

Maximum Permissible Exposure Report

1. Product Information

Name of EUT	GNSS RECEIVER
Model No.	K3, K5, K9, R90i, R8i, C1, T3, T5, H3 plus, A20, M6
Model Declaration	PCB board, structure and internal of these model(s) are the same, so no additional models were tested
Test Model	K5
Power Supply	DC 7.4V by Rechargeable Li-ion Battery(3400mAh) or DC 13.8V by external power Recharged by DC 4.2V 1.35A or DC 8.4V/0.67A for battery
Hardware version	SG3000001
Software version	GalaxyRTK_LWB-V20181210
GSM/EDGE/GPRS Operation Frequency Band	GSM850/PCS1900/GPRS850/GPRS1900/EDGE850/EDGE1900
UMTS Operation Frequency Band	UMTS FDD Band II/IV/V
LTE Operation Frequency Band	LTE Band 38/39/40/41
Modulation Type	GMSK for GSM/GPRS; 8-PSK for EDGE; QPSK for UMTS; QPSK, 16QAM for LTE
GSM/EDGE/GPRS	Supported GSM/GPRS/EDGE
GSM Release Version	R99
GSM/EDGE/GPRS Power Class	GSM850:Power Class 4/ PCS1900:Power Class 1
GPRS/EDGE Multislot Class	GPRS/EDGE: Multi-slot Class 12
GPRS operation mode	Class B
WCDMA Release Version	R8
HSDPA Release Version	Release 8
HSUPA Release Version	Release 8
DC-HSUPA Release Version	Not Supported
LTE Release Version	Release 9
LTE/UMTS Power Class	Class 3
Antenna Type	SMA Antenna
Antenna Gain	2.0dBi (max.) for GSM 850, PCS 1900; 2.0dBi (max.) for WCDMA Band II/IV/V; 2.0dBi (max.) for LTE Band 41
BT FCC Operation frequency	2402-2480MHz
BT FCC Modulation Type	GFSK, $\pi/4$ -DQPSK, 8-DPSK for Bluetooth V4.0 (BDR/EDR) GFSK for Bluetooth V4.0 (BT LE)
Bluetooth Version	V4.0
Antenna Type	Ceramic Antenna
Antenna Gain	2.0dBi (max.) for Bluetooth
WLAN FCC Operation frequency	IEEE 802.11b/g/n HT20:2412-2462MHz
WLAN FCC Modulation Type	IEEE 802.11b: DSSS(CCK,DQPSK,DBPSK) IEEE 802.11g/n: OFDM(64QAM, 16QAM, QPSK, BPSK)
Antenna Type	Ceramic Antenna
Antenna Gain	2.0dBi (max.) for WLAN
PMR FCC Operation frequency	460.125-467.625MHz
Channel Separation	12.5KHz & 25KHz
Modulation Type	GMSK
Emission Designator	11K0G1D for GMSK Modulation at 12.5KHz Channel Separation 16K0G1D for GMSK Modulation at 25KHz Channel Separation
Rate Power	25W/10W
Antenna Type	SMA Antenna
Antenna Gain	5.0dBi (max.) for PMR
GPS function	Support and only RX
FM function	Support and only RX
NFC Function	Support and only RX
Extreme temp. Tolerance	-10°C to +55°C
Extreme Voltage Tolerance	DC 6.66V to 8.14V
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/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

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

External Identification	Antenna type and antenna number	Operate frequency band	Maximum antenna gain
Antenna 0	External Antenna	600 MHz – 2500 MHz	2.0dBi (max.) For all GSM, WCDMA and LTE Band
Antenna 1	Internal Antenna	600 MHz – 2500 MHz	2.0dBi (max.) For Bluetooth
Antenna 2	Internal Antenna	600 MHz – 2500 MHz	2.0dBi (max.) For WLAN
Antenna 3	External Antenna	400 MHz – 500 MHz	5.0dBi (max.) For PMR

6. Conducted Power

General Note:

