Maximum Permissible Exposure Report

1. Product Information

FCC ID	:	2A7L4-SMARTHUB
EUT	:	SmartHub
Test Model	:	SmartHub v2
Additional Model No.	:	SmartHub v3, SmartHub v4, SmartHub v5, SmartHub v6
Model Declaration	:	PCB board, structure and internal of these model(s) are the same, So no additional models were tested
Power Supply	:	Input: 5V⎓2A For Adapter Input: 100-240V~, 50/60Hz, 0.4A For Adapter Output: 5V⎓2000mA
Hardware Version	:	PRE-BND-S71-SH1 V1.1
Software Version	:	/
Bluetooth	:	
Frequency Range	:	2402MHz~2480MHz
Channel Number	:	79 channels for Bluetooth V5.0(DSS) 40 channels for Bluetooth V5.0 (DTS)
Channel Spacing	:	1MHz for Bluetooth V5.0 (DSS) 2MHz for Bluetooth V5.0 (DTS)
Modulation Type	:	GFSK, π/4-DQPSK, 8-DPSK for Bluetooth V5.0(DSS) GFSK for Bluetooth V5.0 (DTS)
Bluetooth Version	:	V5.0
Antenna Description	:	PIFA Antenna, 0.8dBi(Max.)
WIFI(2.4G Band)	:	
Frequency Range	:	2412MHz~2462MHz
Channel Spacing	:	5MHz
Channel Number	:	11 Channels for 20MHz bandwidth (2412~2462MHz) 7 Channels for 40MHz bandwidth (2422~2452MHz)
Modulation Type	:	IEEE 802.11b: DSSS (CCK, DQPSK, DBPSK) IEEE 802.11g: OFDM (64QAM, 16QAM, QPSK, BPSK) IEEE 802.11n: OFDM (64QAM, 16QAM, QPSK, BPSK)
Antenna Description	:	External Antenna, 1.5dBi(Max.)
5.2G WLAN	:	
Frequency Range	:	5180MHz~5240MHz
Channel Number	:	4 channels for 20MHz bandwidth(5180MHz~5240MHz) 2 channels for 40MHz bandwidth(5190MHz~5230MHz) 1 channels for 80MHz bandwidth(5210MHz)

Modulation Type	: IEEE 802.11a/n/ac: OFDM (256QAM, 64QAM, 16QAM, QPSK, BPSK)
Antenna Description	: External Antenna, 2.3dBi(Max.)
5.8G WLAN	:
Frequency Range	: 5745MHz~5825MHz
Channel Number	: 5 channels for 20MHz bandwidth(5745MHz~5825MHz) 2 channels for 40MHz bandwidth(5755MHz~5795MHz) 1 channels for 80MHz bandwidth(5775MHz)
Modulation Type	: IEEE 802.11a/n/ac: OFDM (256QAM, 64QAM, 16QAM, QPSK, BPSK)
Antenna Description	: External Antenna, 2.3dBi(Max.)
LTE Cat M1	:
Support Band	: ☒E-UTRA Band 2(U.S.-Band) ☒E-UTRA Band 4(U.S.-Band) ☒E-UTRA Band 5(U.S.-Band) ☒E-UTRA Band 12(U.S.-Band) ☒E-UTRA Band 13(U.S.-Band) ☒E-UTRA Band 25(U.S.-Band) ☒E-UTRA Band 26(U.S.-Band) ☒E-UTRA Band 66(U.S.-Band)
LTE Release Version	: R8
Type Of Modulation	: QPSK/16QAM
Antenna Description	: External Antenna 2.35dBi (max.) For E-UTRA Band 2 2.35dBi (max.) For E-UTRA Band 4 2.35dBi (max.) For E-UTRA Band 5 2.35dBi (max.) For E-UTRA Band 12 2.35dBi (max.) For E-UTRA Band 13 2.35dBi (max.) For E-UTRA Band 25 2.35dBi (max.) For E-UTRA Band 26 2.35dBi (max.) For E-UTRA Band 66
Power Class	: Class 3
Z-Wave	
Frequency Range	: 908.4-916MHz
Modulation Type	: FSK/GFSK
Antenna Description	: PCB Antenna, 1.0dBi(Max.)
Zigbee	
Frequency Range	: 2405MHz-2480MHz
Channel Spacing	: 5MHz
Channel Number	: 16 Channels
Modulation Type	: O-QPSK

