RF Exposure Evaluation For FCC ID: 2AF6B-RAK724X

Refer user manual this device is a Outdoor LoRa Gateway, and this device was designed used in Mobile devices that the minimum distance between human's body is **20cm.** Based on the 47CFR 2.1091, this device belongs to Mobile device. The definition of the category as following:

Mobile Derives:

CFR Title 47 §2.1091(b)

(b) For purposes of this section, a mobile 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 a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons.

FCC KDB 447498 D01 General RF Exposure Guidance v06 Limit

Devices operating in standalone mobile exposure conditions may contain a single transmitter or multiple transmitters that do not transmit simultaneously. A minimum test separation distance ≥ 20 cm is required between the antenna and radiating structures of the device and nearby persons to apply mobile device exposure limits. The distance must be fully supported by the operating and installation configurations of the transmitter and its antenna(s), according to the source-based time-averaged maximum power requirements of § 2.1091(d)(2). In cases where cable losses or other attenuations are applied to determine compliance, the most conservative operating configurations and exposure conditions must be evaluated. The minimum test separation distance required for a device to comply with mobile exposure conditions must be clearly identified in the installation and operating instructions, for all installation and exposure conditions, to enable users and installers to comply with RF exposure requirements. For mobile devices that have the potential to operate in portable device exposure conditions, similar to the configurations described in § 2.1091(d)(4), a KDB inquiry is required to determine the SAR test requirements for demonstrating compliance.

When the categorical exclusion provision of § 2.1091(c) applies, the minimum test separation distance may be estimated, when applicable, by simple calculations according to plane-wave equivalent conditions, to ensure the transmitter and its antenna(s) can operate in manners that meet or exceed the estimated distance. The source-based time-averaged maximum radiated power, according to the maximum antenna gain, must be applied to calculate the field strength and power density required to establish the minimum test separation distance. When the estimated test separation distance becomes overly conservative and does not support compliance, MPE measurement or computational modeling may be used to determine the required minimum separation distance.

According to FCC Part 1.1307, systems operating under the provisions of this section shall be operated in a manner the ensures that the public is not exposed to radio frequency energy level in excess of the commission's guidelines.

Limits for General Population/ Uncontrolled Exposure			
Frequency Range (MHz)	Electric Field Strength(E)(V/m)	Magnetic Field Strength (H)(A/m)	Power Density (S)(mW/cm^2)
0.3-1.34	614	1.63	(100)*
1.34-30	824/f	2.19/f	(180/f2)*
30-300	27.5	0.073	0.2
300-1500			f/1500
1500-100,000			1.0

MPE calculation formula

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

Where:

S = power density

P = output power (mW)

G = power gain of the antenna in the direction of interest relative to an isotropic radiator

R = Separation distance between radiator and human body (cm)

Test data

WCDMA Band2			
Mode	Low Channel	Middle Channel	High Channel
EIRP (dBm)	25.43	24.91	**25.74**
Note: This report listed the worst case EIRP power value, please refer to RF report BL-SZ1920035-501.			

WCDMA Band4			
Mode	Low Channel	Middle Channel	High Channel
EIRP (dBm)	**26.08**	24.71	24.87
Note: This report listed the worst case EIRPpower value, please refer to RF report BL-SZ1920035-501.			

WCDMA Band5			
Mode	Low Channel	Middle Channel	High Channel
ERP (dBm)	24.68	25.81	**27.07**
Note: This report listed the worst case ERP power value, please refer to RF report BL-SZ1920035-501.			

LTE Band2	
Bandwidth (MHz)	5
UL Channel	Middle Channel
UL Modulation	QPSK
EIRP (dBm)	27.99
LTE Band4	
Bandwidth (MHz)	3
UL Channel	Low Channel
UL Modulation	Q16
EIRP (dBm)	27.80
LTE Band5	
Bandwidth (MHz)	1.4
UL Channel	Low Channel
UL Modulation	Q16
ERP (dBm)	27.05
LTE Band12	
Bandwidth (MHz)	10
UL Channel	Middle Channel
UL Modulation	Q16
ERP (dBm)	22.47
LTE Band13	
Bandwidth (MHz)	5
UL Channel	High Channel
UL Modulation	QPSK
ERP (dBm)	24.65
Note: This report listed the worst case ERP/EIRP power value, please refer to RF report BL-SZ1920035-501.	

