

#### 5.4. RF EXPOSURE REQUIRMENTS [§§ 15.247(i), 1.1310 & 2.1091]

§ 1.1310: The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b).

##### Limits for Maximum Permissible Exposure (MPE)

| Frequency range (MHz)                                          | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density (mW/cm <sup>2</sup> ) | Averaging time (minutes) |
|----------------------------------------------------------------|-------------------------------|-------------------------------|-------------------------------------|--------------------------|
| <b>(A) Limits for Occupational/Controlled Exposures</b>        |                               |                               |                                     |                          |
| 0.3-3.0                                                        | 614                           | 1.63                          | *(100)                              | 6                        |
| 3.0-30                                                         | 1842/f                        | 4.89/f                        | *(900/f <sup>2</sup> )              | 6                        |
| 30-300                                                         | 61.4                          | 0.163                         | 1.0                                 | 6                        |
| 300-1500                                                       |                               |                               | f/300                               | 6                        |
| 1500-100,000                                                   |                               |                               | 5                                   | 6                        |
| <b>(B) Limits for General Population/Uncontrolled Exposure</b> |                               |                               |                                     |                          |
| 0.3-1.34                                                       | 614                           | 1.63                          | *(100)                              | 30                       |
| 1.34-30                                                        | 824/f                         | 2.19/f                        | *(180/f <sup>2</sup> )              | 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

Note 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

Note 2: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

##### 5.4.1. Method of Measurements

Calculation Method of Power Density/RF Safety Distance:

$$S = \frac{PG}{4\pi \cdot r^2} = \frac{EIRP}{4\pi \cdot r^2}$$

Where,

P: power input to the antenna in mW

EIRP: Equivalent (effective) isotropic radiated power.

S: power density mW/cm<sup>2</sup>

G: numeric gain of antenna relative to isotropic radiator

r: distance to centre of radiation in cm

## 5.4.2. RF Evaluation

Pursuant to KDB 447498 D01 General RF Exposure Guidance v06, Section 7.2:

*Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is  $\leq 1.0$ , according to calculated/estimated, numerically modeled, or measured field strengths or power density.*

The EUT is subject to co-location MPE evaluation, below table are the possible option(s):

| Source<br>Option | Lyngsoe Systems Ltd.<br>Active RFID Reader | Lyngsoe Systems Ltd. WiFi<br>and Bluetooth Module<br>(FCC ID: Z64-WL18DBMOD) | Lyngsoe Systems Ltd.<br>UHF RFID Reader Module<br>(FCC ID: PQG-MERCURY6E-M) | Telit Communications S.p.A.<br>Data Terminal Module<br>(FCC ID: RI7LE910CXWWX) |
|------------------|--------------------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| 1                | X                                          | X                                                                            | X                                                                           | --                                                                             |
| 2                | X                                          | X                                                                            | X                                                                           | X                                                                              |

Co-location evaluation is evaluated at a separation distance of 55 cm. The table below is the calculation for all the possible options and the sum of the MPE ratios from all sources.

| Source<br>Option | Maximum MPE Ratio                          |                                                                              |                                                                             |                                                                                | Sum of<br>MPE ratios<br>from all<br>sources |
|------------------|--------------------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------|--------------------------------------------------------------------------------|---------------------------------------------|
|                  | Lyngsoe Systems Ltd.<br>Active RFID Reader | Lyngsoe Systems Ltd. WiFi<br>and Bluetooth Module<br>(FCC ID: Z64-WL18DBMOD) | Lyngsoe Systems Ltd.<br>UHF RFID Reader Module<br>(FCC ID: PQG-MERCURY6E-M) | Telit Communications S.p.A.<br>Data Terminal Module<br>(FCC ID: RI7LE910CXWWX) |                                             |
| 1                | 0.00007                                    | 0.008                                                                        | 0.169                                                                       | --                                                                             | <b>0.177</b>                                |
| 2                | 0.00007                                    | 0.008                                                                        | 0.169                                                                       | 0.133                                                                          | <b>0.310</b>                                |

The sum of the MPE ratios from all sources is  $< 1$ . Thus, in compliant with general public (uncontrolled environment) MPE limit.