Antenna Description	: PCB Antenna, 1.5dBi(Max.)
Extreme temp. Tolerance	: -30°C to +50°C
Extreme vol. Limits	: 4.5VDC to 5.5VDC (nominal: 5VDC)
Exposure category	: General population/uncontrolled environment
EUT Type	: Production Unit
Device Type	: Mobile Device

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/cm²)	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/cm²)	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

EUT can only use antennas certificated as follows provided by manufacturer;

Antenna type and antenna number	Operate frequency band	Maximum antenna gain	Notes
PIFA Antenna	2402MHz~2480MHz	0.8dBi 1.5dBi	BT Antenna 2.4G WLAN Antenna
	5180MHz~5240MHz 5745MHz~5825MHz	2.3dBi	5G WLAN Antenna
	600 MHz – 3000 MHz	2.35dBi	LTE Antenna
PCB Antenna	908.4-916MHz 2405MHz-2480MHz	1.0dBi 1.5dBi	Z-Wave Antenna Zigbee Antenna

6. Conducted Power

[BT Max Conducted Power]

Mode	Channel	Frequency(MHz)	Max Conducted Power (dBm)
GFSK	0	2402	1.46
	39	2441	1.99
	78	2480	2.79
π/4DQPSK	0	2402	3.92
	39	2441	3.4
	78	2480	1.82
8DPSK	0	2402	1.8
	39	2441	1.41
	78	2480	2.51

<BT LE>

Mode	Channel	Frequency (MHz)	Peak Conducted Output Power (dBm)
GFSK	0	2402	3.56
	19	2440	3.52
	39	2480	4.43
GFSK	0	2402	3.12
	19	2440	3.17
	39	2480	4.19

[2.4GWLAN Max Conducted Power]

Mode	Channel	Frequency(MHz)	Max Conducted Power (dBm)
IEEE 802.11b	1	2412	15.33
	6	2437	15.12
	11	2462	15.01
IEEE 802.11g	1	2412	16.30
	6	2437	16.01
	11	2462	15.53
IEEE 802.11n HT20	1	2412	16.27
	6	2437	15.96
	11	2462	15.57
IEEE 802.11n HT40	3	2422	16.25
	6	2437	15.58
	9	2452	15.12

[5.2GHz WLAN]

Mode	Channel	Frequency (MHz)	Average Conducted Output Power (dBm)
IEEE 802.11a	36	5180	13.48
	44	5220	14.52
	48	5240	14.38
IEEE 802.11n HT20	36	5180	12.69
	44	5220	13.48
	48	5240	13.38
IEEE 802.11n HT40	38	5190	13.81
	46	5230	13.55
IEEE 802.11ac VHT20	36	5180	13.19
	44	5220	13.64
	48	5240	13.70
IEEE 802.11ac VHT40	38	5190	13.06
	46	5230	13.30
IEEE 802.11ac VHT80	42	5210	12.81

[5.8GHz WLAN]

Mode	Channel	Frequency (MHz)	Average Conducted Output Power (dBm)
IEEE 802.11a	149	5745	11.77
	157	5785	11.93
	165	5825	10.93
IEEE 802.11n HT20	149	5745	11.89
	157	5785	11.62
	165	5825	10.81
IEEE 802.11n HT40	151	5755	12.21
	159	5795	11.22
IEEE 802.11ac VHT20	149	5745	11.84
	157	5785	11.50
	165	5825	10.82
IEEE 802.11ac VHT40	151	5755	12.00
	159	5795	10.90
IEEE 802.11ac VHT80	155	5775	11.73

[LTE Max Average Power]

BAND	Max Average Power (dBm)
LTE Band 2	21.08
LTE Band 4	21.10
LTE Band 5	21.07
LTE Band 12	21.03
LTE Band 13	21.24
LTE Band 25	21.40
LTE Band 26(814-824MHz)	20.94
LTE Band 26(824-849MHz)	20.96
LTE Band 66	20.93

< Zigbee >

Mode	Channel	Frequency (MHz)	Peak Conducted Output Power (dBm)
O-QPSK	0	2405	8.99
	7	2440	8.21
	15	2480	7.54

7. Manufacturing Tolerance

[BT Max Conducted Power]

