

User Manual for

# **WisLink-LoRa Concentrator Module**

## **Raspberry Pi HAT Edition**

### **RAK2245 Pi HAT**

Version V1.2 | February 2019

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17 PAGES



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## 1 Overview

### 1.1 Introduction

RAK2245 Pi HAT is a module with Raspberry Pi form factor. It can be plugged into Raspberry Pi such as Raspberry Pi 3 Model B+ as a complete RF front end of LoRa gateway. It supports eight channels and is available for LoRaWAN global frequency bands. The board is the smallest LoRaWAN gateway concentrator which integrates the Ublox MAX-7Q GPS Module and heat sink.

The board can provide low data rate LoRa radio links in ultra-fast speed. It is powered by a Semtech SX1301 transceiver concentrator that is capable of managing packets from many remotely dispersed end-points. Two Semtech SX125X are integrated for RF front end I/Q transceivers.

The RAK2245 Pi HAT is a complete and cost efficient LoRa gateway solution that can help you develop a full LoRa system. This is an economical way to create different solutions like smart grid, intelligent farm and other IoT applications. It is also ideal for manufacturing small series that can expand into more applications.

### 1.2 Main Features

- Compatible with Raspberry Pi 3 Model B+ edition.
- Integrated Ublox MAX-7Q GPS Module and heat sink.
- SX1301 base band processor, emulates 49 x LoRa demodulators, 10 parallel demodulation paths, supports 8 uplink / 1 downlink channels.
- 2 units of SX125x Tx/Rx front-ends for high/ low frequency.
- Supports 5V power supply, integrated level conversion circuit.
- TX power up to 11.73dBm, RX sensitivity down to -139dBm@SF12, BW 125KHz.
- Supports latest LoRaWAN 1.0.2 protocol.
- Supports global license-free frequency band (EU433, CN470, EU868, US915, AS923, AU915, KR920, IN865 and AS920).
- Supports SPI, UART, I2C interface.



## 2 RAK2245 Pi HAT Board

### 2.1 Overview

RAK2245 Pi HAT module with Raspberry Pi connector is shown below, it has outer dimensions of 56.00 x 65.00 x 22.00 mm ( $\pm 2$ mm).

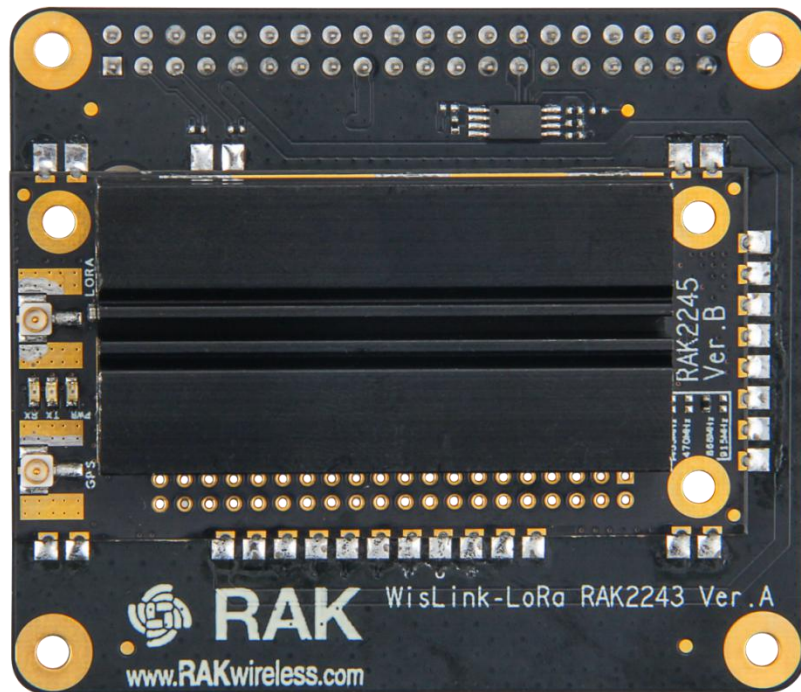


Figure 1 | RAK2245 Pi HAT Overview

### 2.2 Operating Frequencies

The board supports all LoRaWAN frequency channels as below. Which is easy to configure while building the firmware from the source code.

