

# EXO 8 Radio Frequency (RF) Exposure Compliance

## 1 Document Revision History

| Revision | Date        | Author         | Summary         |
|----------|-------------|----------------|-----------------|
| 1        | Nov 5, 2024 | Scott Jacobsen | Initial release |
|          |             |                |                 |
|          |             |                |                 |

## 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 EXO 8.

## 3 Identifiers

### 3.1 Host Product

Internal Product Name: EXO 8

Model: EX8N-01-NA2

Host FCC ID: W77EXO8

### 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            | 20241105 EXO8_Cellular_Antenna_Gain_Compliance.pdf |
| Satellite  | Taoglas           | IP.1621.25.4.A.02 | 3.0            | 20241105 EXO8 Bluetooth and Iridium Antennas.pdf   |
| Bluetooth  | Pulse Electronics | W3008C            | 2.4            | 20241105 EXO8 Bluetooth and Iridium 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) |

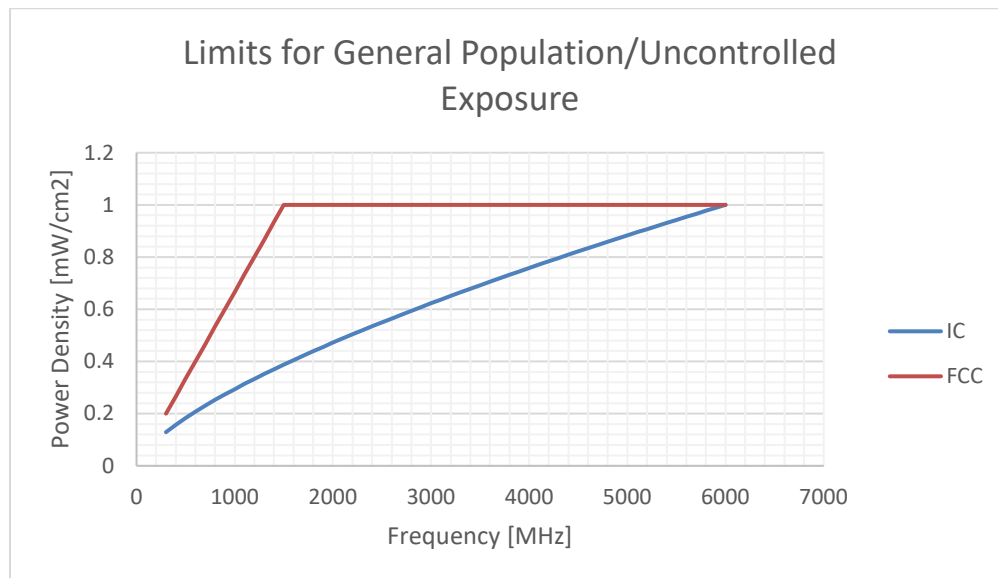
## 6 Limits

### 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 <sup>2</sup> ) |
|-----------------|------------------------|------------------------|-----------------------|-------------------------------------|
| 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 <sup>2</sup> ) | Power density (mW/cm <sup>2</sup> ) |
|-----------------|------------------------|------------------------|-----------------------|-----------------------------------|-------------------------------------|
| 300 – 6000 MHz  | --                     | --                     | --                    | $0.02619f^{0.6834}$               | $0.002619f^{0.6834}$                |