Test Mode	Channel	Max Conducted Power (dBm)	ANT Max. Tune Up Power (dBm)
GFSK	0	1.46	1.0±1.0
	39	1.99	1.0±1.0
	78	2.79	2.0±1.0
π/4DQPSK	0	3.92	3.0±1.0
	39	3.4	3.0±1.0
	78	1.82	1.0±1.0
8DPSK	0	1.8	1.0±1.0
	39	1.41	1.0±1.0
	78	2.51	2.0±1.0

<BT LE Max Conducted Power >

Mode	Channel	Peak Conducted Output Power (dBm)	ANT Max. Tune Up Power (dBm)
GFSK	0	3.56	3.0±1.0
	19	3.52	3.0±1.0
	39	4.43	4.0±1.0
GFSK	0	3.12	3.0±1.0
	19	3.17	3.0±1.0
	39	4.19	4.0±1.0

[2.4GWLAN Max Conducted Power]

Test Mode	Channel	Max Conducted Power (dBm)	ANT Max. Tune Up Power (dBm)
IEEE 802.11b	1	15.33	15.0±1.0
	6	15.12	15.0±1.0
	11	15.01	15.0±1.0
IEEE 802.11g	1	16.30	16.0±1.0
	6	16.01	16.0±1.0
	11	15.53	15.0±1.0
IEEE 802.11n HT20	1	16.27	16.0±1.0
	6	15.96	15.0±1.0
	11	15.57	15.0±1.0
IEEE 802.11n HT40	3	16.25	16.0±1.0
	6	15.58	15.0±1.0
	9	15.12	15.0±1.0

[5.2GWLAN Max Conducted Power]

Test Mode	Channel	Max Conducted Power (dBm)	ANT Max. Tune Up Power (dBm)
IEEE 802.11a	36	13.48	13.0±1.0
	44	14.52	14.0±1.0
	48	14.38	14.0±1.0
IEEE 802.11n HT20	36	12.69	12.0±1.0
	44	13.48	13.0±1.0
	48	13.38	13.0±1.0
IEEE 802.11n HT40	38	13.81	13.0±1.0
	46	13.55	13.0±1.0
IEEE 802.11ac VHT20	36	13.19	13.0±1.0
	44	13.64	13.0±1.0
	48	13.70	13.0±1.0
IEEE 802.11ac VHT40	38	13.06	13.0±1.0
	46	13.30	13.0±1.0
IEEE 802.11ac VHT80	42	12.81	12.0±1.0

[5.8GWLAN Max Conducted Power]

Test Mode	Channel	Max Conducted Power (dBm)	ANT Max. Tune Up Power (dBm)
IEEE 802.11a	149	11.77	11.0±1.0
	157	11.93	11.0±1.0
	165	10.93	10.0±1.0
IEEE 802.11n HT20	149	11.89	11.0±1.0
	157	11.62	11.0±1.0
	165	10.81	10.0±1.0
IEEE 802.11n HT40	151	12.21	12.0±1.0
	159	11.22	11.0±1.0
IEEE 802.11ac VHT20	149	11.84	11.0±1.0
	157	11.50	11.0±1.0
	165	10.82	10.0±1.0
IEEE 802.11ac VHT40	151	12.00	12.0±1.0
	159	10.90	10.0±1.0
IEEE 802.11ac VHT80	155	11.73	11.0±1.0

<LTE Max Average Power>

Test Mode		Max Average Power (dBm)	ANT Max. Tune Up Power (dBm)
LTE	LTE Band 2	21.08	21.0±1.0
	LTE Band 4	21.10	21.0±1.0
	LTE Band 5	21.07	21.0±1.0
	LTE Band 12	21.03	21.0±1.0
	LTE Band 13	21.24	21.0±1.0
	LTE Band 25	21.40	21.0±1.0
	LTE Band 26 (814-824MHz)	20.94	20.0±1.0
	LTE Band 26 (824-849MHz)	20.96	20.0±1.0
	LTE Band 66	20.93	20.0±1.0

< Zigbee Max Conducted Power >

Mode	Channel	Peak Conducted Output Power (dBm)	ANT Max. Tune Up Power (dBm)
O-QPSK	0	8.99	8.0±1.0
	7	8.21	8.0±1.0
	15	7.54	7.0±1.0

8. Measurement 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.

[BT]