2.4 G WLAN			
Mode	Average Power (dBm)		
	Low	Middle	High
802.11b	16.57	15.75	15.54
802.11g	14.15	13.16	13.22
802.11n-20	12.84	11.56	11.58
802.11n-40	12.17	10.99	10.96
Note: This report listed the worst case Average power value, please refer to RF report BL-SZ1920035-601.			

Lora			
Mode	O-QPSK		
	Low Channel	Middle Channel	High Channel
Peak Power (dBm)	10.32	11.20	**12.34**

Note: This report listed the worst case peak power value, please refer to RF report BL-SZ1920035-602.

Turn-up power

Mode	ERP/EIRP Tune up Limit (dBm)
WCDMA Band2	26.00
WCDMA Band4	26.50
WCDMA Band5	27.50
LTE Band2	28.50
LTE Band4	28.00
LTE Band5	27.50
LTE Band12	23.00
LTE Band13	25.00

Mode	Average Power Tune up Limit (dBm)
802.11b	17.00
802.11g	15.00
802.11n-20	13.00
802.11n-40	12.50

Mode	Peak Power Tune up Limit (dBm)
Lora	12.50

Test result

Evolution mode	Maximum ERP/EIRP power (dBm)	Antenna Gain (typical) (dBi)	Total Power (mw)	Distance (cm)	Limit of Power Density (mW/cm²)	Power Density (mW/cm²)	Power Density/ Limit	Verdict
WCDMA Band2	26.00	3.0	794.33	20	1	0.1580	0.1580	Pass
WCDMA Band4	26.50	3.0	891.25	20	1	0.1773	0.1773	Pass
WCDMA Band5	27.50	1.0	707.95	20	0.551	0.1408	0.2555	Pass
LTE Band2	28.50	3.0	1412.54	20	1	0.2810	0.2810	Pass
LTE Band4	28.00	3.0	1258.93	20	1	0.2505	0.2505	Pass
LTE Band5	27.50	1.0	707.95	20	0.550	0.1408	0.2560	Pass
LTE Band12	23.00	1.0	251.19	20	0.468	0.0500	0.1068	Pass
LTE Band13	25.00	1.0	398.11	20	0.521	0.0792	0.1520	Pass

Evolution mode	Maximum Average power (dBm)	Antenna Gain (typical) (dBi)	Total Power (mw)	Distance (cm)	Limit of Power Density (mW/cm²)	Power Density (mW/cm²)	Power Density/ Limit	Verdict
2.4 G WLAN	17.00	3.5	112.20	20	1	0.0223	0.0223	Pass

Evolution mode	Maximum Peak power (dBm)	Antenna Gain (typical) (dBi)	Total Power (mw)	Distance (cm)	Limit of Power Density (mW/cm²)	Power Density (mW/cm²)	Power Density/ Limit	Verdict
Lora	12.50	5.5	63.10	20	0.601	0.0126	0.0210	Pass

Collocated Power Density Calculation

Evolution mode	Frequency(MHz)	Power Density/Limit	Σ (Power Density / Limit) of WWAN + Bluetooth + Zigbee	Verdict
WWAN (LTE Band2)	1850MHz ~ 1910MHz	0.2810	0.3243	Pass
2.4 G WLAN	2400MHz ~ 2483.5MHz	0.0223		Pass
Lora	902MHz ~ 928MHz	0.0210		Pass

Note:

1. Σ (Power Density / Limit): This is a summation of [(power density for each transmitter/ antenna included in the simultaneous transmission)/ (corresponding MPE limit)], for WWAN + 2.4G WLAN + Lora.
2. WWAN, 2.4G WLAN and Lora can transmit simultaneously, the formula of calculated the MPE is CPD1 / LPD1 + CPD2 / LPD2 + ……etc. < 1
   CPD = Calculation power density
   LPD = Limit of power density
3. The worst-case situation is 0.3243, which is less than “1”. This confirmed that the device comply with FCC 1.1310 MPE limit.
4. The Outdoor LoRa Gateway work frequency range used is 1850 MHz ~ 1910 MHz, 1710 MHz ~ 1755 MHz, 824 MHz ~ 849 MHz, 699 MHz ~ 716 MHz, 777 MHz ~ 787 MHz, 2400 MHz ~ 2483.5 MHz, 902 MHz ~ 928 MHz the result close to the limit by the above formula so, we select worst case power to calculate the exclusion power threshold.
5. More power list please refer to RF test report.

Conclusion:

RF exposure Evaluation Results: **Compliance**