Region	Frequency ( MHz )
North America	903-927.5Mhz

Table 1 | Operating Frequencies



## 2.3 Pin Definition

The pin connector of RAK2245 Pi HAT is located at the bottom side. Refer to the diagram and table below for the description and numbering of each pins.

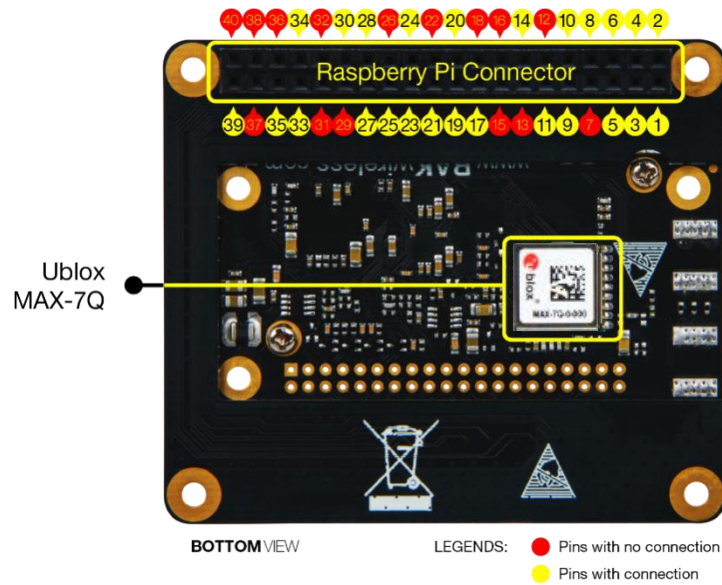


Figure 2 | Raspberry Pi Connector Overview

Pin	Name	Description
1	3.3V	3.3V Supply Voltage
3	SDA	I2C_SDA (Connect to GPS Module I2C_SDA)
5	SCL	I2C_SCL (Connect to GPS Module I2C_SCL)
7	NC	No Connection
9	GND	GND
11	RESET	SX1301 RESET (GPIO17 of RASPBERRY PI)
13	NC	No Connection
15	NC	No Connection

Pin	Name	Description
2	+5V	+5V Supply Voltage
4	+5V	+5V Supply Voltage
6	GND	GND
8	UART_RXD	It should be connected to RASPBERRY PI's UART_TXD. This pin is connected to GPS Module's UART_RXD internally.
10	UART_TXD	It should be connected to RASPBERRY PI's UART_RXD. This pin is connected to GPS Module's UART_TXD internally.
12	NC	No Connection
14	GND	GND
16	NC	No Connection



<b>17</b>	3.3V	3.3V Supply Voltage
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<b>18</b>	NC	No Connection
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*Continuation:*

Pin	Name	Description
<b>19</b>	SPI_M OSI	It should be connected to RASPBERRY PI's SPI_MOSI. This pin is connected to SX1301's SPI_MOSI internally.
<b>21</b>	SPI_MI SO	It should be connected to RASPBERRY PI's SPI_MISO. This pin is connected to SX1301's SPI_MISO internally.
<b>23</b>	SPI_CL K	It should be connected to RASPBERRY PI's SPI_SCLK. This pin is connected to SX1301's SPI_CLK internally.
<b>25</b>	GND	GND
<b>27</b>	ID_SD	I2C_SDA for HAT ID EEPROM
<b>29</b>	NC	No Connection
<b>31</b>	NC	No Connection
<b>33</b>	RESET _GPS	GPS Module reset PIN (GPIO13 of Raspberry Pi)
<b>35</b>	STAND BY_GP S	GPS Module standby PIN (GPIO19 of Raspberry Pi)
<b>37</b>	NC	No Connection
<b>39</b>	GND	GND

