

RF Exposure Exemption Report

Reelables, Inc
Model: N-Label

In accordance with FCC CFR 47 Pt 1.1307



Prepared for: Reelables, Inc.
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A handwritten signature in black ink, appearing to read "S. Marshall".

| NAME | JOB TITLE | RESPONSIBLE FOR | ISSUE DATE |
|----------------|-----------------|----------------------|-----------------|
| Steve Marshall | Senior Engineer | Authorised Signatory | 21 January 2025 |

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD document control rules.

FCC Accreditation

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EXECUTIVE SUMMARY

The wireless devices described within this report are compliant with the exemption criteria related to human exposure to electromagnetic fields laid out in FCC CFR Title 47 Part 1.1307.



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1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

| Issue | Description of Change | Date of Issue |
|-------|--|---------------|
| 1 | First Issue | 06-Jan-2025 |
| 2 | Duty cycles updated as per customer's instruction and recalculated exemption based on FCC 47 CFR Part 1.1307 Option A. | 14-Jan-2025 |
| 3 | Updated Antenna Gains and Output Power | 21-Jan-2025 |

Table 1

1.2 Introduction

| | |
|--------------------------|---|
| Applicant | Reelables, Inc |
| Manufacturer | Reelables Europe, Ltd |
| Model Number(s) | N0001 |
| Hardware Version(s) | 5.61 |
| Software Version(s) | 1.11 |
| Specification/Issue/Date | FCC 47 CFR Part 1.1307: 2022 |
| Order Number | 15018 |
| Date | 9 July 2024 |
| Related Document(s) | <ul style="list-style-type: none">KDB 447498 D04 v01FCC 47 CFR Part 2.1091: 2023 |



1.3 Brief Summary of Results

The wireless devices described within this report are compliant with the exemption criteria related to human exposure to electromagnetic fields laid out in FCC CFR Title 47 Part 1.1307.

The calculations shown in this report were made in accordance with the procedures specified in the applied test specification(s).

1.4 Product Information

1.4.1 Technical Description

The N-Label from Reelables is an NB-IoT cellular device in the form factor of a thin 4x8" shipping label. It tracks the location of parcels and cargo. The intended use is a stickable label to corrugated paper cartons or other shippable containers.

The cellular subsystem attach, data communication, and disconnect takes place in approximately 12seconds with the cellular modem device completely powered off in-between connections. The duty cycle of active TX time as reported by the chip's firmware stack shows active on-time of 2.31sec, occurring every 20min, therefore a duty cycle can be calculated as follows:
 $2.31\text{sec (TX time)} / (20\text{min} * 60\text{ sec}) = < 0.19\% \text{ duty cycle.}$

The Bluetooth subsystem sends advertisements at a data rate of 1Mbps (all other data rates are disabled in firmware) with a period of 10sec, and a total radio on-time below 1ms. Therefore, calculating a duty cycle during a 100ms period of time cannot be calculated. Over longer period of time, such as 6min or 30min, with a transmission time of less than 1ms, the duty cycle is calculated as follows:

$0.001\text{sec (TX time)} / 10\text{sec} = 0.0001 = <0.01\% \text{ duty cycle.}$

1.4.2 Transmitter Description

The following radio access technologies and frequency bands are supported by the equipment under test.

| Radio Access Technology | Frequency Band (MHz) | Minimum Frequency (MHz) | Output Power (dBm) | Duty Cycle (%) |
|-------------------------|----------------------|-------------------------|--------------------|----------------|
| BLE | 2400 to 2483.5 | 2402.0 | 2.5 | 0.01 |
| NB-IoT Band 5 | 826.5 – 846.5 | 826.5 | 18.0 | 0.19 |
| NB-IoT Band 12 | 701.5 – 713.5 | 701.5 | 20.0 | 0.19 |
| NB-IoT Band 13 | 777.0 – 787.0 | 777.0 | 10.0 | 0.19 |

Table 2 – Transmitter Description

Note: Transmitter power includes upper bounds of uncertainty therefore maximum values are used.



1.4.3 Antenna Description

The following antennas are supported by the equipment under test.

| Radio Access Technology | Antenna Model | Gain (dBi) | Antenna length (cm) |
|-------------------------|---------------|------------|---------------------|
| BLE | Custom Dipole | 2.14 | 3.8 |
| NB-IoT Band 5 | Custom PIFA | -2.07 | 14.0 |
| NB-IoT Band 12 | Custom PIFA | -0.43 | 14.0 |
| NB-IoT Band 13 | Custom PIFA | -0.40 | 14.0 |

Table 3 – Antenna description

In the case of more than one type of antenna being supported by the equipment, the calculation is based on the maximum of the antenna gains. If other antennas can be used that have greater gains, the minimum separation distances will need to be recalculated.

Note: Antenna gain includes upper bounds of uncertainty therefore maximum values are used.

