

G7 EXO Radio Frequency (RF) Exposure Compliance

1 Document Revision History

Revision	Date	Author	Summary
1	Sep 22, 2020	Scott Jacobsen	Initial release
2	Sep 24, 2020	Scott Jacobsen	Removed antenna details, creating a separate document for that information
3	June 19, 2024	Scott Jacobsen	-Added LARA R6001D -Update FCC limits

2 Purpose of this Report

The purpose of this report is to show the radio frequency (RF) exposure compliance of certain simultaneous transmission configurations of the modules inside the product named G7EXO.

3 Identifiers

3.1 Host Product

Internal Product Name: G7 EXO

Model: G7EXO-NA2

Host FCC ID: W77EXO

3.2 Radio Identifiers

Radio Description	Model	FCC ID	IC ID	Grantee
Cellular	LARA-R6001D	XPYUBX21BE01	8595A-UBX21BE01	u-blox AG
Satellite	9603N	Q639603N	4629A-9603N	Iridium Satellite LLC
Bluetooth	G7EXO-NA2	W77EXO	8255A-EXO	Blackline Safety

3.3 Antennas

Technology	Vendor	Model	Peak Gain(dBi)	Data Sheet Reference
Cellular	Blackline Safety	103452r2	1.0	G7EXO-NA2 Antennas.pdf
Satellite	Taoglas	IP.1621.25.4.A.02	3.0	G7EXO-NA2 Antennas.pdf
Bluetooth	Pulse Electronics	W3008C	2.4	G7EXO-NA2 Antennas.pdf

4 Test Standards

Test Standard	Version	Test Standard Description
FCC 47 CFR 2.1091	e-CFR May 3, 2021	Radiofrequency radiation exposure evaluation: mobile devices.
FCC 47 CFR 1.1310	e-CFR June 1, 2020	Radiofrequency radiation exposure limits
RSS-102	Issue 6, December 15, 2023	5 Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)

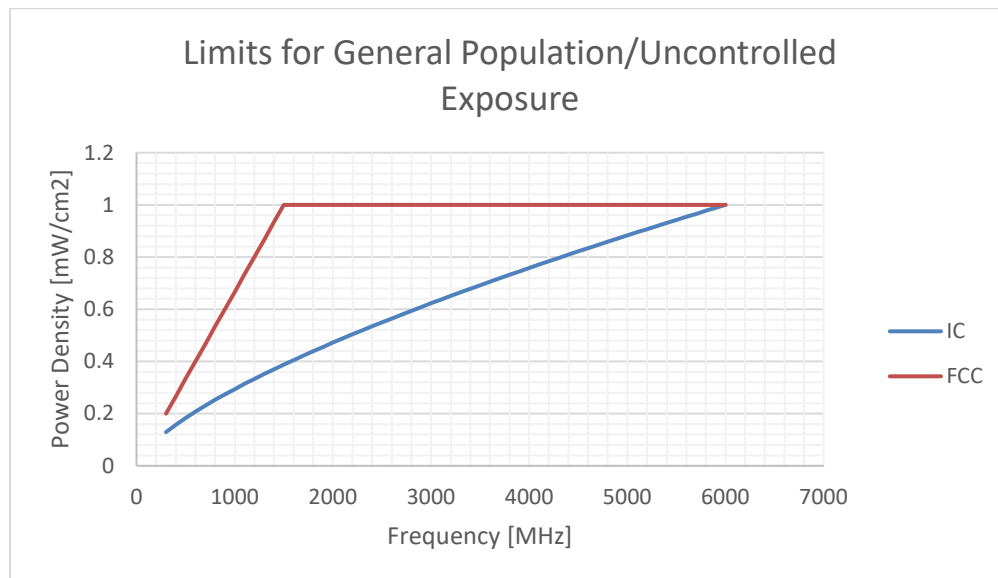
6 Limits

6.1 FCC Limits for General Population/Uncontrolled Exposure

Frequency Range	E-field strength (V/m)	H-field strength (A/m)	B-field strength (μT)	Power density (mW/cm ²)
300 – 1500 MHz	--	--	--	$f(\text{MHz}) / 1500$
1.5 – 100 GHz	--	--	--	1.0