Pin	Name	Description
<b>20</b>	GND	GND
<b>22</b>	NC	No Connection
<b>24</b>	SPI_CS	It should be connected to RASPBERRY PI's SPI_CE0. This pin is connected to SX1301's SPI_CS internally.
<b>26</b>	NC	No Connection
<b>28</b>	ID_SC	I2C_SCL for HAT ID EEPROM
<b>30</b>	GND	GND
<b>32</b>	NC	No Connection
<b>34</b>	GND	GND
<b>36</b>	NC	No Connection
<b>38</b>	NC	No Connection
<b>40</b>	NC	No Connection

Table 2 | Pin Definitions

## 2.4 Power Supply

RAK2245 Pi HAT module is powered through 5V or 3.3V power pins.



## 2.5 SPI Interface

The pin connector provides an SPI connection which allows direct access to the SX1301 SPI interface. This gives the target system the possibility to use existing SPI interfaces to communicate with the module.

*Note: Please reset SX1301 via PIN 11 after turning on RAK2245 Pi HAT.*

## 2.6 UART and I2C

UART and I2C connections are also included on the pin connector. These connections allow direct access to the GPS module. The 1PPS is connected internally to SX1301.

## 2.7 Digital IOs

There are two digital IO PINs, which give the user an interface to reset the GPS module or set it into standby mode.

## 2.8 LEDs

3 x Green LED for indicating the status of PWR, TX, RX.

## 2.9 Antenna RF Interface

The modules have two RF interfaces for LoRa and GPS antennas over the standard UFL connectors (Hirose U. FL-R-SMT). It has a characteristic impedance of 50OHM and supports both Tx and Rx via RF ports, providing the antenna interface.

## 2.10 Electrical Characteristics

The following are the electrical characteristics of RAK2245 Pi HAT. Please contact us if you need other details and/or parameter for your project.

### 2.10.1 Absolute Maximum Rating

The values and range given below are all in accordance with Absolute Maximum Rating System (IEC 134).





Parameter	Description	Min.	Typ.	Max.
Supply Voltage (VDD)	Input DC voltage	-0.3V	5.0V	5.5V
Operating Temperature	Temperature Range	-40°C		+85°C
RF Input Power				-15dBm

Table 3 | Absolute Maximum Ratings

*Note: With RF output power level above +15 dBm a minimum distance to a transmitter should be 1 m for avoiding too large input level.*

### 2.10.2 Maximum ESD

The table below lists the maximum ESD.

Parameter	Min	Typical	Max	Remarks
ESD sensitivity for all pins except ANT1			1 kV	Human Body Model according to JESD22-A114
ESD sensitivity for ANT1			1 kV	Human Body Model according to JESD22-A114
ESD immunity for ANT1			4 kV	Contact Discharge according to IEC 61000-4-2
			8 kV	Air Discharge according to IEC 61000-4-2

Table 4 | Maximum ESD Ratings

*Note: The module is an Electrostatic Sensitive Device and require special precautions when handling.*

### 2.10.3 Operating Conditions

The table below lists the operation temperature range.

Parameter	Min.	Typical	Max.	Remarks
Normal operating temperature	-20°C	+25°C	+65°C	Fully functional and meets 3GPP specifications
Extended operating temperature	-40°C	+25°C	+85°C	RF performance may be affected if outside the normal operating range, but the module is still fully functional

Table 5 | Operation Temperature Range

### 2.10.4 Power Consumption

Mode	Condition	Min	Typical	Max
------	-----------	-----	---------	-----



<b>Active-Mode(TX)</b>	TX enabled and RX disabled.		336mA	
<b>Active-Mode(RX )</b>	TX disabled and RX enabled.		360mA	

Table 6 | Power Consumption

## 2.11 RF Characteristics

### 2.11.1 Transmitter RF Characteristics

The RAK2245 Pi HAT has an excellent transmitter performance. It is highly recommended to use an optimized configuration for the power level configuration, which is part of the HAL. This results in a mean RF output power level and current consumption.