1.4.4 Equipment Configuration

The device supports the following modes:-

- 2.4 GHz Bluetooth Low Energy
- NB-IoT Band 5
- NB-IoT Band 12
- NB-IoT Band 13

Simultaneous transmission for the following configurations;

Combination 1 - 2.4 GHz BLE and NB-IoT Band 5

Combination 2 - 2.4 GHz BLE and NB-IoT Band 12

Combination 3 - 2.4 GHz BLE and NB-IoT Band 13



2 Assessment Details

2.1 Single RF Source options for determination of exemption.

| Option | Reference | RF Exposure Test Exemptions for Single Source | | | | | | | | | | | | |
|----------------------------|---------------------------|--|---------------------------|-----------------------|----------------|---------------|---------------|-------------------|--------------|--------------|-----------------|------------------|---------------------|--------------|
| A (1-mW Test Exemption) | FCC 1.1307(b)(3)(i)(A) | The available maximum time averaged power is no more than 1 mW, regardless of separation distance. | | | | | | | | | | | | |
| B (SAR-Based Exemption) | FCC 1.1307(b)(3)(i)(B) | <p>The available maximum timeaveraged power or effective radiated power (ERP), whichever is greater, is less than or equal to the threshold P_{th} (mW) described in the following formula. This method shall only be used at separation distances (cm) from 0.5 centimeters to 40 centimeters and at frequencies from 0.3 GHz to 6 GHz (inclusive). P_{th} is given by:</p> $P_{th} \text{ (mW)} = \begin{cases} ERP_{20 \text{ cm}} (d/20 \text{ cm})^x & d \leq 20 \text{ cm} \\ ERP_{20 \text{ cm}} & 20 \text{ cm} < d \leq 40 \text{ cm} \end{cases}$ <p>Where</p> $x = -\log_{10} \left(\frac{60}{ERP_{20 \text{ cm}} \sqrt{f}} \right) \text{ and } f \text{ is in GHz;}$ <p>and</p> $ERP_{20 \text{ cm}} \text{ (mW)} = \begin{cases} 2040f & 0.3 \text{ GHz} \leq f < 1.5 \text{ GHz} \\ 3060 & 1.5 \text{ GHz} \leq f \leq 6 \text{ GHz} \end{cases}$ <p>d = the separation distance (cm);</p> | | | | | | | | | | | | |
| C (MPE-Based Exemption) | FCC 1.1307(b)(3)(i)(C) | <p>Or using Table 1 and the minimum separation distance (R in meters) from the body of a nearby person for the frequency (f in MHz) at which the source operates, the ERP (watts) is no more than the calculated value prescribed for that frequency. For the exemption in Table 1 to apply, R must be at least $\lambda/2\pi$, where λ is the free-space operating wavelength in meters. If the ERP of a single RF source is not easily obtained, then the available maximum time-averaged power may be used in lieu of ERP if the physical dimensions of the radiating structure(s) do not exceed the electrical length of $\lambda/4$ or if the antenna gain is less than that of a half-wave dipole (1.64 linear value).</p> <p>TABLE 1 TO § 1.1307(b)(3)(i)(C)—SINGLE RF SOURCES SUBJECT TO ROUTINE ENVIRONMENTAL EVALUATION</p> <table border="1"> <thead> <tr> <th>RF Source frequency (MHz)</th> <th>Threshold ERP (watts)</th> </tr> </thead> <tbody> <tr> <td>0.3–1.34</td> <td>$1,920 R^2$.</td> </tr> <tr> <td>1.34–30</td> <td>$3,450 R^2/f^2$.</td> </tr> <tr> <td>30–300</td> <td>$3.83 R^2$.</td> </tr> <tr> <td>300–1,500</td> <td>$0.0128 R^2 f$.</td> </tr> <tr> <td>1,500–100,000</td> <td>$19.2 R^2$.</td> </tr> </tbody> </table> | RF Source frequency (MHz) | Threshold ERP (watts) | 0.3–1.34 | $1,920 R^2$. | 1.34–30 | $3,450 R^2/f^2$. | 30–300 | $3.83 R^2$. | 300–1,500 | $0.0128 R^2 f$. | 1,500–100,000 | $19.2 R^2$. |
| RF Source frequency (MHz) | Threshold ERP (watts) | | | | | | | | | | | | | |
| 0.3–1.34 | $1,920 R^2$. | | | | | | | | | | | | | |
| 1.34–30 | $3,450 R^2/f^2$. | | | | | | | | | | | | | |
| 30–300 | $3.83 R^2$. | | | | | | | | | | | | | |
| 300–1,500 | $0.0128 R^2 f$. | | | | | | | | | | | | | |
| 1,500–100,000 | $19.2 R^2$. | | | | | | | | | | | | | |



