Maximum Permissible Exposure Report

1. Product Information

FCC ID	:	2ACHBMARS
EUT	:	GNSS Receiver
Test Model	:	Mars
Power Supply	:	DC 7.4V by Rechargeable Li-ion Battery, 3400mAh
Hardware Version	:	V1.11
Software Version	:	V1.4.2
Bluetooth	:	
Frequency Range	:	2402MHz~2480MHz
Channel Number	:	79 channels for Bluetooth V4.2 (DSS) 40 channels for Bluetooth V4.2 (DTS)
Channel Spacing	:	1MHz for Bluetooth V4.2 (DSS) 2MHz for Bluetooth V4.2 (DTS)
Modulation Type	:	GFSK, π/4-DQPSK, 8-DPSK for Bluetooth V4.2 (DSS) GFSK for Bluetooth V4.2 (DTS)
Bluetooth Version	:	V4.2
Antenna Description	:	PIFA Antenna, 1.0dBi (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	:	PIFA Antenna, 1.0dBi (max.)
2G	:	
Support Band	:	☒GSM 900 (EU-Band) ☒DCS 1800 (EU-Band) ☒GSM 850 (U.S.-Band) ☒PCS 1900 (U.S.-Band)
Release Version	:	R99
GPRS Class	:	Class 12
Type Of Modulation	:	GMSK for GSM/GPRS
Antenna Description	:	PIFA Antenna 2.29dBi (max.) For GSM 850 1.59dBi (max.) For PCS 1900
3G	:	
Support Band	:	☒WCDMA Band I (EU-Band) ☒WCDMA Band II (U.S.-Band)

		☒WCDMA Band IV (U.S.-Band)
		☒WCDMA Band V (U.S.-Band)
		☒WCDMA Band VIII (EU-Band)
Release Version	:	R11
Type Of Modulation	:	QPSK,16QAM
Antenna Description	:	PIFA Antenna
		1.59dBi (max.) For WCDMA Band II
		2.0dBi (max.) For WCDMA Band IV
		2.29dBi (max.) For WCDMA Band V
LTE	:	
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 7(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 38(U.S.-Band)
		☒E-UTRA Band 41(U.S.-Band)
LTE Release Version	:	R9
Type Of Modulation	:	QPSK/16QAM
Antenna Description	:	PIFA Antenna
		1.59dBi (max.) For E-UTRA Band 2
		2.0dBi (max.) For E-UTRA Band 4
		2.29dBi (max.) For E-UTRA Band 5
		3.0dBi (max.) For E-UTRA Band 7
		3.26dBi (max.) For E-UTRA Band 12
		4.45dBi (max.) For E-UTRA Band 13
		1.59dBi (max.) For E-UTRA Band 25
		2.53dBi (max.) For E-UTRA Band 26
		2.06dBi (max.) For E-UTRA Band 38
		3.0dBi (max.) For E-UTRA Band 41
Power Class	:	Class 3
NFC	:	
Operating Frequency	:	13.56MHz
Modulation Type	:	ASK
Antenna Description	:	FPC Antenna, -9.55dBi(Max.)
PMR	:	
Operating Frequency	:	410~470MHz
Channel Separation	:	12.5KHz
Modulation Type	:	GMSK/4FSK

Antenna Type	:	External Antenna
Antenna Gain	:	2.0dBi (max.) for PMR
GPS function	:	Support and only RX
Extreme temp. Tolerance	:	-30°C to +50°C
Extreme vol. Limits	:	6.7VDC to 8.4VDC (nominal: 7.4VDC)
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 C95.1–2019: IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz 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/f2)*	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/Uncontrolled Exposure				
0.3 – 3.0	614	1.63	(100) *	30
3.0 – 30	824/f	2.19/f	(180/f2)*	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;

Internal/External Identification	Antenna type and antenna number	Operate frequency band	Maximum antenna gain	Notes
Internal	PIFA Antenna	2400-2500MHz	1.0dBi	BT/BLE/2.4GWIFi
Internal	PIFA Antenna	824-849MHz 1850-1910MHz 1710-1755MHz 1850-1910MHz 1710-1755MHz 824-849MHz	2.29dBi (max.) For GSM 850 1.59dBi (max.) For PCS 1900 1.59dBi (max.) For WCDMA Band II 2.0dBi (max.) For	2G/3G/LTE Antenna