**Note:** The maximum output power setting should not exceed 11.73dBm.

PA Control	DAC Control	MIX Control	DIG Gain	Nominal RF Power Level [dBm]
0	3	8	0	-6
0	3	10	0	-3
0	3	14	0	0
1	3	9	3	4
1	3	8	0	8
1	3	9	0	10
1	3	11	0	12
1	3	12	0	14
1	3	13	0	16
2	3	12	0	17
2	3	13	0	19
2	3	14	0	20
3	3	10	0	0
3	3	11	0	0
3	3	12	0	25
3	3	13	0	26
3	3	14	0	27

Level

T=25°C, V<sub>DD</sub>=5V (Typical) if nothing else stated.

Parameter	Condition	Min	Typ.	Max
<b>Frequency Range</b>		903 MHz		927.5 MHz
<b>Modulation Techniques</b>	FSK/LoRaTM			



<b>TX Frequency Variation vs. Temperature</b>	Power Level Setting : 20	-3 KHz		+3 KHz
<b>TX Power Variation vs. Temperature</b>		-5 dBm		+5 dBm
<b>TX Power Variation</b>		-1.5 dBm		+1.5 dBm

*e 8 | TX RF Characteristics*

### 2.11.2 Receiver RF Characteristics

We recommended you to use optimized RSSI calibration values which is part of HAL v3.1. For both Radio 1 and 2, the RSSI-offset should be set to -169. The following table gives typical sensitivity level of RAK2245 Pi HAT.

Signal Bandwidth/[KHz]	Spreading Factor	Sensitivity/[dBm]
<b>125</b>	12	-139
<b>125</b>	7	-126
<b>250</b>	12	-136
<b>250</b>	7	-123
<b>500</b>	12	-134
<b>500</b>	7	-120

*Table 9 | RX RF Characteristics*

Note: The US915 Band only support 500kHz bandwidth.

### 3 Source Codes

**Here is the open source code link:**

<https://github.com/RAKWireless/RAK2245-RAK831-LoRaGateway-RPi-Raspbian-OS>

## 4 Warning

**FCC Warning:** This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions.

- (1) This device may not cause harmful interference;
- (2) This device must accept any interference received, including interference that may cause undesired operation.

Any Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. When the module is installed in the host device, the FCC ID label must be visible through a window on the final device or it must be visible when an access panel, door or cover is easily removed. If not, a second label must be placed on the outside of the final device that contains the following text: — Contains FCC ID: 2AF6B-RAK2243.

Maximum antenna gain allowed for use with this device is 3dBi.

This module complies with FCC radiation exposure limits set forth for an uncontrolled environment .This equipment should be installed and operated with minimum distance 20 cm between the radiator& your body.

**Manufacture name and address:**

Shenzhen Rakwireless Technology Co., Ltd.

Room 506, Bldg B, New Compark, Pingshan First Road, Taoyuan Street, Nanshan District, Shenzhen



## INTEGRATION INSTRUCTIONS

1. This module has been tested and found to comply with the FCC Part15.247 for Modular Approval.
2. This Modular Approval is limited to OEM installation for mobile and fixed applications only. The antenna installation and operating configurations of this transmitter, including any applicable source-based time- averaging duty factor, antenna gain and cable loss must satisfy MPE categorical Exclusion Requirements of 2.1091. This modular should be installed and operated with minimum distance 20 cm between the radiator& your body.
3. The U.FL connector antenna has been approved for the modular. For situations where the host manufacturer is responsible for an external connector, the integration instructions shall inform the installer that a unique antenna connector must be used on the Part 15 authorized transmitters used in the host product.
4. When the module is installed in the host device, the FCC ID label must be visible through a window on the final device or it must be visible when an access panel, door or cover is easily removed. If not, a second label must be placed on the outside of the final device that contains the following text: —Contains FCC ID: 2AF6B-RAK2243.
5. The Shenzhen Rakwireless Technology Co., Ltd. uses various test mode programs for test set up which operate separate from production firmware. Host integrators should contact Shenzhen Rakwireless Technology Co., Ltd. for assistance with test modes needed for module/host compliance test requirements.
6. Summarize the specific operational use conditions

