FCC RF Exposure Evaluation

1. Product Information

EUT	:	GNSS Receiver
Test Model	:	ORION ONE GNSS Receiver
Additional Model No.	:	Z1, E3, L1, L1 PRO, Orion ONE Lite Laser, Orion ONE Lite AR
Model Declaration	:	PCB board, structure and internal of these model(s) are the same, So no additional models were tested
Power Supply	:	Input: DC 5-15V
Hardware Version	:	v1.1
Software Version	:	1.0.0.1
Bluetooth	:	
Frequency Range	:	2402MHz~2480MHz
Channel Number	:	79 channels for Bluetooth V4.2 (DSS)
Channel Spacing	:	1MHz for Bluetooth V4.2 (DSS)
Modulation Type	:	GFSK, π/4-DQPSK, 8-DPSK for Bluetooth V4.2 (DSS)
Bluetooth Version	:	V4.2
Antenna Description	:	Internal Antenna, 2.24dBi(Max.)
PMR	:	
Operating Frequency	:	410~470MHz
Channel Separation	:	12.5KHz
Modulation Type	:	GMSK
Emission Designator	:	7K60G1D for GMSK Modulation at 12.5KHz Channel Separation
Antenna Type	:	External Antenna
Antenna Gain	:	1.21dBi (max.) for PMR
Extreme temp. Tolerance	:	-30°C to +50°C
Extreme vol. Limits	:	6.7VDC to 8.4VDC (nominal: 7.4VDC)

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.

According to KDB447498 D01 General RF Exposure Guidance v06,
When one of the following test exclusion conditions is satisfied for all combinations of simultaneous transmission configurations, further equipment approval is not required to incorporate transmitter modules in host devices that operate in the mixed mobile and portable host platform exposure conditions. The grantee is responsible for documenting this according to Class I permissive change requirements. Antennas that qualify for standalone SAR test exclusion must apply the estimated standalone SAR to determine simultaneous transmission test exclusion.
The [∑ of (the highest measured or estimated SAR for each standalone antenna configuration, adjusted for maximum tune-up tolerance) / 1.6 W/kg] + [∑ of MPE ratios] is ≤ 1.0.
b)The SAR to peak location separation ratios of all simultaneously transmitting antenna pairs operating in portable device exposure conditions are all ≤ 0.04, and the [∑ of MPE ratios] is ≤ 1.0.
When an antenna qualifies for the standalone SAR test exclusion of 4.3.1 and also transmits simultaneously with other antennas, the standalone SAR value must be estimated according to the following to determine the simultaneous transmission SAR test exclusion criteria:36
1)[(max. power of channel, including tune-up tolerance, mW) / (min. test separation distance, mm)] • [√ f(GHz)/x] W/kg, for test separation distances ≤ 50 mm;
where x = 7.5 for 1-g SAR and x = 18.75 for 10-g SAR.
At frequencies below 100 MHz, the following may be considered for SAR test exclusion, and as illustrated in Appendix C:
a) The power threshold at the corresponding test separation distance at 100 MHz in step 2) is multiplied by [1 + log(100/f(MHz))] for test separation distances > 50 mm and < 200 mm
b) The power threshold determined by the equation in a) for 50 mm and 100 MHz is multiplied by ½ for test separation distances ≤ 50 mm
c)SAR measurement procedures are not established below 100 MHz. When SAR test exclusion cannot be applied, a KDB inquiry is required to determine SAR evaluation requirements for any test results to be acceptable.

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

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

Internal Identification	Antenna type and antenna number	Operate frequency band	Maximum antenna gain	Note
Antenna0	Internal Antenna	2402MHz ~ 2480MHz	2.24dBi (Max.)	BT Antenna
Antenna1	External Antenna	410 ~ 470MHz	1.21dBi (Max.)	PMR Antenna

6. Conducted Power and Manufacturing Tolerance

<BT Max Conducted Power >

Mode	Channel	Frequency (MHz)	Max Conducted Power (dBm)	Tune Up Power (dBm)
GFSK	0	2402	-0.55	0±1.0
	39	2441	-0.17	0±1.0
	78	2480	0.51	0±1.0
π/4DQPSK	0	2402	0.21	0±1.0
	39	2441	0.63	0±1.0
	78	2480	-0.24	0±1.0
8DPSK	0	2402	0.61	0±1.0
	39	2441	1.09	1.0±1.0
	78	2480	0.15	0±1.0

<PMR>

Test Mode		Frequency (MHz)	Max Conducted Peak Power (dBm)	Tune Up Power (dBm)
GMSK	12.5KHz	410.125	29.383	29.0±1.0
		439.625	29.227	29.0±1.0
		469.625	29.430	29.0±1.0
		410.125	26.524	26.0±1.0
		439.625	26.407	26.0±1.0
		469.625	26.443	26.0±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 =20cm, as well as the gain of the used antenna refer to antenna information, the RF power density can be obtained.

<BT>

Band/Mode	RF output power		Antenna Gain (dBi)	MPE (mW/cm2)	MPE Limits (mW/cm2)	MPE ratios1
	dBm	mW				
GFSK	1.0	1.2589	2.24	0.0004	1.0000	0.0004
π/4DQPSK	1.0	1.2589	2.24	0.0004	1.0000	0.0004
8DPSK	2.0	1.5849	2.24	0.0005	1.0000	0.0005

<PMR>

Band/Mode	RF output power		Antenna Gain (dBi)	MPE (mW/cm2)	MPE Limits (mW/cm2)	MPE ratios2
	dBm	mW				
GMSK	30.0	1000.0000	1.21	0.2629	0.2733	0.9619
	27.0	501.1872	1.21	0.1317	0.2733	0.4819

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

The sample support one BLE antenna, another one NFC 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;

$$TER = \sum_{k=1}^{N_S}\left(\frac{SAR_k}{SAR_{\lim}}\right) + \sum_{k=1}^{N_f}\left(\frac{MPE_{field,\,k}}{MPE_{field,\,\lim}}\right)^2 + \sum_{k=1}^{N_{PD}}\left(\frac{MPE_{PD,\,k}}{MPE_{PD,\,\lim}}\right)$$

∑∑of MPE ratios ≤ 1.0

Mode	**∑ MPE ratios**	**Limit**	**Results**
BLE+PMR	0.9624	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.....