		2500-2570MHz 699-716MHz 777-787MHz 1850-1915MHz 814-824MHz 824-849MHz 2570-2620MHz 2496-2690MHz	WCDMA Band IV 2.29dBi (max.) For WCDMA Band V 1.59dBi (max.) For E-UTRA Band 2 2.0dBi (max.) For E-UTRA Band 4 2.29dBi (max.) For E-UTRA Band 5 3.0dBi (max.) For E-UTRA Band 7 3.26dBi (max.) For E-UTRA Band 12 4.45dBi (max.) For E-UTRA Band 13 1.59dBi (max.) For E-UTRA Band 25 2.53dBi (max.) For E-UTRA Band 26 2.06dBi (max.) For E-UTRA Band 38 3.0dBi (max.) For E-UTRA Band 41	
External	External Antenna	410~470MHz	2.0dBi	PMR Antenna

6. Conducted Power

[BT]

Mode	Channel	Frequency (MHz)	Max Conducted Power(dBm)	ANT Max. Tune Up Power (dBm)
GFSK	00	2402	0.24	0±1.0
	39	2441	0.34	0±1.0
	79	2480	0.27	0±1.0
π/4-DQPSK	00	2402	0.03	0±1.0
	39	2441	0.02	0±1.0
	79	2480	-0.05	0±1.0
8-DPSK	00	2402	0.1	0±1.0
	39	2441	0.19	0±1.0
	79	2480	0.14	0±1.0

[BLE]

Mode	Channel	Frequency (MHz)	Max Conducted Power(dBm)	ANT Max. Tune Up Power (dBm)
GFSK	0	2402	0.23	0±1.0
	19	2440	0.06	0±1.0
	39	2480	0.14	0±1.0

[2.4G WIFI]

Mode	Channel	Frequency (MHz)	Max Conducted Power(dBm)	ANT Max. Tune Up Power (dBm)
IEEE 802.11b	1	2412	14.39	14.0±1.0
	6	2437	14.80	14.0±1.0
	11	2462	13.99	13.0±1.0
IEEE 802.11g	1	2412	14.53	14.0±1.0
	6	2437	14.26	14.0±1.0
	11	2462	13.82	13.0±1.0
IEEE 802.11n HT20	1	2412	14.48	14.0±1.0
	6	2437	14.88	14.0±1.0
	11	2462	13.77	13.0±1.0
IEEE 802.11n HT40	3	2422	12.88	12.0±1.0
	6	2437	13.28	13.0±1.0
	9	2452	13.01	13.0±1.0

[GSM Max Average Power]

Test Mode	Channel	Frequency (MHz)	Max Average Power (dBm)	ANT Max. Tune Up Power (dBm)
GSM 850	Low	824.2	32.67	32.0±1.0
	Middle	836.6	32.69	32.0±1.0
	High	848.8	32.66	32.0±1.0
GSM 1900	Low	1850.2	29.67	29.0±1.0
	Middle	1880.0	29.70	29.0±1.0
	High	1909.8	29.62	29.0±1.0

[WCDMA Max Average Power]

Test Mode	Channel	Frequency (MHz)	Max Average Power (dBm)	ANT Max. Tune Up Power (dBm)
WCDMA Band II	Low	1852.4	23.45	23.0±1.0
	Middle	1880	23.65	23.0±1.0
	High	1907.6	23.49	23.0±1.0
WCDMA Band IV	Low	826.4	23.43	23.0±1.0
	Middle	836.4	23.41	23.0±1.0
	High	846.6	23.52	23.0±1.0
WCDMA Band V	Low	1712.4	22.75	22.0±1.0
	Middle	1732.6	22.87	22.0±1.0
	High	1752.6	22.76	22.0±1.0

[LTE Max Average Power]

Test Mode		Channel	Max Average Power (dBm)	ANT Max. Tune Up Power (dBm)
LTE	Band 2	LCH	23.57	23.0±1.0
		MCH	23.46	23.0±1.0
		HCH	23.35	23.0±1.0
	Band 4	LCH	22.57	22.0±1.0
		MCH	22.47	22.0±1.0
		HCH	22.81	22.0±1.0
	Band 5	LCH	23.76	23.0±1.0
		MCH	23.54	23.0±1.0
		HCH	23.34	23.0±1.0
	Band 7	LCH	23.60	23.0±1.0
		MCH	23.32	23.0±1.0
		HCH	23.56	23.0±1.0
	Band 12	LCH	23.94	23.0±1.0
		MCH	23.92	23.0±1.0
		HCH	23.80	23.0±1.0
	Band 13	LCH	23.63	23.0±1.0
		MCH	23.81	23.0±1.0
		HCH	23.87	23.0±1.0
	Band 25	LCH	23.50	23.0±1.0
		MCH	22.65	22.0±1.0
		HCH	22.58	22.0±1.0
	Band 26	LCH	23.12	23.0±1.0
		MCH	23.11	23.0±1.0
		HCH	23.26	23.0±1.0
	Band 38	LCH	22.71	22.0±1.0
		MCH	22.72	22.0±1.0
		HCH	22.59	22.0±1.0
	Band 41	LCH	23.15	23.0±1.0
		MCH	23.22	23.0±1.0
		HCH	23.59	23.0±1.0