This module can be used in household electrical appliances as well as lighting equipments.The input voltage to the module should be nominally 4.5 to 5.5VDC,typical vale 5.0VDC and the ambient temperature of the module should not exceed 85° C.This module using only one kind of antennas with maximum gain is 3.0dBi.Other antenna arrangement is not covered by this certification.

The antenna is not field replaceable.If the antenna needs to be changed,the certification should be re-applied.

### 7. Information on test modes and additional testing requirements

- a) The modular transmitter has been fully tested by the module grantee on the required number of channels,modulation types,and modes,it should not be necessary for the host installer to re-test all the available transmitter modes or settings.It is recommended that the host product manufacturer,installing the modular transmitter,perform some investigative measurements to confirm that the resulting composite system does not exceed the spurious emissions limits or band edge limits(e.g.,where a different antenna may be causing additional emissions).
- b) The testing should check for emissions that may occur due to the intermixing of emissions with the other transmitter,digital circuitry,or due to physical properties of the host product(enclosure).This investigation is especially important when integrating



multiple modular transmitters where the certification is based on testing each of them in a stand-alone configuration. It is important to note that host product manufacturers should not assume that because the modular transmitter is certified that they do not have any responsibility for final product compliance.

c) If the investigation indicates a compliance concern the host product manufacturer is obligated to mitigate the issue. Host products using a modular transmitter are subject to all the applicable individual technical rules as well as to the general conditions of operation in Sections 15.5, 15.15, and 15.29 to not cause interference. The operator of the host product will be obligated to stop operating the device until the interference has been corrected.

Below are steps for on test mode:

```
killall lora_pkt_fwd
```

```
reset_lgw.sh start 11
```

```
util_tx_continuous -f 923 -r 1257 --dig 0 --mix 8 --pa 0 --mod LORA --sf 7 --bw 500
```

```
~~~~~
```

```
-f      <float>  Tx RF frequency in MHz [800:1000]
```

```
-r      <int>    Radio type (SX1255:1255, SX1257:1257)
```

```
--dig   <uint>   Digital gain trim, [0:3]
```

0:1, 1:7/8, 2:3/4, 3:1/2

```
--mix   <uint>   Radio Tx mixer gain trim, [0:15]
```

15 corresponds to maximum gain, 1 LSB corresponds to 2dB step

```
--pa    <uint>   PA gain trim, [0:3]
```

```
--mod   <char>   Modulation type ['LORA','FSK','CW']
```

```
--sf    <uint>   LoRa Spreading Factor, [7:12]
```

```
--bw    <uint>   LoRa bandwidth in kHz, [125,250,500]
```

## 8. Additional testing, Part 15 subpart B disclaimer

The final host/module combination needs to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device.

The host integrator installing this module into their product must ensure that the final composite product complies with the FCC requirements by a technical assessment or evaluation to the FCC rules, including the transmitter operation and should refer to guidance in KDB 996369.

## 5 Contact Information

### Shenzhen



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## 6 Revision History

Revision	Description	Date
1.0	Initial version	2018-12-21
1.1	Modify Pin definition	2019-01-23
1.2	Add source codes chapter	2019-02-14

## 7 Document Summary

**Document Name:** RAK2245 Pi HAT User Manual

**Revision Number:** V1.2

Prepared by	Checked by:	Approved by:
Jeff & Penn	Jeff	



### About RAKwireless:

RAKwireless is the pioneer in providing innovative and diverse cellular and LoRa connectivity solutions for IoT edge devices. It's easy and modular design can be used in different IoT applications and accelerate time-to-market .

For more information, please visit RAKwireless website at [www.rakwireless.com](http://www.rakwireless.com).