6.2 ISED Limits for General Population/Uncontrolled Exposure

Frequency Range	E-field strength (V/m)	H-field strength (A/m)	B-field strength (μT)	Power density (W/m ²)	Power density (mW/cm ²)
300 – 6000 MHz	--	--	--	$0.02619f^{0.6834}$	$0.002619f^{0.6834}$

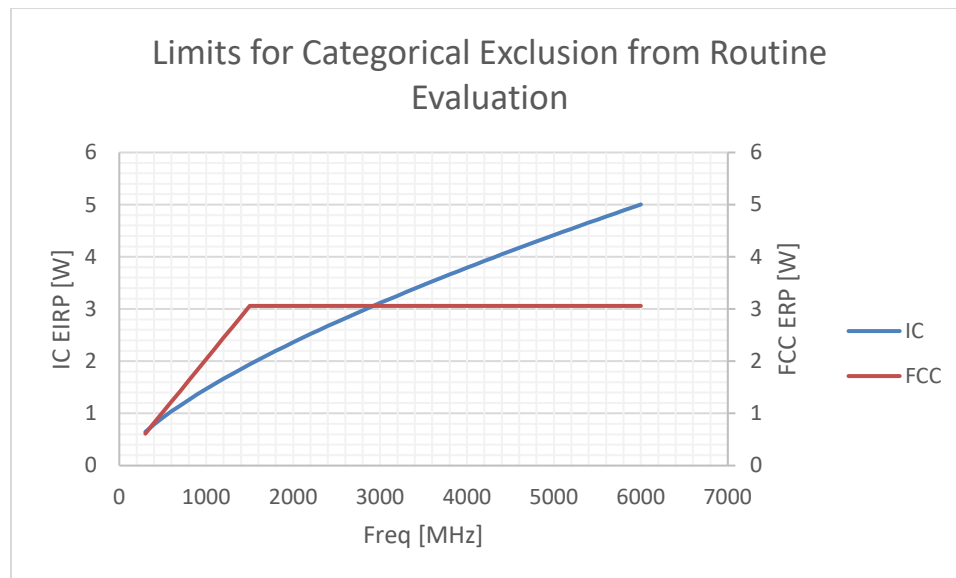


6.3 FCC Limits for Categorical Exclusion from Routine Evaluation

Frequency Range	Specification
$0.3 \text{ GHz} \leq f < 1.5 \text{ GHz}$	ERP < 2040f mW
$1.5 \text{ GHz} \leq f < 6 \text{ GHz}$	ERP < 3060 mW

6.4 ISED Limits for Categorical Exclusion from Routine Evaluation

Frequency Range	Specification
$300 \text{ MHz} \leq f < 6 \text{ GHz}$	Source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834} \text{ W}$ (adjusted for tune-up tolerance), where f is in MHz



7 RF Exposure Assessment

7.1 Maximum permissible exposure (MPE)

Fixed/mobile exposure conditions of multiple transmitters installed in different hosts represent the most difficult situation in terms of the determination of minimum safety distances. While EMF measurements most often only refer to a single configuration with only one transmitter or with multiple co-located transmitters a general approach is needed to determine a worst case condition under which several transmitters and their antennas can be installed to prevent additional RF exposure evaluation for each host.

This test report illustrates how three specific radio modules can be integrated in a host without the need of further testing.

The background of the calculation is a minimum distance of 20 cm between antenna(s) and user (mobile exposure condition), and the compliance with the requirements of section 5.