For detailed MPE ratios calculation, refer to the following tables.

| Calculated MPE Ratio for Lyngsoe Systems Ltd. Active RFID Reader                                                                                                                                                                                                                                                                                                                                               |                |                          |                                     |                                 |                |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|--------------------------|-------------------------------------|---------------------------------|----------------|
| Frequency (MHz)                                                                                                                                                                                                                                                                                                                                                                                                | *EUT EIRP (mW) | Evaluation Distance (cm) | Power Density (mW/cm <sup>2</sup> ) | MPE Limit (mW/cm <sup>2</sup> ) | MPE Ratio      |
| 0.125                                                                                                                                                                                                                                                                                                                                                                                                          | --             | --                       | --                                  | --                              | --             |
| 433.92                                                                                                                                                                                                                                                                                                                                                                                                         | 0.589          | 55                       | 0.00002                             | 0.289                           | <b>0.00007</b> |
| *EIRP is calculated from the measured field strength and measurement distance using formula: $EIRP = (E \times d)^2 / 30$ , where: E = electric field strength in V/m and d = measurement distance in meters (m).<br><br>Measured max. field strength for 433.92 MHz Tx at 3m = 92.93 dBuV/m = 0.04431 V/m<br>$EIRP = (E \times d)^2 / 30 = (0.04431 \times 3)^2 / 30 = 0.000589 \text{ W} = 0.589 \text{ mW}$ |                |                          |                                     |                                 |                |

| Calculated MPE Ratio for Texas Instruments WiFi and Bluetooth Module                                                                     |                 |                                 |                                  |                                 |                               |                                |                                             |                                 |           |
|------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------------------------|----------------------------------|---------------------------------|-------------------------------|--------------------------------|---------------------------------------------|---------------------------------|-----------|
| Band                                                                                                                                     | Frequency (MHz) | <sup>2</sup> Antenna Gain (dBi) | <sup>1</sup> Maximum Power (dBm) | <sup>1</sup> Maximum EIRP (dBm) | <sup>1</sup> Maximum EIRP (W) | <sup>1</sup> Average EIRP (mW) | Power Density at 55cm (mW/cm <sup>2</sup> ) | MPE Limit (mW/cm <sup>2</sup> ) | MPE Ratio |
| Bluetooth                                                                                                                                | 2402            | 3.2                             | 12.5                             | 15.7                            | 0.037                         | 37.154                         | 0.001                                       | 1.000                           | 0.001     |
| 2.4GHz WLAN                                                                                                                              | 2412            | 3.2                             | 17.5                             | 20.7                            | 0.117                         | 117.49                         | 0.003                                       | 1.000                           | 0.003     |
| 5GHz WLAN                                                                                                                                | 5180            | 4.5                             | 19.5                             | 24                              | 0.251                         | 251.189                        | 0.007                                       | 1.000                           | 0.007     |
| Sum of MPE Ratios from Bluetooth and 5GHz WLAN:                                                                                          |                 |                                 |                                  |                                 |                               |                                |                                             |                                 | 0.008     |
| <sup>1</sup> Data derived from Texas Instruments WiFi and Bluetooth Module RF exposure evaluation test report, Test Report No. FA741330. |                 |                                 |                                  |                                 |                               |                                |                                             |                                 |           |
| <sup>2</sup> Maximum permitted antenna gain.                                                                                             |                 |                                 |                                  |                                 |                               |                                |                                             |                                 |           |

| Calculated MPE Ratio for Lyngsoe Systems Ltd. UHF RFID Reader Module                                                         |                                            |                                 |            |           |               |                           |                             |           |
|------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|---------------------------------|------------|-----------|---------------|---------------------------|-----------------------------|-----------|
| Frequency (MHz)                                                                                                              | <sup>1</sup> Maximum Conducted Power (dBm) | <sup>1</sup> Antenna Gain (dBi) | EIRP (dBm) | EIRP (mW) | Distance (cm) | MPE (mW/cm <sup>2</sup> ) | Limit (mW/cm <sup>2</sup> ) | MPE Ratio |
| 902.625                                                                                                                      | 29                                         | 6.9                             | 35.9       | 3890.451  | 55            | 0.102                     | 0.602                       | 0.169     |
| <sup>1</sup> Data derived from Lyngsoe Systems Ltd., UHF RFID Reader Module test report, Test Report No. 23LYI-213_FCC15C247 |                                            |                                 |            |           |               |                           |                             |           |

