

Test report No:
NIE: 77596RAN.002

Assessment report

RF EXPOSURE REPORT ACCORDING TO FCC 47 CFR Part 2.1091; FCC 47 CFR Part 1.1307 FCC 47 CFR Part 1.1310

(*) Identification of item under evaluation	Worldsensing LoRa Module LR112X
(*) Trademark	Loadsensing G7
(*) Model and /or type reference	WS-BRD-LR112X
(*) Other identification of the product	HW version: WS-BRD-LR112X-2 SW version: 3.01 FCC ID: 2AHN4-WSBRDLR112X IC: 21260-WSBRDLR112X
(*) Features	LoRa Communication Module at 868, 915, 923 MHz and 2.4 GHz
(*) Manufacturer	Worldsensing S.L. C/ Viriat 47, planta 10, 08014, Barcelona, Spain
Test method requested, standard	FCC 47 CFR Part 2.1091 Radiofrequency radiation exposure evaluation: mobile devices. FCC 47 CFR Part 1.1307: Actions that may have a significant environmental effect, for which Environmental Assessments (EAs) must be prepared. FCC 47 CFR Part 1.1310: Radiofrequency radiation exposure limits.
Summary	IN COMPLIANCE
Approved by (name / position & signature)	José De La Plaza Regulatory Lab Director
Date of issue	2024-08-23
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Data provided by the client

The following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item under evaluation", "Trademark", "Model and/or type reference", "General description of the device", "Other identification of the product").
2. Maximum output power, antenna gain and request for evaluation under mobile exposure conditions
3. The device under evaluation consists of a LoRa module with optimized temperature stability for communicating in sub Ghz and 2.4GHz bands.

DEKRA Testing and Certification S.A.U. declines any responsibility with respect to the information provided by the client and that may affect the validity of results.

Identification of the client

Worldsensing S.L.
C/ Viriat 47, planta 10, 08014, Barcelona, Spain

Document history

Report number	Date	Description
77596RAN.002	2024-08-23	First release

Appendix A: FCC RF Exposure assessment result

General description of the equipment under evaluation

Table 1 shows information used for the RF Evaluation, taking into account the following declared specifications for the device:

Description and technologies: the device under evaluation consists of a module with the following features: LoRa Communication Module at 868, 915, 923 MHz and 2.4 GHz. The module can be used with both an internal and an external antenna, as defined in the “Antenna gain” section of this report.

Evaluation Distance: a conservative evaluation distance of 20 cm has been used to perform the assessment.

Maximum output power:

- Values corresponding to maximum output power have been declared by the device manufacturer (maximum output power values stated in module manufacturer’s datasheet).

Antenna Gain:

- Values corresponding to “Affini SRFL064” internal antenna gain have been declared by the device manufacturer (maximum peak gain stated in antenna manufacturer’s datasheet).
- Values corresponding to “Kyocera Part No. 9000046-XLPDNB” external antenna gain have been declared by the device manufacturer (maximum peak gain stated in antenna manufacturer’s datasheet).

The following table shows the information provided above:

Technology / Mode	Operating Band	Frequency under evaluation (MHz)	Maximum Conducted Output Power (Incl. Tune-Up) (dBm)	Internal Antenna peak gain (dBi)	External Antenna peak gain (dBi)	Internal Antenna Maximum E.I.R.P. (dBm)	Internal Antenna Maximum E.I.R.P. (mW)	Internal Antenna Maximum E.I.R.P. (dBm)	Internal Antenna Maximum E.I.R.P. (mW)	External Antenna Maximum E.I.R.P. (dBm)	External Antenna Maximum E.I.R.P. (mW)	External Antenna Maximum E.I.R.P. (dBm)	External Antenna Maximum E.I.R.P. (mW)
LoRa	ISM (USA)	902 - 928	22.00	1.71	0.90	21.56	143.22	23.71	234.96	20.75	118.85	22.90	194.98
LoRa	2400 - 2480 MHz	2400 - 2480	13.00	3.90	-	14.75	29.85	16.90	48.98	-	-	-	-

Table 1: Equipment specifications

Maximum Antenna Gain determination for RF Exposure compliance

Summary of maximum antenna gain values:

Maximum antenna gain for mobile operation to comply with MPE and EIRP limits (see Appendix B) shall not exceed the following values:

Technology / Mode	Operating Band	Frequency under evaluation (MHz)	Max Gain to comply with RF Exp Limits (dBi)	Max Gain to comply with EIRP Limits (dBi)	Maximum allowed Gain (worst case) (dBi)
LoRa	ISM (USA)	902 - 928	12.80	14.00	12.80
LoRa	2400 - 2480 MHz	2400 - 2480	24.01	23.00	23.00