7.2 Formulas

1. Average power density for each transmitter at a distance of 20 cm, S_{eq} , is calculated using the following formula:

$$S_{eq} = \frac{P \cdot G}{4\pi \cdot r^2} \times \eta$$

where

P is the peak power conducted into the antenna

G is the peak antenna gain

η is the duty cycle of transmissions

R = 20 cm

2. Then the ratio S_{eq}/S_{lim} is calculated for all applied limits, where S_{lim} is the limit at the frequency of interest, as specified in section 6. This essentially converts the power densities into unit-less values representing the portion of the power density limit generated by individual transmitters.
3. Finally, it must be ensured that the sum of all worst case power densities of all active transmitters do not exceed the limits, even if they are far below the limits for the single transmitter. The ratios for all the transmitters calculated in step 2 are summed together in all possible combinations of transmitters such that

$$\sum_{1}^n \frac{S_{eq\ n}}{S_{lim\ n}} = \frac{S_{eq\ 1}}{S_{lim\ 1}} + \frac{S_{eq\ 2}}{S_{lim\ 2}} + \dots + \frac{S_{eq\ n}}{S_{lim\ n}} \leq 1$$

7.3 Individual Radiated Power Densities

Module	Frequency (MHz)	Conducted Output Power (mW)	Conducted Output Power (dBm)	Antenna Gain (dBi)	Antenna Gain (linear)	EIRP (dBm)	EIRP (mW)	Duty Cycle (%)	S_{eq} - Average Power Density (mW/cm ²)	FCC S_{lim} - Power Density Limit (mW/cm ²)	IC S_{lim} - Power Density Limit (mW/cm ²)	Portion of FCC Limit	Portion of IC Limit
Bluetooth	2441.0	10	10.17	2.20	1.66	12.37	17	100	0.00343	1.000	0.541	0.003	0.006
Satellite	1616.0	1410	31.49	3.00	2.00	34.49	2813	10.36	0.05798	1.000	0.408	0.058	0.142
FDD Band 2	1852.4	203	23.08	-0.30	0.93	13.33	22	100	0.00429	1.000	0.448	0.004	0.010
FDD Band 5	836.6	212	23.27	-3.10	0.49	10.57	11	100	0.00227	0.558	0.260	0.004	0.009
FDD LTE Band 12	699.7	275	24.39	-7.20	0.19	17.19	52	100	0.01042	0.466	0.230	0.022	0.045
FDD LTE Band 13	779.5	255	24.07	-4.00	0.40	20.07	102	100	0.02020	0.520	0.248	0.039	0.081
FDD LTE Band 2	1880.0	222	23.47	-0.60	0.87	13.11	20	100	0.00407	1.000	0.453	0.004	0.009
FDD LTE Band 26	819.0	259	24.13	-3.60	0.44	10.23	11	100	0.00210	0.546	0.256	0.004	0.008
FDD LTE Band 4	1710.7	249	23.96	1.60	1.45	25.56	360	100	0.07160	1.000	0.424	0.072	0.169
FDD LTE Band 5	836.5	254	24.04	-3.10	0.49	10.71	12	100	0.00234	0.558	0.260	0.004	0.009
FDD LTE Band 7	2502.5	186	22.70	1.20	1.32	23.90	245	100	0.04878	1.000	0.550	0.049	0.089
FDD LTE Band 8	899.0	191	22.81	-1.40	0.72	21.41	138	100	0.02753	0.599	0.273	0.046	0.101
GSM1900	1850.2	716	28.55	-0.30	0.93	14.26	27	100	0.00530	1.000	0.448	0.005	0.012
GSM850	824.2	1429	31.55	-3.60	0.44	27.95	624	100	0.12409	0.549	0.258	0.226	0.482
TDD LTE Band 38	2572.5	248	23.94	1.40	1.38	25.34	342	100	0.06811	1.000	0.561	0.068	0.121
TDD LTE Band 41	2593.0	187	22.73	1.40	1.38	14.97	31	100	0.00624	1.000	0.564	0.006	0.011
Bluetooth	2441.0	10	10.17	2.20	1.66	12.37	17	100	0.00343	1.000	0.541	0.003	0.006
Satellite	1616.0	1410	31.49	3.00	2.00	34.49	2813	10.36	0.05798	1.000	0.408	0.058	0.142
FDD Band 2	1852.4	203	23.08	-0.30	0.93	13.33	22	100	0.00429	1.000	0.448	0.004	0.010
FDD Band 5	836.6	212	23.27	-3.10	0.49	10.57	11	100	0.00227	0.558	0.260	0.004	0.009

