

1 Test Sample Description:

Product Name: eBeat Sensor

Functional Description: The eBeat is a compact and cost effective LoRa health monitoring sensor for IoT applications that is designed to be worn on the user's person. The product is designed to operate in a North American ISM band (Tx 902.3 – 914.9 MHz, Rx 923.3 – 927.5 MHz).

Power supply: Internal Battery

Radio LoRa:

Frequency Range: 902.3 – 914.9 MHz

Mode of operation: DTS and DSS

Antenna Description: PCB Max Gain: 2.2 dBi

Transmitter Category: **Portable device** (A portable device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that the RF source's radiating structure(s) is/are within 20 centimeters of the body of the user.)

Reference Standards

§ 1.1310: Radiofrequency radiation exposure limits.

§ 2.1093: Radiofrequency radiation exposure evaluation: portable devices.

§ 2.1091: Radiofrequency radiation exposure evaluation: mobile devices.

§ 1.1307(b) (3) (i) (b): For single RF sources (i.e., any single fixed RF source, mobile device, or portable device, as defined in paragraph (b) (2) of this section)

KDB 447498 D01 General RF Exposure Guidance v06

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2 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) of this section): 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 $\lambda/2\pi$, 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).

Table 1 to § 1.1307(b)(3)(i)(C)- Single RF Sources Subject to Routine Environmental Evaluation				
RF Source frequency (MHz)		Minimum Distance		Threshold ERP (watts)
FL	FH	$\lambda L/2\pi$	$\lambda H/2\pi$	
0.3	1.34	159 m	35.6m	$1,920 R^2$.
1.34	30	35.6 m	1.6m	$3,450 R^2/f^2$.
30	300	1.6 m	0.159 m	$3.83 R^2$.
300	1,500	0.159 m	0.0318 m	$0.0128 R^2 f$.
1,500	100,000	0.0318 m	0.0005 m	$19.2R^2$.

R= minimum separation distance in meter

f= frequency in MHz

3 Calculation:

Using equation i(B) as per determination of exemption, minimum antenna separation distance of 0.5 cm from the human body, and maximum Tx frequency is 914.9 MHz.

$$ERP_{20cm} \text{ (mW)} = 2040 \times f \text{ (Frequencies = } 0.3\text{GHz} \leq f \leq 1.5 \text{ GHz)}$$

$$ERP_{20cm} \text{ (mW)} = 2040 \times 0.9149 \text{ (GHz)}$$

$$ERP_{20cm} = 1866.396 \text{ mW}$$

$$x = -\log_{10} (60 / ERP_{20cm} \sqrt{f}) \text{ (f in GHz)}$$

$$x = -\log_{10} (60 / 1866.396 \sqrt{0.9149})$$

$$x = 1.47354$$

$$P_{th} \text{ (mW)} = ERP_{20cm} (d / 20 \text{ cm})^x$$

Note1 $P_{th} \text{ (mW)} = 1866.396 (0.5\text{cm} / 20 \text{ cm})^{1.47354}$

$$P_{th} = 8.134 \text{ (mW)}$$

Considering this limit as well as the maximum possible duty cycle of 28.45%, calculated above P_{th} converts to

$$P_{th, \text{duty cycled}} = P_{th} / 0.2845$$

$$P_{th, \text{duty cycled}} = 8.134 / 0.2845$$

$$P_{th, \text{duty cycled}} = 28.5906 \text{ mW} = 14.562 \text{ dBm}$$

$$P_{th, \text{duty cycled}} = 14.562 \text{ dBm}$$

It's a maximum ERP power and ebeat sensor, antenna peak gain is 2.2 dBi, and therefore,

$$\text{Antenna Gain dBd} = \text{dBi} - 2.15$$

$$\text{dBd} = 2.2 - 2.15$$

$$\text{dBd (Gain)} = 0.05$$

$$\text{ERP} = \text{Antenna port conducted Power} + 0.05(\text{dBd})$$

So

$$\text{ERP} \leq P_{th, \text{duty cycled}}$$

$$\text{ERP} \leq 14.562 \text{ dBm}$$

Note1 As per KDB447498 D01 General RF Exposure Guidance v06, when the minimum test separation distance is < 5 mm, a distance of 5 mm according to 4.1 f is applied to determine SAR test exclusion.

TX (Mode)	Frequency (MHz)	Max Conducted RF Output 100% Duty Cycle (dBm)	Max. antenna gain (dBi)	Max. antenna gain (dBd)	ERP 100% Duty Cycle (dBm)	ERP 100% Duty Cycle (mW)	ERP Exemption limit	Simultaneous transmission mode
LoRa 500 KHz DTS	903.0	13.48	2.2	0.05	13.48	22.28	28.5906 mW = 14.562 dBm	N/A
	907.8	13.59	2.2	0.05	13.64	23.12		
	914.2	13.54	2.2	0.05	13.59	22.86		
LoRa 125 KHz DSS	902.3	13.33	2.2	0.05	13.38	21.78		
	908.7	13.44	2.2	0.05	13.49	22.34		
	914.9	13.59	2.2	0.05	13.64	23.12		
Maximum output power limitation for LoRa (As per tuning procedure)		14	2.2	0.05	14.05	25.41		

4 Conclusion:

Maximum transmit power	Distance	SAR Exemption limit	Result
14.05 dBm (25.41mW)	5 mm	14.562 dBm (28.5906mW)	Compliant

EUT meet SAR exemption limit