Table 2: Maximum Antenna Gain values

Maximum Gain to meet FCC Radiofrequency radiation exposure limits:

Technology / Mode	Operating Band	Frequency under evaluation (MHz)	Distance (cm)	Power density for Gain = 0 dBi (mW/cm²)	FCC General Population Limit (mW/cm²)	Maximum Gain to comply with RF Exposure Limits (dBi)
LoRa	ISM (USA)	902 - 928	20.00	0.03	0.60	12.80
LoRa	2400 - 2480 MHz	2400 - 2480	20.00	0.00397	1.00	24.01

Table 3: Maximum Antenna Gain values based on FCC MPE limits

Maximum Gain to meet FCC EIRP limits

Technology / Mode	Operating Band	Frequency under evaluation (MHz)	Maximum Output power (dBm)	EIRP Limits (dBm)	Maximum Gain to meet EIRP Limits (dBi)
LoRa	ISM (USA)	902 - 928	22.00	36.00	14.00
LoRa	2400 - 2480 MHz	2400 - 2480	13.00	36.00	23.00

Table 4: Maximum Antenna Gain values based on FCC EIRP limits

Evaluation Results

RF Exposure Exemption evaluation:

Technology / Antenna	Operating Band	Frequency under evaluation (MHz)	Distance (cm)	Maximum E.R.P. (mW)	§1.1307(b)(3).i.(C) Exposure Limit (mW)	Verdict for exemption § 1.1307(b)(3).i
LoRa / Internal Antenna	ISM (USA)	902 - 928	20.00	143.22	461.82	Pass
LoRa / Internal Antenna	2400 - 2480 MHz	2400 - 2480	20.00	29.85	768.00	Pass
LoRa / External Antenna	ISM (USA)	902 - 928	20.00	118.85	461.82	Pass

Table 5: FCC Exemption Evaluation Results

The computed value(s) are below the exemption limit(s), so these modes meet the requirements stated in FCC 47 CFR Part 1.1307.

Appendix B: FCC RF Exposure information

RF Exposure determination of exemption

According to FCC 47 CFR §1.1307 (b)(3) Determination of exemption:

(i) For single RF sources (i.e., any single fixed RF source, mobile device, or portable device, as defined in paragraph (b)(2), a single RF source is exempt if:

(A) The available maximum time-averaged power is no more than 1 mW, regardless of separation distance. This exemption may not be used in conjunction with other exemption criteria other than those in paragraph (b)(3)(ii)(A) of this section. Medical implant devices may only use this exemption and that in paragraph (b)(3)(ii)(A);

(B) Or the available maximum time-averaged 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:

$$P_{th} \text{ (mW)} = \begin{cases} ERP_{20 \text{ cm}} (d/20 \text{ cm})^x & d \leq 20 \text{ cm} \\ ERP_{20 \text{ cm}} & 20 \text{ cm} < d \leq 40 \text{ cm} \end{cases}$$

Where

$$x = -\log_{10} \left(\frac{60}{ERP_{20 \text{ cm}} \sqrt{f}} \right) \text{ and } f \text{ is in GHz;}$$

and

$$ERP_{20 \text{ cm}} \text{ (mW)} = \begin{cases} 2040f & 0.3 \text{ GHz} \leq f < 1.5 \text{ GHz} \\ 3060 & 1.5 \text{ GHz} \leq f \leq 6 \text{ GHz} \end{cases}$$

d = the separation distance (cm);

(C) 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 λ/2π, 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 λ/4 or if the antenna gain is less than that of a half-wave dipole (1.64 linear value).

TABLE 1 TO §1.1307(b)(3)(i)(C)—SINGLE RF SOURCES SUBJECT TO ROUTINE ENVIRONMENTAL EVALUATION

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	19.2R ² .

(ii) For multiple RF sources: Multiple RF sources are exempt if:

(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) 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.

$$\sum_{i=1}^a \frac{P_i}{P_{th,i}} + \sum_{j=1}^b \frac{ERP_j}{ERP_{th,j}} + \sum_{k=1}^c \frac{Evaluated_k}{Exposure Limit_k} \leq 1$$

Where:

a = number of fixed, mobile, or portable RF sources claiming exemption using paragraph (b)(3)(i)(B) of this section for P_{th}, including existing exempt transmitters and those being added.

b = number of fixed, mobile, or portable RF sources claiming exemption using paragraph (b)(3)(i)(C) of this section for Threshold ERP, including existing exempt transmitters and those being added.

c = number of existing fixed, mobile, or portable RF sources with known evaluation for the specified minimum distance including existing evaluated transmitters.

P_i = the available maximum time-averaged power or the ERP, whichever is greater, for fixed, mobile, or portable RF source i at a distance between 0.5 cm and 40 cm (inclusive).