1. Per KDB 447498 D01v06, the maximum output power channel is used for SAR testing, further SAR test reduction and MPE.

<Bluetooth Max. Conducted Power>

Test Mode		Channel	Frequency (MHz)	Max. Conducted Power (dBm)
Bluetooth Classic	GFSK	LCH	2402	0.002
		MCH	2441	1.464
		HCH	2480	1.572
	π/4-DQPSK	LCH	2402	-0.507
		MCH	2441	0.652
		HCH	2480	0.542
	8-DPSK	LCH	2402	-0.549
		MCH	2441	0.566
		HCH	2480	0.621
Bluetooth LE	GFSK	LCH	2402	2.314
		MCH	2440	1.642
		HCH	2480	1.566

<2.4GWLAN Max. Conducted Power>

Test Mode		Channel	Frequency (MHz)	Max. Conducted Power (dBm)
2.4GWLAN	IEEE 802.11b	LCH	2412	17.11
		MCH	2437	17.31
		HCH	2462	17.11
	IEEE 802.11g	LCH	2412	16.59
		MCH	2437	16.06
		HCH	2462	16.15
	IEEE 802.11n HT20	LCH	2412	16.27
		MCH	2437	16.76
		HCH	2462	16.43

<PMR Max. Conducted Power>

Test Mode	Channel Separation	Rate Power	Channel	Frequency (MHz)	Max. Conducted Power (dBm)
GMSK	12.5KHz	High	LCH	460.125	38.223
			MCH	463.625	38.233
			HCH	467.625	38.233
		Low	LCH	460.125	34.260
			MCH	463.625	34.257
			HCH	467.625	34.395
GMSK	25KHz	High	LCH	460.125	38.224
			MCH	463.625	38.229
			HCH	467.625	38.231
		Low	LCH	460.125	34.437
			MCH	463.625	34.439
			HCH	467.625	34.436

<GSM Max. Conducted Power>

Test Mode	Channel	Frequency (MHz)	Max. Conducted Power (dBm)
GSM 850	LCH	824.2	32.64
	MCH	836.6	32.70
	HCH	848.8	32.57
PCS 1900	LCH	1850.2	29.67
	MCH	1880.0	29.70
	HCH	1909.8	29.70

<WCDMA Max. Conducted Power>

Test Mode	Channel	Frequency (MHz)	Max. Conducted Power (dBm)	
WCDMA	Band II	LCH	1852.4	23.48
		MCH	1880.0	23.43
		HCH	1907.6	23.54
WCDMA	Band IV	LCH	1712.4	23.43
		MCH	1732.6	23.43
		HCH	1752.6	23.52
WCDMA	Band V	LCH	826.4	23.41
		MCH	836.6	23.40
		HCH	846.6	23.50

<LTE Max. Conducted Power>

Test Mode	Channel	Frequency (MHz)	Max. Conducted Power (dBm)	
LTE	Band 41	LCH	2497.5	22.80
		MCH	2593.0	20.55
		HCH	2687.5	21.27

7. Manufacturing Tolerance

<Bluetooth>

Test Mode	Channel	Max. Conducted Power (dBm)	ANT Max. Tune Up Power (dBm)	
Bluetooth Classic	GFSK	LCH	0.002	1±1.0
		MCH	1.464	1±1.0
		HCH	1.572	1±1.0
	π/4-DQPSK	LCH	-0.507	0±1.0
		MCH	0.652	0±1.0
		HCH	0.542	0±1.0
	8-DPSK	LCH	-0.549	0±1.0
		MCH	0.566	0±1.0
		HCH	0.621	0±1.0
Bluetooth LE	GFSK	LCH	2.314	2±1.0
		MCH	1.642	2±1.0
		HCH	1.566	2±1.0

<2.4GWLAN>

Test Mode		Channel	Max. Conducted Power (dBm)	ANT Max. Tune Up Power (dBm)
2.4GWLAN	IEEE 802.11b	LCH	17.11	17.0±1.0
		MCH	17.31	17.0±1.0
		HCH	17.11	17.0±1.0
	IEEE 802.11g	LCH	16.59	16.0±1.0
		MCH	16.06	16.0±1.0
		HCH	16.15	16.0±1.0
	IEEE 802.11n HT20	LCH	16.27	16.0±1.0
		MCH	16.76	16.0±1.0
		HCH	16.43	16.0±1.0