2.2 Multiple RF Sources options for determination of exemption.

| Option | Reference | |
|--|----------------------------|--|
| A 1-mW Test Exemption for Multiple Sources | FCC 1.1307(b)(3)(ii)(A) | The available maximum time averaged power of each source is no more than 1 mW and there is a separation distance of two centimeters between any portion of a radiating structure operating and the nearest portion of any other radiating structure in the same device, except if the sum of multiple sources is less than 1 mW during the time-averaging period, in which case they may be treated as a single source (separation is not required). This exemption may not be used in conjunction with other exemption criteria other than those in paragraph (b)(3)(i)(A) of this section. Medical implant devices may only use this exemption and that in paragraph (b)(3)(i)(A). |
| B Simultaneous Transmission with both SAR-based and MPE- Based Test Exemptions | FCC 1.1307(b)(3)(ii)(B) | in the case of fixed RF sources operating in the same time-averaging period, or of multiple mobile or portable RF sources within a device operating in the same time averaging period, if the sum of the fractional contributions to the applicable thresholds is less than or equal to 1 as indicated in the following equation. $\sum_{i=1}^a \frac{P_i}{P_{th,i}} + \sum_{j=1}^b \frac{ERP_j}{ERP_{th,j}} + \sum_{k=1}^c \frac{Evaluated_k}{Exposure Limit_k} \leq 1$ |



2.3 Individual Antenna Port Exposure Results

2.3.1 Single Source Calculation of Exposure at Specified Separation Distance FCC 1.1307 (b)(3)(i)(A) 'Option A'

| RAT | Frequency (MHz) | Conducted Power Output mW | Duty Cycle % | Time Average Conducted Power Output mW | Separation Distance | 1.1307(b)(3)(ii)(A) Exemption (Yes/No) |
|----------------|-----------------|---------------------------|--------------|--|---------------------|--|
| BLE | 2402.0 | 1.778 | 0.01 | 0.000178 | 0 mm | Yes |
| NB-IoT Band 5 | 826.5 | 63.096 | 0.19 | 0.119881 | 0 mm | Yes |
| NB-IoT Band 12 | 701.5 | 100.000 | 0.19 | 0.190000 | 0 mm | Yes |
| NB-IoT Band 13 | 777.0 | 10.000 | 0.19 | 0.019000 | 0 mm | Yes |

Table 4 –Transmitter Result

The calculations show that the individual transmitters comply with FCC 1.1307(b)(3)(i)(A) 1 mW based exception.



2.4 Combined Antenna Port RF Exposure Results FCC 1.1307(b)(3)(ii)(A)

2.4.1 Combination 1 – Option A 1mW Summation

| RAT | Frequency (MHz) | Conducted Power Output mW | Duty Cycle % | Time Average Conducted Power Output mW | Separation Distance (mm) | The sum of multiple sources is less than 1 mW during the time-averaging period? |
|---------------|-----------------|---------------------------|--------------|--|--------------------------|---|
| BLE | 2402.0 | 1.7783 | 0.01 | 0.000178 | 0 | - |
| NB-IoT Band 5 | 826.5 | 63.0957 | 0.19 | 0.119881 | 0 | - |
| | | Summation | 0.120059 | | | Yes |

Table 5 –Transmitter Result

The calculations show that the multiple transmitters comply with FCC 1.1307(b)(3)(ii)(A) summation-based exemption.

2.4.2 Combination 2 – Option A 1mW Summation

| RAT | Frequency (MHz) | Conducted Power Output mW | Duty Cycle % | Time Average Conducted Power Output mW | Separation Distance (mm) | The sum of multiple sources is less than 1 mW during the time-averaging period? |
|----------------|-----------------|---------------------------|--------------|--|--------------------------|---|
| BLE | 2402.0 | 1.7783 | 0.01 | 0.000178 | 0 | - |
| NB-IoT Band 12 | 701.5 | 100.0000 | 0.19 | 0.190000 | 0 | - |
| | | Summation | 0.190178 | | | Yes |

Table 6 –Transmitter Result

The calculations show that the multiple transmitters comply with FCC 1.1307(b)(3)(ii)(A) summation-based exemption.



2.4.3 Combination 3 – Option A 1mW Summation

| RAT | Frequency (MHz) | Conducted Power Output mW | Duty Cycle % | Time Average Conducted Power Output mW | Separation Distance (mm) | The sum of multiple sources is less than 1 mW during the time-averaging period? |
|----------------|-----------------|---------------------------|--------------|--|--------------------------|---|
| BLE | 2402.0 | 1.7783 | 0.01 | 0.000178 | 0 | - |
| NB-IoT Band 13 | 777.0 | 10.0000 | 0.19 | 0.019000 | 0 | - |
| Summation | | 0.019178 | | | | Yes |

Table 7 –Transmitter Result

The calculations show that the multiple transmitters comply with FCC 1.1307(b)(3)(ii)(A) summation-based exemption.