P_{th,i} = the exemption threshold power (P_{th}) according to paragraph (b)(3)(i)(B) of this section for fixed, mobile, or portable RF source i.

ERP_j = the ERP of fixed, mobile, or portable RF source j.

ERP_{th,j} = exemption threshold ERP for fixed, mobile, or portable RF source j, at a distance of at least λ/2π according to the applicable formula of paragraph (b)(3)(i)(C) of this section.

Evaluated_k = the maximum reported SAR or MPE of fixed, mobile, or portable RF source k either in the device or at the transmitter site from an existing evaluation at the location of exposure.

Exposure Limit_k = either the general population/uncontrolled maximum permissible exposure (MPE) or specific absorption rate (SAR) limit for each fixed, mobile, or portable RF source k, as applicable from §1.1310 of this chapter.

The available maximum time-averaged power or effective radiated power (ERP), can be calculated using the following formula to assess compliance with the Exemption Limits:

$$P_{E.I.R.P.} = P_T + G_T - L_C$$

Where:

P_T = transmitter time-averaged output power (including Duty Cycle and tune-up tolerance, if applicable)

G_T = gain of the transmitting antenna

L_C = signal attenuation in the connecting cable between the transmitter and the antenna if applicable

$$P_{E.R.P.} = P_{E.I.R.P.} - 2.15 \text{ dB}$$

RF Exposure evaluation

Limits for Maximum Permissible Exposure (MPE) for RF sources are defined in FCC 47 CFR “§1.1310 Radiation Exposure limits, paragraph (e)”:

TABLE 1 TO §1.1310(E)(1)—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(i) 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
300-1,500			f/300	<6
1,500-100,000			5	<6
(ii) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	<30
1.34-30	824/f	2.19/f	*(180/f ²)	<30
30-300	27.5	0.073	0.2	<30
300-1,500			f/1500	<30
1,500-100,000			1.0	<30

f = frequency in MHz. * = Plane-wave equivalent power density.

Each supported transmission technology will be evaluated to determine if it is in compliance with limits for Maximum Permissible Exposure (MPE) to radiofrequency electromagnetic fields.

In order to perform the assessment, the following equations have been used for the calculations; these equations are accurate in the far-field of an antenna and will over-predict power density in the near field, where they could be used for making a "worst-case" or conservative prediction:

Power density: $S[mW / cm^2] = \frac{P_{E.I.R.P.}[mW]}{4\pi R[cm]^2}$

Where:

S = power density

$P_{E.I.R.P.}$ = Equivalent isotropically radiated power

R = distance to the center of radiation of the antenna (evaluation distance)

$P_{E.I.R.P.} = P_T + G_T - L_C$

Where:

P_T = transmitter time-averaged output power (including Duty Cycle and tune-up tolerance, if applicable)

G_T = gain of the transmitting antenna

L_C = signal attenuation in the connecting cable between the transmitter and the antenna if applicable

FCC MPE Evaluation

Each supported transmission technology will be evaluated to determine if it is in compliance with limits for Maximum Permissible Exposure (MPE) to radiofrequency electromagnetic fields.

In order to perform the assessment, the following equations have been used for the calculations; these equations are accurate in the far-field of an antenna and will over-predict power density in the near field, where they could be used for making a "worst-case" or conservative prediction:

Power density: $S[mW/cm^2] = \frac{P_{max}[mW]}{4\pi R[cm]^2}$

Maximum gain to meet the MPE limit: $G_{max}[dBi] = (10 * \log[S[mW/cm^2] * 4\pi R[cm]^2] - P_{max}[dBm])$

S = power density

P_{max} = power input to the antenna

R = distance to the center of radiation of the antenna (evaluation distance)

G_{max} = power gain of the antenna in the direction of interest relative to an isotropic radiator

FCC ISM bands limits

Maximum FCC conducted output limits are stated into FCC 47 CFR §15.247 (b) (4) standard. The limit depends on the antenna value as follows, for antenna gains with 6dBi:

Standard	Band (MHz)	Conducted output limit (W)	Maximum EIRP (dBm)
FCC 47 CFR §15.247 (b)	2400-2483.5	1.0	36.0
FCC 47 CFR §15.247 (b)	902-928	1.0	36.0

For antenna gains exceeding 6dBi, the conducted output power from the intentional radiator shall be reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

Maximum FCC EIRP limits for 5GHz bands are stated into FCC 47 CFR §15.407 standard. The limit depends on the antenna value as follows, for antenna gains with 6dBi:

Standard	Band (MHz)	Conducted output limit (W)	Maximum EIRP (dBm)
FCC 47 CFR §15.407	5150-5250	0.25	30.0
	5250-5725	0.25	30.0
	5725-5850	1.0	36.0

For antenna gains exceeding 6dBi, the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.