<PMR>

Modulation Type	Channel Separation	Rate Power	Channel	Max. Conducted Power (dBm)	ANT Max. Tune Up Power (dBm)
GMSK	12.5KHz	High	LCH	38.223	38±1.0
			MCH	38.233	38±1.0
			HCH	38.233	38±1.0
		Low	LCH	34.260	34±1.0
			MCH	34.257	34±1.0
			HCH	34.395	34±1.0
GMSK	12.5KHz	High	LCH	38.224	38±1.0
			MCH	38.229	38±1.0
			HCH	38.231	38±1.0
		Low	LCH	34.437	34±1.0
			MCH	34.439	34±1.0
			HCH	34.436	34±1.0

<GSM>

Test Mode		Channel	Max. Conducted Power (dBm)	ANT Max. Tune Up Power (dBm)
GSM 850		LCH	32.64	32.0±1.0
		MCH	32.70	32.0±1.0
		HCH	32.57	32.0±1.0
PCS 1900		LCH	29.67	29.0±1.0
		MCH	29.70	29.0±1.0
		HCH	29.70	29.0±1.0

<WCDMA>

Test Mode		Channel	Max. Conducted Power (dBm)	ANT Max. Tune Up Power (dBm)
WCDMA	Band II	LCH	23.48	23.0±1.0
		MCH	23.43	23.0±1.0
		HCH	23.54	23.0±1.0
WCDMA	Band IV	LCH	23.43	23.0±1.0
		MCH	23.43	23.0±1.0
		HCH	23.52	23.0±1.0
WCDMA	Band V	LCH	23.41	23.0±1.0
		MCH	23.40	23.0±1.0
		HCH	23.50	23.0±1.0

<LTE Max. Conducted Power>

Test Mode		Channel	Max. Conducted Power (dBm)	ANT Max. Tune Up Power (dBm)
LTE	Band 41	LCH	22.80	22.0±1.0
		MCH	20.55	20.0±1.0
		HCH	21.27	21.0±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 100 cm from any body part of the user or nearby persons; from the maximum EUT RF output power, the minimum separation distance, $r=100\text{cm}$, as well as the gain of the used antenna refer to antenna information, the RF power density can be obtained.

Antenna 0

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW				
GSM 850	33.00	1995.2623	2.0000	1.9953	0.0252	0.5493
PCS 1900	30.00	1000.0000	2.0000	1.9953	0.0126	1.0000
WCDMA Band II	24.00	251.1886	2.0000	1.9953	0.0032	1.0000
WCDMA Band IV	24.00	251.1886	2.0000	1.9953	0.0032	1.0000
WCDMA Band V	24.00	251.1886	2.0000	1.9953	0.0032	0.5493
LTE Band 41	23.00	199.5262	2.0000	1.9953	0.0025	1.0000

Antenna 1

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW				
BT Classic GFSK	2.00	1.5849	2.0000	1.5849	0.0000	1.0000
BT Classic $\pi/4$ -DQPSK	1.00	1.2589	2.0000	1.5849	0.0000	1.0000
BT Classic 8-DPSK	1.00	1.2589	2.0000	1.5849	0.0000	1.0000
BT LE GFSK	3.00	1.9953	2.0000	1.5849	0.0000	1.0000

Antenna 2

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW				
IEEE 802.11b	18.00	63.0957	2.0000	1.5849	0.0008	1.0000
IEEE 802.11g	17.00	50.1187	2.0000	1.5849	0.0006	1.0000
IEEE 802.11n HT20	17.00	50.1187	2.0000	1.5849	0.0006	1.0000

