1. Radio Frequency Exposure

RESULT: **Pass**

Test standard	:	FCC Part 2: Section 2.1091 KDB 447498 D01 General RF Exposure Guidance v06 RSS-102 Issue 6, December 2023

1.1 Product Technical Information

The EUT is a WisDuo LPWAN+BLE Module which supports Lora and Bluetooth Low Energy technologies.
This module has two different antennas for Lora and one antenna for BLE, the details specifications for these antennas as below:

For Lora:

Antenna #	Model	Antenna Gain	Antenna Type	Connector Type
1#	RAKARJ14	2.3 dBi	Dipole Antenna	RP-SMA connector
2#	RAKARJ16	2.3 dBi	Dipole Antenna	RP-SMA connector

Note:
1. When connecting to the module, all antennas listed above need to transfer to an **IPEX connector**.
2. Antennas 1# and 2# have the same type and similar in-band and out-of-band characteristics and only the color of enclosure differnet, they are considered as equivalent antennas. Thus, the antenna 1# was selected to be tested.

For BLE:

Antenna #	Model	Antenna Gain	Antenna Type	Connector Type
1#	S2B1BH2A1B01000	3.12 dBi	PCB Layout Antenna	IPEX connector

This report is a FCC CIIPC and IC CIIIPC report for adding additional LoRa operating bands. New added LoRa has two different independent configurations and they cannot work simultaneously, details as below:

Configuration 1:

Data Rate	SF (Spreading factor)	Operating Frequency
0	LoRa Modulation: SF10 / Bandwidth 125 kHz	Original: 902.3 – 914.9 MHz **New: 915.1 – 927.7 MHz**
1	LoRa Modulation: SF9 / Bandwidth 125 kHz	
2	LoRa Modulation: SF8 / Bandwidth 125 kHz	
3	LoRa Modulation: SF7 / Bandwidth 125 kHz	
4	LoRa Modulation: SF8 / Bandwidth 500 kHz	Original: 903 – 914.2 MHz **New: 915.8 – 927.0 MHz**

Configuration 2:

Data Rate	SF (Spreading factor)	Operating Frequency
0	LoRa Modulation: SF12 / Bandwidth 500 kHz	Original: n/a **New: 902.5 – 927.1 MHz**
1	LoRa Modulation: SF11 / Bandwidth 500 kHz	
2	LoRa Modulation: SF10 / Bandwidth 500 kHz	
3	LoRa Modulation: SF9 / Bandwidth 500 kHz	
4	LoRa Modulation: SF8 / Bandwidth 500 kHz	
5	LoRa Modulation: SF7 / Bandwidth 500 kHz	

This report only includes test data for new operating frequency for both config1&2.

For details refer to the User Manual, Technical Description and Circuit Diagram.

General Information of EUT	Value
Kind of Equipment	WisDuo LPWAN+BLE Module
Type Designation	RAK11720
Trademark	RAK
FCC ID	2AF6B-RAK11720
IC	25908-RAK11720
HVIN	RAK11720
FVIN	RUI_3.5.2+user_final.hex

Operating Voltage	DC 3.6V Max. (Supplied by socket of PCB borad)
Testing Voltage	DC 5V Via USB port
Technical Specification of Lora DTS	
Operating Frequency	903 – 914.2 MHz and 915.8 – 927.0 MHz 902.5 – 927.1 MHz
Type of Modulation	Lora
Data Rate	SF8 / DR4 for 903 – 914.2 MHz and 915.8 – 927.0 MHz SF7-SF12 / DR0 to DR5 for 902.5 – 927.1 MHz
Channel Number	16 channels (Upstream)
Channel Separation	1.6 MHz
Occupied Bandwidth	500 kHz
Technical Specification of Lora FHSS	
Frequency Range	902.3 – 914.9MHz and 915.1 – 927.7 MHz
Type of Modulation	Lora
Data Rate	SF7 to SF10 / DR0 to DR3
Channel Number	127 channels (Upstream)
Channel Separation	200 kHz
Occupied Bandwidth	125 kHz
Technical Specification of BLE	
Operating Frequency	2402 - 2480 MHz
Type of modulation	GFSK
Channel Number	40 channels
Channel Separation	2 MHz
Data Rate	1Mbps

1.2 Product Classification

This device defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at 20 cm is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons.

1.3 Radio Frequency Exposure Limit

For FCC:

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Average Time (minutes)
(A) 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	--	--	1.0	<6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-3.0	614	1.63	*100	<30
3.0-30	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.

For IC:

Frequency range (MHz)	Electric field (V_{RMS}/m)	Magnetic field (A_{RMS}/m)	Power density (W/m^2)	Reference period (minutes)
10-20	27.46	0.0728	2	6
20-48	$58.07 / f^{0.25}$	$0.1540 / f^{0.25}$	$8.944 / f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142 f^{0.3417}$	$0.008335 f^{0.3417}$	$0.02619 f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158 f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000/f^{1.2}$

Note: f is frequency in MHz.

1.4 Radio Frequency Exposure Calculation Formula

$$S = \frac{PG}{4\pi R^2}$$

where: S = power density (in appropriate units, e.g. mW/cm^2)
P = power input to the antenna (in appropriate units, e.g., mW)
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

or:

$$S = \frac{EIRP}{4\pi R^2}$$

where: EIRP = equivalent (or effective) isotropically radiated power

1.5 Calculation Result

1.5.1 Stand-alone transmission MPE, LoRa Configuration 1

Operating Mode	Band	PG (dBm)	PG (W)	Calculation (mW/cm^2)	FCC Limit (mW/cm^2)	Verdict
Lora	902-928MHz	23.61	0.2296	0.046	0.601	Pass
BLE	2.4G	5.92	0.00391	0.001	1.0	Pass

Operating Mode	Band	PG (dBm)	PG (W)	Calculation (W/m^2)	IC Limit (W/m^2)	Verdict
Lora	902-928MHz	23.61	0.2296	0.457	2.74	Pass
BLE	2.4G	5.92	0.00391	0.008	5.35	Pass

1.5.2 Stand-alone transmission MPE, LoRa Configuration 2

Operating Mode	Band	PG (dBm)	PG (W)	Calculation (mW/cm^2)	FCC Limit (mW/cm^2)	Verdict
Lora	902-928MHz	23.66	0.2323	0.046	0.601	Pass
BLE	2.4G	5.92	0.00391	0.001	1.0	Pass

Operating Mode	Band	PG (dBm)	PG (W)	Calculation (W/m^2)	IC Limit (W/m^2)	Verdict
Lora	902-928MHz	23.66	0.2323	0.462	2.74	Pass
BLE	2.4G	5.92	0.00391	0.008	5.35	Pass

1.5.3 Simultaneous transmission MPE, LoRa Configuration 1

FCC					
Operating Mode	Lora Ratio	BLE Ratio	Sum Ratio	Limit	Result
Lora+ BLE	0.077	0.001	0.078	<1	Pass
IC					
Operating Mode	Lora Ratio	BLE Ratio	Sum Ratio	Limit	Result
Lora+ BLE	0.167	0.001	0.168	<1	Pass

1.5.4 Simultaneous transmission MPE, LoRa Configuration 2

FCC					
Operating Mode	Lora Ratio	BLE Ratio	Sum Ratio	Limit	Result
Lora+ BLE	0.077	0.001	0.101	<1	Pass
IC					
Operating Mode	Lora Ratio	BLE Ratio	Sum Ratio	Limit	Result
Lora+ BLE	0.169	0.001	0.170	<1	Pass

Note:
1. R = 0.2m