7.4 Total Radiated Power Densities from Transmitter Combinations – Against FCC Limits

Radio	Portion of FCC Limit
Bluetooth	0.0034
GSM850	0.2258
Satellite	0.0580
	0.2873
Bluetooth	0.0034
GSM1900	0.0053
Satellite	0.0580
	0.0667
Bluetooth	0.0034
FDD Band 2	0.0043
Satellite	0.0580
	0.0657
Bluetooth	0.0034
FDD LTE Band 2	0.0041
Satellite	0.0580
	0.0655
Bluetooth	0.0034
FDD LTE Band 4	0.0716
Satellite	0.0580
	0.1330
Bluetooth	0.0034
FDD Band 5	0.0041
Satellite	0.0580
	0.0655
Bluetooth	0.0034

FDD LTE Band 5	0.0042
Satellite	0.0580
	0.0656

Bluetooth	0.0034
FDD LTE Band 26	0.0038
Satellite	0.0580
	0.0653

Bluetooth	0.0034
FDD LTE Band 7	0.0488
Satellite	0.0580
	0.1102

Bluetooth	0.0034
FDD LTE Band 13	0.0389
Satellite	0.0580
	0.1003

Bluetooth	0.0034
FDD LTE Band 12	0.0223
Satellite	0.0580
	0.0838

Bluetooth	0.0034
FDD LTE Band 8	0.0459
Satellite	0.0580
	0.1073

Bluetooth	0.0034
TDD LTE Band 38	0.0681
Satellite	0.0580
	0.1295

Bluetooth	0.0034
TDD LTE Band 41	0.0062
Satellite	0.0580
	0.0677

The summations of the individual radiated power density portions for the transmitter combinations are both less than the limits, and hence the total radiated power density from the G7 EXO is deemed to be compliant with the regulatory requirements.

7.5 Total Radiated Power Densities from Transmitter Combinations – Against ISED Limits

Radio	Portion of IC Limit
Bluetooth	0.0063
GSM850	0.4817
Satellite	0.1421
	0.6301
Bluetooth	0.0063
GSM1900	0.0118
Satellite	0.1421
	0.1603
Bluetooth	0.0063
FDD Band 2	0.0096
Satellite	0.1421
	0.1580
Bluetooth	0.0063
FDD LTE Band 2	0.0090
Satellite	0.1421
	0.1574
Bluetooth	0.0063
FDD LTE Band 4	0.1687
Satellite	0.1421
	0.3172
Bluetooth	0.0063
FDD Band 5	0.0087
Satellite	0.1421
	0.1571

Bluetooth	0.0063
FDD LTE Band 5	0.0090
Satellite	0.1421
	0.1574

Bluetooth	0.0063
FDD LTE Band 26	0.0082
Satellite	0.1421
	0.1566

Bluetooth	0.0063
FDD LTE Band 7	0.0886
Satellite	0.1421
	0.2371

Bluetooth	0.0063
FDD LTE Band 13	0.0814
Satellite	0.1421
	0.2299

Bluetooth	0.0063
FDD LTE Band 12	0.0453
Satellite	0.1421
	0.1937

Bluetooth	0.0063
FDD LTE Band 8	0.1007
Satellite	0.1421
	0.2491

Bluetooth	0.0063
TDD LTE Band 38	0.1215
Satellite	0.1421
	0.2699

Bluetooth	0.0063
TDD LTE Band 41	0.0111

Satellite	0.1421
	0.1595

The summations of the individual radiated power density portions for the transmitter combinations are both less than the limits, and hence the total radiated power density from the G7 EXO is deemed to be compliant with the regulatory requirements.

8 Statement of Compliance

The electromagnetic field (EMF) values found for the co-located modules of G7 EXO are below the maximum allowed levels according to the standards listed in section 5 when used with the antennas specified in section 3.3.