| Calculated MPE Ratio for Telit Communications S.p.A. Data Terminal Module                                       |                 |                              |                                                    |                          |                                     |                                 |           |
|-----------------------------------------------------------------------------------------------------------------|-----------------|------------------------------|----------------------------------------------------|--------------------------|-------------------------------------|---------------------------------|-----------|
| Band / Mode                                                                                                     | Frequency (MHz) | <sup>1</sup> Max Power (dBm) | <sup>1</sup> Maximum Permissive Antenna Gain (dBi) | Evaluation Distance (cm) | Power Density (mW/cm <sup>2</sup> ) | MPE Limit (mW/cm <sup>2</sup> ) | MPE Ratio |
| GSM/GPRS Cell                                                                                                   | 824.2 - 848.8   | 27.5                         | 6.91                                               | 55                       | 0.073                               | 0.549                           | 0.133     |
| EDGE Cell                                                                                                       | 824.2 - 848.9   | 22                           | 12.41                                              | 55                       | 0.073                               | 0.549                           | 0.133     |
| GSM/GPRS PCS                                                                                                    | 1850.2 - 1909.8 | 24.5                         | 8.51                                               | 55                       | 0.053                               | 1.000                           | 0.053     |
| EDGE PCS                                                                                                        | 1850.2 - 1909.8 | 21                           | 12.01                                              | 55                       | 0.053                               | 1.000                           | 0.053     |
| WCDMA Cell                                                                                                      | 826.4 - 846.6   | 24.5                         | 9.92                                               | 55                       | 0.073                               | 0.551                           | 0.132     |
| WCDMA AWS                                                                                                       | 1712.4 - 1752.6 | 24.5                         | 5.50                                               | 55                       | 0.026                               | 1.000                           | 0.026     |
| WCDMA PCS                                                                                                       | 1852.4 - 1907.6 | 24.5                         | 8.51                                               | 55                       | 0.053                               | 1.000                           | 0.053     |
| LTE BAND25/2                                                                                                    | 1850.7 - 1914.3 | 24                           | 9.01                                               | 55                       | 0.053                               | 1.000                           | 0.053     |
| LTE BAND4                                                                                                       | 1710.7 - 1754.3 | 24                           | 6.00                                               | 55                       | 0.026                               | 1.000                           | 0.026     |
| LTE BAND26/5                                                                                                    | 824.7 - 848.3   | 24                           | 10.41                                              | 55                       | 0.073                               | 0.550                           | 0.133     |
| LTE BAND7                                                                                                       | 2502.5 - 2567.5 | 24                           | 9.01                                               | 55                       | 0.053                               | 1.000                           | 0.053     |
| LTE BAND8                                                                                                       | 898.2 - 899.8   | 24                           | 10.79                                              | 55                       | 0.079                               | 0.599                           | 0.132     |
| LTE BAND12                                                                                                      | 699.7 - 715.3   | 24                           | 9.70                                               | 55                       | 0.062                               | 0.466                           | 0.133     |
| LTE BAND13                                                                                                      | 779.5 - 784.5   | 24                           | 10.17                                              | 55                       | 0.069                               | 0.520                           | 0.133     |
| LTE BAND14                                                                                                      | 790.5 - 795.5   | 24                           | 10.23                                              | 55                       | 0.070                               | 0.527                           | 0.133     |
| LTE Band26(Part.90)                                                                                             | 814.7 - 823.3   | 24                           | 10.36                                              | 55                       | 0.072                               | 0.543                           | 0.133     |
| <sup>1</sup> Data derived from Telit Data Terminal Module MPE test report, Test Report No. 1M2106040065-03.RI7. |                 |                              |                                                    |                          |                                     |                                 |           |

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All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)