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm^2)	MPE Limits (mW/cm^2)
	dBm	mW				
GFSK	3.00	1.9953	0.8	1.2023	0.0005	1.0000
π/4DQPSK	4.00	2.5119	0.8	1.2023	0.0006	1.0000
8DPSK	3.00	1.9953	0.8	1.2023	0.0005	1.0000

[BT LE]

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm^2)	MPE Limits (mW/cm^2)
	dBm	mW				
GFSK	5.00	3.1623	0.8	1.2023	0.0008	1.0000
GFSK	5.00	3.1623	0.8	1.2023	0.0008	1.0000

[2.4G WLAN]

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm^2)	MPE Limits (mW/cm^2)
	dBm	mW				
IEEE 802.11b	16.00	39.8107	1.5	1.4125	0.0112	1.0000
IEEE 802.11g	17.00	50.1187	1.5	1.4125	0.0141	1.0000
IEEE 802.11n HT20	17.00	50.1187	1.5	1.4125	0.0141	1.0000
IEEE 802.11n HT40	17.00	50.1187	1.5	1.4125	0.0141	1.0000

[5.2G WLAN]

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm^2)	MPE Limits (mW/cm^2)
	dBm	mW				
IEEE 802.11a	15.0	31.6228	2.3	1.6982	0.0107	1.0000
IEEE 802.11n HT20	14.0	25.1189	2.3	1.6982	0.0085	1.0000
IEEE 802.11n HT40	14.0	25.1189	2.3	1.6982	0.0085	1.0000
IEEE 802.11ac VHT20	14.0	25.1189	2.3	1.6982	0.0085	1.0000
IEEE 802.11ac VHT40	14.0	25.1189	2.3	1.6982	0.0085	1.0000
IEEE 802.11ac VHT80	13.0	19.9526	2.3	1.6982	0.0067	1.0000

[5.8G WLAN]

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm^2)	MPE Limits (mW/cm^2)
	dBm	mW				
IEEE 802.11a	12.0	15.8489	2.3	1.6982	0.0054	1.0000
IEEE 802.11n HT20	12.0	15.8489	2.3	1.6982	0.0054	1.0000
IEEE 802.11n HT40	13.0	19.9526	2.3	1.6982	0.0067	1.0000
IEEE 802.11ac VHT20	12.0	15.8489	2.3	1.6982	0.0054	1.0000
IEEE 802.11ac VHT40	13.0	19.9526	2.3	1.6982	0.0067	1.0000
IEEE 802.11ac VHT80	12.0	15.8489	2.3	1.6982	0.0054	1.0000

[LTE]

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm2)	MPE Limits (mW/cm2)
	dBm	mW				
LTE Band 2	22.00	158.4893	2.35	1.7179	0.0542	1.0
LTE Band 4	22.00	158.4893	2.35	1.7179	0.0542	1.0
LTE Band 5	22.00	158.4893	2.35	1.7179	0.0542	0.55
LTE Band 12	22.00	158.4893	2.35	1.7179	0.0542	0.47
LTE Band 13	22.00	158.4893	2.35	1.7179	0.0542	0.52
LTE Band 25	22.00	158.4893	2.35	1.7179	0.0542	1.0
LTE Band 26 (814-824MHz)	21.00	125.8925	2.35	1.7179	0.0430	0.54
LTE Band 26 (824-849MHz)	21.00	125.8925	2.35	1.7179	0.0430	0.55
LTE Band 66	21.00	125.8925	2.35	1.7179	0.0430	1.0

[Zigbee]

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm^2)	MPE Limits (mW/cm^2)
	dBm	mW				
O-QPSK	9.00	7.9433	1.5	1.7179	0.0027	1.0000

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

8.2 Simultaneous Transmission MPE

The sample support one BT&BLE&2.4GWLAN&5.2GWLAN&5.8GWLAN&Zigbee and another one LTE transmit antenna, so need consider simultaneous transmission;
Simultaneous transmission MPE
According to KDB447498 for Transmitters used in mobile exposure conditions for simultaneous transmission operations;
∑∑of MPE ratios ≤ 1.0

Mode	∑ MPE max ratios	Limit	Results
BT+WLAN +LTE+Zigbee	0.0718	1.0000	Pass

9. Conclusion

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

----------THE END OF REPORT----------