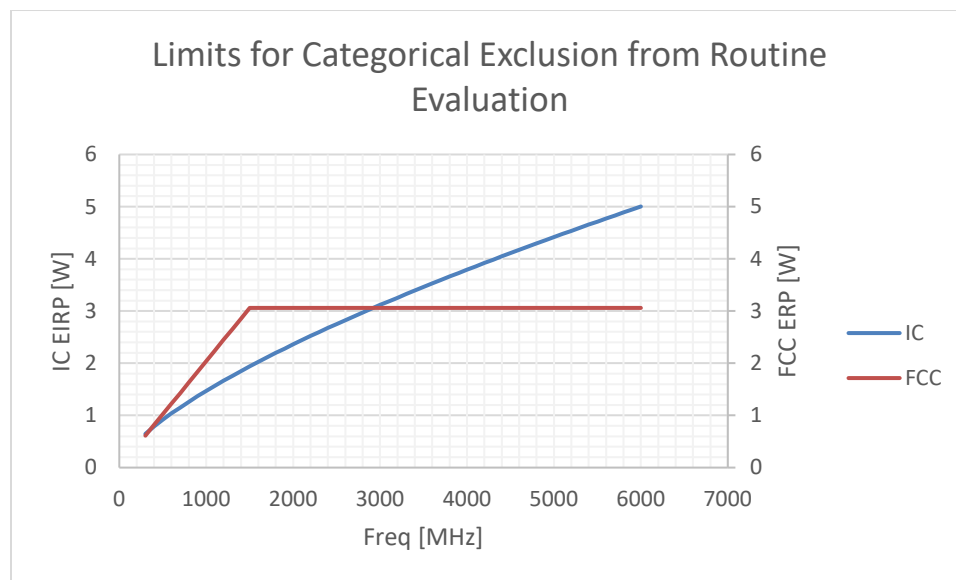


### 6.3 FCC Limits for Categorical Exclusion from Routine Evaluation

| 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

$\eta$  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 <sup>2</sup> ) | FCC $S_{lim}$ - Power Density Limit (mW/cm <sup>2</sup> ) | IC $S_{lim}$ - Power Density Limit (mW/cm <sup>2</sup> ) | 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<br>of FCC<br>Limit |
|----------------|----------------------------|
| Bluetooth      | 0.0034                     |
| GSM850         | 0.2258                     |
| Satellite      | 0.0580                     |
|                | <b>0.2873</b>              |
| Bluetooth      | 0.0034                     |
| GSM1900        | 0.0053                     |
| Satellite      | 0.0580                     |
|                | <b>0.0667</b>              |
| Bluetooth      | 0.0034                     |
| FDD Band 2     | 0.0043                     |
| Satellite      | 0.0580                     |
|                | <b>0.0657</b>              |
| Bluetooth      | 0.0034                     |
| FDD LTE Band 2 | 0.0041                     |
| Satellite      | 0.0580                     |
|                | <b>0.0655</b>              |
| Bluetooth      | 0.0034                     |
| FDD LTE Band 4 | 0.0716                     |
| Satellite      | 0.0580                     |
|                | <b>0.1330</b>              |
| Bluetooth      | 0.0034                     |
| FDD Band 5     | 0.0041                     |
| Satellite      | 0.0580                     |
|                | <b>0.0655</b>              |
| Bluetooth      | 0.0034                     |

|                |               |
|----------------|---------------|
| FDD LTE Band 5 | 0.0042        |
| Satellite      | 0.0580        |
|                | <b>0.0656</b> |

|                 |               |
|-----------------|---------------|
| Bluetooth       | 0.0034        |
| FDD LTE Band 26 | 0.0038        |
| Satellite       | 0.0580        |
|                 | <b>0.0653</b> |

|                |               |
|----------------|---------------|
| Bluetooth      | 0.0034        |
| FDD LTE Band 7 | 0.0488        |
| Satellite      | 0.0580        |
|                | <b>0.1102</b> |

|                 |               |
|-----------------|---------------|
| Bluetooth       | 0.0034        |
| FDD LTE Band 13 | 0.0389        |
| Satellite       | 0.0580        |
|                 | <b>0.1003</b> |

|                 |               |
|-----------------|---------------|
| Bluetooth       | 0.0034        |
| FDD LTE Band 12 | 0.0223        |
| Satellite       | 0.0580        |
|                 | <b>0.0838</b> |

|                |               |
|----------------|---------------|
| Bluetooth      | 0.0034        |
| FDD LTE Band 8 | 0.0459        |
| Satellite      | 0.0580        |
|                | <b>0.1073</b> |

|                 |               |
|-----------------|---------------|
| Bluetooth       | 0.0034        |
| TDD LTE Band 38 | 0.0681        |
| Satellite       | 0.0580        |
|                 | <b>0.1295</b> |

|                 |               |
|-----------------|---------------|
| Bluetooth       | 0.0034        |
| TDD LTE Band 41 | 0.0062        |
| Satellite       | 0.0580        |
|                 | <b>0.0677</b> |

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 EXO 8 is deemed to be compliant with the regulatory requirements.

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

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

|                |               |
|----------------|---------------|
| Bluetooth      | 0.0063        |
| FDD LTE Band 5 | 0.0090        |
| Satellite      | 0.1421        |
|                | <hr/>         |
|                | <b>0.1574</b> |

|                 |               |
|-----------------|---------------|
| Bluetooth       | 0.0063        |
| FDD LTE Band 26 | 0.0082        |
| Satellite       | 0.1421        |
|                 | <hr/>         |
|                 | <b>0.1566</b> |

|                |               |
|----------------|---------------|
| Bluetooth      | 0.0063        |
| FDD LTE Band 7 | 0.0886        |
| Satellite      | 0.1421        |
|                | <hr/>         |
|                | <b>0.2371</b> |

|                 |               |
|-----------------|---------------|
| Bluetooth       | 0.0063        |
| FDD LTE Band 13 | 0.0814        |
| Satellite       | 0.1421        |
|                 | <hr/>         |
|                 | <b>0.2299</b> |

|                 |               |
|-----------------|---------------|
| Bluetooth       | 0.0063        |
| FDD LTE Band 12 | 0.0453        |
| Satellite       | 0.1421        |
|                 | <hr/>         |
|                 | <b>0.1937</b> |

|                |               |
|----------------|---------------|
| Bluetooth      | 0.0063        |
| FDD LTE Band 8 | 0.1007        |
| Satellite      | 0.1421        |
|                | <hr/>         |
|                | <b>0.2491</b> |

|                 |               |
|-----------------|---------------|
| Bluetooth       | 0.0063        |
| TDD LTE Band 38 | 0.1215        |
| Satellite       | 0.1421        |
|                 | <hr/>         |
|                 | <b>0.2699</b> |

|                 |        |
|-----------------|--------|
| Bluetooth       | 0.0063 |
| TDD LTE Band 41 | 0.0111 |

|           |               |
|-----------|---------------|
| Satellite | 0.1421        |
|           | <hr/>         |
|           | <b>0.1595</b> |

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 EXO 8 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 EXO 8 are below the maximum allowed levels according to the standards listed in section 5 when used with the antennas specified in section 3.3.