Antenna 3

Modulation Type	Output power		Antenna Gain (dBi)	Antenna Gain (linear)	MPE (mW/cm ²)	MPE Limits (mW/cm ²)
	dBm	mW				
GMSK (460-467MHz)	39.00	7943.2823	5.0000	3.1623	0.1999	0.3067

Remark:

1. Output power including turn-up tolerance;
2. Output power is burst average power;
3. MPE evaluate distance is 100cm from user manual provide by manufacturer;
4. $MPE\ values = PG/4\pi R^2$
5. MPE limits for PCS 1900 refer 1850MHz, GSM 850 and WCDMA Band V refer 824MHz, LTE Band 41 refer 2496MHz and PMR refer 460MHz as it is lowest frequency.

8.2 Simultaneous Transmission MPE

The sample support one 2.4G WLAN, one Bluetooth antenna and another one GSM WCDMA and LTE transmit antenna, so need consider simultaneous transmission;

The GSM&WCDMA<E and PMR use the same antenna port, so no need consider simultaneous transmission; Simultaneous transmission MPE;

According to KDB447498 for Transmitters used in mobile exposure conditions for simultaneous transmission operations;

$\Sigma \Sigma$ of MPE ratios ≤ 1.0

Simultaneous Transmission MPE			
Mode	Σ MPE ratios	Limit	Results
BT Classic + IEEE 802.11b	0.0008	1.000	Pass
BT Classic + IEEE 802.11g	0.0006	1.000	Pass
BT Classic + IEEE 802.11n20	0.0006	1.000	Pass
BT Classic + PMR	0.1999	1.000	Pass
BT LE + PMR	0.1999	1.000	Pass
IEEE 802.11b + PMR	0.2007	1.000	Pass
IEEE 802.11g + PMR	0.2005	1.000	Pass
IEEE 802.11n20 + PMR	0.2005	1.000	Pass
BT Classic + GSM 850	0.0252	1.000	Pass
BT LE + GSM 850	0.0252	1.000	Pass
IEEE 802.11b + GSM 850	0.0260	1.000	Pass
IEEE 802.11g + GSM 850	0.0258	1.000	Pass
IEEE 802.11n20 + GSM 850	0.0258	1.000	Pass
BT Classic + PCS 1900	0.0126	1.000	Pass
BT LE + PCS 1900	0.0126	1.000	Pass
IEEE 802.11b + PCS 1900	0.0134	1.000	Pass
IEEE 802.11g + PCS 1900	0.0132	1.000	Pass
IEEE 802.11n20 + PCS 1900	0.0132	1.000	Pass
BT Classic + WCDMA Band II	0.0032	1.000	Pass
BT LE + WCDMA Band II	0.0032	1.000	Pass
IEEE 802.11b + WCDMA Band II	0.0040	1.000	Pass
IEEE 802.11g + WCDMA Band II	0.0038	1.000	Pass
IEEE 802.11n20 + WCDMA Band II	0.0038	1.000	Pass
BT Classic + WCDMA Band IV	0.0032	1.000	Pass
BT LE + WCDMA Band IV	0.0032	1.000	Pass
IEEE 802.11b + WCDMA Band IV	0.0040	1.000	Pass
IEEE 802.11g + WCDMA Band IV	0.0038	1.000	Pass
IEEE 802.11n20 + WCDMA Band IV	0.0038	1.000	Pass
BT Classic + WCDMA Band V	0.0032	1.000	Pass
BT LE + WCDMA Band V	0.0032	1.000	Pass
IEEE 802.11b + WCDMA Band V	0.0040	1.000	Pass
IEEE 802.11g + WCDMA Band V	0.0038	1.000	Pass
IEEE 802.11n20 + WCDMA Band V	0.0038	1.000	Pass
BT Classic + LTE Band 41	0.0025	1.000	Pass
BT LE + LTE Band 41	0.0025	1.000	Pass
IEEE 802.11b + LTE Band 41	0.0033	1.000	Pass
IEEE 802.11g + LTE Band 41	0.0031	1.000	Pass
IEEE 802.11n20 + LTE Band 41	0.0031	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.

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