1 Test Sample Description:

Product Name:	CHICKADEE
Functional Description:	It is a low-power, LoRaWAN location tracker suitable for indoor and outdoor applications. It gathers positioning data from its onboard GNSS, Wi-Fi, and/or BLE modules and transmits that information via its LoRa radio to a Network Server. The Network Server then forwards the data to their respective position resolver components which return position fixes that can be visualized using a third-party application.
Power supply:	Internal Battery
LoRa:	
Frequency Range:	902.3 – 914.9 MHz
Mode of operation:	DTS and DSS
Antenna Description:	PCB Max Gain: 2.2 dBi
Bluetooth:	
Frequency Range:	2402 – 2480 MHz
Mode of operation:	BLE (DTS)
Antenna Description:	PCB Max Gain: 1.1 dBi

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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:

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

Where

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

and

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

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)		Minimum Distance		Threshold ERP (watts)
FL	FH	λL/2π	λH/2π	
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} (mW) = 2040 x f (Frequencies = 0.3GHz ≤ f ≤ 1.5 GHz)

ERP_{20cm} (mW) = 2040 x 0.9149 (GHz)

ERP_{20cm} = 1866.396 mW)

x = − log10 (60 / $ERP_{20\,cm}\sqrt{f}$) (f in GHz)

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

$x = 1.47354$

P_{th} (mW) = ERP20 cm (d / 20 cm)^×

P_{th} (mW) = 1866.396 (0.5cm / 20 cm)^ 1.47354

P_{th} = 8.134 (mW)

Considering this limit as well as the maximum possible duty cycle of 28.45%, calculated above Pth converts to

P_{th},duty cycled = P_{th} / 0.2845

P_{th},duty cycled = 8.134 / 0.2845

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

P_{th},duty cycled = 14.562 dBm

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

Antenna Gain dBd = dBi – 2.15

dBd = 2.2 – 2.15

dBd (Gain) = 0.05

ERP = Antenna port conducted Power + 0.05(dBd)

So

ERP ≤ P_{th},duty cycled

ERP ≤ 14.562 dBm

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	12.32	2.2	0.05	12.37	17.2584	28.5906 mW = 14.562 dBm	NO
	907.8	12.33	2.2	0.05	12.38	17.2982		
	914.2	12.16	2.2	0.05	12.21	16.6341		
LoRa 125 KHz DSS	902.3	12.47	2.2	0.05	12.52	17.8649		
	908.7	12.55	2.2	0.05	12.6	18.197		
	914.9	12.26	2.2	0.05	12.31	17.0216		
BLE	2402	-2.19	1.1	-1.05	-3.24	0.474242		
	2440	-2.30	1.1	-1.05	-3.35	0.462381		
	2480	-2.47	1.1	-1.05	-3.52	0.446313		
Maximum output power limitation for BLE		0	1.1	-1.05	-1.05	0.7852356	28.5906 mW = 14.562 dBm	NO
Maximum output power limitation for LoRa (As per tuning procedure)		14	2.2	0.05	14.05	25.41		

4 Conclusion:

EUT meet SAR exemption limit