	100%	0.0017	1.0000

Bluetooth(BLE)

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	Duty Cycle	MPE (mW/cm^2)	MPE Limits (mW/cm^2)
	dBm	mW					
GFSK	6.50	4.4668	2.39	1.7338	100%	0.0015	1.0000

WiFi 2.4GHz Band

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	17.00	50.1187	2.39	1.7338	100%	0.0173	1.0000
IEEE 802.11g	21.00	125.8925	2.39	1.7338	100%	0.0434	1.0000
IEEE 802.11n HT20	21.00	125.8925	2.39	1.7338	100%	0.0434	1.0000
IEEE 802.11n HT40	19.00	79.4328	2.39	1.7338	100%	0.0274	1.0000

UNII-1 Band

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	13.50	22.3872	1.99	1.5812	100%	0.0070	1.0000
IEEE 802.11n HT20	12.50	17.7828	1.99	1.5812	100%	0.0056	1.0000
IEEE 802.11ac VHT20	12.50	17.7828	1.99	1.5812	100%	0.0056	1.0000
IEEE 802.11n HT40	12.50	17.7828	1.99	1.5812	100%	0.0056	1.0000
IEEE 802.11ac VHT40	12.50	17.7828	1.99	1.5812	100%	0.0056	1.0000
IEEE 802.11ac VHT80	11.00	22.3872	1.99	1.5812	100%	0.0070	1.0000

Remark:

1. Output power including tune-up tolerance;
2. MPE evaluate distance is 20cm from user manual provide by manufacturer;

8.2 Simultaneous Transmission MPE

Bluetooth + Wi-Fi

Maximum MPE(mW/cm ²) BT Ant.	Maximum MPE(mW/cm ²) WIFI Ant.0	Σ MPE (mW/cm ²)	Limit (mW/cm ²)	Results
0.0017	0.0434	0.0451	1.0000	PASS

Remark:

1. Output power including tune-up tolerance;
2. MPE evaluate distance is 20cm from user manual provide by manufacturer;

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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