<PMR>

Test Mode		Frequency(MHz)	Max Conducted Peak Power (dBm)	Tune Up Power (dBm)
GMSK	12.5KHz	410.125	29.318	29±1.0
		439.625	29.223	29±1.0
		469.625	29.144	29±1.0

7. Measurement Results

7.1 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 =50cm, 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/cm2)	MPE Limits (mW/cm2)
	dBm	mW				
GFSK	1.0	1.2589	1.0	1.2589	0.0001	1.0000
π/4-DQPSK	1.0	1.2589	1.0	1.2589	0.0001	1.0000
8-DPSK	1.0	1.2589	1.0	1.2589	0.0001	1.0000

[BT LE]

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm2)	MPE Limits (mW/cm2)
	dBm	mW				
BT LE	1.0	1.2589	1.0	1.2589	0.0001	1.0000

[2.4GWLAN]

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm2)	MPE Limits (mW/cm2)
	dBm	mW				
IEEE 802.11b	15.0	31.6228	1.0	1.2589	0.0013	1.0000
IEEE 802.11g	15.0	31.6228	1.0	1.2589	0.0013	1.0000
IEEE 802.11n HT20	15.0	31.6228	1.0	1.2589	0.0013	1.0000
IEEE 802.11n HT40	14.0	25.1189	1.0	1.2589	0.0010	1.0000

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm2)	MPE Limits (mW/cm2)
	dBm	mW				
GSM 850	33.0	1995.2623	2.29	1.6943	0.1076	0.5493
GSM 1900	30.0	1000.0000	1.59	1.4421	0.0916	1.0000
WCDMA Band II	24.0	251.1886	1.59	1.4421	0.0115	0.5493
WCDMA Band IV	24.0	251.1886	2.0	1.5849	0.0127	1.0000
WCDMA Band V	23.0	199.5262	2.29	1.6943	0.0673	0.4660
LTE Band 2	24.0	251.1886	1.59	1.4421	0.0115	1.0000

LTE Band 4	23.0	199.5262	2.0	1.5849	0.0101	1.0000
LTE Band 5	24.0	251.1886	2.29	1.6943	0.0135	0.5493
LTE Band 7	24.0	251.1886	3.0	1.9953	0.0160	1.0000
LTE Band 12	24.0	251.1886	3.26	2.1184	0.0169	0.4660
LTE Band 13	24.0	251.1886	4.45	2.7861	0.0223	0.5180
LTE Band 25	24.0	251.1886	1.59	1.4421	0.0115	1.0000
LTE Band 26	24.0	251.1886	2.53	1.7906	0.0143	0.5427
LTE Band 38	23.0	199.5262	2.06	1.6069	0.0102	1.0000
LTE Band 41	24.0	251.1886	3.0	1.9953	0.0160	1.0000

<PMR>

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm2)	MPE Limits (mW/cm2)
	dBm	mW				
GMSK/4FSK 410 ~ 470MHz	30.0	1000.0000	2.0	1.0000	0.0504	0.2733

NFC:
13.56MHz:69.54dBuV/m@3m
@50cm=69.54+40lg(3/0.5)=100.67dBuV/m=0.108V/m<60.77V/m

Remark:
1. Output power including turn-up tolerance;
2. Output power was adjust to duty cycle at 100% if measured duty cycle less than 98%;
3. MPE evaluate distance is 20cm from user manual provide by manufacturer.

8.2 Simultaneous Transmission MPE Evaluation

The sample support one BT&BLE&2.4GWLAN, another one GSM&WCDMA&LTE, another one NFC transmit antenna and another one PMR 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	MPE1 Max.	MPE2 Max.	MPE3 Max	MPE4 Max	∑ MPE ratios	Limit	Results
2.4GWIFI+LTE+PMR	0.0013	0.1959	0.1844	0.0018	0.3834	1.000	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----------